Symposium on
‘Global Review of Institutional Reforms in Irrigation Sector for Sustainable Agriculture Water Management, including Water Users’ Association’

Country Papers and Case Study
Volume II
Symposium on ‘Global Review of Institutional Reforms in Irrigation Sector for Sustainable Agriculture Water Management, including Water Users’ Association’

Country Papers and Case Study

Volume II

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AUSTRALIA COUNTRY PAPER: INSTITUTIONAL REFORMS IN IRRIGATION SECTOR FOR SUSTAINABLE AGRICULTURE WATER MANAGEMENT, INCLUDING WATER USERS’ ASSOCIATIONS

1 INTRODUCTION

Australia is the driest inhabited continent. Our use of water in irrigation has reaped great rewards in terms of the development of rural industries, the growth of the economy and the modernisation of Australia. Water resource policies since European Settlement were, like those relating to other resources, focused on promoting economic and population growth, and creating jobs.¹

The formative years of irrigation in Australia were in the 19th Century and the major irrigation developments occurred initially in the Murray-Darling Basin, where the conditions were the most conducive to such development. The late 19th and early 20th centuries saw a dramatic increase in irrigation development both in the Murray Darling Basin and elsewhere as governments attempted to overcome a natural water scarcity. Drought was always of concern.

The Australian Government recognised that turning the coastal (eastern) flowing streams of the Snowy Mountains of south east Australia inland could improve water security for irrigation as well as be a source of hydroelectricity production. The Scheme was completed 1974 and increased irrigation allocations to farmers in the Murray Darling Basin’s main southern rivers.

The implications of this additional water use together with water pricing policies which undervalued this resource were not fully understood and there was a cost, not just in terms of environmental degradation of productive land and river systems. There have also been costs in terms of lost agricultural production value, lost investment and increasing uncertainty about the availability of water.

Australia has now moved well away from the traditional thinking, attitudes and actions which underpinned Australia’s use of water since European settlement. Over the past 20 years or so, it has become clear that this approach has not served Australia well.

As with other industries, the 1980s saw a change in focus for water management. No longer was the focus on bigger dams to solve water issues, but rather, consistent with other microeconomic reforms of the time, options were being examined to improve the allocation of existing entitlements. The objective behind this was to promote efficiency and equity in water allocation while protecting the environment. At the same time, droughts during the 1980s forced governments to consider flexibility and transferability of water allocations/licences as farmers sought to transfer unused allocations from farm to farm in the same ownership. Farmers were also seeking greater input into the operation and management of irrigation schemes, first steps in irrigation management transfer.

By the 1990s, most of the available economic water resources had been exploited and the incremental cost of water supply was increasing sharply. Conflict was starting to emerge between the old developmental objectives and newer economic and environmental objectives.

Reforms were needed to improve the efficiency of the water sector and in 1994 the Council of Australian Governments (COAG) endorsed a framework of initiatives for the water industry to run over a seven-year period. This covered:

- water pricing reforms based on the principles of consumption-based pricing and full cost recovery;
- elimination of cross subsidies and making other subsidies transparent;
- clarifying water property rights;
- allocating sufficient water for environmental purposes;
- facilitating and promoting water trading;
- rigorous assessment of new rural water projects; and
- reforming water industry institutions.

The COAG water reform framework required the development of a comprehensive system of water allocations (including water sharing plans) and entitlements. These reforms were enhanced in 1995 when NSW, Victoria, South Australia and Queensland agreed to implement a cap on diversions as part of the Murray-Darling Basin Agreement, based on 1993-94 levels of utilisation. The Cap had the effect of requiring users to obtain additional water requirements through the market rather than through increased diversions under existing or new entitlements, thus taking a significant step towards sustainable water use.

In 2003, COAG agreed to refresh its 1994 water reform agenda by developing a new National Water Initiative. Among other things, the Initiative set out reforms for best practice pricing and institutional arrangements. This included:

- promoting the economically efficient and sustainable use of water;
- giving effect to the principles of user-pays;
- achieving pricing transparency; and
- facilitating the efficient functioning of water markets.

The Australian Government recognise the returning of diversions to sustainable levels would be facilitated by a funding stream that would also minimise impacts on regional and rural communities. The Sustainable Rural Water Use and Infrastructure Program (SRWUIP) was established as a national program which invests in rural water use, management and efficiency, including improved knowledge and market reforms. Water savings arising from SRWUIP investment in infrastructure efficiencies are shared between the irrigators/irrigation water providers and the Commonwealth (for environmental use). As part of the ongoing reforms the Australian Government has implemented a strategy to secure Australia’s long-term water supply. The ‘Water for the Future’ program is investing $12.9 billion over 10 years in water buybacks, infrastructure and policy reforms. The program includes $3.1 billion for purchasing water entitlements in the Murray Darling Basin to return to the river, and $450 million for improving water information systems (Box 1).

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Table 1. Comparative data on irrigation service providers

<table>
<thead>
<tr>
<th>Year established</th>
<th>CMW</th>
<th>MI</th>
<th>MIL</th>
<th>RIT</th>
<th>WML</th>
<th>SRWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corp.</td>
<td>1905</td>
<td>1912</td>
<td>1929</td>
<td>1893</td>
<td>1914</td>
<td>1917</td>
</tr>
<tr>
<td>2,245,865</td>
<td>876,400</td>
<td>1,291,181</td>
<td>37,924</td>
<td>240,459</td>
<td>29,675</td>
<td></td>
</tr>
<tr>
<td>22,525</td>
<td>3,024</td>
<td>2,419</td>
<td>1,123</td>
<td>2,727</td>
<td>401</td>
<td></td>
</tr>
<tr>
<td>915,461</td>
<td>483,000</td>
<td>749,202</td>
<td>7,285</td>
<td>27,627</td>
<td>4,492</td>
<td></td>
</tr>
<tr>
<td>568,761</td>
<td>119,000</td>
<td>411,532</td>
<td>4,084</td>
<td>10,872</td>
<td>4,154</td>
<td></td>
</tr>
</tbody>
</table>

Notes: ML delivered is the total for all users; ‘Report of the National Program for Irrigation R&D Benchmarking Project’, edited by Barraclough & Co, Occasional Paper 17/98.
Box 1. Overview of Australia’s national water reform and key events

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1863</td>
<td>Inter-colonial conference discusses management of the River Murray</td>
</tr>
<tr>
<td>1887</td>
<td>South Australian Royal Commission examines the effects of irrigation on river navigation in the River Murray</td>
</tr>
<tr>
<td>1914–1917</td>
<td>New South Wales, Victoria and South Australia sign the River Murray Waters Agreement and establish the River Murray Commission</td>
</tr>
<tr>
<td>1970</td>
<td>River Murray Commission publishes detailed study of irrigation and salinity</td>
</tr>
<tr>
<td>1981</td>
<td>River Murray mouth closes temporarily</td>
</tr>
<tr>
<td>1987</td>
<td>Murray–Darling Basin Agreement signed</td>
</tr>
<tr>
<td>1989</td>
<td>River Murray Salinity and Drainage Strategy agreed</td>
</tr>
<tr>
<td>1992–1996</td>
<td>Commencement of corporatisation and price regulation in urban water</td>
</tr>
<tr>
<td>1994</td>
<td>COAG agrees to Water Reform Framework and National Competition Policy</td>
</tr>
<tr>
<td>1995</td>
<td>Initial cap on water diversion from the River Murray</td>
</tr>
<tr>
<td>1997</td>
<td>Millennium Drought commences (persists until 2009)</td>
</tr>
<tr>
<td>2004</td>
<td>National Water Initiative</td>
</tr>
<tr>
<td>2007–2008</td>
<td>Water Act 2007 (Cwlth) passed and Murray–Darling Basin Authority created as a result of the National Plan for Water Security</td>
</tr>
<tr>
<td>2008–2009</td>
<td>Further water reform agreements by COAG</td>
</tr>
<tr>
<td>2012</td>
<td>Murray–Darling Basin Plan takes effect</td>
</tr>
<tr>
<td>2013</td>
<td>COAG agrees next steps in water reform.</td>
</tr>
<tr>
<td>2017</td>
<td>Review of the Murray Darling Basin Plan commences</td>
</tr>
<tr>
<td>2017</td>
<td>Productivity Commission Review into National Water Reform progress</td>
</tr>
</tbody>
</table>


2 LEGAL FRAMEWORK AND INSTITUTION REVIEW

2.1 Water Ownership

The Australian Constitution (drafted at end of 19th Century) vests ownership of the water with the Crown, but restricts the role of the Commonwealths with natural resources policy, including that relating to water, remaining the responsibility of states. The Commonwealth Government has, however, the capacity to indirectly influence the public policy and has done so with water by developing national policies through agreements with the State and Territory Governments.¹

A water access licence or other approval from the state is generally required to extract water from rivers or aquifers to use for commercial purposes. This also applies to rainfall runoff and flood flows on an individual farm.

Trading in water, sometimes referred to as transferable water entitlements (TWEs) in Australia was as a concept introduced in the 1980s. The various state jurisdictions all have their own timelines around the development of water trading however the COAG water reforms have brought a uniformity/commonality to TWEs to enable trading within and between jurisdictions. Table 2 shows the development of the idea of water trading in Victoria, a state on the cutting edge of the water trading concept.

From the first tentative steps in 1980s, by the 1990s most states had implemented procedures for transfers within their State. Although initial results in the Murray-Darling Basin were not encouraging (caused by 15% increase of water extraction, due to holders of licenses that would not have used the water, so-called ‘sleepers’ selling their rights to other irrigators), TWE is now recognised as a successful innovation, with transfers now occurring between irrigators in different states and between sectors (irrigation districts and riparian/river pumpers, irrigation to urban water supply) and discussions about
trading ground water (between interconnected systems) or sewage effluent. A service sector as developed which facilitates this trading. Trades are placed on a register which includes volumes traded and price.

**Table 2. Steps That Promoted Water Transfers in Victoria**

<table>
<thead>
<tr>
<th>Period</th>
<th>Actions promoting Water Transfer in Victoria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909</td>
<td>Introduction of the concept of water entitlement</td>
</tr>
<tr>
<td>1940s</td>
<td>Informal, short-term transfers during severe droughts</td>
</tr>
<tr>
<td>1979</td>
<td>Limited annual transfer of sales water between properties in common ownership</td>
</tr>
<tr>
<td>1984</td>
<td>Recommendations in the ACIL Australia report to implement water transfers</td>
</tr>
<tr>
<td>1987</td>
<td>Introduction of temporary water transfers after necessary legislative amendments in 1987</td>
</tr>
<tr>
<td>1989</td>
<td>Introduction of Water Act 1989</td>
</tr>
<tr>
<td>1991</td>
<td>Implementation of permanent water transfers under provisions made in the Water Act 1989</td>
</tr>
<tr>
<td>1995</td>
<td>Amendments to the Water Act 1989 to promote inter-state temporary water transfers</td>
</tr>
<tr>
<td>1997</td>
<td>Amendments to the Water Act 1989 to promote inter-state permanent water transfers</td>
</tr>
</tbody>
</table>

The major area that is at the forefront of water trading is Murray-Darling Basin. An important Pilot Interstate Water Trading Project was located in the Mallee Region of South Australia, Victoria and New South Wales. This pilot project commenced in 1998 contributed towards fulfilling COAG objectives, defined as improvement efficiency of (especially irrigation) water consumption, whilst maintaining and improving both economic and environmental sustainability.

Water ‘ownership’ in the Australian context is denoted by licenses/water entitlements. Some major licenses may have an allowance for conveyance losses (generally not tradeable) as part of the license. The allowances can be significant, for example Murrumbidgee Irrigation has an extraction right of 1,200 GL and a license to use/divert to farmers (or sell) 900 GL.

As a principle under COAG whoever invests in water use efficiency activities should benefit from this investment. Hence if Murrumbidgee Irrigation manage to save some of the divertible water (and prove that), they sell the savings to their members or could place these savings on the open market for sale elsewhere. Savings in conveyance allowance can only be transferred to Australian government. In Victoria and New South Wales, a farmer can sell what he saved, thus the farmer would be interested in investing into water saving technologies. Even if the states are not allowed to sell the savings (because of the ‘cap’ for each state by the MDBA), the savings are beneficial in lean years, or simply result in releasing more water as environmental flow.

### 2.2 Legal Framework of Australian Water

The evolution of water law in Australia can be broadly conceptualized as comprising of four distinct phases:

**The first phase: The Common Law** assigned rights to water users and gave very little consideration to the environment. The riparian rule created a right and duty to not sensibly diminish, although the groundwater rule encouraged unfettered use.

**The second phase: Vesting of the Use Power and Control Power in the States** was the period of vesting water in allocation systems to widen its use. This approach created licenses representing a mere claim on the water in law rather than the law per se. In the minds of many farmers, however, they had a right to the water (called water rights) and it was rarely taken away or challenged. During

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3 This Chapter is cited from: McKay J, *The Legal Framework of Australian Water: Progression from Common Law to Sustainable Shares*. 
this phase groundwater was also subject to licenses, although this was, in practice, little different than the open access regime of the earlier phase. Rarely was there a charge imposed on water use itself but charges were often applied for the administration of this use and the rationale that underpinned this phase largely encouraged the creation of over-allocated systems, especially in New South Wales in pursuit of development of rural communities.

The third phase: Council of Australian Governments (CoAG) Reforms 1994-2004 imposed an obligation to include Environmentally Sustainable Development (ESD) principles on water allocation decisions as well as other market reforms to promote private sector provision of water and water trading. This was the time of community agitation over drought and blue-green algae. Stressed rivers were identified in many states and plans made to alter allocation processes. There was considerable angst over loss of consumptive water rights and acrimonious debates about compensations. Importantly, it signalled the formal enhancement of the role of the Commonwealth in water policy formulation.

The fourth phase: National Water Initiative and Commonwealth Water Bill 2007 imposed a clear rule of allocation of water for consumptive use. This rule is consistent across state jurisdictions and amounts to a perpetual share of the consumptive pool of the resource. Arguably, this represents the weakest legal right for users to date. The NWI approach requires conformance to a local water sharing plan (drafted under various state laws) which allocates the quantum of water in local resources over a set time period: however, as a product of Section100 of the constitution and attendant political issues, variations of the definition of ESD between states has the potential to prove problematic.

Most importantly the direct outcome for the farmer is that previous allocated volumes of water are replaced by a percentage share of an annual sustainable yield or surface water or groundwater. Accordingly, irrigators (and other right holders) have a right to that share but the quantum varies annually. The annual quantum in each river system is decided by a process of water plans, which endeavour to integrate scientific data with economic and social information as required to achieve ESD. These processes continue to evolve and have already been contested in New South Wales and Victoria. The processes themselves also differ markedly between the states.

The final phase also confirms the expanded role of the Commonwealth government, despite Section 100, and attempts to have the state’s referred. This has manifested itself in considerable persuasion over the shaping of early CoAG reforms and the more recent NWI. Although this influence can undoubtedly be traced to the vertical fiscal imbalance that typifies Commonwealth – state relations, the future legal standing of these arrangements has yet to be fully tested.

2.3 Institutional Review

As an illustration of the complexity of the issue in Australian context, Table 3 gives a cross-section of basic institutional arrangements for water resources management, in the four states of the Murray-Darling Basin. These institutional arrangements have continued to evolve as governments have sought to improve accountability and functionality of government departments.

Finally, a 1994 COAG Communique reads:

... In relation to water allocations or entitlements: the State Government members of the Council, would implement comprehensive systems of water allocations or entitlements backed by the separation of water property rights from land title and clear specification of entitlements in terms of ownership, volume, reliability, transferability and, if applicable, quality...

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4 See first paragraph of the Chapter 2.1 Water Ownership.
5 Source: Young M D, McColl J C, Robust Separation, CSIRO, 2002, which cites the paragraph from the 1994 COAG communiqué
Table 3. Institutional Arrangements for Water in Murray-Darling Basin (2001)\textsuperscript{a}

<table>
<thead>
<tr>
<th>State</th>
<th>Water Resource Management</th>
<th>Service Provision</th>
<th>Environmental Regulations</th>
<th>Economic Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>QLD</td>
<td>Department of Water Resources</td>
<td>Local government and state government</td>
<td>State Government</td>
<td>Environmental Protection Agency equivalent</td>
</tr>
<tr>
<td>NSW (ACT &amp; TAS)</td>
<td>Department of Water Resources</td>
<td>Local government and state government</td>
<td>Private and Department of Water Resources</td>
<td>Environmental Protection Agency equivalent</td>
</tr>
<tr>
<td>VIC</td>
<td>Department of Conservation and Natural Resources</td>
<td>Local government and state government</td>
<td>Five Irrigation Corporations</td>
<td>Environmental Protection Agency equivalent</td>
</tr>
<tr>
<td>SA</td>
<td>Department of Conservation and Environment</td>
<td>Local government and state government</td>
<td>State Government</td>
<td>Environmental Protection Agency equivalent</td>
</tr>
</tbody>
</table>

3 \textbf{CHALLENGES}

3.1 \textbf{Water Accounting}

Assessing water resources and accounting for their availability and use at a regional and national scale require comprehensive and consistent information on water distribution, storage, availability, and use. This information needs to be accurate, up-to-date and take account of local climatic and hydrological conditions. It also needs to be produced in a robust, transparent and repeatable manner. As the competition for water resources increases, it is more important than ever to fully account for how water is shared between the economy, critical human needs and the environment. Water accounting is a relatively new concept in water resources management, and Australia is leading the world in this discipline. Australian Water Accounting Standards provide guidance and explanatory material to assist in preparing, presenting and assuring general purpose water accounting reports.

Water accounting integrates hydrological processes with land use, managed water flows and the services that result from water consumption in river basins. Its objective is to strive to achieve equitable and transparent water governance for all water users and a sustainable water balance. Users can provide value assessments of certain process, and more accurate data sets, that replaces the default data collected from open access sources that represent “best estimates”. Accurate measurement of water use is a critical component of this, particularly at the farm level.

How the environment is conceptualised for the National Water Account

The National Water Account focuses on the volume of water in the environment, its availability, the rights to abstract it and its actual abstraction over time. The National Water Account reports on the total water resource of a region: the inputs to, outputs from and movements of water within a hydrological region. It includes atmospheric inputs and outputs, such as rainfall and evaporation, as well as flows of water through rivers, pipes, channels and aquifers within the region.

In Australia, the water available for abstraction is a subset of this total water resource, as some of the water is not physically or legally accessible. Legal rights and claims to water regulate the volume of water that is available for abstraction by individuals and businesses. This differs from the Water Account, Australia, as presented by the Australian Bureau of Statistics (ABS), which presents information on the physical and monetary supply and use of water in the Australian economy. It is compiled, as far as possible, in accordance with the System of Environmental-Economic Accounting

The Water Account also provides information on the water use and consumptive practices of households and key industries (Agriculture and Water Supply, Sewerage and Drainage Services).

Under the Commonwealth Water Act 2007 the Bureau of Meteorology is responsible for compiling and delivering comprehensive water information across Australia. This includes publishing an annual National Water Account. The Bureau’s National Water Account contains standardised information about the management of Australia’s water resources.

The National Water Account provides a detailed insight into the management of Australia’s water resources at the national and regional scale. It supports the National Water Initiative, disclosing the total water resource, the volume of water available for abstraction, the rights to abstract water, and the actual abstraction of water for economic, social, cultural and environmental benefit across Australia.

The National Water Account is produced for a water year from 1 July to 30 June. It focuses on hydrologically defined regions of national significance and is:

- compiled from the best available data
- produced and reviewed using standardised processes
- guided by Australian Water Accounting Standard 1

The National Water Account makes a significant contribution to the management of Australia’s water resources by informing decision making. The process of reporting in the National Water Account is transparent which builds confidence and understanding in the volumes published regarding water traded, extracted for use, recovered and managed for economic, public and environmental purposes.

**Australian Water Accounting Standards**

Australian Water Accounting Standards provide guidance and explanatory material to assist in preparing, presenting and assuring general purpose water accounting reports. The theoretical foundation of water accounting is contained in the *Water Accounting Conceptual Framework for the Preparation and Presentation of General Purpose Water Accounting Reports*. The primary purpose of the framework is to guide the development of Australian Water Accounting Standards, to ensure they remain cohesive and integrated. The framework was first issued in 2009 and revised in 2014 by the Water Accounting Standards Board, as part of the Bureau of Meteorology’s water accounting function. The framework was developed by consulting water industry experts, financial accountants, and financial accounting standard setters.

**Australian Water Accounting Standard 1** explains how to prepare and present a general-purpose water accounting report. It sets out requirements for the recognition, quantification, presentation and disclosure of items in such a report. The document also includes three appendices:

- a list of defined terms;
- implementation guidance; and
- a basis for conclusions, which outlines the discussions and assumptions that informed decisions made during its preparation.

**The Water Cycle**

In the National Water Account accounting for water flows and changes in water storage is based on a conceptualisation of the terrestrial part of the water cycle as shown in Figure 1. The terrestrial part of the water cycle includes all water that has precipitated on the land and has not yet evaporated or flowed into the sea. For the purposes of the National Water Account it excludes water in tidal estuaries, which is considered to be sea water.
Water flows
Water flows are fluxes of water that occur between a region’s water stores or between water stores inside and outside of the region. Data on the volumes of water flows are aggregated as separate line items. Examples of water flows shown in Figure 2 are:
- precipitation (snow and rain on surface water stores)
- evaporation from surface water stores
- runoff (the net of precipitation on and evapotranspiration from the landscape)
- recharge of the groundwater from the landscape
- water abstractions from the various water stores
- water transfers between the region’s water stores and from other regions
- returns after use of urban water and irrigation water.

Information about these water flows is collected as line items. Line items are numbered in a way that is consistent across all regions. This means that direct comparisons can be drawn about the water flows (or line items) across all the regions reported in the National Water Account.

Water stores
The intersection of the objective of the National Water Account and the structure of water management in Australia has shaped the identification of the separate water stores in the National Water Account. The water stores separately identified and used are (see Figure 3):
- surface water
- groundwater
- urban water system
- irrigation scheme
- off-channel water
- landscape water.
These water stores differ from those of classical hydrology in that:
- water available for sharing is separated from the rest of the water resource of the region; and
- water stores are aligned to the water access rights that are granted by State governments.

Water available for sharing constitutes the physical water assets of the water accounting region. It may include water in the following water stores:
- surface water
- groundwater
- urban water system
- irrigation scheme.

Water located within the boundary of a region but not available for sharing includes:
- off-channel water
- landscape water.

Figure 2. Water Cycle

Figure 3. Various stores of water
**Definition of the water accounting region**

In the National Water Account, a region is a hydrological region. All water resources that are available for sharing within a region form the water accounting region. Whether a water resource is included in the specification of a water accounting region directly influences the way it is reported in the National Water Account, as follows:

- Water that is counted as a water asset of the water accounting region may be reported in the water accounting statements.
- Water that is not counted as a water asset of the water accounting region may be reported only in the notes.

The water accounting regions covered by the National Water Account differ in terms of their water assets.

For example: In mainly rural regions of the National Water Account, such as the Murray–Darling Basin or the Ord, most of the water assets are made up of surface water and groundwater. In the Murray–Darling Basin, for instance, there is relatively little water that is transferred in by users (individuals or utilities).

**Structure (Product outcomes)**

The National Water Account is a collection of water accounting reports on nationally significant water use regions across Australia. Each water accounting report presents quantitative and qualitative information on the water resources of the region. The structure of each report derives from the Australian Water Accounting Standard 1, and is as follows:

- contextual information
- water accounting statements presented in the form of financial statements
- detailed notes
- an accountability statement.

**Contextual information**

A comprehensive picture of the region is provided in the contextual information. It provides important background for understanding the water accounting statements. The contextual information includes:

- a general description of the geographic features, land use and population centres
- the administrative and legal frameworks of water management
- information about water rights including entitlements, allocations and trade
- an overview of the climatic conditions and important water related events during the reporting period
- a description of the surface and groundwater resources.

**Water accounting statements**

The National Water Account reports volumetric information about regional water resources in three Water Accounting Statements:

- **Statement of Water Assets and Water Liabilities**
- **Statement of Changes in Water Assets and Water Liabilities**
- **Statement of Physical Water Flows**.

Water assets in the National Water Account include water (physical water assets) and rights or claims to water (non-physical water assets). Only information that meets the recognition criteria specified in the Australian Water Accounting Standard 1 is presented in the statements. Quantitative information that does not meet the recognition criteria but is still important to understanding the region’s water resources is provided in the notes. Each of the three water accounting statements presents a different but related perspective of the region’s water.
They present information about changes in the status of the region’s water assets and water liabilities. These changes arise from the various transactions to and from the region during the reporting year. The prior year information is also presented for comparison. The water transactions of most relevance to the National Water Account are those that change the volume of water held in the water stores that make up the physical water assets of the region. The water stores of a region may include the surface water, groundwater, urban water system water and irrigation scheme water stores. These transactions are reflected in aggregate in the line items of the water accounting statements.

Transactions between the water stores are not presented in the statements. This is because intra-regional transactions do not affect the total water assets or water liabilities of the region. Information about intra-regional transactions can be found in the notes. They are also recorded separately in water trade registers.

**Statement of Water Assets and Water Liabilities**

The *Statement of Water Assets and Water Liabilities* is like a balance sheet. It presents the volume of water assets and water liabilities at the start and end of the reporting year. Water assets in the National Water Account include water (physical water assets) and rights or claims to water (non-physical water assets).

- Physical water assets are referred to as the water stores, and include:
  - surface water
  - extractable groundwater
  - urban water system water
  - irrigation scheme water

- Non-physical water assets include claims to water located outside the region.

**Statement of Changes in Water Assets and Water Liabilities**

Water liabilities in the National Water Account include commitments to deliver water to users, and other agreements to transfer water outside the region. The *Statement of Changes in Water Assets and Water Liabilities* is like an income statement. This statement shows the changes to water assets and water liabilities that occurred during the reporting year.

In the same manner as an income statement that is prepared on an accrual basis, the changes in water assets and water liabilities are recognised in the statement when the claim to water or the obligation to deliver it is recorded and not when the actual flow occurs.

The transactions that change the water assets and water liabilities of a region, including:

- accrual transactions (non-physical transactions) are represented by purple arrows;
- physical transactions (actual water flows) are represented by black arrows:
- natural water flows are represented by dotted black arrows
- engineered flows are represented by solid black arrow.

**Statement of Physical Water Flows**

The *Statement of Physical Water Flows* is like a cashflow statement. This statement shows the actual water inflows into and outflows from the water stores of the region that occurred during the reporting year.

The actual water flows, including those corresponding to the accrual transactions that are shown in Figure 2. In a region where no accrual transactions were recorded, the *Statement of Physical Water Flows* and the *Statement of Changes in Water Assets and Water Liabilities* contain identical information.
The relationship between the water accounting statements
The three water accounting statements reconcile with one another.

1. The **Statement of Water Assets and Water Liabilities** reconciles to the **Statement of Changes in Water Assets and Water Liabilities** as follows:
   - The difference between the opening and closing volumes of net water assets in the **Statement of Water Assets and Water Liabilities** equals the change in net water assets reported in the **Statement of Changes in Water Assets and Water Liabilities**.
   - The unaccounted-for difference on the **Statement of Changes in Water Assets and Water Liabilities** represents the unexplained change in water assets and water liabilities during the reporting year.

2. The **Statement of Water Assets and Water Liabilities** relates to the **Statement of Physical Water Flows** as follows:
   - The difference between the opening and closing volumes of the physical water assets in the **Statement of Water Assets and Water Liabilities** equals the total water inflows minus outflows minus any unaccounted-for difference in the **Statement of Physical Water Flows**.
   - The unaccounted-for difference on the **Statement of Physical Water Flows** represents the unexplained change in physical water assets during the reporting year.

The Bureau of Meteorology's National Water Account and the Australian Bureau of Statistics' Water Account Australia emphasise different aspects of Australian water resources and the use of these resources by the Australian community.

The National Water Account by the Bureau focuses on the volume of water in the environment, its availability, the rights to abstract water and the actual abstraction over time. It includes information on climate and weather impacts on water availability, along with water management policies and practices.

The Water Account Australia by ABS shows how much water is used by human activity. It focuses on flows of water from the environment to the water supply industry and other economic activities, particularly agriculture and the flows of water from the water supply industry to households and businesses. The Water Account Australia also records the monetary values associated with water supplied and used in the economy and is able to link water use to the economic data contained in the System of National Accounts (from which the headline indicator Gross Domestic Product is derived).

The area of intersection between the accounts is the amount of water abstracted from the environment by the water supply industry and other economic activities. Within a region, the volume, in the National Water Account, of actual water abstraction is equal to the volume, in the Water Account Australia, of water abstracted for own use (agricultural irrigation) plus water abstracted for supply to others. This equivalence facilitates the integration of information from the two accounts. It is important to note however that with the exception of the Murray-Darling Basin, the reporting regions for the two accounts are different. The information sheet provides more detail on Australian Government Water Accounting.[3]

3.2 Method and Mechanism for Determination of Cost Recovery and Water Charges
Prior to the 1994 COAG agreement the various states with irrigation determined their water charges by whatever principles they wish to employ. Full cost recovery, including charges for resource utilisation, were not utilised. In many instances, there was no accounting for the actual resource use and charges basically related to administration and delivery of the resource in both government and non-government schemes. Sinking funds were not utilised to fund asset refurbishment/replacement.
The 1994 COAG agreement included general principles for pricing, including consumption-based pricing, full-cost recovery and (desirably) the removal of cross-subsidies. In respect of rural water supply, the agreement provided for a move to full cost-recovery and to achieve positive real rates of return on the written-down replacement costs of assets in rural water. The various states agreed to aim to implement this new pricing regime by 2001.

Further advancing these goals, the 2004 NWI required that the parties:

- promote economically efficient and sustainable use of water resources, water infrastructure assets, and government resources;
- ensure sufficient revenue streams to allow efficient delivery of the required services;
- facilitate the efficient functioning of water markets; and
- give effect to the principles of user-pays and achieve pricing transparency in respect of water storage and delivery in irrigation systems and cost recovery for water planning and management.

The agreement specifically provided for consumption based pricing, coupled with full cost recovery for water services, to ensure business viability and avoid monopoly rents, including (where feasible and practicable) the recovery of environmental externalities. It requires:

- full cost recovery (save some small community services/obligations) with:
  - lower bound pricing;
  - a move towards upper bound pricing, where practicable; and
  - public reporting of subsidies where full cost recovery is unlikely to be achieved in the long term;
- recovery of water planning and management costs, through:
  - identification of costs associated with water planning and management; and
  - identification of the proportion of those costs that can be attributed to water access entitlement holders;
- future investment in water infrastructure to be assessed as economically viable and ecologically sustainable prior to investment occurring;
- annual independent, public report benchmarking of pricing and service quality for rural water delivery agencies;
- an independent pricing regulator together with regular review and public reporting.

The approaches taken by Queensland, New South Wales and Victoria may be different but all comply with the NWI principles. In NSW, the Independent Pricing and Regulatory Tribunal (IPART) is accredited by the ACCC under the Commonwealth Government’s Water Charge (Infrastructure) Rules 2010 (WCIR) to set bulk water prices for WaterNSW within the Murray-Darling Basin (MDB) and sets maximum prices that WaterNSW can charge for its monopoly bulk water services in rural areas. IPART is required to conduct the price review in accordance with the requirements set out in the WCIR for valleys in the MDB. IPART’s review of WaterNSW’s prices for coastal valleys is conducted under the IPART Act. In Victoria, the Victorian Essential Services Commission (‘ESC’) is responsible for the economic regulation including regulating prices and service standards – of the Victorian water sector, including both urban and rural water services.

The implementation of these principles in the various states has had different timeframes and hence stages of completion, particularly due to the political sensitivities associated with increasing water charges. In many instances, States have adopted price paths, typically for 5-year periods, to incrementally move towards full-cost recovery prices.

It has long been acknowledged that increasing water prices is not of itself a sufficient policy response to promote efficiency in use and delivery and the NWI provides for benchmarking of service providers.
Annual performance reports for water service providers were compiled by the National Water Commission as part of a benchmarking exercise.

While the States were slower than originally anticipated in achieving lower bound pricing (the 1994 COAG originally set a target of 2001), this goal has now been realised in the vast majority of government-owned water supply schemes. Where government entities were required to provide water supply services to irrigators at a price that is less than lower bound levels, the balance was paid by government as a transparent community service obligation (‘CSO’) payment.

In Victoria, water access entitlements (i.e. an irrigator’s right to a share of the available water resource) and delivery rights (a right to a share of the capacity of a distribution system) have been unbundled. Consequently, irrigators in Victorian supply schemes hold both a water access entitlement and a delivery share. The unbundling process has (necessarily) been applied to the water pricing regime, with different charges attached to each of these two elements. The system allows for greater freedom for an irrigator to sell their water share outside of the scheme’s delivery system, while ensuring someone (whoever owns the delivery share) remains liable for the fixed charges associated with the delivery share, thus contributing to operation and maintenance of the delivery assets. This approach protects a water supply scheme owner from the risk of lost revenue as a result of water access entitlements being traded out of the scheme and reducing the scheme’s revenue (i.e. the issue of stranded assets). It also provides a more cost-reflective approach to addressing the issue of capacity constraints associated with peak delivery periods. In other Australian states, typically an “exit fee” must be paid before a water entitlement can be transferred out of a supply scheme, to protect the revenue base of the supply scheme operator (Seamus Parker, 2010).

3.3 Engineering Challenges

Irrigation infrastructure operator in Australia typically provides two main services to its customers: to make available capacity of its irrigation network for the delivery of water to be used in irrigation; and to make available capacity of its irrigation/drainage network for the drainage of water previously used in irrigation. Originally, most irrigation in Australia was carried out via irrigation schemes which were built, operated and maintained by governments. Over time private schemes and private infrastructure for individuals were developed. With IMT/privatisation occurring, the proportion of irrigation occurring in government owned schemes is decreasing.

Initially irrigation schemes were designed to supply irrigation on a roster/rotation basis, usually about every 7 or 10 days. Irrigators, over time irrigators demanded delivery of water to meet crop demand, not just for ease of delivery. Fortunately, irrigation system design had been conservative and so much larger volumes of water were able to be delivered under this new regime. These larger volumes of delivery required higher flow rates both in terms of water velocity and depth of the flow. This placed strain on the supply infrastructure both in terms of erosion and siltation.

With income for the delivery of water in these government schemes often being less than the required operation, maintenance and renewal costs these systems deteriorated over time. Minor upgrades and refurbishments were being paid for by government but construction was not at a rate that would keep the systems at state-of-the-art irrigation infrastructure in many instances.

With the commencement of irrigation management transfer/corporatisation/privatisation farmers realised that they would be getting a second-rate irrigation supply and drainage system if they took over the existing systems in the conditions they were. In New South Wales, a dowry was negotiated between irrigators and government to upgrade irrigation infrastructure such that irrigation systems being taken over would be upgraded to an adequate level. For the more extensive broad area schemes this mainly involved the replacement/upgrading of structures. Rarely were channels themselves upgraded. However, for the intense horticulture irrigation schemes the importance of replacing open
concrete lined channels to mitigate against seepage in the generally lighter soils resulted in replacing open concrete channels with pipelines and in most instances in New South Wales this was completed prior to irrigation management transfer. No dowry was therefore required.

The Australian government recognised that funding was required to these new system operators to undertake ‘hot spot’ analysis to identify where the systems had excessive leakage or operational constraints, which were seen as major contributors to poor irrigation delivery efficiency. The Irrigation Hotspots Assessment Program is a component of the Sustainable Rural Water Use and Infrastructure Program (SRWUIP). The program funded 9 irrigation water providers to identify their sources of water loss. All of these providers also received funding under the Irrigation Modernisation Planning Assistance program to develop a plan to address identified hotspots and funding has been provided to address these sources of inefficiency.

The more extensive irrigation infrastructure operators have made use of this and other government funding to modernise their irrigation infrastructure. Under this modernisation, old manually operated structures have been replaced with automated gates, leaky channels have been replaced by lined channels and pipelines and old-style Dethridge outlets have been replaced with modern accurate farm outlets. Now some irrigation infrastructure operators have totally automated systems and others, the larger scheme, have hybrid systems where automation is combined with manual control. Many of these automated systems are so controlled that farmers are able to order water and see it being delivered to their farm offtake via computer.

Water savings from efficiency gains from these modernisations have been reallocated to the environment to reduce diversions to sustainable levels. Much of this reallocation of water for environmental benefit has occurred in the Murray Darling Basin but some has also been directed to streams impacted by the snowy Mountains hydroelectricity scheme.

### 3.4 Water for Irrigation

Irrigation providers are the organisations which undertake retail water distribution, primarily to agricultural and horticultural irrigators but also to agricultural stock water users, rural house and garden users and bulk purchasers. Bulk purchasers include rural towns, factories and industry, and stock and domestic leagues (groups of agricultural stock and rural house users). Irrigation providers divert water from the river systems released on an allocative basis which is matched to specific orders of irrigation providers. GMW is Australia’s largest rural water corporation and manages Australia’s largest irrigation delivery network (the Goulburn-Murray Irrigation District (GMID)). GMW services a region of 68,000 km².

Goulburn Murray Water (GMW) in Victoria is the largest provider in terms of water delivery, numbers of customers and area serviced. GMW also covers the most diverse variation in regions and water uses. Murrumbidgee Irrigation (MI) and Murray Irrigation Limited (MIL) (Murray Irrigation provides irrigation water to over 2,200 farms in southern NSW taking in 724,000 hectares of farmland north of the Murray River), both in NSW, have a number of similarities in terms of climate, land type and land uses. However, MI has a greater proportion of intensive horticultural irrigation. Renmark Irrigation Trust (RIT) (South Australia), Sunraysia Rural Water Authority (SRWA) (Victoria) and Western Murray Irrigation Limited (WML) (NSW) generally supply irrigation water for horticultural production.

### 3.5 Possibility of Public Private Partnership (PPP) for Financing and Improved Service Delivery

The cooperative approach taken by the Commonwealth and the states has resulted in benefits to irrigation infrastructure operators, irrigators themselves, the environment and the people of Australia. The question as to how much water is required by the environment is one that is worthy of significant debate and this has seen very polarised views. Prior to European settlement and the subsequent
irrigation development the environment received all benefit however as irrigation development extracted more and more water the environment began to suffer badly. The massive blue-green algae outbreak of the Murray Darling Basin and the cessation of flows the Murray Mouth created a demand to limit irrigation extractions. The Australian government recognised that to minimise impacts on rural communities dependent on irrigation for their survival and an approach that balanced the demands for extraction of water for irrigation and the needs of the rivers themselves had to be implemented.

The Water for the Future initiative was developed in which the Commonwealth has invested substantial funds into the purchase of water entitlements from willing sellers, upgrading on-farm and off farm irrigation infrastructure to increase water use efficiency both in delivery and on-farm systems with a proportion of water savings being transferred to the Commonwealth for use in environmental activities and a range of other activities. This initiative has invested in programs/projects across all Australian states including coastal and Murray Darling Basin regions.

The Water for the Future initiative may be considered as an application of a public private partnership (PPP). Often public-private partnerships are about private enterprise joining with public enterprise for the benefit of both: the benefit that private enterprise often seeks is a financial reward. PPP in the irrigation sector is about investment by both private enterprise and principally by the Australian government in improvements to irrigation infrastructure, both off farm and on-farm, that results in an outcome for both of improved delivery and water use efficiency with most savings being transferred to the environment and hence the people of Australia.

The Australian Government has set a maximum 2.5 multiplier of market price of water as an upper limit for investment. This higher level of investment (1.5 water price) reflects additional unquantified benefits to regional and rural communities of improvements in water use efficiency.

3.6 Water Trading

In Australia, prior to the Mid 1980s, with water ownership explicitly linked to land ownership, trading in water itself as a commodity was not allowed. However, the major drought of the mid 80s resulted in a start to loosening of trading constraints with water being able to be moved between farms of the same ownership, in the Murray Valley. Now, Water markets are very active and are increasingly being relied upon as an instrument to reallocate water between competing users under conditions of water scarcity, and within an environment of fully committed water resources (Bjornlund, 2003). In Australia and in particular in the Murray Darling Basin (MDB), water markets operate within all irrigation management systems, both surface and groundwater. The existence of this water market mechanism, has enabled irrigators to manage the risk of increased supply uncertainty along with facilitating a continued reallocation of water both within and between seasons and within and between competing uses (such as irrigation and environment).

In MDB, most of irrigation water providers/supply are engaged in water trading through advanced water exchange mechanism (online system). However, water markets and their proper functioning are facing many impediments (Qureshi et al. 2009). These impendiments including variation in allocation of water access rights (supplementary, general and high security) and level of water security, variation in the management regimes of different irrigation authorities and administrative and regulatory constraints for trading water within and between irrigation districts, between irrigation districts and riparian irrigators and within and between water users in various jurisdictions. Variation in water prices charged by different irrigation water providers has also been seen as one of the key factors. Further, it has been recognised that water entitlements are not well defined (Crase et al., 2000) and rationalisation of the complex and inconsistent water entitlements within and across jurisdictions is inevitable to facilitate water markets (Shi, 2006).
4 PARTICIPATORY IRRIGATION MANAGEMENT (PIM) AND IRRIGATION MANAGEMENT TRANSFER (IMT)

4.1 Need and Objectives of PIM and IMT

Irrigation is almost using around 75%-85% of water supplies. Sustainable irrigation water use and supplies associated with appropriate policies and investments can provide water-food secure world. Globally, the water leaders introduce different policy that can deliver efficient, sustainable and equitable water system. However, to realise the role of irrigation system in economic sector, around the world many countries invested in development of irrigation system. In Australia and around the world, most of the state/government-owned irrigation projects suffered in the past from some deficiencies such as irrigation systems were not self-sustaining because water charges were kept low and were not collected efficiently over the years. Another deficiency, unreliability in the water distribution system resulted from inefficient mechanism for allocated fund for the operation and maintenance for the irrigation system. These lead to a conclusion within the water sector that unless farmers become involved in more structure way for operation, management and maintenance, the whole objectives of the irrigation schemes would not be delivered.

In late 1990, there were a global call to shift the ownership and management of irrigation systems to farmers. The World Bank has attempted a systematic classification of participatory management into these types:

- privately managed;
- individually managed – systems that are managed by one farmer or a company (private or government owned like a parastatal);
- farmer managed – systems that are managed autonomously by a group of farmers who have the legal authority to take decisions about all aspects and all levels of water management;
- jointly managed: systems that are managed by an agency and farmers together;
- agency managed: systems where agency staff has the major responsibility to manage most operation and maintenance activities (Vuren and Mastenbroek, 2000).

Some countries in the world took an early lead in management transfer. It was advocated worldwide that farmers should participate more in governance, management and financing resource development in order to promote sustainable and equitable development (Restrepo et al., 2007). Since 1980s there have been many experiments in Asia adopted the irrigation management transfer programme with varying degrees of effort and success.

4.2 PIM and IMT Approach

Irrigation Management Transfer programmes are referred to by different names in different countries. In Australia, it has been primarily called corporatisation/privatisation, however in other countries sometimes it has been called participatory irrigation management (PIM). In Indonesia and Philippines, it is called “turn over”, in Mexico and Turkey it is called “management transfer”, in Colombia it is called “take over”, in China it is called “post-responsibility system” or “responsibility contract system”, while in Sri Lanka it is called “participatory management”. The name is somewhat irrelevant as it is the process of transfer of operation and management of irrigation infrastructure to those who directly benefit which will make these systems sustainable in the longer term.

Participatory irrigation management (PIM) refers to the involvement of farmers (water users) in different aspects of irrigation management such as planning, designing, construction and supervision, policy and decision making, operation and maintenance and evaluation of irrigation systems. PIM appears to be a subset of the broader concept of irrigation management transfer (IMT). IMT is the full or partial transfer of responsibility and authority for the governance, management and financing of irrigation systems from the government to water user associations (WUAs). Australia adopted IMT
and have followed this approach in its economically important river basins including the Murray-Darling Basin (MDB). Some smaller schemes were transferred to WUAs as early as the mid-1980s (e.g. Gumly Gumly and Hay in the Murrumbidgee valley). In the Murray Darling Basin, major irrigation infrastructure is now operated/managed by WUAs through various types of ownership, these include private companies, cooperatives, trusts and state-owned corporations.

4.3  Status of PIM/IMT in Major Basin

IMT has successfully been implemented in Australia and the key motivations seem to be farmers’ perception of rising costs, poor operation of irrigation systems and their own initiative to take over management on one hand and governments seeing the renewal of aging infrastructure as a drain on the state Treasury, on the other. The transfer process was assisted/facilitated by the government, farmers, industry organizations and irrigation agencies. Momentum for further devolution of powers to water users was provided by the Water Reform Framework (1994) which required that constituents in the irrigation sector be given a greater degree of responsibility in irrigation management. As a result, various irrigation water providers (IWP)s emerged in the MDB deriving their origin from the respective State Government Acts. For example, New South Wales has Water Management Act 2000, Victoria has Victoria Water Act 1989 and South Australia has Irrigation Act 1994. Australian IMT implementation processes include IMT steering committees, farmer participation in planning/review, formation of WUAs, Water Services Committees (WSCs), democratic selection of WUA leaders, training of WUA staff in finance and administration, farmer participation in identifying repairs/improvements, farmers’ share of cost of repairs/improvements, training irrigation agency staff and a monitoring and evaluation programme. In some instances, governments paid for or contributed to the upgrading of infrastructure (both on farm and off-farm) prior to transfer. Vuren and Mastenbroek, (2000) estimated that the average total irrigated area (1.19 million ha), the area managed by farmers was estimated at 30%, while the area managed by agencies was 14%. Irrigated area jointly managed was of the order of 55%.

The Murray-Darling Basin (MDB) is well known as Australia’s “food basket” but it is much more than that, as its agricultural output makes a major contribution to the national economy. Agriculture is the dominant economic activity in the MDB accounting for about 39% of the nation’s gross value of agricultural production in 2005/2006 (Australian Bureau of Statistics (ABS), 2008). Located in the south-east of Australia, the basin extends over three quarters of New South Wales, more than half of Victoria, together with significant portions of Queensland and South Australia, and includes the whole of the Australian Capital Territory. On an area basis, in 2005-06, the MDB contained 65% of Australia’s total area of irrigated crops and pastures. Important irrigation industries are dairy, cotton, rice and horticulture (in particular viticulture). The MDB, being the predominant part of irrigated farming in Australia, has been the initiator of many experiments in irrigation reforms including irrigation management transfer and transferable water entitlements (TWEs) with a pilot scheme operating between states in the tristate area from 1995.

Before the 1970s, property rights to irrigation water in the MDB resided largely with state governments. Since the 1970s, there has been a transfer of property rights from state governments to either individual irrigators or to collectives of irrigators that have taken over ownership and management of the distribution infrastructure (Challen, 2001). In the MDB, the Murray-Darling Basin Authority (formerly the Murray-Darling Basin Commission restructured in 2008) is the supreme body to address land, water and environmental management issues across the basin (ACIL Tasman, 2003). Currently, various legal and corporate forms of irrigation management entities are operating in the MDB (see table 4). These are private companies like Murray Irrigation, Murrumbidgee Irrigation, Western Murray and Jemalong in New South Wales, Central Irrigation in South Australia; statutory trusts, where assets are owned by irrigators like Golden Heights, Renmark and Sunlands in South Australia; and two-tier cooperatives like Coleambally in NSW. Most of these entities have converted
from existing government owned schemes to local irrigator ownership over a period of time and especially since the 1995 Council of Australian Governments (CoAG) agreement.

Table 4. Legal and Corporate forms operating in the Murray Darling Basin

<table>
<thead>
<tr>
<th>State Jurisdiction</th>
<th>Organisation</th>
<th>Corporate form</th>
<th>Number of customers or properties serviced (2005/06)</th>
<th>Average annual water supplied (GL) in 2006/07</th>
<th>Area under the agency (ha)</th>
<th>Irrigated area under the agency (ha) 2006–07</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>Culumba irrigation</td>
<td>Each irrigator is a shareholder of private cooperative</td>
<td>452 customers</td>
<td>362</td>
<td>95,153</td>
<td>70,577</td>
</tr>
<tr>
<td></td>
<td>Murray Irrigation</td>
<td>Each irrigator is a shareholder of private company</td>
<td>2,400 customers</td>
<td>1,126</td>
<td>748,000</td>
<td>190,000</td>
</tr>
<tr>
<td></td>
<td>Murray Bridge irrigation</td>
<td>Each irrigator is a shareholder of private company</td>
<td>24,757 properties</td>
<td>862</td>
<td>6,000,000</td>
<td>450,000</td>
</tr>
<tr>
<td></td>
<td>Western Murray Irrigation</td>
<td>Private company</td>
<td>330 irrigation customers</td>
<td>30</td>
<td>4,337</td>
<td>3,764</td>
</tr>
<tr>
<td></td>
<td>West Condamine Irrigation</td>
<td>statutory authority</td>
<td>300 properties</td>
<td>46</td>
<td>212,000</td>
<td>45,642</td>
</tr>
<tr>
<td></td>
<td>Jerilderie irrigation</td>
<td>Unincorporated public company</td>
<td>119 irrigation customers</td>
<td>3,966</td>
<td>96,000</td>
<td>N/A</td>
</tr>
<tr>
<td>Victoria</td>
<td>Goulburn-Murray Water</td>
<td>State government owned statutory authority</td>
<td>24,757 properties</td>
<td>2,100</td>
<td>68,000,000</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Southern Rural Water</td>
<td>State government owned statutory authority</td>
<td>10,000 customers</td>
<td>190</td>
<td>58,444</td>
<td>37,663</td>
</tr>
<tr>
<td></td>
<td>Lower Murray/Southen Water</td>
<td>State government owned statutory authority</td>
<td>1,091 private directors, 305 stock, 854 garden water</td>
<td>90</td>
<td>12,552</td>
<td>11,121</td>
</tr>
<tr>
<td></td>
<td>Irrigation</td>
<td>customers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Murray Irrigation</td>
<td>State government owned statutory authority</td>
<td>11,000 customers</td>
<td>90</td>
<td>7,853</td>
<td>6,773</td>
</tr>
<tr>
<td></td>
<td>Grampians-Wimmera-Mallee</td>
<td>State government owned statutory authority</td>
<td>7300 customers</td>
<td>158</td>
<td>7,552</td>
<td>N/A</td>
</tr>
<tr>
<td>South Australia</td>
<td>Central Irrigation</td>
<td>Private company</td>
<td>1538 irrigation customers</td>
<td>116</td>
<td>15,000</td>
<td>13,564</td>
</tr>
<tr>
<td></td>
<td>Golden Heights</td>
<td>Incorporated trust</td>
<td>60 irrigation customers</td>
<td>3,7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Renmark</td>
<td>Incorporated trust</td>
<td>700 irrigators and 20 private directors</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>


This confidence catalysed the process of irrigation management transfer to local communities and the set-up of institutional arrangements was changed as shown in the following two Tables (Table 5 and Table 6). As a result, ownership and management of schemes were totally transferred to the local customer-owned business organisations. Thus, the existing irrigator-customers became the initial shareholders. There was no sale of schemes to a third party, which was a concern to the public at large. Shares were distributed in proportion to the water allocations that irrigators held. This move to local ownership was consistent with the goals of CoAG’s Strategic National Water Framework 1994. In the basin, each irrigation company manages a large quantum of water, irrigation systems and properties in its respective jurisdiction. For example, the Murray Irrigation Company, one of the largest irrigation providers in Australia, provides irrigation water and drainage services to 2400 properties, managed by 1200 family farm businesses. The company manages an average of 1.2 million megalitres of water for consumptive use distributed to an area of 748,000 ha (Murray Irrigation Limited, 2008).

4.6 Lessons Learnt

Appropriate institutional arrangements to facilitate the management of surface water on a basin scale, as has been demonstrated in the MDB with some success, would help forge common goals in water management and avoid inter-state conflicts over the water-sharing arrangement. Some other lessons that can be adopted by other regions/basins from the MDB are formulation and implementation of effective land and water management plans for the jurisdiction of the entity, volumetric supply of water, cost recovery and command area communication, design and operation of the accounting system. Further, the size of WUAs needs to be enlarged along with upscaling of water management into water distribution, works, engineering, environmental services and financial services. Water rights of individuals and the entities need to be clearly defined and enforced effectively. These rights are also critical for establishment and functioning of water market and trading. Adoption of these technological and institutional options is conditioned by the socio-political and economic situation in other regions/basins and requires tackling simultaneously.
Table 5. Institutional arrangements for irrigation management transfer in Murray-Darling basins

<table>
<thead>
<tr>
<th>Activity</th>
<th>MDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation</td>
<td>Agency</td>
</tr>
<tr>
<td>Ownership of structures and assets</td>
<td>Company</td>
</tr>
<tr>
<td>O&amp;M responsibility</td>
<td>Company</td>
</tr>
<tr>
<td>Collection of water charges</td>
<td>Company and user committees</td>
</tr>
<tr>
<td>Unit of representation</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Peter (2004)

Table 6. Key characteristics of devolution in Murray-Darling Basin, Australia

<table>
<thead>
<tr>
<th>Elements</th>
<th>Murray-Darling Basin (MDB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water right vested in legally recognized WUA</td>
<td>Water right and strong legal status</td>
</tr>
<tr>
<td>Legally binding service agreement</td>
<td>Between govt and irrigation water</td>
</tr>
<tr>
<td>Balance between management responsibility and authority</td>
<td>Provider companies and irrigators approve O&amp;M plan</td>
</tr>
<tr>
<td>Management of financing, O&amp;M, conflict resolution</td>
<td>Full authority for management and independent responsibility</td>
</tr>
<tr>
<td>Balance between incentives and type of accountability required in farmer organisation</td>
<td>Integrated and independent</td>
</tr>
<tr>
<td>Financial autonomy</td>
<td>Autonomous</td>
</tr>
<tr>
<td>Financial accounting</td>
<td>Highly advanced</td>
</tr>
<tr>
<td>Water pricing mechanism</td>
<td>Independent regulator andGovernments</td>
</tr>
<tr>
<td>Enforcement of regulations</td>
<td>Strict</td>
</tr>
</tbody>
</table>

Source: Adapted from Vermillion (1997)

5 OBSERVED IMPACTS OF PIM/IMT

5.1 Water Pricing and Cost Recovery

In the MDB basin, the degree of pricing oversight by government or regulatory agencies tends to depend on ownership arrangements and corporate form. For privately owned businesses, price determination is conducted “in-house” according to the charter of each entity and/or according to the objectives agreed to by nominated shareholders. With regard to the impact of IMT on water pricing, Mapson and Poulton (2001) reported that with management transfer, although water charges decreased, there was an overall increase in cost of irrigation to farmers collectively because of their greater investment in farm- and system-level management. Not surprisingly, state government investment has decreased. The efficiency of fee collection, quality of maintenance and timeliness of water delivery showed improvements in the post-management transfer scenario. Irrigation companies in the MDB have also been successful in achieving a substantial amount of financial autonomy and improvements in the design and operations of the water accounting system.

5.2 Water Use Efficiency

Irrigation technology continues to evolve both at the system and farm level and to keep up to date requires significant investment. Investment by governments (principally via SRWUIP) has seen dramatic improvements in water use efficiency in systems by reducing conveyance losses (operational, seepage and evaporation) and on-farm by adoption of ‘state of the art’ micro, spray and surface irrigation systems.
Irrigation infrastructure operators have often seen system efficiencies improve by more than 15% with some realising much higher efficiency gains (more than 30%). While many lower cost system efficiency options have been implemented by system operators, it is the cooperative approach between governments and system operators, involving millions of dollars, which has reaped the benefits to operators, farmers and the environment.

5.3 Devolution and Irrigation Services

Within these companies, the irrigation water shareholders take decisions regarding land and water management plans. For example, Murray Irrigation has 10 company directors including 8 irrigator-directors and 2 directors with skills in engineering and finance, elected by irrigator-shareholders. Water management operations are divided into different sections such as water distribution, works, engineering services, environmental services, financial services, policy development and liaison, corporate services, etc. (ACIL Tasman, 2003). Irrigation companies generally own water-related structures and are responsible for construction, management and operation of channels, pipes, and other structures.

Volumetric measurement and water supply. Efficiency in measurement and supply of irrigation water on a volumetric basis is demonstrated by the fact that nearly 98% of the irrigation water supply points are metered (Australian National Committee on Irrigation and Drainage (ANCID), 2007). Irrigation water is supplied to the members on advance ordering through telephone, Internet, etc. Effective communication systems facilitate sound and informed water management and farm business decisions. To achieve the appropriate volumetric supply old devices like Dethridge Wheels are being replaced by modern electronic Doppler meters.

5.4 Irrigated Crop Area, Productivity and Diversification

As management transfer progressed in the MDB, although there was an increase in area irrigated, no change in crop yields or farm incomes was observed (Mapson and Poulton, 2001; Restrepo et al., 2007). However, the interpretation of these findings requires caution; it is impossible to predict what might have happened to the irrigated area and productivity with the continuance of a governmentally led “top down” approach. Future studies may bring out the real impacts of management transfers in the MDB.

5.5 Efficiency, Equity and Sustainability Issues

Although IMT/privatisation is a key component of water resource management reform in the MDB, there was no significant difference in water delivery efficiency (i.e. physical efficiency in delivering water from the storage to the farmer’s offtake?) between private and publicly run schemes. The average efficiency score of publicly run schemes was 52%, about 10 points higher than that of privately run schemes, but the percentage of efficient schemes among total privately-run schemes was 25%, exceeding 10% of publicly run schemes (Gang and Felmingham, 2002). With regard to distribution efficiency (i.e. the portion of water diverted from headworks which is delivered to customers), companies recorded more than 87% efficiency and in some cases (such as piped deliveries in the case of Central Irrigation) reaching as high as 100% (Australian National Committee on Irrigation and Drainage (ANCID), 2007).

An irrigation company, Murrumbidgee Irrigation, recorded a system efficiency ranging from 74 to 79%. Early in the water reform process, there were no substantial differences in equity of water delivery (Mapson and Poulton, 2001) due to the fact that the water regulation and distribution mechanism had been streamlined effectively irrespective of type of management system. Thus, no inter-farm and inter-regional inequities could be noticed in water distribution. However, the possible social equity concerns of accelerated water trading on small farms need to be addressed as the most efficient big farms may squeeze small farms out of business, but is this a market issue, not a reform issue.
In the MDB, environmental sustainability is a matter of great concern. Sustainability is threatened by deteriorating river health and dryland salinity (Purdie, 2003), which are the result of over-extraction of available water. While there has been a general willingness to contemplate change, there have been concerns in the past about the procedural justice of the local irrigators (and other stakeholders’) inputs into the decision-making process. While the allocation of water to the environment is an obvious issue, there are other more detailed studies required on such issues as those associated with the introduction of markets (Tisdell and Ward, 2003). These issues include the social impact on those farmers who have sold their water entitlement and left the industry and the resultant effects on a system for those who remain in the system with fewer participants. One hotly contested issue, for example, is the impost of departure levies on those leaving the system to assist with future irrigation system operation. Thus, while much change has been achieved in the last decade the institutional and participative evolution of reform and the role of individual irrigators within it have some way to go (Young et al., 2006).

Regarding the impact on the local and regional environment, Mapson and Poulton (2001) reported no changes in salinity and waterlogging conditions due to management transfer. Restrepo et al. (2007) confirmed that the extent of soil salinity and waterlogging remained about the same even after management transfer. To manage environmental externalities, most of the IWPs have developed sustainability plans including environment management systems with a high standard ISO 14100 certification. To restore river health and environmental flows, currently there are efforts to acquire water from the irrigators with alternative policy options, such as buying back water entitlements from willing irrigators, providing financial assistance to irrigators and irrigation water providers for irrigation efficiency improvement and acquiring the saved water for environmental flows. However, a recent study by Qureshi et al. (2013), reporting on the effectiveness of financial incentives for irrigation efficiency improvement, concluded that increasing irrigation efficiency may not provide enough water for the environment. Policy options of a similar kind are currently being debated in the context of the fast deteriorating health of the MDB.

5.6 Indicative Outcomes of Irrigation Management Transfers

IMT has been discussed above in terms of parameters like institutional structures, crop pattern and productivities, efficiency, equity and sustainability, devolution of power, volumetric water supply and cost recovery and water market. As far as the origin of irrigation management transfer is concerned, IMT in the MDB was launched at the initiative of irrigators, and consequent to IMT reforms in Australia, irrigation water providers (IWPs) in the MDB have been modernising (with government funds) irrigation management systems with volumetric water supply, advanced measuring systems, effective cost recovery, financial autonomy and effective enforcement. With regard to institutional arrangements and devolution of powers, Australian IMT showed greater decentralisation and autonomy compared to other regions. In the MDB, ownership and management of schemes have been transferred to the local customer-owned business organisations. The size and capacity of the irrigation management entities have been large and are functioning in a corporate style.

In Australia, water and land rights have been unbundled and water rights have been made more secure by transferring them to private irrigators, which has provided incentives for proper management and investment decisions. Water trading encompasses all types of irrigation management systems whether in the public domain or outside. The ownership of the water rights needs to be conferred on end users to provide incentives to invest and maintain the irrigation system. Outdated infrastructure and control structures, in the MDB efficiency in volumetric supply is clearly demonstrated through the adoption of modern irrigation technologies (like Doppler meters). The post-IMT scenario in Australia has shown a significant increase in water pricing, fee collection, quality maintenance and operation of the accounting system. With regard to efficiencies in water delivery and distribution, IWPs in the MDB recorded high levels of distributional efficiency. In relation to the
equity issues, there were no significant inter-farm or inter-regional inequities in distribution of water in the MDB. Further, it is difficult to isolate the impact of management transfer on crop yields or farm incomes. Therefore, there is a need to initiate empirical studies to assess the agro-economic impacts of irrigation management transfer.

Even though Australian studies confirmed that the extent of soil salinity and waterlogging remained the same after the management transfer, most IWPs were found to have put in place effective sustainability plans. However, the issues of environmental sustainability in the MDB pose serious challenges, as reduced flows in the rivers have become causes of concern in the MDB. A sustainable irrigation management policy in the MDB, while driving water to its highest value, needs to address the issues of long-term environmental sustainability.

6 WAY FORWARD AND RECOMMENDATIONS

6.1 Best Practices for Replication and Recommendations

The present paper compares the performance of IMT/PIM in Australia in terms of parameters like institutional structures, crop pattern and productivities, efficiency, equity and sustainability, devolution of power, volumetric water supply and cost recovery and water market. As far as the origin of irrigation management transfer is concerned, IMT was launched at the initiative of irrigators.

Consequent to IMT reforms in Australia, irrigation water providers (IWPs) in the MDB have been modernising irrigation management systems with volumetric water supply, advanced measuring systems, effective cost recovery, financial autonomy and effective enforcement. With regard to institutional arrangements and devolution of powers, Australian IMT showed greater decentralisation. In the MDB, ownership and management of schemes have been transferred to the local customer-owned business organisations. The size and capacity of the irrigation management entities have been large and are functioning in a corporate style.

In Australia, water and land rights have been unbundled and water rights have been made more secure by transferring them to private irrigators, which has provided incentives for proper management and investment decisions. Water trading encompasses all types of irrigation management systems whether in the public domain or outside.

In the MDB efficiency in volumetric supply is clearly demonstrated through the adoption of modern irrigation technologies (like Doppler meters). The post-IMT scenario in Australia has shown a significant increase in water pricing, fee collection, quality maintenance and operation of the accounting system.

Water accounting and assessment in Australia is well developed and serve the water management and reform by providing information that has previously been difficult to access or unavailable in a standardised form. Preparing the National Water Account also helps identify and understand information gaps and limitations in data collection methods so that they can be addressed better. It discloses information about water stores and flows, water rights and water use and reports on the volumes of water traded, extracted and managed for economic, social, cultural and environmental benefit.

An analysis of equity issues revealed that there were no significant inter-farm or inter-regional inequities in distribution of water in the MDB. Even though Australian previous studies confirmed that the extent of soil salinity and waterlogging remained the same after the management transfer, most IWPs were found to have put in place effective sustainability plans. However, the issues of environmental sustainability in the MDB pose serious challenges, as reduced flows in the rivers have
become causes of concern in the MDB. A sustainable irrigation management policy in the MDB, while driving water to its highest value, needs to address the issues of long-term environmental sustainability.

Appropriate institutional arrangements to facilitate the management of surface water on a basin scale, as has been demonstrated in the MDB with some success, would help forge common goals in water management and avoid inter-state conflicts over the water-sharing arrangement.

Some other lessons that can be learnt from the MDB are formulation and implementation of effective land and water management plans for the jurisdiction of the entity, volumetric supply of water, cost recovery and command area communication, design and operation of the accounting system.

Further, the size of WUAs needs to be enlarged along with upscaling of water management into water distribution, works, engineering, environmental services and financial services. Water rights of individuals and the entities need to be clearly defined and enforced effectively. These rights are also critical for establishment and functioning of water market and trading. Adoption of these technological and institutional options is conditioned by the socio-political and economic situation in other areas and requires tackling simultaneously.

Finally, water reforms in Australia have been going on for more than 100 years, adapting to the changes in environment or society and in the shape, they are now, are still considered a “work in progress” and will continue to change and refine overtime. This is more obvious today when most of us would agree that climate change is real.

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PEOPLE’S REPUBLIC OF CHINA COUNTRY PAPER: INSTITUTIONAL REFORMS IN IRRIGATION SECTOR FOR SUSTAINABLE AGRICULTURE WATER MANAGEMENT, INCLUDING WATER USERS’ ASSOCIATIONS

1 INTRODUCTION

As a significant part of China’s irrigation management, rural water cooperation organizations are an innovation that suits rural land contract reform and an important form of self-governing by the grassroots in the rural area. In line with the hope and demand of the rural population, the organizations were born to and developed in distinctive historical context. In the mid and late 1990s, as the second round of land contract operation kicked off in the rural area of China, the system of unified management combined with independent management based on the household contract responsibility system was widely put into practice, and the irrigation management and agricultural production functions of collective economic organizations under the village level weakened gradually, leading to the absence of management and maintenance for small irrigation and drainage facilities. Against this backdrop, some provinces began to solve this problem by developing water user associations.


2 LEGAL FRAMEWORK

2.1 Water and Soil Resources in China

By law, water and soil resources in China are owned by the state, while organizations and individuals of various levels enjoy the rights of utilization. Due to its geographical and climatic conditions, China is a country with frequent floods and droughts. Water per capita is only 2100 m³. Influenced by monsoon climate and topographical conditions, the spatial-temporal distribution of water resources is extremely imbalanced. River basins north to the Yangtze River take up 64% of the total land area of China, while their water resources are only 19% of the national total. Drought is the major natural disaster in northern China. In most parts of the country, 70% of rainfall is concentrated between June and September, increasing the possibility of flooding. Therefore, to maximize the benefits brought by and minimize the damages caused by water resources, Chinese government has always attached great importance to developing irrigation and drainage, improving irrigation probability and drainage capacity, and enhancing the resilience of irrigation and drainage facilities against natural disasters, viewing them as the foundation for sustainable agricultural development.
2.2 Organization and Management of Irrigation and Drainage Sectors in China

In China, irrigation and drainage facilities are jointly managed by professionals and the general public. For large and medium sized irrigation and drainage projects, the government set up specialized regulatory bodies staffed with professionals in irrigation and drainage. These professionals are in charge of the daily operation and management of water delivery and distribution. The regulatory bodies are funded by public finance and agricultural water fees. On-farm and small irrigation and drainage projects are managed by the general public. Before 1980, the management is conducted by farmers organized by village authorities. Since 1980, household contract system of responsibility linked to production has been introduced to the rural area, and the land owned by the state and the village collectives is handed to farmers for agricultural production under contracts. As the farmland reform progresses, small irrigation and drainage projects are suffering from the absence of management. Though governments proposed management reform models such as lease, auction and contract, the results were not satisfactory and conflicts over water use could not be avoided. To improve the efficiency of small irrigation and drainage projects and promote the well-being of agriculture, the government has launched a reform of the management system and mechanism for small irrigation and drainage projects. Under this reform, rural water cooperation organizations are established by project beneficiaries for the purposes of facility construction, maintenance, operation and management. Therefore, the current management organization of China’s irrigation and drainage sector is a combination of irrigation district authorities and rural water cooperation organizations.

2.3 Demands for the Reform of Management System

A complete irrigation and drainage system and good management system and mechanism are the key to and foundation of agriculture modernization in China. Chinese government has long been increasing investment of public finance into the renovation and construction of irrigation and drainage facilities, and adopting positive policy measures to stimulate the relevant reform of management system.

For specialized regulatory bodies of key irrigation and drainage projects such as irrigation schemes and pump stations, position and personnel arrangements are made according to the management scope and work intensity, while personnel and maintenance expenditure is decided by position and personnel arrangement and the basic quota of management. The expenditure is covered by the public finance of the same level as the regulatory bodies and agricultural water fees. In this way, the well-being of the key irrigation and drainage projects is ensured.

For on-farm projects and small irrigation and drainage facilities, the format of self-construction and self-management by farmers is promoted. Participatory irrigation management by farmers, mainly in the form of rural water cooperation organizations, is vigorously promoted by the Chinese government. Cooperation organizations are the managers of small irrigation and drainage projects. The cost of management is repaid in the form of water fees, and water pricing is subject to government guidance and consultation within the organization. To ensure the orderly development of rural water cooperation organizations, the government encourages pluralistic development that suits the local conditions. Large crop producers, family farms, farmer co-ops, water user associations are all encouraged to become the managers of small irrigation and drainage projects as long as the following results are achieved: the projects are managed efficiently; agricultural water use is optimized; water-saving agriculture is promoted; sustainable agricultural development is ensured through sustainable utilization of water resources; national food security and water security are guaranteed.
3 RURAL WATER COOPERATION ORGANIZATIONS PARTICIPATING IN IRRIGATION MANAGEMENT AND IRRIGATION MANAGEMENT REFORM

3.1 Overview of the Development of Rural Water Cooperation Organizations

In the mid-1990s, some irrigation scheme renovation projects of provinces such as Hubei and Hunan were partly funded by loans from the World Bank which required the establishment of rural water cooperation organizations. The innovation was first called self-independent irrigation and drainage districts (SIDD) and then gradually evolved into self-managed water user associations (WUA). This kind of exploration and development has been widely applauded in the international exchanges of irrigation and drainage experience. WUA model was extended through the boost from foreign-invested projects and is an example of exploring the combination of foreign models and local conditions.

As the reform of rural economy deepened after 2000, water resources authorities enhanced the efforts of extending water user associations. Pilot projects were launched in large and medium sized irrigation schemes. The follows were listed as one of the targets of management reform for small rural water projects: to establish multiple forms of rural water cooperation organization, including water user association, and to set up a management system that boasts both self-management by investors and service by professional organizations based on clear project ownership.


3.2 The Demands and Targets of Establishing Water User Associations

1) Rural water cooperation organizations, an inevitable choice to adapt to the transformation of agricultural production and business mode, have played significant role in solving the absence of management for irrigation and drainage facilities following the introduction of household contract responsibility system. As the rural reform deepens, land transfer accelerates, and modern agriculture develops, new agricultural business entities are making higher and more urgent demands for the reliability of irrigation and drainage facilities and professional teams of irrigation and drainage facility management and construction. Therefore, innovative development of rural water cooperation organizations has become a must.
The development of rural water cooperation organizations could serve as a handhold for solving the last mile problem in the irrigation and drainage sector. Irrigation and drainage facilities are key to enhancing agriculture’s resilience to natural disasters, improving agricultural production conditions, boosting overall agricultural production capacity, increasing farmer income, and assisting rural economic development. Farmers should be encouraged and guided towards voluntary organizations for cooperation, mutual aid, and the construction, management, and maintenance of irrigation and drainage facilities. In this way, the last mile problem could be solved.

The development of rural water cooperation organizations is the foundation of establishing new mechanisms for irrigation and drainage facility construction and management. The organizations play significant role in participation in irrigation management, shouldering project maintenance, and ensuring orderly and efficient irrigation water use. The organizations should first balance their relations with governments and markets, and then push towards further innovation and capacity building so as to serve as a backstop for improving the construction and management mechanism of irrigation and drainage facilities.

### 3.3 Methods of Forming Rural Water Cooperation Organizations

1) To form rural water cooperation organizations on the basis of irrigation and drainage facility construction. The forming of this type of organizations, targeting at meeting the demand of irrigation and drainage facility construction and depending upon government guidance and project funding, is fast but faces the problems of uneven staff quality, sloppy management, unsustainable momentum, and insufficient functioning.

2) To form rural water cooperation organizations through the volunteering of farmers. This type of organizations, based on existing projects and promoted by governments, is spontaneously and voluntarily established by farmers. The management is solely carried out by the farmers, while governments only provide policy guidance and technical service. This type of organizations usually functions well in terms of operation and management.

3) To form rural water cooperation organizations depending on other organizations. Targeting at expanding the services of their parent organizations and combined with agricultural production process and other business co-ops, this type of organizations provides members with a variety of services.

4) To form rural water cooperation organizations based on land transfer. To increase irrigation water use efficiency and reduce water use cost, large agricultural producers voluntarily set up rural water cooperation organization taking the chance of land transfer. As the result of combination of large producers, this type of organizations enjoys sufficient funding and thus good effectiveness.

### 3.4 Nature and Responsibilities of Rural Water Cooperation Organizations

Established voluntarily by water users within the irrigation district and targeting at voluntary establishment, self-management and self-service, rural water cooperation organizations provide members with public services such as project maintenance and irrigation and drainage management. The government encourages farmers to actively participate in irrigation and drainage management either by establishing specialized associations or by utilizing the assistance from business entities, water co-ops, and farmers’ co-ops. In this way, the sustainability of irrigation and drainage facilities could be ensured.

Rural water cooperation organizations have the following duties: first, they are responsible for managing the irrigation and drainage facility construction within their jurisdictions and organizing members for raising fund and labor based on rules and regulations. Second, they are responsible for repairing and maintaining irrigation and drainage facilities within their jurisdictions, ensuring the smooth operation of facilities, and protecting the water sources. Third, they are responsible for
irrigation water management within their jurisdictions, including making water use plans, distributing water, and settling water use conflicts among members. Fourth, they should participate in the water-pricing process for the farm-level canals within the irrigation district, collect water bills, and manage the income from water bills. The organizations should observe the transparency principle and regularly release to members data on water use and water bill collection. Fifth, they should cooperate with water authorities, local governments and irrigation district authorities, participate in the planning and construction of the irrigation districts, publicizing laws and regulations on water, extending advanced irrigation technologies, and promoting water-saving agriculture.

3.5 Conditions for Rural Water Cooperation Organizations to Achieve Success in Irrigation and Drainage Management

For rural water cooperation organizations to achieve success in irrigation and drainage management, two conditions have to be met. First, the irrigation and drainage facilities managed by the organizations are of sound system, reliable water sources, the facilities are in good conditions, and they can meet the irrigation and drainage demand by agricultural production through irrigation at proper time with proper volume. Second, they enjoy enough funding from water bills and government subsidies, their staff are qualified in terms of irrigation and drainage knowledge and management capacity, and they are equipped with sound regulations on management and legal support and guarantees.

4 IMPACT OF IRRIGATION MANAGEMENT BY RURAL WATER COOPERATION ORGANIZATIONS

Rural water cooperation organizations play significant roles in promoting participative irrigation management, maintaining irrigation and drainage facilities, ensuring facility functioning, collecting water bills, saving irrigation water, raising agricultural productivity, reducing conflicts over water use, and protecting the irrigation rights of the disadvantaged.

4.1 Fostering Farmers’ Awareness of Participation in Irrigation Management

Promoting the development of rural water cooperation organizations could raise farmers’ awareness of participative irrigation management, and push forward scientific project management and irrigation water use. According to the results of typical research, before the foundations of rural water cooperation organizations, farmers only care about the sufficiency and timeliness of irrigation water supply and neglect the quality of irrigation and drainage facilities. After the organizations are established, water users are more active in project construction, operation and management. As the external environment of the organizations improves, their role clarifies, and their rules on operation become clearer, farmers have developed deeper understanding of irrigation water use and water-pricing and higher awareness of water-saving in agriculture.

4.2 Improving Management and Maintenance of Irrigation and Drainage Facilities

After the foundation of rural water cooperation organizations, the tasks of maintaining irrigation facilities are assigned to specific persons, and related regulations ensure that people who fail to perform their duties would be held accountable. Therefore, if the facilities are broken, they will be repaired, and if they are stolen, the loss will be paid for, which could guarantee the smooth running of the projects and intactness of facilities.

4.3 Fully Capitalizing Upon Irrigation Water

In China, surface irrigation is the dominant irrigation method, which means relatively low water use efficiency. After the foundation of rural water cooperation organizations, irrigation water is priced,
which means more water use, higher water bills. In this way, farmers are more aware of water saving, reducing the attractiveness of flood irrigation and hence reducing the water used per unit area and increasing irrigation efficiency.

4.4 Transforming the Mode of Agricultural Production and Operation
Observing the principle of benefiting farmers and voluntary cooperation, some rural water cooperation organizations are assisting the process of land transfer. Farmers who own small pieces of farmland or do not want to manage farmland themselves could contract to lease farmland to the organizations. In this way, the service scope of the organizations could be extended, the efficiency of agricultural production improved, and the sustainability of irrigation and drainage facilities ensured.

4.5 Reducing the Overall Cost of Agricultural Production
After the foundation of rural water cooperation organizations, rules and regulations are set up, leading to enhanced water use management, higher irrigation efficiency, improved utilization ratio of agricultural means of production, and lower farming cost.

4.6 Assisting Water Bill Collection
Water bill plays a significant role in ensuring the smooth operation of irrigation and drainage facilities, raising the utilization efficiency of water resources, and guaranteeing the stability of overall agricultural production capacity. The foundation of rural water cooperation organizations could assist the collection of water bills and hence ensuring the operation of irrigation projects.

4.7 Reducing Conflicts over Water Use
Before the foundation of rural water cooperation organizations, conflicts over water use frequently happen when irrigation takes place in large scales and irrigation water is stressed. After the foundation of the organizations, specialized staff is assigned to distribute water. During the period when irrigation is stressed, the sequence and frequency of irrigation are determined by the organizations based on the principle of “downstream first, upstream second”. In this way, the order of irrigation is ensured.

4.8 Protecting Farmers’ Rights to Irrigation
In the rural area of China, many young adult men are migrant workers, and women and old people are left to do farm work. Before the establishment of rural water cooperation organizations, women and old people are troubled by broken irrigation canals, which has affected irrigation and crop yield. After the foundation of the organizations, specialized staff is assigned to maintain the canals and guard the irrigation water, which is of great help to the disadvantaged. The organizations’ feature of mutual aid could in practice protect the farmers’ rights to irrigation.

5 CHALLENGES FACING THE DEVELOPMENT OF RURAL WATER COOPERATION ORGANIZATIONS

5.1 Difficulties and Problems Facing Rural Water Cooperation Organizations
With a relatively weak basis, rural water cooperation organizations lack capacities of selecting small irrigation and drainage facility construction plans, participating in construction and management, water-pricing for farm-level canals, collecting water bills, upholding property rights, and managing independently. Other difficulties include: the society has not reached a consensus on this matter, leading to insufficient funding and policy support and high threshold of business and civil affairs registrations; water bills are hard to collect due to farmer resistance; the sound operation of the organizations is hard to maintain since there is not enough funding to pay the staff and repair the
facilities; the organizations see heavy turnover since capable people tend to work in cities, leading to low staff quality and hence low management capacity.

5.2 Monitoring and Supervision of Irrigation Water Consumption

For the purposes of enhancing irrigation water management and establishing rural water cooperation organizations as the governing body of irrigation water, the monitoring and supervising mechanisms of water consumption have to be improved. Currently, irrigation water management within an irrigation district is jointly carried out by the irrigation district authority and rural water cooperation organizations. The volume of water distributed by the district to the organizations is monitored by water measuring facilities at the transition sections of sub-lateral canals. Water distribution within the organizations is supervised by farmers. Water distribution within the irrigation district is done according to the water use plan. Water consumption data is regularly released for public supervision. Currently, Chinese government is promoting the construction of water measuring facilities to enhance water use management.

5.3 Irrigation Cost and Methods and Mechanisms of Water Pricing

In China, there are three terms for the price of irrigation water: total cost water price, running cost water price, and de facto water price. Currently, Chinese government is promoting comprehensive reform of agricultural water price, gradually increasing the de facto water price to the level of running cost water price. If the increase of water price still cannot cover the running cost, financial subsidy will be issued to ensure the operation of irrigation and drainage facilities. Total cost water price includes the depreciation cost of irrigation and drainage facilities, cost of operation and management, staff salary, and cost of repair and maintenance. Running cost water price does not include the cost of depreciation. Provinces set up de facto water prices according to how much local farmers could afford. Water bills are collected by rural water cooperation organizations or village authorities. In some regions, water bills are collected and turned into the state treasury instead of directly funding relevant organizations for necessary expenses.

5.4 Facility Challenges

Only if irrigation and drainage facilities are in good conditions and operate well can the rural water cooperation organizations function effectively. Therefore, Chinese government is investing heavily in the renovation and construction of irrigation and drainage facilities, targeting at improving the irrigation and drainage system and increasing auxiliary projects. While accelerating project construction, the government is also promoting the construction of water measuring facilities to control the total volume of irrigation water consumption and set up water use quotas, carrying out scientific irrigation with the results of irrigation tests, formulating rules and regulations on water rights and water rights trade, enhancing irrigation water management, and facilitating water saving in agriculture.

5.5 PPP Model in Irrigation Projects

Chinese government is actively encouraging private capital to participate in the construction and management of irrigation and drainage facilities. Rules and regulations have been issued, and pilot projects launched. For these pilot projects, the general requirement is to establish mechanisms first, and to construct projects next; the principles of transparency, fairness, and mutual benefit are observed; the reform of irrigation and drainage facility property rights and water rights distribution serves as foundation; participation of farmers in the whole process acts as the precondition; good policy environment and service serve as the guarantee measures; the economic leverage of agricultural water price is brought into full play; all of these are done for one purpose—to attract private capital and business entities to participate in the construction, operation, and management of irrigation and drainage facilities.
5.6  Capacity Building for Rural Water Cooperation Organizations

To improve the currently inadequate capacity of rural water cooperation organizations, in addition to achieving standardized management through formulating policies, rules and regulations, irrigation district authorities should enhance technical guidance, and the local governments should organize training sessions and experience sharing conferences, and provide funding to subsidize their operation, management, and office equipment.

6  FUTURE DEVELOPMENT OF RURAL WATER COOPERATION ORGANIZATION

6.1  Thoughts on Future Development of Rural Water Cooperation Organizations

The following thoughts have been put forward to solve the current problems facing rural water cooperation organizations and to promote their innovative development.

6.1.1  Enhancing the inner strength for development through comprehensive reform

According to the requirements of irrigation and drainage facility property rights reform, agricultural water rights reform, and agricultural water price reform, the property rights of small irrigation and drainage projects should be transferred to village authorities, and right of use should be transferred to qualified rural water cooperation organizations; irrigation water rights should be transferred to mature rural water cooperation organizations, organizations that have adopted water-saving measures should be awarded, and compensated transfer of agricultural water rights should be achieved inside and outside the organizations; the roles of rural water cooperation organizations in operating and maintaining water supply projects, managing water use, and collecting water bills should be brought into full play, the organizations’ chain of profits should be completed, and their internal strength for development enhanced.

6.1.2  Developing Socialized Service Agencies Depending on Specialized Co-ops

Various farmer co-ops with higher professional levels and closer relations of interest should be developed. Their service scope should cover the whole process of agricultural production, including irrigation. The development of socialized water service agencies should be supported to provide carriers and market entities for the professional maintenance of irrigation and drainage facilities.

6.1.3  Expanding Channels of Financial Support and Enhancing Regulation of Agricultural Water Consumption

Financial support to rural water cooperation organizations should be strengthened through purchase subsidies for irrigation and drainage facilities, subsidies for agricultural water bills, and service purchases; measures such as “reward instead of subsidy”, and “construction first, subsidy next” should be explored; the requirements for rural water cooperation organizations as the declarant and constructor of irrigation and drainage facilities should be standardized.

6.2  Future Plans

Future plans include: increasing government investment to improve the quality of irrigation and drainage facilities; standardizing the management of rural water cooperation organizations and exploring development models that suit local conditions; enhancing capacity building and formulating policies of government subsidies; organizing training sessions and encouraging experience exchange to improve management; and to introducing private capital into the establishment and management of rural water cooperation organizations.
6.3 Suggestions for the Development of Rural Water Cooperation Organizations

6.3.1 Solidifying the foundation for the Development of Rural Water Cooperation Organizations

The structure of the organizations should be improved, the quality and capacity of operation elevated, and the functioning of the organizations ensured; the internal management system of the organizations should be perfected, including irrigation management system, financial management system, reward and punishment system, and democratic rules of procedure; the organizations’ public-interest nature and legal status should be clearly defined.

6.3.2 Supporting the Capacity Building of Rural Water Cooperation Organizations

The service scope of rural water cooperation organizations should be extended so that they could shoulder the construction and management of irrigation and drainage facilities; the organizations should be encouraged to serve as the applicant and constructor of irrigation and drainage facilities and to provide public services such as maintaining water projects, combating drought, and draining flooded fields; grass-roots water reform should be carried out with the assistance of rural water cooperation organizations, clarifying the property right, right of use, beneficial right, and accountability of small irrigation and drainage projects; local governments and water authorities should transfer the management and operation of small water projects to rural water cooperation organization to improve the business conditions of the latter; the channels of funding for project management should be extended, agricultural water pricing reform promoted, water price for small irrigation and drainage projects determined through democratic consultation within the organizations, water bills collected and managed by the organizations, and project management fund set up.

6.3.3 Encouraging the Diversified Development of Rural Water Cooperation Organizations

Specialized co-ops should be encouraged to provide irrigation service. The business scope of rural water cooperation organizations should be expanded. The establishment of new agricultural business entities should be guided. The types of rural water cooperation organizations should be diversified for better management and operation of irrigation and drainage facilities.

6.3.4 Handling the Relations between Rural Water Cooperation Organizations and Other Parties Properly

The target of establishing rural water cooperation organizations is to provide an organizational carrier for participative irrigation management. Therefore, it is important to handle properly their relations with the government. The government should support, guide and assist them instead of intervention, coercion and taking care of everything.

6.3.5 Selecting the Development Model that Suits the Local Conditions

The development model of rural water cooperation organizations should suit the local conditions. For large and medium irrigation districts with irrigation service as the main demand and areas with low concentration of land and low level of mechanization, water user association should be the dominant model. For developed areas with high land concentration and mature co-ops and areas with highly commercialized and specialized agricultural production, water use co-ops and comprehensive co-ops with water services should be encouraged. WUAs mainly serve the farmer members, while the co-ops could provide profit-oriented services.

*******************************************************************************
INTRODUCTION

1.1 Historical Perspective of Irrigation Development in India

Growth of Indian civilization has been closely dependent upon development and sustenance of irrigated agriculture. The Indus Valley Civilization covering parts of north India had flourished under canal irrigation system. The Vedas and other ancient Indian scriptures make references to wells, canals, tanks and dams. In south, the perennial irrigation commenced with construction of the Grand Anicut by the Cholas as early as second century. The entire landscape in the central and southern India is covered with numerous irrigation tanks constructed many centuries before the beginning of the Christian era. Irrigation is said to be one of the major reasons for the growth and expansion of the Vijayanagar Empire in the fifteenth century. In north also there are number of small canals in the upper valleys of rivers which are very old.

Famines of 1897-98 and 1899-1900 necessitated British to appoint first irrigation commission in 1901; and as a result of its recommendations, the total irrigated area under colonized India (including areas now in Pakistan) expanded to 16 million hectares by 1921. At the time of independence, the net irrigated area of India was about 19.4 million hectare (Mha). India’s irrigation development has accelerated in the period immediately after independence resulting in construction of several large storage based irrigation systems. With the groundwater irrigation development in subsequent period, the irrigation utilization has extended to over 89 Mha, which is highest in the world today.

1.2 Importance of Irrigation in Socio-Economic Development of India

Importance of irrigation in socio-economic development of India is highlighted as under:

- Irrigation has facilitated India’s journey from the brink of famine to food self-sufficiency and now to a net exporter of agricultural commodities\(^7\).
- Expansion of irrigation has provided the backbone to India’s "Green Revolution" by contributing for about two-thirds, possibly more, of total agricultural output [1].
- Irrigation has enabled increase in cropping intensity\(^8\) thereby stabilizing the net sown area at around 140 Mha, even while the share of cultivable land is gradually decreasing\(^9\).
- Irrigation enables a higher productive potential from the land, and significant production response from associated use of high yielding varieties, fertilizer and other inputs.
- Irrigation plays a vital role in poverty alleviation\(^10\); a significant inverse relation is found between the incidence of poverty and the extent of irrigation development\(^11\).

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\(^7\) During 2014-15, agricultural exports was to the tune of Rs. 2,29,996 crores, as compared to Rs 1,22,188 crore of agricultural import bill [3].

\(^8\) Cropping intensity (i.e. number of times a crop is planted per year in a given agricultural area) is high in irrigated areas. The state-wise coverage of irrigated area under major crops in 2012-13 shows that several states have less than 50 per cent irrigated area, but the cropping intensity in these states is very high [2].

\(^9\) Agricultural and cultivable land has declined from 185.16 million ha in 1980-81 to 181.95 million ha in 2012-13 [2].

\(^10\) Agriculture sector contributed 15.2% to India’s GDP during Eleventh Plan [10].

\(^11\) While the incidence of poverty is as high as 69% in districts with less than 10% of cropped area under irrigation, it is about 26% in districts where irrigation covers more than 50% of cropped area, and just 10% in states of Punjab and Haryana with over 70% of their cropped area under irrigation [1].
Out of a total workforce of about 467 million, 228.3 million are engaged in agricultural sector [4]. Irrigation is vital for sustaining and increasing the employment rate of the country.

Promotion of irrigation, especially through surface water projects, has enabled advancement of social and economic equity under vast areas of irrigated command.

Supported by irrigation, the exports of agriculture products reached $31.86 billion in 2012-13. The share of agricultural commodities in India’s overall export basket rose to 10.66 per cent in 2012-13 from 7.06 per cent in 2009-10 [6].

Faced with the vagaries of rainfall, the fully developed and reliable irrigation system alone can provide an effective drought proofing mechanism.

### 1.3 Issues of Irrigation Sector & Need for Reforms

In a monsoon-dependent farming system, with unreliable and scanty rainfall over large areas, the irrigation has been crucial for the growth of agricultural production. However, the development of irrigation has not seen the desired and viable coverage owing to various socio-economic causes, at both macro and micro levels. The issues encountered can be broadly classified under two streams:

- Inadequacy of irrigation potential created (IPC) in relation to the ultimate irrigation potential (UIP) available as per techno-economic assessments;
- Broadening of gap between irrigation potential utilized (IPU) and the created potential.

The present percentage coverage of gross irrigated area over gross cropped area is only about 48% despite mammoth efforts made by the Central and State governments over past several decades. The efforts for expansion of irrigation coverage through new surface water projects (for tapping vast realizable potential of river valleys) has slowed down considerably because of declining budgetary allocation to the irrigation sector, and also owing to the failure of project authorities in overcoming the challenges of complex socio-environmental issues.

The collective water resources development efforts of the country have led to development of storage capacity of about 225 BCM from major and medium irrigation projects; irrigation potential of about 100 BCM through minor projects, check dams, small structures, ponds, etc; and groundwater potential of about 243 BCM. Even then, the shortfall between the IPU and the UIP is not only large, but also widening because of gradual increase in the gap between IPC and IPU. Against the estimated ultimate irrigation potential of 139.9 Mha, irrigation potential created is about 112.53 Mha; however, the extent of irrigation utilization is only about 89.26 Mha thereby leaving a utilization gap of over 23.27 Mha [7]. The major causes for IPC-IPU gaps are poor maintenance of the canal system, lack of participatory management, changing land use pattern, soil degradation and delay in the development of the command area. The larger issue of irrigation underperformance expressed in terms of difference in UIP and IPU also gets aggravated because of dynamic factors related to: (i) year to year variability of rainfall; (ii) variability in farmers’ behaviour in terms of land-use and cropping choices, and (iii) possible errors in presentation of the irrigation data.

India has a total land resource of 328.73 Mha of which about 55% area is agricultural land and only 42.57% of area (accounting for 139.99 Mha) is actually sown as per land-use proportions given in Table 1 below. Owing to the combined effect of above discussed factors, the irrigation was covered in only

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12 Percentage of people employed in agriculture has been consistently declining, from around 60% in 1999-2000 to 49% in 2011-12 [4].
13 Droughts are frequently encountered in large parts of India affecting rural employment and causing migration of the landless and bovine populations; and they also factor in the increasing suicide rates amongst distressed farmers.
14 Gross irrigated area of the country is estimated to be 92.58 Mha against total cropped area of 194.40 Mha [8].
about 66.10 Mha of the total 139.99 Mha of net sown area as per the land use statistics (2012-13) of Ministry of Agriculture & Farmers’ Welfare.

<table>
<thead>
<tr>
<th>Table 1. India’s Land-use Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land-use</td>
</tr>
<tr>
<td>Forest area</td>
</tr>
<tr>
<td>Non-agricultural uses</td>
</tr>
<tr>
<td>Barren &amp; uncultivable</td>
</tr>
<tr>
<td>Culturable waste</td>
</tr>
<tr>
<td>Permanent pastures</td>
</tr>
<tr>
<td>Miscellaneous tree crops</td>
</tr>
<tr>
<td>Fallow land</td>
</tr>
<tr>
<td>Agricultural land</td>
</tr>
<tr>
<td>Net Sown Area</td>
</tr>
</tbody>
</table>

*Million hectares

## 2 LEGAL, FINANCIAL & INSTITUTIONAL FRAMEWORKS

### 2.1 Legal & Financial Frameworks

The irrigation development essentially falls in the domain of State’s subject. However, the central government, by way of central budgetary support and also through arrangement of external assistance in some cases, has been funding the irrigation projects of the country to a very large extent. The Central Government’s assistance to the States’ is provided by way of Grant Based Schemes (GBS) such as Accelerated Irrigation Benefit Program (AIBP), ‘Command Area Development and Water Management (CADWM)’ Program, and Watershed Development Program.

Being the State’s subject, major portion of irrigation related investments are made by the State Governments through own budgetary resources. However, in this regard, the States to a considerable extent are also supported by the Rural Infrastructure Development Fund (RIDF) setup by Government of India in NABARD (National Bank for Agriculture and Rural Development).

In terms of source of water, the irrigation sector is broadly classified as surface water irrigation and groundwater irrigation. In terms of extent of coverage, the irrigation projects are further classified as under:

- **Major Irrigation Projects**: Projects which have Culturable Command Area (CCA) of more than 10,000 hectares (ha). Possible only for surface water projects, such projects usually include huge storage reservoirs and river flow diversion structures.

- **Medium Irrigation Projects**: Projects which have CCA less than 10,000 ha but more than 2,000 ha. These projects are also intended for surface water resources utilizing medium size storages and diversion structures.

- **Minor Irrigation Projects**: Projects which have CCA below 2,000 ha. The source of water is either groundwater from wells or tube-wells or surface water lifted by pumps or by gravity flow from tanks.

The typical Major and Medium Irrigation (MMI) project covers the creation of storage, head-works, main and branch canal works, as well as the distribution system including irrigation outlets\(^{15}\) to serve the chaks (or blocks) up to 40 hectares. The creation of field channels, for the last mile hydraulic connectivity up to individual farms, is generally taken up under a separate ‘Command Area

\(^{15}\) The irrigation outlets are of a capacity of about 0.03 cumec. The capacity may, however, vary depending on local conditions relating to topography, crop pattern, etc.
Development (CAD)’ project. All MMI projects are supported by public investment through funding by the Central and State Governments; whereas a significant part of the Minor Irrigation (MI) development, especially groundwater development, is supported through private investment.

2.2 Institutional Framework

The subject matter of irrigation is spread over multiple ministries of the central government. The majority of expenditure with regard to irrigation is met through Ministry of Water Resources, RD & GR; with the lion’s share of funding allocated to MMI projects and balance for MI (surface water) and MI (groundwater) schemes. The Ministry in its endeavour is supported by the Central Water Commission (CWC) in matters related to surface water development, and the Central Ground Water Board (CGWB) for groundwater subjects.

The other central ministries dealing with irrigation include: (i) Ministry of Agriculture and Farmers’ Welfare dealing mostly with development of micro-irrigation and to some extent with ‘on-farm development’ and; (ii) Ministry of Rural Development/ Department of Land Resources dealing with water shed development. Some of the irrigation interventions at localized levels, such as restoration of farm ponds etc, are also covered under Mahatma Gandhi National Rural Employment Guarantee Act.

The institutional framework for irrigation development widely varies from state to state. In most cases, the development of MMI projects are dealt by the State Water Resources Departments; however, the Command Area Development works of these same projects are entrusted to the Command Area Development Authorities operating under the control of State Revenue Departments. The groundwater development in most cases is done by the State Groundwater Boards.

One of the most crucial component of institutional framework envisaged for the success of irrigation is ‘Water Users’ Association (WUAs)’ and their federations operating at higher levels (i.e. Distributary Committees and Project Committee). It is estimated that there are over 85,000 WUAs which have been formed under various projects with the help of interventions taken under CADWM program. However, in most cases the WUAs have not been adequately developed in terms of capacities needed for taking over the control and management of irrigation system.

2.3 Issues of Water Availability

The annual precipitation including snowfall, which is the main source of water in India, is about 4000 billion cubic meters (BCM). About 53.3 percent of the total precipitation is lost due to evapotranspiration which leaves a balance of 1869 BCM water in the country. Further, about 40 per cent of the water available can’t be put to beneficial use due to topographical constraints and uneven distribution of water resources over space and time; thus, utilizable water potential of the country is estimated to be 1123\textsuperscript{16} BCM as summarized in Table-2 below. The average annual rainfall varies considerably from one region of the country to another. The North-East region receives about 1000 cm and the Western Rajasthan gets less than 10 cm of annual precipitation. The Ganga-Brahmaputra-Barak river basins\textsuperscript{17} alone contribute about 59 percent of the total water resources of the country. Further, most of the rainfall occurs during the season of the south-west monsoon in four months of the year i.e. from June to September.

\textsuperscript{16} In 1999, the ‘National Commission for Integrated Water Resources Development (NCIWRD)’ assessed the utilizable potential as 1086 BCM.

\textsuperscript{17} Since the river basin forms the natural hydrologic unit, the surface water resource estimates are made basin-wise and the annual mean flow in a basin is reckoned as water resource of the basin.
The assessment of the utilizable water potential of the country as 1123 BCM has been made considering two types of resources, namely: surface water and groundwater. The estimate of the annual utilizable extent of surface water is 690 BCM, while that of groundwater is 433 BCM. Both the resources, assessed on annually renewable terms, depend on the same source of supply (i.e. rainfall) and are also intricately linked to each other. It may not be entirely wrong to say that it is the same water which appears as surface water at some places and sometimes, and as groundwater at other places and other times. In most cases, the extensive development of surface water irrigation has improved the groundwater availability. The overall contribution of rainfall to country’s annual replenish-able groundwater resource is 68% and the share of other sources viz. canal seepage, return flow from irrigation, recharge from tanks, ponds, and water conservations structures taken together is 32%.

The ‘National Commission for Integrated Water Resources Development’ (NCIWRD) has assessed the projected demand of water for the years 2025 and 2050. The assessment has been made both for high and low demand scenarios. Projections of high and low demands are based on upper and lower limit of the population projection for the year. By the year 2050, the total demand for water is expected to be 973 BCM for low demand scenario and 1,180 BCM for high demand scenario. Thus, the estimated utilizable water resources of the country, if fully developed, will be barely sufficient to meet the projected demand of water by the year 2050. The Report of NCIWRD (1999) estimates that India’s population by 2050 will be between 1346 to 1581 million and the water requirements for irrigation alone – so as to maintain food self-sufficiency – will be in the range of 628 to 807 BCM as brought out in Table-3 below.

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**Table 2. India’s Average Annual Water Availability**

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Quantum (BCM*)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation received</td>
<td>4000</td>
<td>100</td>
</tr>
<tr>
<td>Water Resource Potential</td>
<td>1869</td>
<td>46.7</td>
</tr>
<tr>
<td>Utilizable Water Resource</td>
<td>1123</td>
<td>28.1</td>
</tr>
<tr>
<td>Ground Water</td>
<td>433</td>
<td>10.8</td>
</tr>
<tr>
<td>Surface Water</td>
<td>690</td>
<td>17.2</td>
</tr>
</tbody>
</table>

*Billion Cubic Meters*

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**Table 3. India’s Projected Demand for Water**

<table>
<thead>
<tr>
<th>Sectors of Water-use</th>
<th>Projected Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2025  (BCM*)</td>
</tr>
<tr>
<td>Irrigation</td>
<td>611</td>
</tr>
<tr>
<td>Domestic</td>
<td>62</td>
</tr>
<tr>
<td>Industries</td>
<td>67</td>
</tr>
<tr>
<td>Environment</td>
<td>10</td>
</tr>
<tr>
<td>Energy</td>
<td>33</td>
</tr>
<tr>
<td>Others</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>843</td>
</tr>
</tbody>
</table>

*Billion Cubic Meters*

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18 The CGWB’s Report of Dynamic Groundwater Resources of India (March, 2011) states that 433 BCM is the estimate of annual replenish-able groundwater resource, and keeping an allocation of 35 BCM for natural discharge, the net annual ground water availability is 398 BCM. Accordingly, the net utilizable water resource potential of the country will stand at 1088 BCM.

19 About 58% recharge (253 BCM) of groundwater is from the monsoon rainfall.
2.4 Stagnation in Surface Water Development

While India’s share in world’s water resources is roughly 4.0% and remains very small and invariable, its population is ever-burgeoning and presently constitutes 17.86% of the world population. Besides, the per capita consumption of water has been continuously on rise owing to extensive urbanization and industrialization. The above facts present ample reasons for India leveraging full potential of its river valley projects. However, the surface water development projects, taken up with earnest in the early five-year plans\(^{20}\) has got somewhat stagnated during the recent plan periods, and its share in total water utilization has declined for reasons listed below:

- Substantial decline in governments’ budgetary allocations;
- Interstate conflicts on river water sharing issues;
- Complex impeding factors during construction immensely delaying ongoing projects, altering their scope, or immobilizing them permanently;
- Shortfalls in proper operations and maintenance of completed projects disrupting judicious, equitable, and efficient distribution of the limited resource.

In terms of major irrigation projects, there were 260 completed projects up to 10\(^{th}\) Five-year Plan (1902-2007) and another 35 were completed in 11th Plan (2007-12); and over 149 projects were spilled over to the 12th Plan (2012-17) period. In regard to the medium irrigation projects, 956 projects were completed up to 10th Plan and another 62 were completed in 11th Plan; while 138 projects were spilled over to 12th Plan period. In addition to the above-mentioned spill-over projects, 27 major projects and 32 medium projects were also included as new projects under the 12th Plan. Besides development of MMI projects, the Extension, Renovation and Modernization (ERM) of existing projects were also taken up during different plan periods. A total of 121 such projects were completed up to 10th Plan and 19 projects were completed in 11th Plan; and 39 ongoing ERM projects along with 27 new ERM projects were included in 12th Plan.

With the combined efforts under different plan periods, India’s present surface water live storage capacity stands at about 253 BCM and an additional 50 BCM is expected to get added up with the completion of ongoing large dam projects. This live storage of about 303 BCM is expected to make available over 450 BCM of utilizable surface water constituting about 65% of the total available surface water capacity estimated at 690 BCM. However, a part of the created capacity is simultaneously being lost due to siltation\(^{21}\) in dam reservoirs.

2.5 Uncontrolled Groundwater Development

Technically, the dynamic ground water refers to the quantity of ground water available in the zone of water level fluctuation, which is replenished annually. Thus, the annual availability of groundwater is determined by the annual recharge of aquifer by rainfall and surface water. However, the actual groundwater development – mostly funded by private individual investment and indirectly supported by bank credits, government subsidies, low diesel pricing, free electricity etc. – has happened in an uncontrollable manner without any consideration for the annual recharge capacity of the aquifers. According to Agriculture Census\(^{22}\), number of wells and tube wells has gone up from 12.1 million in

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\(^{20}\) From 1951 to 1997, gross irrigated area expanded four-fold, from 23 to 90 Mha. Major and medium surface schemes have increased more than three-fold, while groundwater irrigation, largely through private investment, expanded seven-fold [1].

\(^{21}\) As per the Working Group on Water Resources for 11\(^{th}\) Plan, siltation is expected to lead to loss of about 53 BCM of storage capacity by 2050.

\(^{22}\) The groundwater development statistics are not very reliable. As per Minor Irrigation Census, the number of wells and tube wells has increased from 11.4 million in 1986-87 to 19.7 million in 2006-07.
The spread of high-yielding varieties, which are more profitable but also require more water, and the reduction in the cost of lifting water by energised pumps and rural electrification programs have given a powerful impetus to groundwater exploitation in agriculture. This exploitation has been entirely left to the decision of individual with little, if any, effective regulation.

Share of bore well irrigation went up from a mere 1 percent during 1960-61 to 60 percent during 2006-07 as per Indian Agricultural Statistic, 2008.

Warabandi is a rotational method for equitable distribution of the available water in an irrigation system by turns fixed according to a predetermined schedule specifying year, day, time and duration of supply to each irrigator in proportion to the size of his landholding in the outlet command.
The implementation of PIM by most states is sought through enactment of Participatory Irrigation Management Act. In April 1987, recognizing the need for sound legal framework for PIM in the country, the central government had issued guidelines for farmers participation under CADWM programme. Subsequently, in 1998, the central government brought out and circulated a model act to be adopted by the States legislatures for enacting new irrigation acts or amending existing irrigation acts. In response, overall 16 States (viz. Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Nagaland, Odisha, Rajasthan, Sikkim, Tamil Nadu and Uttar Pradesh) have either enacted exclusive legislation or amended their Irrigation Acts for involvement of farmers in irrigation management as per details given in Table-4 below; while other States are also taking steps in this direction.

### Table 4. States PIM Legislation and Year

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>State</th>
<th>Year</th>
<th>Name of the Act</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Andhra Pradesh</td>
<td>1997</td>
<td>Andhra Pradesh Farmers Management of Irrigation Systems Act</td>
</tr>
<tr>
<td>2</td>
<td>Assam</td>
<td>2004</td>
<td>The Assam Irrigation Water Users Act</td>
</tr>
<tr>
<td>3</td>
<td>Bihar</td>
<td>2007</td>
<td>The Bihar Irrigation, Flood Management and Drainage rules, 2003</td>
</tr>
<tr>
<td>5</td>
<td>Arunachal Pradesh</td>
<td>2007</td>
<td>Arunachal Pradesh Water Resources Regulatory Authority Act</td>
</tr>
<tr>
<td>6</td>
<td>Jharkhand</td>
<td>2014</td>
<td>Jharkhand Participatory Irrigation Management Rules</td>
</tr>
<tr>
<td>7</td>
<td>Karnataka</td>
<td>1965</td>
<td>The Karnataka Irrigation Act</td>
</tr>
<tr>
<td>9</td>
<td>Maharashtra</td>
<td>2005</td>
<td>Maharashtra Management of Irrigation Systems by Farmers Act, 2005</td>
</tr>
<tr>
<td>10</td>
<td>Uttar Pradesh</td>
<td>2009</td>
<td>Uttar Pradesh Participatory Irrigation Management Act, 2009</td>
</tr>
<tr>
<td>12</td>
<td>Rajasthan</td>
<td>2000</td>
<td>The Rajasthan Farmers Participation in Management of Irrigation Systems Act, 2000</td>
</tr>
<tr>
<td>13</td>
<td>Tamil Nadu</td>
<td>2000</td>
<td>The Tamilnadu Farmers Management of Irrigation Systems Act</td>
</tr>
<tr>
<td>14</td>
<td>Orissa</td>
<td>2002</td>
<td>The Orissa Pani Panchyat Act, 2002</td>
</tr>
<tr>
<td>15</td>
<td>Chhattisgarh</td>
<td>2006</td>
<td>Chhattisgarh Sinchai Prabandhan Me Krishkon Ki Bhagidari Adhiniyam</td>
</tr>
<tr>
<td>16</td>
<td>Goa</td>
<td>1997</td>
<td>Goa Command Area Development Act 1997</td>
</tr>
</tbody>
</table>

### 3.2 PIM Approach

PIM has been conceived as the thrust area in effective irrigation management by involving and associating farmers in planning, operation and maintenance of the irrigation systems. PIM is the irrigation management by participation of the beneficiary farmers right from planning of irrigation in the command area, canal maintenance and repairs, collection of water tax, maintaining of financial accounts and settlement of disputes through formation of Water Users’ Association.

The proper management and maintenance of the irrigation system already created is extremely crucial; but the wide spread of the system, the large manpower and establishment requirement for the regular operation and maintenance (O&M), and the huge financial requirement for the routine maintenance makes it difficult for the state governments to bear the whole burden of managing irrigation system. Since farmers are the real stakeholders, they have to come forward through their
associations to look after their interest so that they get water from system according to the predetermined time and space for planning their crops. Thus, the broad objectives of PIM are set as under:

- To create a sense of ownership of water resources and the irrigation system among the users, so as to promote economy in water use and preservation of the system;
- To improve service deliveries through better operation and maintenance;
- To achieve optimum utilization of available resources through sophisticated deliveries, precisely as per crop needs;
- To achieve equity in water distribution;
- To increase production per unit of water, where water is scarce and to increase production per unit of land where water is adequate;
- To make best use of natural precipitation and ground water in conjunction with flow irrigation for increasing irrigation and cropping intensity;
- To facilitate the users to have a choice of crops, cropping sequence, timing of water supply, period of supply and also frequency of supply, depending on soils, climate and other infrastructure facilities available in the commands such as roads, markets, cold storages, etc, so as to maximize the incomes and returns;
- To encourage collective and community responsibility on the farmers to collect water charges and payment to irrigation agency;
- To create healthy atmosphere between the irrigation agency personnel and the users.

3.3 Promotion of PIM through Command Area Development Program

The promotion of PIM in India is mainly guided by the Command Area Development program. The Centrally Sponsored Command Area Development (CAD) Programme was launched in 1974-75 for development of adequate delivery system of irrigation water up to farmers’ field with an objective to enhance water use efficiency and production and productivity of crops per unit of land and water for improving socio-economic condition of farmers. The Programme envisages integration of all activities relating to irrigated agriculture in a coordinated manner with multi-disciplinary team under a Command Area Development Authority. The Programme was restructured in 2004 and renamed as Command Area Development and Water Management (CAD&WM) Programme. The Programme is being implemented pari-passu with Accelerated Irrigation Benefits Programme (AIBP) during the 12th Five Year Plan.

In terms of manner of application of water, the irrigation is broadly classified as flow (flood) irrigation, and micro-irrigation. The traditional flow/flood irrigation method requires large quantum of standing water over the targeted field, whereas in micro-irrigation much lesser extent of water is applied to the field by way of sprinkler or drip irrigation. To promote water use efficiency in irrigation, financial assistance under CADWM is also provided to the States for development of infrastructure for micro-irrigation to facilitate use of sprinkler / drip irrigation as an alternative to construction of field channels; and at least 10% CCA of each project is required to be covered under micro-irrigation. Micro-irrigation infrastructure includes components of sump, pump, HDPE pipelines, and pertinent devices needed for bringing efficiency in water conveyance and field applications (through sprinklers, rain guns, pivots etc).

The activities covered under CAD component of a Project are broadly categorized as ‘Structural’ and ‘Non-Structural’ interventions. Structural Intervention includes survey, planning, design and execution of: (i) On-Farm Development (OFD) works;(ii) Construction of field, intermediate & link drains; (iii) Correction of system deficiencies; and (iv) Reclamation of waterlogged areas. Non-Structural

26 Conventionally, the Major and Medium Irrigation (MMI) projects as well as Minor Irrigation (MI) projects have been designed and executed for flow/ flood irrigation. However, many of these projects can be tailored for micro-irrigation with minor engineering modifications, provided an adaptable change in the mind-set of farmers is brought about.
Intervention includes activities directed at strengthening of Participatory Irrigation Management and cover: (i) One-time Functional Grant to the registered Water Users’ Associations; (ii) One-time Infrastructure Grant to the registered WUAs; (iii) Trainings, demonstration, and adaptive trials with respect to water use efficiency, increased productivity, and sustainable irrigation participatory environment.

So far 84,779 Water Users’ Associations have been formed in various States covering an area of 17.84 million hectare under various commands of irrigation projects. Under the restructured “Command Area Development & Water Management” Programme, more emphasis is being given to participatory approach; and payment of Central Assistance to State is linked with the formation of WUAs. A separate Incentivization scheme for Bridging of Irrigation Gap (ISBIG) is also being formulated by the central government wherein ‘taking over of the control and management of irrigation system by WUAs’ will be considered as necessary condition for the completion of targeted projects.

4 OBSERVED IMPACTS OF PIM

4.1 Issues of Sustainability of Water Users Association

During 11th five-year plan period, central government engaged Agricultural Finance Corporation (AFC) for Evaluation and Impact Study of CADWM Programme along with functioning of WUAs in the country. The AFC studied the working of Water Users’ Associations in all States across the country; and they also interviewed 151 WUAs, resulting in following main findings:

- 81% of WUAs have been formally registered;
- Involvement of women farmers in management committees of WUAs is insignificant (3%) across the States whereas the representation of small and marginal farmers and tail end farmers in the committees is 78% and 83% respectively;
- The farmers in around 70% of WUAs have contributed up to 10% according to their capacity towards the project cost in terms of labour, cost produce, construction material and others;
- Above 60% of WUAs have been handed over the charge of water distribution system and 48% of WUAs are involved in water distribution mechanism whereas 28% of them are involved in collection of water charges;
- Around 22% of the studied WUAs have made expenditure on repair and maintenance;
- Around 30% of the WUAs have enough funds, especially in Maharashtra and Gujarat, to sustain.

Though the PIM is expected to bring substantial improvement in the overall irrigation system as well as economic conditions of the farmers, yet its impact cannot be ascertained with confidence owing to the issues of sustainability of the WUAs encountered in many of the projects. The sustainability of WUAs depends on various factors including equity in water distribution to its members, effective operation and maintenance system, transparency in participatory management system, active participation of WUA members, adequate capacities of WUA office bearers and its members, ensured

27 As per the guidelines of CADWM Programme, the one-time functional grant is to be given to WUAs at the rate of Rs. 1200 per hectare which will be shared at ratio of 45:45:10 between centre, state, and beneficiaries. The infrastructure grant of Rs. 3 Lakh per WUA will be shared in the ratio of 75:25 by central government and concerned state government.

28 The new Incentivization Scheme for Bridging of Irrigation Gap (ISBIG) being formulated in consultation with the State Governments targets CADWM works in about 80 Lakh hectares of balance command in 317 Major and Medium Irrigation Projects in 25 States. Besides making PIM the focal point of CAD works under each targeted project, the Scheme also aims for correction of system deficiency, higher extent of micro-irrigation (30% of balance CCA), solar power for micro-irrigation, conjunctive use of groundwater, reuse of waste water in irrigation (limited projects on pilot basis), automation for control and measurement (limited projects on pilot basis), and modernization and extension of ‘Water And Land Management Institutes (WALMI)’. 
mechanisms for generating financial resources like water charges, collective approach to access the agriculture inputs and marketing of crops etc.

Evaluation and impact study of CADWM program has indicated that WUAs have been formed in many states but the same have yet not reached the required level to become self-reliant and sustainable. Some of the observed key limitations are:

- WUAs are yet to develop clear institutional vision and mission;
- WUAs lack clear understanding of their roles and responsibilities, and also lack adequate capacities to perform their roles effectively;
- Inability to develop transparent and participatory systems and procedures;
- Inability to follow the concept of equity and / or equality;
- Inability to establish linkages with outside agencies including the government, non-government and private agencies;
- WUAs yet not have access and capacities to negotiate with departments and other agencies;
- WUAs have not developed regular source of income;
- WUAs lack capacity to deal with internal conflicts;
- Absence of visionary and dynamic leadership.

The legal framework created out of PIM Acts is intended to result in creation of farmers’ organizations at three different levels of irrigation system, namely: Water Users’ Association (WUA), Distributory Committee (DC), and Project Committee (PC). However, in absence of credible WUAs, the other two levels of farmers’ organizations, namely DC and PC, have also not been able to come up in most projects; and even in few cases where they have been created, their functions have not been evolved to the desired extent. There is hence an urgent need for the states to develop approach and strategies to deal with issues related to empowerment and sustainability of WUAs. The capacity development of WUAs at in-situ level is an urgent need of the CADWM projects. The states need to involve external agencies with regard to capacity building of the farmers’ institutions in the framework of participatory irrigation management.

4.2 Success Story of PIM under Odisha Community Tank Management Programme

Despite encountering issues of empowerment and sustainability of WUAs in most cases, the cause of PIM is not being diluted as there are pockets of success stories as well. One such case of successful PIM relates to the Odisha Community Tank Management Programme (OCTMP) wherein Pani-Panchayats (Water Users Association) have come up in commendable manner transforming sizeably the socio-economic conditions of the farmers in concerned commands.

OCTMP was implemented by Government of Odisha in partnership with Government of India with funding from the World Bank. The program put into operation in 12 Districts of Odisha covered 324 minor irrigation projects for stabilizing 60,000 hectares with sizes of minor irrigation projects varying from 40 to 2000 hectares. It involved collaboration with 374 Pani Panchayats, with number of Pani Panchayats per Minor Irrigation Project varying from one to eleven. The program aims at achieving sustainability of restored minor irrigation system through community participation and empowerment to develop self-owned, self-managed and self-controlled Pani Panchayats. Program was taken up with intent to create an enabling legal and institutional environment to implement the solutions emerging out of participatory and demand driven process, and also to usher in sustainable improvement in tank based agriculture livelihood system by increasing production, productivity and profitability of agriculture, horticulture, fisheries, and livestock production system. The program encompassed four main project components as described below:

- Institutional Strengthening;
- Tank System Improvement;
- Agriculture Livelihood Support Services;
Under OCTMP, the PIM has penetrated to a deeper extent and is substantially effective. There is a heightened sense of teamwork amongst farmers, coupled with a high level of awareness of the collective benefits accruable through PIM. There is substantial jump in the level of farm production, and also in farmers’ income as a direct outcome of the PIM. WUAs have elected bodies which function with a proper office set-up with well-maintained records of membership, farm plots, details of expenditures etc. The Project Implementing Agency (PIA) has put in immense efforts and also adopted innovative approach in bringing the PIM to a successful level. Some of the laudable approach, which can be emulated by other PIAs as well, include the following:

- Bringing a shift in the implementation objective from “handing over by the department” to “taking over by the WUAs”, which could draw focus on the capacity related issues of WUAs.
- Bringing PIM related interventions simultaneously with efforts on engineering saturation.
- Hiring of a centralized account auditing agency, and evolving effective methodology for handholding support and timely auditing.
- Training of farmers/ WUA office bearers at Auroville (Pondicherry) which helped in team building and bringing a qualitative change in their vision.
- High level of empowerment of WUAs including empowerment for fixing water tariff as well as its collection.
- High level of coordination amongst different agencies enabling holistic development of village community through agricultural livelihoods support services for development of fisheries, horticulture and poultry; with successful diversification into more market oriented agriculture (e.g. vegetables and mushroom) and livestock production (e.g. local variety of chicken); and equitable development involving women and weaker sections.
- Holding of ‘Pani Panchayat Fortnight’ event/ festival for promotion of PIM, facilitating of cross-learning, and encouragement to WUAs through awards.

4.3 Issues of Water Use Efficiency and Equitable Distribution

Water use efficiency is an index of percentage of gainful performance of irrigation water released. It indicates how efficiently the available water supply is being used and the principal factors affecting the water use efficiency are the design of irrigation system, degree of land preparation, and skill and care of irrigation practices. The PIM can be leveraged upon for improving water use efficiency as well as equitable distribution through various interventions including land development related activities, optimizing water use in accordance with effective crop planning, land consolidation or land pooling, realignment of field channels, effective water rotational system, and system for water measurement.

Although enhancing water potential through optimum utilization is one of the core objectives of the CADWM program, yet there are gaps in achieving of improvements in water use efficiency and in managing of the equitable water distribution owing to the issues of sustainable WUAs. Evaluation and impact study of CADWM program has indicated following limitations with regard to water use efficiency and equitable distribution:

- Water distribution measuring devices such as flumes, notches and weirs have been installed and are operational in only few of the projects;
- The concept of water conveyance efficiency is primarily ensured by increasing length of lined channels in the command areas; however, it covers only a limited extent of the network of channel needed to connect each farm field;
- Most of the farmers are getting irrigation water through the inefficient system of field-to-field irrigation;
- The efforts for land consolidation, land realignment, and realignment of field channels are either meagre or ineffective;
Prevailing concept of crop planning does not prevent farmers at head from growing high water consuming crops leading to inequitable water use at the cost of tail enders.

4.4 Issues of Capacity Building of WUAs and Farmers

Capacity building of WUAs along with training of farmers and extension of recommended package of practices, promotion of improved and advanced technologies to enhance agriculture production and productivity is an important component of CADWM program. Adaptive trials ascertaining suitability of newly developed varieties of different crops have to be made on farmers’ field by scientists. Demonstration of scientific technology covering scientific water management and land development practices, introduction of suitable crops and varieties, proper dose and method of application of fertilizers, irrigation practices etc. on farmers’ field are very important for increasing productivity. Focus is also laid on effective crop planning, efficient water use and promotion of collective action to facilitate easy access to agriculture inputs and marketing with a view to enhance productivity, reduce cost of cultivation, reduce crop losses, increase profitability resulting in additional income. Evaluation and impact study of CADWM program has indicated following limitations with regard to capacity building of WUAs and farmers:

- The major concern with regard to adaptive trials and frontline demonstration is related to inadequacy of subject matter specialists within the project establishments and also with the supporting agencies including the line departments, Water And Land Management Institute (WALMI), and State Agriculture Universities;
- Inadequate funds to carry out a holistic approach with regard to the activity is another factor that marginalizes the intervention in most of the cases;
- Projects are coordinated by engineering professionals who needs to be further oriented on importance of the concept of action research and adaptive trials and replication of the learning on larger scale in the command areas;
- A direct formal association with the agriculture research centres (or similar other agencies) needs to be established for further innovation and replication of the same in the command areas.

4.5 Issues of PIM Legislations

The total number of states in India, those have formulated legislation especially for Participatory Irrigation Management are 16 in numbers. The state of West Bengal has a World Bank funded project “The West Bengal Accelerated Development of Minor Irrigation Project” operating in 19 districts across the state where provisions of PIM are being implemented though West Bengal is yet to enact an act. The Tata Institute of Social Sciences (TISS), in association with National Water Mission (NWM)\(^29\), has recently carried out an analysis of the existing State PIM Acts and provisions of PIM in West Bengal and summarised the key features as under:

- **Policy and Legal framework:** The power to delineate an area under one water user association is varied. Respective canal officers are empowered to delineate an area in Maharashtra and in Goa. Whereas District collector is empowered to delineate in the states of Assam, Madhya Pradesh, Tamil Nadu and Chhattisgarh on the hydraulic basis and administrative ease. In case of Chhattisgarh the district collector needs to consult with respective presidents of the distributory committee. In case of others it is varied, for example, in Andhra Pradesh it is the irrigation department, in Gujarat it is Executive engineer, and in case of Orissa it is superintending engineer.

- **The process of formation of WUA:** The process is given in detail in case of Andhra Pradesh, Gujarat, Uttar Pradesh, Orissa, Goa, which involves giving prior notification, giving power to the authority to notify as well as for the parties to raise their concerns. In case of all the acts, all of the WUA

\(^{29}\) National Water Mission is in the Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India.
members consist the general body and from which election for selecting representative and office holders are drawn by method of secret ballot or by direct voting depending upon the state acts which may have sub committees for lower level constituencies like in case of Orissa it is the ‘Chak’ which elect members for ‘Chak’ committee which again elect representative for respective Pani-Panchayat.

- **Organizational Structure**: A crucial step in making WUAs independent and developing grass-root leadership are totally absent in many acts in the states. But in some like that of Gujarat, Jharkhand, Karnataka, Kerala, Maharashtra and Uttar Pradesh (on payment basis) and in Goa there are provisions for training and capacity building for farmers and farmer representative as well as government officials. Another issue is how the information reach the masses, which is absent in many of the acts, except Jharkhand, Kerala and Maharashtra. In case of a non-PIM act state of west Bengal, to involve more farmers and build their capacity there are provisions for sharing success stories and case studies.

- **Participation**: Participatory irrigation management should include each and every land holder (water user) irrespective of his gender and caste to create an atmosphere for equity. Out of the total 17 PIMs analyzed only 5 contain some certain reservation for women (Andhra Pradesh, Jharkhand, Maharashtra, Madhya Pradesh and Chhattisgarh.). Out of these 5, only one clearly states that reservation for women belonging to each category (SC/ST/OBC). In non-PIM state west Bengal, farmers as well as their wives are the members of the water user association.

- **Special provisions**: Special provision for Scheduled caste and tribe population is totally absent in these acts except in Chhattisgarh where it is said that reservation in accordance with the population of the area. Whereas in west Bengal, it is stated that 13 % of total expenditures are need to be utilized in the tribal areas. Water rights for landless is totally absent in these acts.

- **Role and responsibility**: The WUAs should have enough power to supply and take decisions of their own and maintain distribution, and prepare schedules for maintenance before or after each cropping season. In all of them they are written explicitly. Measurement of flow and amount of water is very important for equitable distribution of water. In some acts like those of Gujarat, Maharashtra, Goa and Uttar Pradesh there are provisions for measuring devices and to be monitored by appropriate authority in the respective states. In each and every act as the name specifies the farmers are empowered with making schedules for maintenance through the water user association. In some cases, before handling over the installation a joint inspection is done to ensure everything is under working condition (Maharashtra). Exception is the Rajasthan, where the operation and maintenance of the main canal, its branches and larger distributaries of major and medium projects shall continue to be the responsibility of the Irrigation/Command Area Development Department.

- **Autonomy of WUA**: Each state PIMs give more or less same ways to address the disputes by putting steps to be followed before in each level of organization if disputes arise. The WUAs are given autonomy to collect charges for water use for its farmers, but in case of Jharkhand if a farmer fails to pay his payments, he may have to face no water for the next season. This also applies for the water users’ association as a whole.

- **Cropping Choice**: Freedom to carry on with crops of farmer’s choice is also varied in different states. For example, there are freedom to carry out crops of their choice in Andhra Pradesh and Assam, but in case of Goa, Arunachal Pradesh and Jharkhand it may prohibit use of certain crops.

- **Use of Ground Water**: There are also specific provisions for ground water in conjunction with surface water use and conservation in Goa, Uttar Pradesh, Maharashtra, and Bihar. In case of
Gujarat, WUAs shall take all possible measures to keep ground water table in its area of operation below 3 meters from ground level, to avoid the incidents of salinity and water logging. In order to protect the environment, government can impose restrictions on the use of ground water.

- **Financial Provisions:** For WUA the source of funds are mainly their own contributions gathered from the farmers for service as well as funds from Government. There are also provisions for other income generation activities. There is specific guidance in some state acts on self-evaluation to increase the performance of a WUA as well as the irrigation as a system in states like Andhra Pradesh, Gujarat, Jharkhand and Kerala. In case of Uttar Pradesh, the Apex Committee is responsible for monitoring, evaluation and research on the participatory irrigation management process in the State and shall provide necessary feedback to the State Government and advise it on policy matters.

## 5 CHALLENGES

### 5.1 Challenge of Bridging the Gap in Demand and Supply of Irrigation Water

The challenges of development and management of irrigation system is essentially a challenge of bridging the gap in demand and supply of irrigation water, with water delivered in right quantity and right time to every individual farmer’s field. This challenge of demand and supply imbalance can be managed by:

- Enhancing supply (i.e. Supply-side solution);
- Curtailing demand (i.e. Demand-side solution).

The water related challenges are multidimensional since they encompass social, political, economic, environmental, and human aspects, besides the technical issues connected with water resource development and management. The above multidimensional aspects fuel the fire of ever continuing debate on the pros and cons of different possible solutions. Thus, issues such as groundwater depletion, chronic droughts, recurring floods, river sharing disputes, displacement of people by dam construction, problems of water conveyance and pilferage, excessive usage and water logging, sectoral and regional conflicts amongst project beneficiaries, project stagnations and the state of financial quandary, enormity of investments and meek financial returns, impact on ecology and environment, etc. fill up the canvas of water resource development debate; besides, being intricately interwoven, they make the problem more complex. Time has come for moving beyond the debate on pros and cons of Supply-side and Demand-side solutions, and to adopt both solutions in holistically and balanced manner in order to achieve a sustainable irrigation development in the country.

In terms of interventions needed for bringing Supply-side and Demand-side solutions, the challenges can be further divided in to two sets. The first set of challenges pertains to the category of Structural interventions, mostly of engineering nature, which will require immense financial resources as well as capacity building of the government’s irrigation related institutional framework. The second set pertains to the category of Non-structural interventions, seeking behavioural changes in farmers’ irrigation practices, which will require deeper penetration of water education, high level of collaboration with non-governmental organizations and various other institutions, and capacity building of the Water Users’ Associations.

In order to bring convergence of efforts under Structural and Non-structural interventions, the unit for targeted interventions shall be ‘farmers within the irrigation command’ rather than the ‘command area’. For ease of handling, the challenges shall be broken down and targeted at a select group of farmers in a specific command area, so that outcomes of Structural and Non-structural interventions can be aggregated over time. Both Structural and Non-structural sets of challenges pertaining to a
specific target group needs to be addressed comprehensively for holistic resolution of the overall irrigation challenge. However, a time lag between interventions may happen because some of the Non-structural interventions may become meaningful only on saturation of the Structural interventions. For micro level penetration of sustainable development, both Supply-side and Demand-side solutions will be required for each target group; and for both the solutions, Structural as well as Non-structural interventions will be required.

The demand and supply gap is in respect of utilizable irrigation water, irrespective of its potential sources (i.e. surface water or groundwater). The nature of source of water for bridging irrigation may vary from place to place, and hence from one target group to another; and in many cases, balance in use of both sources will be required – i.e. conjunctive use of surface and groundwater. The surface water and groundwater are not complementary sources, but meant to supplement each other; and in contradiction to the general notion, the development of canal irrigation and local groundwater conservation measures can easily go hand-in-hand.

5.2 Challenge of Supply-side Solutions

The domain of supply-side challenge of meeting our present and future irrigation demand is constituted of three components:

1. Challenge of creating new potentials for enhancing supply;
2. Challenge of achieving equitable distribution;
3. Challenge of meeting the needs of sustainable development.

An acceptable and sustainable solution for enhancing supplies has to be found within the domain of supply-side challenge, encompassing domains of all three components as illustrated in Figure-1 below:

![Figure-1: Domain of Supply-side Challenge](image)

(i) **Challenge of creating new potentials**: Given the water demand projections, India would be required to tap 75% of its utilizable water resources by year 2025 and 100% by 2050. However, for a lower population growth projection, the ultimate water demand by 2050 may get restricted to about 87% of the utilizable potential. The utilizable water resource potential of the country has been estimated at 1123 BCM, which includes 690 BCM of surface water and 433 BCM of groundwater. At present about 450 BCM of surface water (as estimated by CWC in 2009) and about 245 BCM of groundwater (as estimated by CGWB in 2011) is being put to use; indicating thereby the total developed utilization capacity of 695 BCM, which is about 62% of the total utilizable capacity. Hence the challenge of creating new supply potential can be judiciously broken down as under:

- Creation of 13% of the new utilizable capacity (i.e. 146 BCM) by 2025;
- Creation of additional 12% utilizable capacity (i.e. 134 BCM) by 2035;

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30 Information is as per a reply given to the Parliament (Lok Sabha) on 6th April 2017.
Creation of balance utilizable capacity (if required, and as per actual population growth scenario) up to maximum extent of 13% (i.e. 146 BCM) by 2050.

Therefore, against the present utilization level of 695 BCM, the new minimum capacity to be created by year 2035 will measure 280 BCM; which will correspond to a jump of about 40% over and above the existing capacities. The cumulative targeted capacity by 2035 will be 975 BCM, which will be about 87% of the total utilizable potential. The targeted new capacity will include:

- 110 BCM of groundwater achieved with 90% saturation of groundwater development (assuming 395 BCM of total utilizable groundwater capacity, accounting for natural draft); and
- 170 BCM of surface water, which is expected to become available through creation of new live storage capacities of about 100 BCM.

The presently developed live storage capacity of reservoirs in India is estimated to be about 253 BCM, and projects targeting additional 50 BCM of live storage are under construction. Not only the ongoing projects are required to be fast tracked, but also new projects need to be identified and taken up from scratch for creation of added live storage capacity of 50 BCM by year 2035. Taking up of new river valley projects will present a formidable challenge.

(ii) **Challenge of achieving equitable distribution:** This challenge is about equitable distribution of water between different regions of the country; within regions, between urban and rural areas; and within urban and rural areas, between the rich and the poor. The aggregate supply and aggregate demand can be matched at macro level only by extraordinary efforts for creating new supplies, but matching the supply and demand positions at micro levels, by judicious and equitable distribution of water, are Herculean tasks.

There is large imbalance in the spatial availability of water between different regions of the country\(^{31}\), which coupled with variation in timing of the availability, creates a ‘flood-drought-flood’ syndrome\(^{32}\) experienced by the country. It is technically feasible to achieve regional balance in distribution of water, by inter-basin transfer of water. The scheme essentially involves interlinking of rivers to transfer water from those water surplus regions where sufficient storage sites are not available, to those water scarce regions where good storage sites are available. Implementation of such options have potential to help India to overcome its notable limitation of the skewed distribution of water (both in space and time), and also to resolve the technical issue of inadequacy of storage sites in India’s surplus basins. However, the plan of interlinking rivers would involve construction of many more reservoirs and large water conductor systems; and a significant proportion of capital. The time and cost of mitigating the social and environmental impact would also be large. Further, this plan cannot be implemented without resolution of inter-state conflicts among upper-end and lower-end beneficiaries.

There is also a large social imbalance in water distribution. Prioritisation of potential creation over network development has often excessively delayed the irrigation benefits reaching tail ends. In few such cases, the change in land use pattern of command area with increasing urbanisation has led to rejection of planned irrigation, while unplanned urban consumption has grown by leaps and bounds. In areas where surface irrigation facilities are inadequate, excessive ground water usage has depleted ground water table to extreme depths rendering

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\(^{31}\) The availability of utilisable water per capita (1991 population level) varies from 182 m\(^3\) in Sabarmati basin to 3082 m\(^3\) in Narmada basin while its availability per hectare of Culturable area varies from 1244 m\(^3\) in Sabarmati basin to 8320 m\(^3\) in Mahanadi basin \([9]\).  

\(^{32}\) While the states of Karnataka, Tamil Nadu, Rajasthan, Gujarat, Andhra Pradesh, and Maharashtra, are more often the drought prone states; the states of Uttar Pradesh, Bihar, West Bengal, Orissa, and Assam, frequently face the problems of floods.
rural poor in a disadvantageous position over their rich counterparts, who have access to deeper bore wells.

(iii) **Challenge of meeting the needs of sustainable development:** This challenge is about attaining sustainable level of development in which the needs of the present can be met without compromising ability of the resources to meet the needs of the future. Since creation of new potential of water resources is to some extent at the cost of land resources, which is already under high population pressure, the issue of sustainable development of land resources also gets linked. Besides, the pressing issues of submergence by reservoirs, river valley projects also impact river stretches downstream of projects with consequential reduction in river flows affecting a larger area and population of river plains.

5.3 **Challenge of Demand-side Solutions**

The three formidable challenges posed by the Demand-side solution are:

1. Challenge of creating new technologies for reducing water demand;
2. Challenge of bringing change in the societal mindset about water usage;
3. Challenge of initiating and enforcing water related structural reforms.

Solutions shall preferably be found for all three components of Demand-side challenges; and success in each would independently add to overall success of the demand management as illustrated in Figure-2 below:

![Figure-2: Domain of Demand-side Challenge](image)

(i) **Challenge of creating new technologies:** Nearly 80% of water usage is in agricultural sector, for which contribution through advancement in agricultural technology seeking reduction in overall water demand can be two-pronged:

- Develop higher yield crop varieties so that water consumption per unit of the food-grain produce is reduced; and
- Develop crop varieties that would require lower frequency and less quantum of water application.

Technological developments are also called for in the area of irrigation methodology. The national weighted-average value of Net Irrigation Requirement is estimated as 0.36 metre depth of water application, against which the Gross Irrigation Requirement is on an average estimated as 0.65 metre in the case of groundwater usage and 0.9 metre in the case of surface-water usage [9]. The surplus water requirement of about 80% (for groundwater usage) to 150% (for surface water usage) is mainly on account of conveyance and application inefficiencies. Implementation of Micro Irrigation can increase crop productivity as well as save water up to 50%.
In the irrigated command area of over 66 Mha, the use of high yielding varieties can increase crop production by many folds. The present national average yield ranging between 2.059 (for food grains) to 2.396 (for cereals) tonnes per hectares can be raised to a much higher level of 6.0 tonnes per hectares or more (as being achieved by some of the countries today), which alone can cut down India’s irrigation water requirement to about one third for the same agricultural production. On the other hand, about 53% of the sawn area, accounting for nearly 40% of country’s total food grain production, remains under dry-land or rain-fed farming. In this large area, use of low water consuming plant varieties can help farmers produce food and non-food crops on a sustainable basis.

In the open canal water-conductor system presently in use, the conveyance efficiency is adversely affected due to excessive seepage, evaporation, leakage, evapo-transpiration (through weeds), pilferage etc. Developments for replacement of open canal system with pressurised underground pipes will remove most of the water losses associated conveyance system; in addition, this will bring reduction in land acquisition requirements and also help in implementation of micro-irrigation.

Advancements in the area of cost-effective treatment and recycling of domestic and industrial wastewater, and its reuse in agriculture, would reduce demand for water and also abate pollution of fresh water sources.

(ii) **Challenge of bringing change in the societal mindset:** Apart from a faulty sense of abundance, the common farmer believes that larger application of water yields larger produce. This not only allows water to go waste by surface drain, ground seepage or evaporation, but also affects soil fertility by washing away its nutrients, water logging and salination effects. Excessive use of water is damaging to farm fertility and also detrimental to the crop yield. This calls for changing the traditional view about watering of fields, which will enhance the farm yield and phenomenally reduce irrigation water demand. Immediate attention needs to be given in areas where groundwater situations have deteriorated alarmingly, or where surplus capacities can be created from existing irrigation schemes by curtailing requirement of present command.

The population growth has also been a cause of fragmentation of the farmland holdings, which in turn again becomes a factor of aggravating water situation. There is an urgent need for creating the mind-set for cooperative farming, leading to consolidation of farmland and thereby reducing the farm-water demand.

It is generally accepted that consumptive use of water is only about 20% of the gross urban demand and hence huge quantity of wastewater is generated in urban areas. Industries also discharge large amount of waste water in natural streams, which in turn pollutes the fresh water aggravating the condition even further. If municipal and industrial wastewater were to be treated and put to reuse for agriculture purposes, it would be possible to bring additional area under irrigation and also reduce the freshwater demand. The society also needs to be educated about necessity of recycling wastewater, and wherever possible the treated wastewater should be allowed to re-enter water conveyance systems so as to augment the downstream supply potential.

(iii) **Challenge of initiating and enforcing water related structural reforms:** Even with limited land properties, people have access to unlimited groundwater reserves by deploying powerful pumps. The Government of India prepared a model bill for scientific regulation of groundwater and many states have also passed similar acts. However, the enforcement of these acts is tardy due to various reasons. Further, the regulatory bodies need to have adequate funds and technical expertise to implement and enforce the acts. The will of the political leadership is necessary for the success of these structural reforms.

33 Around 85 percent of the operational holdings in the country are small and marginal, i.e. these farm holdings are of less than 2 hectares [2].
as early as 1970, but very few states have enacted groundwater legislations; and even in these states, the legislations are either not implemented or are not sound enough to bring effective control over groundwater abuse. Also, the powers vested with Central Ground Water Board (CGWB) with regard to regulation and control in groundwater management and development seems to be inadequate to deal with the sensitive issues of water effectively.

Area-wise documentation of tube-well inventory, water extraction and water recharging needs to be carried out as tool for groundwater monitoring. In areas where at times recharging falls short of extraction, suitable controls should be exercised to regulate groundwater demand. In areas subjected to alarming levels of groundwater depletion, irrigation by groundwater needs to be banned for appropriate periods, till the situation gets normalised. Meaningful structural reforms need to be brought about by enacting appropriate laws and suitably empowering regulating agencies. Reforms will be more effective if controls are decentralised and local level bodies (Panchayats, Municipalities etc.) are empowered with regulating powers. There is also an urgent need for developing the WUAs and building up their capacities to deal with dynamic groundwater situation. Imparting water education at grassroots’ level shall precede the enforcement of regulations.

Another aspect calling for structural reforms to improve demand-side management is the pollution of surface and ground water bodies. Besides the industrial wastes, domestic waste and farm waste (with high chemical contents of pesticides and insecticides) are also responsible for increasing pollution of the water sources. The Environment Protection Act - 1986 empowers the Central Government to take expedient measures to protect and improve quality of environment, including that of water. There are several other acts and regulations at central and state levels, to safeguard water bodies from disposal of toxic and hazardous wastes. Nevertheless, vast stretches of rivers, lakes and ponds, and also subsoil water are subjected to onerous levels of pollution today. There is an urgent need to educate people about their duties and rights on pollution related issues, and to strengthen regulatory institutions.

Demand for irrigation water is considerably affected by the farmer’s choice of crops and cropping pattern. The choice of crops is largely influenced by the differential money available to the farmer, which in turn is governed by the pricing of farm inputs and outputs. With the highly subsidized energy charges (diesel, as well as farm electricity charges) for groundwater, and abysmally low surface irrigation charges, water as an input-cost factor seldom influences the farmer’s choice of crops. On the other hand, intervention in regulating the prices of other inputs and outputs, and the export-import restrictions by government plays vital role in influencing the crops and cropping pattern of the area. Many a time this leads to serious distortion in the cropping pattern, with water intensive crops becoming the prime choices of farmers. This affects the ground water table adversely, and in cases of surface irrigation schemes, deprives the tail end farmers even the minimum irrigation water. This problem has already taken serious proportion, and even new irrigation projects are being subjected to doubts on their promised irrigation potentials in light of the farmers’ tendency to go for water-intensive and cash-rewarding crops like sugarcane. There is an urgent need to check distortion in cropping pattern by suitable policy initiatives in farm input and output pricing and export-import regulations.

Reform in the area of canal water pricing is probably the most crucial change needed for influencing irrigation water demand. Presently, irrigation water rates in most states are a trifle of the total farm input costs, and in a few cases, such as in Punjab, water comes to the farm free of cost. In some of the states the water charges are hidden as they are levied with land revenues, while in others they are levied per hectare basis, rather than on volumetric basis. Thus, a large number of Indian farmers enjoy the benefits of irrigation from numerous water
resources projects with scant regard for volumetric consumption. For sure, they draw more water from the irrigation systems than what is genuinely needed, thereby inflating irrigation demand considerably. There is an urgent need to correct the manner and magnitude of water pricing so as to bring an impact on irrigation demand.

Since enhanced canal water prices will affect the competitiveness of farm-produce, it should be comparable with the tangible cost of pumped groundwater, and should be uniformly implemented across different states. A meaningful irrigation pricing reform (to check total irrigation water demand) can be accomplished only if subsidies on energy charges of groundwater pumping are also curtailed rationally.

6 WAY FORWARD AND RECOMMENDATIONS

6.1 Planned Integrated Approach – Way Forward

Despite the interdisciplinary reality, the development and management of irrigation in India is unfortunately compartmentalised; and any way forward shall first seek to dismantle all barriers between various fields and between institutions dealing with such fields. Further, the vibrant pulse of irrigation problems can be deciphered and resolved judiciously only by keeping the stakeholders, mainly the farmers, at the forefront. Finally, only the holistic approach, involving both Structural and Non-structural interventions, can provide a comprehensive and sustainable solution for India’s irrigation development.

Because of capacity related and other practical considerations, and also with a view of benefiting from a gradually developed learning curve, the way forward shall be charted in terms of short-term plan (up to year 2020), medium-term plan (up to year 2025), and the long-term plan (up to year 2035). The three plans are not sequential; rather works for each plan needs to be taken up now, and continued concurrently for achieving specific targets set under each plan.

The short-term plan will essentially focus on consolidation of efforts for the successful completion of all irrigation development projects already in hand. The programs that are under formulation for immediate inclusion will also form part of the short-term plan. The medium-term plan will target those projects which have commenced in the past but languishing for numerous reasons, and which are left out from the present prioritization. For these projects, the engineering preparations have been completed and techno-economic viabilities have been accepted; hence these shall form the low hanging fruits for creation of new utilization capacities. Completion of these projects together with projects completed under short term plan will develop adequate water utilization capacities needed for meeting demands of 2025.

The long-term plan will target new projects starting from scratch. This will require taking up of pre-feasibility studies, preparation of detailed project reports, impact assessment studies, techno-economic and socio-environmental clearances, followed by construction activities. These projects will be highly challenging and may require out-of-box approaches for adding new utilization capacities matching with demand projections for 2035, and possibly covering substantial demand projections of 2050 as well. Hence for implementation of long term policy, focussed studies will be required for:

- Realistic assessment of current supply potential for both surface and ground water;
- Assessment of current demand for all sector of water usage;
- Identification of areas for convergence of efforts between different institutions/ ministries for holistic water resource development, and modalities for bringing such convergences;
- Identification of focussed areas of research for demand-side management;

34 The desired unity of purpose amongst institutions shall be achieved by collaboration rather than by centralization – which has its own limitations.
Identification of areas of structural reforms for improving demand-side management of water (including prevention of pollution of water sources) through education and regulations.

6.2 Strengthening of PIM

The PIM is being continuously promoted under the Command Area Development & Water Management (CADWM) program of the central government. Even then there is an urgent need for bringing paradigm shift in the implementation of CADWM program for holistic development and strengthening of PIM in the country. The following recommendations are made in this regard:

(a) In principle, the control and management of irrigation network below the government controlled outlets is the responsibility of Water Users’ Association. The CADWM program has been taken up to facilitate the process of creation of WUAs and their taking over of the control and management of irrigation system (i.e Participatory Irrigation Management); and the completion (saturation) of engineering works under CADWM structural interventions is only a means for seeking the PIM objective and not an objective in itself. This is the reasons why land is not acquired by government for CADWM interventions, and the assets created under CADWM not accounted as government assets. For this basic reason, the regular maintenance of field channel created under CADWM program shall not be construed as responsibility of government; and funds shall not be released by default for its routine maintenance.

(b) In CADWM implementation, standardization can be beneficial in terms of ease of doing, quality control, comparison of cost of construction etc. At the same time, too much standardization may limit the advantages available in terms of use of local material, local skills, and traditional irrigation practices; hence an optimal approach with regard to standardization may be adopted.

(c) The overall improvement in financial strength of WUAs is essential for their long-term sustainability. However, this shall not be attempted by consideration of higher grants for WUAs; rather they shall be empowered for taking financial decisions on their own in relation to water tariffs, differential pricing of water, fines for deferred payments, share in profit margins for common services, etc.

(d) The concept of warabandi, for equitable distribution of the available water through rotation of supplies, is built-in in the optimal design of irrigation canals; and its exercise is not optional but essential. However, a greater level of coordination and communication needs to be established with WUAs for determination and enforcement of a predetermined schedule specifying year, day, time and duration of supply to each Chak; and a cascading communication and coordination is also required between a WUA and the individual farmer for ensuring timely supply of water in proportion to the size of farmer’s landholding in the outlet command and the choice of crop.

(e) The rampant variation in cropping pattern vis-a-vis assumptions made in original estimation of project’s irrigation potential is the leading cause for non-equitable distribution of irrigation water in command. However, enactment of irrigation laws in this regard and their strict regulations may not be very fruitful. Instead, the issue at best can be resolved by market level intervention for farm produce influencing farmer’s crop choices; or by demand-side management of irrigation water achieved through: (i) deeper penetration of water education; (ii) empowerment of WUAs for levying differential pricing; and (iii) control on irrigation releases to WUAs at government controlled outlets (for successful outcomes, the suggested interventions for the demand-side management shall be implemented in the sequence as stated).
Any proposal for reclamation of water-logged area shall be tailored keeping in mind the future scenario evolving from higher application efficiency targeted under CADWM. In areas where the water logging is caused by other sources such as canal leakage, the intervention shall be directed at the root cause. Only in cases where water logging is attributed for reasons of soil quality, the interventions of surface and sub-surface drainage shall be attempted; and even in such cases, the implementation of micro-irrigation will be a more desirable action.

A greater level of awareness and vision needs to be built-in through capacity building programs directed at WUAs for ensuring timely and regular elections. The shortcut of unified notification, for same day State-level election, though effective for meeting the requirement of election, is fraught with the risks of politicisation of the process.

The present guideline mandates micro-irrigation coverage in at least 10% of the CCA of the project. In exceptional cases, the shortfall in micro-irrigation target from one project may be shifted to (more suitable) another project; and in this manner, some of the lift irrigation schemes can be targeted for 100% micro-irrigation in a cost-effective manner benefitting from economies of scale.

Involvement of WUAs in planning of field channel has been desired without making it mandatory that actual work is also to be executed through WUAs. The execution of the works through WUAs have the limitations of: (i) attracting contractors in WUA’s elected body if large packages are given; (ii) work progress becoming very slow if small packages are given; (iii) absence of mechanization and quality of works that can come from established large contractors; (iv) absence of competitive pricing. Hence it is desirable to go for large contract packages with stipulation for prior consent of farmers/ WUAs in planning of the field channel layout.

The charges for canal water should be levied on volumetric basis at the last government-controlled outlet. Logically the annual recovery made should cover a portion of capital investment and full portion of operation and maintenance (O&M) cost. But since irrigation projects in India are constructed and operated at very high costs - often on account of organisational inefficiencies - levying water prices on actual cost basis would be inappropriate and impracticable. In absence of a viable alternative to the farmer, this would mean loading cost-inefficiencies of the projects to the farm-input costs; thereby reducing farm’s cost efficiency. So, instead of cost recovery aspect, the focus of irrigation pricing should be on creation of a deterrent level against overuse or misuse of water.

Provision of suitable measuring devices and control structures may enable WUAs to gradually adopt the concepts of water budgeting and help in its regulation; and it can also pave way for enforcing differential water pricing for the cash crops. A small-scale application of canal automation, integrated backward from the field level, can provide a cost effective and technologically viable option.

Cooperative farming leading to pooling of land resources may facilitate efficient water utilization; much higher agricultural productivity; lowering of input costs; and better market returns. In this scenario, the cost-effective system of mechanized Pivot irrigation can also be adopted for implementation of micro-irrigation aiming for substantial improvement in cropping intensity as well as crop productivity.

One way of creating deterrence against overuse is to raise water prices to a level, where its impact per unit of the produce becomes comparable with cost impacts of other farm inputs, such as seeds, fertiliser etc.
(m) Impetus to PIM process shall be given by involving Social Facilitators\textsuperscript{36} for guiding WUAs seeking following objectives:

- Facilitate capacity building and promote effective functioning of WUAs and enable them to perform their roles effectively and responsibly for improving the distribution, operation and maintenance of irrigation system with efficiency and equity;
- Facilitate and improve interaction and clarity in functions among the WUA members and departmental functionaries from Irrigation, Agriculture and Rural Development;
- Bring water use efficiency by mobilising, coordinating, planning and monitoring support, and facilitate training and capacity building for behaviour changes;
- Promote cooperative farming for bringing cost efficiency in micro-irrigation (e.g. pivots), farm-mechanization, and other farm inputs; and for improving their capacities in storing, transporting and marketing of farm produce;
- Facilitate implementation of ‘Agriculture Livelihoods Support Services (ALSS)’ and the conjunctive use of groundwater;
- Assess performance of WUAs and be a part of the feedback loop and drive the spirit of continuous improvement.

(n) During eighties, 14 numbers of ‘Water And Land Management Institutes (WALMIs)’ were set up to provide need based trainings in water and land management. However, WALMIs have not been successful to the extent required due to numerous constraints, including limited and continuously declining manpower and infrastructure. There is an urgent need for modernization and extension of WALMIs with vision to function as: “\textit{premier institution for water education to all stakeholders across all sectors of water use for providing interdisciplinary training, consultancy, action research and advocacy on integrated management of water and land resources for socio economic well-being in ecologically sustainable manner}”. The modernized and strengthened WALMIs shall carry out following functions:

- Promote advancement of science and acquisition of scientific knowledge through capacity building programmes on development and management of water, land and other related natural resources for sustainable development and livelihood generation;
- Promote participatory management of water, land and environmental resources by involving all stakeholders;
- Undertake research on various aspects of water and land development including challenges of emerging climate change scenario and collaborate with other organisation with similar objectives;
- Develop innovative mechanisms demos and pilots on water management in different agro-ecological zones of the State;
- Provide consultancy services to the Government and local bodies and other organizations in water management and land development for: irrigated agriculture, watershed management for dry land agriculture, drinking water and sanitation, industrial water, eco-system water, water for religious, cultural and tourism activities;
- Support information system for water and land related data for resource planning and management using Geo-ICTs;
- Disseminate the water and land management knowledge to all stakeholders across all sectors of water through print and digital media;
- Advise in matters of legal framework, water legislations, water rights, water policies, regulatory concerns etc. for surface and ground water development;

\textsuperscript{36} A Social Facilitator may be an NGO, or similar entity, having substantial experience in influencing village level social activities and reforms; they will render service as per TOR, and payment made to them will be linked to the specified deliverables.
- Support farmers and WUAs in developing forward, backward and lateral linkages for improving their socio-economic conditions;
- Promote advancement of knowledge and skill in do it yourself (DIY) mode;
- Identify best water management practices, and develop mechanisms for scaling up of the best practices;
- Develop expertise and strength in emerging water management challenges, such as: virtual water, water footprints, water markets, PPP, precision agriculture, smart use of water etc.

7 REFERENCES


**************************
1 INTRODUCTION

1.1 Geography

Indonesia is the largest archipelago in the world. It consists of five major islands and about 30 smaller groups. The total number of islands is estimated to be 17,508 according to the Indonesian Naval Hydro-Oceanographic office. This archipelago is located between the Pacific and the Indian Oceans, and bridges two continents, Asia and Australia. This strategic position has influenced the cultural, social, political, and economic life of the country. The territory of Indonesia stretches from 6°08’ north latitude to 11°15’ south latitude and from 94°45’ to 141°05’ east longitude. The sea area of Indonesia (about 7.9 million square kilometers [km²], including an exclusive economic zone) constitutes about 81% of the total area of the country and is four times its land area (1.9 million km²).

The five main islands are Sumatera (473,606 km²), the most fertile and densely populated island; Java-Madura (132,107 km²); Kalimantan (539,460 km²) comprises two-thirds of the island of Borneo; Sulawesi (189,216 km²); and Papua (421,981 km²), which is part of the world’s second-largest island, New Guinea. The other islands in Indonesia are smaller. Indonesia has been divided into 131 river basin territories (wilayah sungai) with more than 5,700 rivers, containing many dams, weirs, and canals.

1.2 Population Distribution in Indonesia

The Indonesian population reached a total of 238 million in 2015, with a very uneven spread among islands (see Table 1). Based on the 2010 Population Census, 57% of the population inhabit the island of Java which merely represents 7% of total land in Indonesia. On the other hand, Maluku and Papua, with 25% of Indonesian territory are only inhabited by 2% of the total population. With the projected population growth of 1% per annum, the total population of Indonesia is predicted to reach 271 million by 2025. In 2010 50% of the population lived in urban areas. By 2025 this is projected to rise to 60%, compared to 38% in 1995.

<table>
<thead>
<tr>
<th>Island</th>
<th>Census 2000</th>
<th>Census 2015</th>
<th>Projected population 2025</th>
<th>Projected population 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatera</td>
<td>43,3</td>
<td>50,9</td>
<td>59,3</td>
<td>65,9</td>
</tr>
<tr>
<td>Jawa</td>
<td>121,4</td>
<td>137,0</td>
<td>152,4</td>
<td>163,8</td>
</tr>
<tr>
<td>Bali &amp; Nusa Tenggara</td>
<td>11,1</td>
<td>13,1</td>
<td>15,0</td>
<td>16,8</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>11,3</td>
<td>13,9</td>
<td>16,8</td>
<td>19,3</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>11,3</td>
<td>17,4</td>
<td>19,9</td>
<td>22,0</td>
</tr>
<tr>
<td>Maluku</td>
<td>14,9</td>
<td>22,0</td>
<td>28,9</td>
<td>32,0</td>
</tr>
<tr>
<td>Papua</td>
<td>0,2</td>
<td>3,6</td>
<td>4,4</td>
<td>5,1</td>
</tr>
<tr>
<td>INDONESIA</td>
<td>206,3</td>
<td>238,5</td>
<td>271,1</td>
<td>296,4</td>
</tr>
</tbody>
</table>


1.3 Climate

Indonesia is a tropical country, and the climate is fairly even all year round. The year can roughly be divided into two distinct seasons, “wet” and “dry.” The East Monsoon, from June to September, brings in dry weather whereas the West Monsoon, from December to March, brings in rain. Even in the midst
of the wet season, temperatures range from 21°C to 33°C, except at higher altitudes where it can be much cooler. The heaviest rainfall is usually recorded in December and January. Average humidity is generally between 75% and 100%.

1.4 Irrigated Agricultural Sector in Indonesia

Irrigation in Indonesia, particularly in the Java Island, has been practiced for the cultivation of rice from ancient times, and to date covers around 7.23 million ha. The development started during the era of the East Indian Company VOC, before the Netherlands Colonial Government took over early 19th century, while in the second part of the 19th century in central and eastern Java numerous schemes were developed, the most modern of which in the Brantas River area, constructed in the period 1857 - 1920. In the colonial approach, the focus was on the construction of diversion weirs, storage works, pumps, etc. As the quality of these projects was good, many are still operational to date. The importance of the 2nd crop to meet the need of the growing population, resulted in the construction of reservoirs to store the west monsoon flows for use during the dry monsoon for irrigation of a second crop, and also in attention for the distribution system. In between 1914 and 1942 the irrigation area more than doubled from 1.4 million ha in 1914 to 3.3 million ha in 1943, which also resulted that towards the 1940s Java became a major rice-exporter with the rice production nearly doubled from 1920 to 1940 (from 2.9 M tons in 1920 to 4.4. M tons in 1940).

Compared with the other 2 largest irrigation-countries in Asia, India and China, Indonesia has the lowest ratio of irrigation size/population, at 30 persons per ha, while India has (only) 19 persons per ha irrigation area.

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>IRRIGATED AREA (million ha)</th>
<th>POPULATION (in million)</th>
<th>RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>55</td>
<td>1.300</td>
<td>1 : 23</td>
</tr>
<tr>
<td>India</td>
<td>57</td>
<td>1.100</td>
<td>1 : 19</td>
</tr>
<tr>
<td>Indonesia</td>
<td>7.2</td>
<td>220</td>
<td>1 : 30</td>
</tr>
</tbody>
</table>

Source: ICID, 2007

1.5 Land Holding Situation in Indonesia

Agricultural policy in Indonesia has been primarily concerned with policies designed to pursue food self-sufficiency, which was achieved in 1984 for the first time. In 2008 Indonesia joined the ranks of rice exporting countries for the first time when domestic rice production exceeded domestic rice consumption. In Indonesia, the by far dominant farm-holding size are ‘landless farmers who cultivate and live off land less than 0.5 ha. This group of farmers is not only limited by small land size, but they also face limitations in access to capital, knowledge, information, seeds and fertilizers and very importantly markets, making them extremely vulnerable. In line with the growth of the national population, so does the number of small holder farmers.

National SENSUS data (BPS) reveal that in a period of 10 years (from 1993 to 2003) the percentage of landless peasants has increased from (national average of) 51.9 % in 1993 to (a national average of) 53.9 % in 2003 (ten years later), or in numbers in 2003 13.7 million out of the total national number of 25.4 million farmer households, with in 1993 (Ten years earlier), a total of 11, 2 million peasants out of 20.8 farmer households. Between Java and the other islands there are big differences with on Java in 2003 more than 70 % of farmers are landless peasant, and outside Java only around 30 % (Figure 1). Of the 2003 total some 74.9% reside on Java Island with 33.9% in outside Java Island. In 2008, estimated the number of landless small folders (peasants) was reported to have reached 55.1% of the total farmer households. Other data also show land conversion significantly increasing, for about 40.000 ha per year (Word bank 2009). This indicates possession of the land also tend to
decrease.

The contribution to the national food security of these peasants is very significant, yet economically they are living just slightly above the poverty line. Based on the Farming survey by Central Statistical Biro (BPS) on 2003, their average monthly income is Rp. 158,000 of the average poverty line of Rp. 105,000. Their large contribution to national food security warrants attention of these small holder farmers.

The first, most directly linked to water-management, approach is to unite them in Water Users' Organizations (WUAs) and training and strengthening these organizations.

A 2nd group concern agricultural factors, such as optimizing their resources of land, water, energy, and by improving their access to credit and appropriate technologies. The 3rd level is to provide them with opportunities to develop the skills and provide them with access to health care and sanitation; and education and reproductive and social services. Given the national and international policies that facilitate access to such resources, there would be confident expectation that small-scale agriculture could and would achieve higher production and income and that the livelihoods of small-holder families and communities would be enhanced.

1.6 Water Situation in Indonesia

1.6.1 Seasonal Water Availability

As an archipelago the conditions, and problems of, water resources in Indonesia vary enormously, between the Islands of Java and Bali, as well as other islands. Because of the tropical climate condition, national gross per capita water availability is very high. But the monsoon characteristics, and urbanization and economic development have created conflicts in the distribution and utilization of these water resources, both surface as well as ground water. As a result, in the near future water security is at risk especially in the most populated islands of Java and Bali. In addition, in many islands the water security situation is also problematic due to the insufficient availability of water infrastructure to provide services and to overcome the long dry seasons. The wet and dry season water balance by island is presented below.

<table>
<thead>
<tr>
<th>Island</th>
<th>Rainy Season Availability</th>
<th>Rainy Season Need</th>
<th>Dry Season Availability</th>
<th>Dry Season Need</th>
<th>Total Availability</th>
<th>Total Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatra</td>
<td>384,744.4</td>
<td>9,485.8</td>
<td>96,193.6</td>
<td>13,280.2</td>
<td>480,968.0</td>
<td>22,766.0</td>
</tr>
<tr>
<td>Java &amp; Bali</td>
<td>101,160.8</td>
<td>31,487.1</td>
<td>25,290.2</td>
<td>44,081.9</td>
<td>126,451.0</td>
<td>75,569.0</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>389,689.3</td>
<td>2,505.8</td>
<td>167,009.7</td>
<td>3,508.2</td>
<td>556,699.0</td>
<td>6,014.0</td>
</tr>
</tbody>
</table>
### Table: Availability vs Need for Irrigation Water

<table>
<thead>
<tr>
<th>Island</th>
<th>Rainy Season</th>
<th>Dry Season</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Availability</td>
<td>Need</td>
<td>Availability</td>
</tr>
<tr>
<td>SULAWESI</td>
<td>129,400.2</td>
<td>6,921.7</td>
<td>14,377.8</td>
</tr>
<tr>
<td>NTB, NTT</td>
<td>37,940.4</td>
<td>1,552.5</td>
<td>4,215.6</td>
</tr>
<tr>
<td>MALUKU</td>
<td>49,420.8</td>
<td>106.2</td>
<td>12,355.2</td>
</tr>
<tr>
<td>PAPUA</td>
<td>381,763.9</td>
<td>117.1</td>
<td>163,613.1</td>
</tr>
</tbody>
</table>


### 1.6.2 Characteristic of Indonesia’s Irrigation Water supply

Out of the total irrigated area of 7.23 million ha, only around 800,000 ha (11%) is fed with water from a storage dam, with the remainder so-called *run-of-the-river* systems from weirs. Nearly half of the total irrigation area (46% or 3.32 million ha) is located on the island of Java, 28% on the island of Sumatra, 12% on the island of Sulawesi, with the remaining 14% elsewhere. The 2 provinces with the largest size are West Java and East Java, with each nearly 1 million ha. This area of 7.23 million ha is distributed over 33,282 irrigation schemes, with 96% of these schemes being small schemes (smaller than 1,000 ha).

### 1.6.3 Degradation of Catchments - Floods and Droughts – Pollution

More and more locations in Indonesia face frequent droughts, and floods and landslides. Floods occur yearly and hit both urban locations as well as agricultural lands. The occurrence of floods on one hand is caused by the increased direct run-off due urbanization and land use changes in the catchment areas resulting in inadequate capacity of rivers, as well with the disappearance of sites for floods storage, such as flood plains, marshlands, lakes, ponds, etc. The reduced river flood conveyance capacity occurs due to development and construction in the floodplains, especially in urban areas, and the rapid rate of sedimentation due to the high level of erosion and volume of waste carried by the river water flow. In the meantime, the disappearance of flood retention and water conservation areas occurs because most of the wet lands (marshlands, lakes, ponds, pools) have been reclaimed for housing or industrial purposes.

Degradation of catchment areas results in less water infiltrating in the soil causing an extra increase in flood discharge and reduced dry season flows. As a consequence, there is insufficient irrigation water during the dry season in several regions, since only 15% of irrigation land is supported by reservoirs. Figure 2 shows a tendency towards increased harvest failure, whether due to floods or dry spells in the period 1993 till 2006.

**Figure 2. The Effect of floods and dry spells towards food staple production (Anshori, 2007)**

Conflicts of interest in efforts towards water conservation and flood management also occur between the communities in upstream areas and the communities in downstream locations. The need to maintain green areas, protection forests and control over erosion in the upstream areas is contrary to the fulfillment of food security for the communities who need additional agricultural land. In the
meantime, in the downstream locations, the need for land to accommodate flood waters is in conflict with the need for land for settlement (residential areas).

Urban development has yet to be supported by an adequate waste water treatment and management system. Numerous cities in Indonesia are currently relying on an on-site sanitation system for its waste-water management, and only a few acquire off-site sanitation systems through sewage systems. Such condition is the cause for the still high pollution level in surface water and ground water, which can be seen in the grey to black coloring of the river water and the sharp smells one meets in some large cities in Indonesia.

1.6.4 Global Climate Change Impact
As an archipelago, Indonesia is extremely vulnerable towards impacts from climate changes. Extended dry spells increase the frequencies in extreme rains, heavy rains that cause flash floods, inundations and less water available for the dry season. The forecasted sea level rise due to global warming and ice meltdown could result in the submerging of coastal lowlands in various locations in the country, including urban areas or agricultural lands, also some of smaller islands may be completely submerged. This shall bring about a negative impact on activities covering agriculture, fishery and forestry, threatening the overall food security and sources of livelihood of the communities.

1.7 Indonesian Water Institutional Set-Up
1.7.1 Historic Review
Institution for water and irrigation management in Indonesia was inherited from the Netherland Colonial Government who established a special Public Works Department (BOW) in 1854 to manage irrigation development and next by Kotubu Bunsitsu in Japan colonial era. It then be the embryo for the establishment and development of the Public Works Department since early independence era, the Public Works and Electricity Department (PUTL) in early 1970, the Regional Development and Housing Ministry, the Regional Infrastructure and Housing Ministry, the Public Works and People Housing from 2000 until now. In addition to irrigation, river and water resources at all were also include in the scope of management responsibility of the institutions together with other regional/infrastructure affairs. Until the year of 2000, the institutions existed in the central, provincial and district government level with centralized authority and relatively homogenous. However, with more decentralized government system, since 2000 more variety regional institutions emerged but still maintained the vertical sector relations with central institutions. A special commission for coordination of irrigation management was established in provincial and district level initially in 1969 and since the mid of 1990 decade, coordination committees for water resources management were established in watershed and provincial level which then transformed to be the water council in central and provincial level while still maintained a new version of coordination committee in watershed level since 2009.

The changes of the institutions name describe dynamic of issues and driving forces of reforms occurred in the institution development along its history, particularly in relation with water and irrigation issues. In addition to natural resources and environment issues as above described, the issues concerning political, social and economic situation in Indonesia also contributed to the reforms. The prominent political changes having fundamental impacts to water and irrigation sector occurred in 1969/1970 and 1998 which at last lead to the institutional reform on water and irrigation sector in Indonesia.

1.7.2 Indonesia’s Water Legal Infrastructure
a) **UU 11/1974:** The first legal base for irrigation management after Indonesia gained Independence was Law No 11/1974 on Water Resources Development. This law mainly focuses on development of water resources but mainly irrigation, with little attention for management. Another characteristic is
the dominant position of the central government with little or no authority for the regional levels (provinces and districts/kabupaten). The regulation was a typical product of the New Order period, in which the position of the central government was dominant. In accordance with the preamble, the regulation contained several articles about sustainability and conservation. However, in practice these articles were not supported with other legal instruments and hence were not IAMd attention. The fundamental principles of the law encompass:

(i) Water and its sources, including natural resources contained in it, are the gift of God Almighty, which has versatile benefits fulfilling human needs of all times, both in the economic, social and cultural aspects;

(ii) Earth, water, and natural resources contained in it are controlled by the state and are used for the greatest prosperity of the people in a fair and equitable way; and

(iii) Commercial operation of water resources should be devoted to the interests and welfare of the people while creating growth, social justice, and the ability to be autonomous in a just and prosperous society based on Pancasila.

b) **UU 07/2004**: In the period 2002/2003, the National Parliament debated for a long period the contents of the New Water Way, which was finally passed by the parliament early 2004 and enacted in late March 2004 by President Megawati as UU 7/2004. The basic 4 elements of SDA in the UU 7/2004 Water Law are:

(i) The formation of Water Councils (*Dewan Sumber Daya Air*) and Irrigation Committees (KOMIR) at District and Province levels. An earlier government regulation (1996) requires the establishment of basin water management organizations (Balai PSDA), which are responsible for management of surface water within basins.

(ii) All river basin management and planning activities should fit into a comprehensive water resource management framework (Pola SDA) that provides guidance for development and management. Pola SDAs must be (i) formed in a participatory manner through public consultations with all stakeholders, (ii) consistent with current spatial planning, and (iii) enacted as local government regulations.

(iii) For all irrigation, the government is responsible for development and O&M of all primary and secondary level infrastructure.

(iv) Involvement of users is required for all steps of development and management in participative approaches.

c) **First Constitutional Review 2005**: Immediately after the new water law was enacted, a group of 80 NGOs filed 4 petitions to the Constitutional Court requesting the cancellation of the new Water Law on the grounds that certain articles in the law relating to private sector involvement in water resource management contravened Article 33(3) of the 1945 Constitution, which calls for public use of water. The petitioners feared that the 2004 law would turn water into a ‘tradable commodity’ sold for profit, thus causing a burden for millions of farmers and poor people. All these requests concerned the ‘drinking water’ aspects of the water law and none of them had any relation to the irrigation aspects as regulated in the 2004 water law.

On 19 July 2005, the Constitutional Court rejected these NGO petitions, but ordered the Government to issue supplementary regulations in line with the court’s ruling otherwise it will open a second review if implementation of the Law was not in line with the court’s ruling. Therefore, the Law had a conditionally constitutional meaning possible for a second review. In its ruling, the court stated that the government has the right to award licenses to private sector firms, cooperatives and the public sector to manage water resources. The issuance of a license must be based on a ‘water resources management system’ prepared with public participation. The Court also ruled that the government and local administrations should subsidize water so as to reduce its cost. Local water utilities must be positioned as operational units of the state and fulfill the state’s duty to provide guaranteed access for the public, rather than as profit-oriented companies’. The Court also confirmed that farmers must
be freed from the obligation to pay water management service charges.

d) **Second Constitutional Review 2015**: Considering development of the Water Law implementation after almost a decade, a group of NGOs issued in 2014 a second request for constitutional review of the 2004 Water Law. Surprisingly, on 18 February 2015 the Constitutional Court approved/endorsed this second request and canceled the Law No 7/2004 as requested by the second NGO’s petition which possible by the Law’s status of conditionally constitutional after the first rejected petition. Together with the cancelation of the Law, all derivate regulations based on the Law were also canceled, including the regulations on irrigation. Hence until the issuance of the new Law, the Law No 11/1974 and its derivate regulations were enacted.

e) **New Legal Framework**: Since the fall-out of the water law of 1974 the main 2 legal documents regulating the WRM sector are:

   (i). The 1974 first water law No 11/1974 h
   (ii). The Law 23/2014 on regional administration which with regards to water resources and irrigation identical arrangements as in the 2004 Water Law and PP 20/2006.

As a result of the fact that with regards to irrigation the law on regional autonomy contains the same regulations as in the irrigation regulation PP 20/2016, for the irrigation sector the fallout of the 2004 water law has little impact. To fill the legal gap until the new water law issued, the government issues two PPs on Utilization of Water Resources and Drinking Water and tens of Public Works and Public Ministerial’s regulations.

2 LEGAL FRAMEWORKS

2.1 Issue and Challenges Related to Land and Water

2.1.1 Fragmented Government’s Institutional Set-Up
The main issues and challenges related to land and water are that due to the structure of the Government’s institutional set-up support for ‘irrigated agriculture’ over the last decades has been very fragmented and as a result not very effective. This fragmentation is related to the factors that

a) several government agencies at several levels are partly responsible,

b) the routine O&M allocations are too low and come only available too late in the year,

c) lack of dedicated and capable field staff both for irrigation and agriculture,

d) poor planning and implementation of O&M of the irrigation infrastructure in only a few months of the years,

e) little involvement of the farmers in scheme O&M,

f) no special extension service for the irrigated agriculture sector,

g) no/little credit support and/or

h) no ‘value chain’ support, and

i) last but not least low law enforcement power.

Other occurring developments negatively affecting the general conditions for irrigated agriculture are changes in the river flow regimes due to uncontrolled land development both in the catchments both affecting water discharges and sediment loads changing he relative position of the canals in relation to the land, and uncontrolled changes in the land use within the irrigation schemes themselves.

As a result, agricultural yields have been stagnant already for around 30 years at around 5.5 tons/ha resulting in low farmers’ income low also as the local situation does not allow for crop to diversify and plant high yielding crops in the third season to top up income. The total rice field in Java, but also to a somewhat lower extend on the outer islands, is reducing due to the conversion of agricultural land caused by the urbanization and industrialization and it gives serious problem to the rice production at field level and to securing the national food security. Fragmentation over Various Government Levels
In 2001 Indonesia changed from a very centralistic government structure to a heavily decentralized setup of Government structure and financial management, in which the public works service responsible for the irrigation infrastructure is divided over 3 levels with the central government responsible for the financing of the irrigation services in the larger schemes in size larger than 3,000 ha, the provincial level for the financing of all irrigation services of schemes in size in-between 1,000 and 3,000 ha and the kabupatens responsible for the financing of the irrigation infrastructure in size below the 1,000 ha. For the other 3 related main government agencies involved in irrigated agriculture, as described in 1.2 above, this split does not apply.

2.1.2 Degradation of Catchment Areas
As mentioned afore, degradation of catchment areas with its all damaged impacts continue to occurs and tend to increases. Number of critical watersheds continue to increase from 22 in 1984, 39 in 1994 and 62 in 1999. In 2013, out of the total number of watershed of 458, as many as 60 are in heavy critical, 222 are critical and 176 are potentially critical. The government has launched many programs to prevent and rehabilitate critical lands and watersheds but it seems still incapable to counterbalance the degradation rate. A more strategic approach should be integrated in the water and irrigation sector which include conservation and flood and drought management as part of water resources management.

2.1.3 Limitedness of irrigated land area
As mentioned earlier, with 7.23 million ha of irrigated area and only 11% having reliable supplied water from storage dams, it is far from enough to ensure sustainability of national food security. Indonesia still need not less than 1 million ha addition of new irrigated area otherwise it will suffer deficit of rice production in next several years. A projection of irrigated areas needed to support rice production in Indonesia showed as many as 1.07 million ha of new irrigated area would be needed in 2020 and increased to 1.71 million ha in 2025 to ensure sufficiency of rice production. Only relying on intensification of the given irrigated area and other rice fields now Indonesia can maintain sufficiency of rice production thanks to the significant increase of the national budget for agriculture sector. Since the last three years, the government has been launching an acceleration program for development of 65 dams and I million new irrigation schemes throughout Indonesia region.

2.1.4 Damage of Existing Irrigation schemes
Until recent years, irrigation scheme damages are still a serious problem hampering food production in Indonesia. Of the 7.23 million irrigated area, only 3,481,297 ha (48%) were in good condition while 705,571 ha (10%) were heavily damage, 1,873,184 (26%) moderately damage and 1,170,128 ha lightly damage. The damages exist in all irrigation systems under central, provincial and district government’s authorities. Every year the central government has allocated funds to rehabilitate the scheme damages under its authority and also supports the provincial and district government in relAMring and rehabilitating the schemes under their responsibility. During 2015-2019, the central government has been targeting 3 million ha of irrigation schemes for rehabilitation.

2.1.5 Agricultural land conversions
Agricultural land conversions including irrigated land areas to housing, industry and urban area have been a serious threat hard to be overcome and controlled while continuing to decrease existing agricultural lands. The agreed number from various version of agricultural land conversion data is about 110 000 ha yearly (Sayaka and Tariyan, 2011), either for non-agricultural lands or non-irrigated land cultivations. During 1979-1999 it was reported 2.917.738 ha have been conversed, 1999-2002 as many as 330 000 ha and between 2002-2008 reached 100,000-110,000 ha every year. Meanwhile according to Irawan’s calculation, during 1978-1998 impact of land conversions has reduced 19,4 %
rice production\textsuperscript{40}. It was due to two factors: (1) land conversions reduce rice production accumulatively; (2) land conversions tend to occur in irrigated area having high productivity. Many regulations and policies have been issued to control nevertheless it seems was not so effective even after issuance of the Law No 41/2009 on Protection of Sustainable Food Agricultural Lands.

2.1.6 Increasing Demand for Non-Agricultural Water

As consequences of population and economic growth and social developments, demands for non-agricultural water also increase either for urbans, industries, domestic or recreations and etc. Water for irrigated agriculture was estimated around 80\% and the rest 20\% was utilized for domestic, industry and urban (Samekto dan Winata, 2010). Growing water demand for non-irrigated agriculture was shown from the Jatiluhur Irrigation Area during 1994-2003 which revealed 458.09 million m\textsuperscript{3} (7.8\%) water for domestic, live stocks and fisheries and industries in 1994 and increased to 736.99 million m\textsuperscript{3} (12.69\%). Whereas water for irrigation decreased from 5,418.73 (92.2\%) to 5,069.52 million m\textsuperscript{3} (87.3\%) for the same period (PJTI II, 2004). It means that water supply for agriculture will more compete tightly leading to possible conflicts among users and increasing urgency for more efficient water uses. In addition, it will also necessary to be more effective in coordinating all parties in using water either internally or cross-sectors. Coordination institutions in all levels need to be strengthened while capabilities of water and irrigation managements in resolving potential conflicts among users and in relations with other sector must be increased.

2.1.7 Limitedness of irrigation budget allocation from regional governments

Decentralization of irrigation system management since 2004 which shared authorities and responsibilities between central, provincial and district government was not soon balanced by regional government’s’ capabilities to finance and manage. As consequence, it made the central government must support financing especially for rehabilitation of schemes under provincial and district responsibilities. Meanwhile budget for routine O&M was still limited and must be financed by the regional governments respectively. Most irrigation systems under regional government responsibility still have routine O&M budgets less than the real need budget (AKNOP).

2.2 Review of institutional and organizational aspects of irrigation and drainage sector

2.2.1 Inventory of Agencies Involved in Water and Irrigation

A brief inventory of central government ministries involved in water, directly or through delegated subnational departments, is given below.

<table>
<thead>
<tr>
<th>NATIONAL AGENCY</th>
<th>WATER-RELATED RESPONSIBILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Ministry of National Development (BAPPENAS)</td>
<td>Responsible for national development planning matters, and this is undertaken through five-year plans in cooperation with the line ministries.</td>
</tr>
<tr>
<td>Ministry of Finance</td>
<td>Responsible in terms of government financing of water resources management (WRM) through the normal government budgeting processes.</td>
</tr>
<tr>
<td>Ministry of Foreign Affairs</td>
<td>Responsible for the management of trans boundary (trans country) river basins in so far as the management affects international relations and national government’s foreign affair policies.</td>
</tr>
<tr>
<td>Ministry of Public Works and Public Housing</td>
<td>Responsible for WRM, including dam safety and standard operating agreements such as for hydropower developers. Owns and operates river infrastructure (multipurpose dams, weirs), primary and secondary canals of irrigation system; Directorate General Cipta Karya responsible for water supply and sanitation.</td>
</tr>
<tr>
<td>Ministry of Mines and Energy</td>
<td>Responsible for groundwater management, including management and monitoring of the resource, both with regard to quantify and quality;</td>
</tr>
</tbody>
</table>
NATIONAL AGENCY | WATER-RELATED RESPONSIBILITIES
--- | ---
Ministry of Agriculture | Licensing of groundwater drilling and use; maintaining databases of groundwater use, etc. The ministry is also responsible for hydropower development and may own and operate hydropower systems according to standard operating agreements.
Ministry of Environment and Forestry | Responsible for management of water quality through controlling pollution and river zoning (water quality targets in river reaches) and watershed management, including land use planning in watershed areas as well as its responsibilities for promoting and regulating the forestry sector. It is also responsible for Environmental Impact Assessment of major projects.
Ministry of Home Affairs (Interior Ministry) | Responsible for the domestic governance, public order, and regional development at provincial and district levels. This includes decentralization of policies and laws and local autonomy, and increasing community empowerment and poverty reduction.
Ministry of Transport | Responsible for transport facilities, infrastructure, community access, and quality of services. This includes navigation on rivers and lakes.
Central Statistics Agency | A no departmental government responsible for the provision of basic statistical data, both for the government at all levels and for the general public.
Ministry of Agrarian and Spatial Planning | Responsible for formulation of land policies and spatial policies and, in relation to WRM, land mapping, land titles, and rights over land.

Particularly for irrigation sector, the prominent central government agencies having tasks and responsibilities are the Ministry of Public Works and Public Housing regarding infrastructure development, operation and maintenance; the Ministry of Agriculture regarding utilization of irrigation water for farmers and empowerment of water user associations; the Ministry of Home Affairs regarding strengthening regional governments and the National Development Planning Agency regarding national planning.

Meanwhile in provincial and district levels, irrigation sector is under three agencies responsibilities, i.e. the Public Works/Water Resources Development Agency, the Agriculture Agency and the Regional Planning Agency. In the field level, there are Water Users Association having responsibilities in tertiary unit of irrigation schemes and village irrigation systems.

2.2.2 Authorities and responsibilities division of irrigation management and development
Based on the division of responsibilities between the Kabupaten/districts, provincial and central level as given in UU 23/2014, the total irrigation area of 7.4 million is divided as shown below.

<table>
<thead>
<tr>
<th>Responsible Level</th>
<th>Size Group</th>
<th>SCHEMES</th>
<th>AREA (HA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL</td>
<td>Distribution (%)</td>
<td>TOTAL</td>
</tr>
<tr>
<td>District</td>
<td>0 – 1,000 Ha</td>
<td>31,860</td>
<td>95.73 %</td>
</tr>
<tr>
<td>Province</td>
<td>0 – 3,000 Ha + Cross District</td>
<td>1,115</td>
<td>3.35 %</td>
</tr>
<tr>
<td>National</td>
<td>&gt; 3,000 Ha + Cross Province</td>
<td>307</td>
<td>0.92 %</td>
</tr>
<tr>
<td>Total</td>
<td>33,282</td>
<td>100.0 %</td>
<td>7,469,797</td>
</tr>
</tbody>
</table>

The 2 main laws in water resource management are water law UU 11/1974 and the law on regional authorities UU 23/2014 (which is an update of earlier laws).
2.2.3 Coordination for irrigation management
Coordination for irrigation management involving government’s agencies, water users’ association and other water users is carried out by Irrigation Commissions established in provincial and district levels. The District Irrigation Commissions coordinate irrigation management for irrigation systems which wholly located in a district and the Provincial Irrigation Commission for irrigation systems crossing border of district areas. For a cross provincial areas schemes, it can be established an inter provincial irrigation commission. The commission has comprehensive tasks of irrigation management needing coordination as formulation of planting plans, water distribution and delivery plans, maintenance and rehabilitation plans, setting priorities for funds allocation and so on.

2.2.4 Water User Associations
For every tertiary unit of irrigation scheme and village system, farmers establish a water users’ association (WUA). It then can be developed to a WUA Federation (WUAF) in the secondary unit and a WUA Apex (WUAA) in a whole irrigation system if needed. Establishment of WUA was encouraged first time by the government in 1984 by issuance of the President Instruction No 2/1984 to facilitate the farmers in organizing their tasks and responsibilities of irrigation management in a tertiary unit as part of irrigation management in a whole system where the government had responsibilities in the main system. The WUA is also useful to ease communication with the government agencies and encourage farmers participation in irrigation management. As formal organization WUAs are formed generally base on traditional institutions which have been existed and functioned for a long time in the past with various names as subak in Bali, tuobanda in West Sumatera, panitia siring in South Sumatera etc. Despite not all success, a traditional farmer institution which is well integrated in the formal organization of WUA usually will make the WUA active and effective functioning.

The district government has responsibility to empower and strengthen WUAs which is operationally carried out by its agencies according to their competences. Formerly facilitating WUAs establishment and empowering them under the Ministry of Public Work’s responsibility while still let the role of the Ministry of Agriculture and the Ministry of Home Affairs in strengthening agricultural aspect and institution aspect respectively. Since 2007 the WUAs establishment responsibility was transferred to the Ministry of Agriculture while the Ministry of Public Works had a role in technical irrigation aspect strengthening. Due to ineffectively of WUAs empowerment now it is being consideration to bring back the WUA establishment and empowerment to the Ministry of Public Works.

2.3 Need for Institutional Reforms
With cancellation of the Law No 7/2004, water and irrigation sector in Indonesia back to the Law No 11/1974 as legal basis. However due to many new developments and challenges which cannot be accommodated by the old law, a new law has been preparing. While waiting for the issuance of the new law two government regulations and tens of ministerial regulations have been issued to support water and irrigation management and programs.

In formulating the new law and regulations the issues requiring concerns and will be addressed among others are the field level of central and provincial government agency and its personnel having tasks and responsibilities in irrigation management, effective coordination inter sectors and inter central, provincial and district government in supporting strategic national program for national food security, effective WUAs empowerment and strengthening and synchronization of government agencies task and responsibilities in the water and irrigation sector.

2.4 Institutional and organizational structure for sustainable water management
For sustainable water management, institutional and organizational structure in the future will base on some guiding principles as follow:
Concern on water resources conservation and water-related disasters should be integrated in institutional and organizational function and structures;
- A productive and effective relations between central, provincial and district government;
- More effective coordination inter stakeholders;
- Clear and efficient role sharing among stakeholders.

2.4.1 Balancing of functions of conservations, utilizations and water-related disasters control and management
Due to focus on water utilizations and less concerns on conservations and water related risk management many problems of degradations in upstream areas and damages in downstream areas prevailed for previous years. The problems have been part of reflections to be corrected and improved by promoting a new paradigm in water resources management adopted in the Law No 11/1974. Thus, for the future vision of water resources management it has been agreed to be more comprehensive and balance regarding water conservations, utilization and water related risk control and management. These principles also match the concept of IWRM adopted in the Law. These three functions should be proportionally embedded in the institutional and organizational structure of water resources management in all levels to ensure sustainability.

2.4.2 Clear relation of central and regional governments
The relation of central and regional government should be effective and productive by avoiding constraints and obstacles either embedded in regulations or emerged in practices. Learning from experiences it was still found weaknesses in the division of authorities between the central, provincial and district government in water resources and irrigation management that should be resolved in the future. Strict division of the authorities openly make difficulties for the central government to harmonize implementation of a national strategic program that needs supports from provincial and district government. Conversely problems emerged in remote areas under the central government responsibility sometimes need quick response that cannot be provided due to long bureaucracy.

2.4.3 Effective coordination of inter-stakeholders
Varied interests, roles, tasks and responsibilities among many stakeholders of water resources management require effective coordination of inter-stakeholders both government and non-government. Many institutions for water resources and irrigation management coordination have been established both in central and regional level, as Water Resources Council in central and provincial level, Water Resources Management Coordination Team in watershed level and Irrigation Commission in provincial and district level. Nevertheless, it is still found many infectivity’s in the operations of the institutions due to less concerns, less understanding and ego sectorial attitudes among government agencies. Strengthening all existing coordination institutions will be next the agenda while increasing understanding and concerns of stakeholders to make coordination more effective.

2.4.4 Clarity of role sharing in water and irrigation management
The complexity of water and irrigation management with various roles of stakeholders frequently creates overlapping and vague functions and roles among stakeholders. These are problems caused by lack of coordination and should be resolved firstly by make role sharing among stakeholders clearer. Generally, the roles sharing among government agencies are embedded in their tasks and responsibilities stipulated in the decree of President, Ministry, Governor or Regent. Nevertheless, for detail and clear roles sharing regarding specific policy or program, the original roles sharing requires breakdown and detailing further. Especially for implementation of Participatory Irrigation Management and Development (PPSIP), it has been agreed and established a role sharing among National Development Planning Agency (Bappenas), Ministry of Public Works, Ministry of Agriculture and Ministry of Home Affairs. The role sharing has been implemented since 2006 and revised several times to accommodate new developments.
3 PARTICIPATORY IRRIGATION MANAGEMENT (PIM) AND IRRIGATION MANAGEMENT

3.1 Need and objectives of PIM

The objective of PIM has been formulated in the PERMEN No 15/PRT/M/2015, i.e. to increase farmers’ sense of belonging, sense of responsibility and their capabilities in order to realization of effective, efficient and sustainability of the irrigation system.

The needs for PIM in Indonesia is based on considerations that based on the law the irrigation management is under responsibility of the government and the farmers where the government has responsibility in the main system while the farmer in the tertiary unit of system. For effective and productive irrigation management in the whole system the PIM should be applied.

3.2 Indonesian’s PIM Approach

Indonesia’s experience with PIM can be divided into 3 phases, 1) 1982-1998, 2) 1997 – 2004, 3) 2004 – Now

3.2.1 Period 1982-1999

In this period Indonesia’s water resources were governed by the 1974 Water law which was mostly a development law with little guidance on management issues.

a) First PIM Initiatives based on PP 23/1982: The first Government Regulation on Irrigation came 8 years after the law, PP41 No. 23 of 1982, detailing the management and planning functions and the implementation methodology originally defined in the Law 11/1974. The first legal regulation regarding WUA involvement in irrigation was INPRES42 No. 2/1984 on ‘Guidance to Water Users Associations (WUAs), providing a basic regulation for the establishment of WUAs in tertiary unit or village irrigation area. Centralized authority was applied in irrigation system management complying the Law 11/1974 but delegated to the provincial governments to manage the irrigation systems in each administrative jurisdiction respectively. Meanwhile management of tertiary irrigation systems were under farmers’ responsibility while the government manage the primary and secondary systems. It was applied in all irrigation system built by the government and for those built by the farmers would be the responsibility of themselves. To manage the tertiary irrigation system under their responsibility or a village irrigation system built by the themselves, most farmers relied on their traditional institution which have been existed and rooted in their community. In general, they manage without formal organization nevertheless they have informal regulations and customs in managing irrigation systems.

b) Guidance to WUA Development 1984: The first legal regulation regarding WUA involvement in irrigation was INPRES43 No. 2/1984 on ‘Guidance to Water Users Associations (WUAs), providing a basic regulation for the establishment of WUAs in tertiary unit or village irrigation area. Base on this regulation, farmers were encouraged to establish a WUA for formally organizing all their activities and customs of irrigation management previously carried out through their informal institution. Beside advantages for the farmers, a formal organization of WUA will ease communication between the government and the farmers as first step to empower them according to the government’s responsibility. The regulation divided the government’s tasks and responsibilities in empowering WUAS in three specialized field which each carried out by different department, i.e. organization and institution field by Home Affairs Department, agriculture by Department of Agriculture and irrigation by Department of Agriculture.

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41 PP = Peraturan Pemerintah (Government Regulation)
42 INPRES = Instruksi Presiden (Presidential Instruction)
43 INPRES = Instruksi Presiden (Presidential Instruction)
Public Works. Nevertheless, as first regulation on WUA development, the INPRES was still
general in substances, tend to homogenize all farmer organizations and limiting the WUA’s
role in managing the tertiary irrigation schemes or village irrigation systems.

c) **Irrigation Operation and Maintenance Policy IOMP -1987:** The first legal document on
Irrigation O&M was issued in 1987, the so-called ‘Irrigation Operation and Maintenance Policy’
(IOMP). Its’ main aim was to raise funding levels for O&M and improved irrigation
management, and comprised 3 elements:

- Introduction of needs-based Efficient Operation and Maintenance (EOM);
- Cost recovery from beneficiaries through Irrigation Service Fees (ISF);
- Transfer of O&M responsibility to farmer groups (WUA) in small (< 500 ha) public
irrigation systems.

In the period 1998 – 1998 an extensive program to implement the proposed measures was
formulated and, supported by loans from World Bank, ADB, OECF and other donors and
implemented over nearly the entire.

d) **Turn-Over of Small Schemes 1989:** The first legal regulation regarding PIM was PERMEN PU
No. 42/1989 on ‘System of Turnover of Small Scale Irrigation System and Management
Authority to WUAs’. These were the basic regulation which provided guidelines for turnover
of responsibility for operation and maintenance to WUAs of small scale schemes. This
concerns the handover of responsibility for the operation and maintenance of irrigation
schemes from the government to the WUAs, starting with irrigation schemes smaller than 500
ha. Initially the program targeted irrigation schemes grouped together into large block and
turned over to WUAs en-masse. There was, however, usually a considerable delay before
turnover was actually carried out, due to lack of coordination (central, provincial, and
district/Kabupaten levels) and too many procedures for processing program. The small-scale
irrigation system turn-over program was the first policy and program formally using
participative approach. This approach was applied start from the first step when the irrigation
schemes were inventoried and profiled and then rehabilitated with participation of farmers.
In involving the farmers, a community organizer (CO) was tasked to facilitate, supervise and
bridge the farmers-governments relation. Long before formalized in the PERMEN PU, the
participatory approach in irrigation development has been introduced in Indonesia since early
1980 decade and trial-tested in some projects as the High Performance Simple Irrigation
System (HPSIS) (1982-1985), the Tertiary Irrigation Schemes Development with Farmer
Coincide with the Turn over Program launching by the government, it was also carried out the
Small-Scale Irrigation Management Project (SSIPM) which implemented participatory
approach in development of bigger irrigation schemes with around 5,000 ha of irrigation area
in 1990-199544. Later the SSIMP transforms to be the DISMP until now.

e) **PP on WUA Development:** Also in 1992, the Department of Home Affairs (MOHA) issued a
first Government Regulation (PERMEN PU No. 12 of 1992) on the Establishment and
Development of Water Users Associations. This regulation followed-up on number or previous
legal documents on village structure and responsibilities such as the INPRES No. 2/1984 on
Guidance to the Water Users Association. The MOHA regulation was released to improve and
clarify the status of WUAs; that it was really time to enforce the regulation of WUAs, one of
which is the obligation to pay service fee for maintenance.

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3.2.3 Reform Swings 1998-2004

In the period 1997/1998 Indonesia suffered from Asia’s monetary/fiscal crises, which in Indonesia in 1998 developed into a political crisis and in May 1998 led to the fall of the Soeharto regime. After his departure from power, a new Government came into power and in an effort to cope with the situation of political instability, initiated a comprehensive program of reforms including:

- Macro-economic reforms
- Financial and corporate sector restructuring
- Protection for the poor and preservation of human assets and
- Reform of economic institutions.

In October 1998, the national assembly (DPR) approved a policy reform agenda aiming at administrative decentralization, State revenue-sharing, local governance and community empowerment, government transparency and democracy. With respect to the water sector the National Planning Board (Bappenas) took the lead to initiate a national forum for water policy dialogue with representatives of government departments, NGOs and universities, and appointed a Task Force for Reform of Water Resources Sector Policy. This Task Force formulated an ‘agenda for water resources policy and program reform” which became part of an ambitious program started for reform of the water resource sector called Water Sector Adjustment Program (WATSAP). The main objectives of these water sector reforms were to promote the sustainability of water resource management through improvement of:

- The institutional framework for water resources development and management
- The organizational and financial framework for river basin management
- Regional water quality management regulatory institutions and management
- National irrigation management policy, institutions and regulations

In order to preserve a sustainable irrigated food production through an effective O&M program, the President of Indonesia in April 1999 announced the irrigation management policy reforms (formulated in INPRES 3/99), comprising five principles:

i. Redefinition of tasks and responsibilities of irrigation management institutions to ensure a larger role for the farmer communities in decision-making;
ii. Empowerment of farmers through autonomous, self-reliant WUAs;
iii. Phased, selective and democratic transfer of irrigation management to WUAs, with the principle of one system, one management;
iv. Finances to pay for O&M, rehabilitation and development of irrigation systems to be collected and managed by the WUAs and FWUAs in that system;
v. Sustainability of irrigation systems through a general policy of water resources conservation and controlled conversion of irrigated land.

The IMPR emphasizes (a) the central role of WUAs in decision-making and financing and (b) the changing role of the irrigation department and related water management institutions “from provider to enabler”. The IMPR aims at an increased accountability and transparency of the government to the farmer community that should result in more effective and efficient irrigation management.

Also in 1999, the Government of Indonesia reviewed their Water Resources and Irrigation Sector, with the following conclusions:

- Efficient and sustainable irrigation O&M was not achieved despite O&M funding levels of US$70-80 million per year because funds were primarily used for staff support and administrative activities;
- ISF had failed because of a lack of accountability and direct linkage to irrigation service. The fees were collected in districts and subsequently redistributed to the irrigation systems. There was no clear linkage between ISF revenues collected in an irrigation system and O&M services provided for the same irrigation system;
Despite the EOM program, deferred maintenance grew larger, leading to expensive rehabilitation or short-lived irrigation systems.

Based on INPRES 3/99 the Government went ahead to issue a new regulation on irrigation, the PP 77/2001, with as four main implementing decrees for PP 77/2001 were:

i. Guidelines on task distribution for authority and responsibility of Irrigation management (Decree 22/2003 of the Minister of Finance).
ii. Guidelines on WUA establishment and empowerment (Decree 50/2001 of the Minister of Home Affairs).
iii. Guidelines on Irrigation management authority (Decree 529/KPTS/M2001 of the Minister of Resettlement and Regional Infrastructure).

However, the PP 77/2001 and its implementing regulations existed in a transitional period with unstable situation of reform process so practically the all regulations were not effective. Moreover, with the issuance of the Law No 7/2004 on Water Resources substances of INPRES 3/1999 were corrected fundamentally especially regarding the policy of management transfer of irrigation system to WUA.

3.2.3 Period 2004 – Now

With regards to Irrigation Management, the main elements of the Irrigation Management Policy Reform, issued under a 1999 Presidential Decree (INPRES 3/99), were also included in the 2004 law. These are:
1. Redefinition of tasks and responsibilities for irrigation management institutions.
2. Empowerment of WUAs and FWUAs.
3. Restructuring of the financial setup of irrigation management.

While the main principles of participative irrigation management reform continue to remain valid, transfer of irrigation management was not considered feasible for the primary- and secondary levels as this was considered too much a burden for the poor farmers. Instead, the in the new, balanced, irrigation paradigm, the water-users were made an active partner in every decision-making process, from the initial RRA, IAM-IPIIDM, SID, Rehabilitation and O&M. Water User’s organizations however remained fully responsible for village irrigation systems and for the tertiary level hydraulic infrastructure in government managed irrigation systems. The primary and secondary irrigation systems will remain the responsibility of the government in line with UU 7/2004. Farmers may also request assistance from the government to upgrade tertiary irrigation and drainages facilities.

With regards to the management of irrigation schemes, the UU 7/2004 Water Law stipulates that the ownership of primary- and secondary level canals and drains of government managed schemes remains with the Government in order to ensure continued Government support for O&M and rehabilitation. However, the 2004 law stipulates that the farmer beneficiaries have to be consulted and involved in all phases of irrigation development and management.

An intensive discussion has taken place during the parliamentary debate about the proposed responsibility division. The result of this discussion was that (in addition to the general administrative criteria) for the O&M of irrigation systems specific area criteria are established. Central Government is responsible for the O&M of primary and secondary irrigation systems of sizes more than 3,000 ha, provinces for systems of sizes between 1,000 and 3,000 ha, and districts for irrigation systems of up to 1,000 ha.

PP 20/2006: On 30 May 2006, a new Government Regulation on irrigation was issued based on UU
7/2004, including chapters on water users’ participation (Chapter 4), funding (Chapter 11), asset management (Chapter 10) and land use conversion (Chapters 12 and 82). The institutional structure for irrigation systems established in the law, is further elaborated in the PP on Irrigation 2006 (PP 20/2006). Central Government is responsible for the development of primary and secondary cross-province/cross-country/national strategic irrigation systems. National strategic irrigation systems are systems of more than 10,000 ha (elucidation of article 16). Furthermore, Central Government is responsible for the O&M of primary and secondary irrigation systems of more than 3,000 ha, and cross-province/cross-country/national strategic irrigation systems.

3.3 Status of PIM – WUAs, their roles and responsibilities

3.3.1 Responsibilities of WUA/WUAFS in Irrigation Management and Development

The aim of strengthening water users’ organizations through (i) information campaigns on PPSIP, and (ii) establishing and/or strengthening WUA with PPISP policies disseminated at the field level through media publicity campaigns and through workshops for farmers engaged in irrigated agriculture. In schemes with primary and secondary systems GP3A and/or IP3A are formed. WUA are assisted in obtaining legal status through registration with district authorities. As part of this process, legal literacy is also provided to help individual water users and their associations better understand their rights and responsibilities under the new policies and enter in contracts with third parties to improve marketing of irrigated agriculture products. Institutional strengthening support to WUA is provided initially for 1 year and thereafter for 2 more years during implementation of the scheme-level irrigation management plan (IMP).

Under this sub-activity WUAs are supported to enter into a participatory irrigation management agreements (PIMA) with the concerned government levels. WUA are also trained in (i) organizational and managerial practices; (ii) participatory survey, investigation and design (SID); and (iii) implementation of improvements to the irrigation and drainage systems; and also receive agricultural training.

After initial strengthening of district irrigation agencies and WUA, in selected subproject schemes the following activities are implemented: (i) undertaking a participatory review of the irrigation schemes (Profil Sosial, Ekonomi, Kelembagaan, dan Teknik [PSETK]) to assess scheme performance, identify requirements for improving O&M, and participation levels of P3A and GP3A; (ii) formulating a scheme specific IMP covering a 5-year period; (iii) preparing a needs-based budget for an adequate level of operation and maintenance and (iv) preparing a proposal for scheme improvements to address the effects of past deferred maintenance.

The proposals for scheme improvements will originate from WUA, be based on the PSETK surveys, and endorsed by the IC in conformity with the IPIDM. Furthermore, the proposals will be reviewed by relevant district agencies for technical, financial, and economic viability. The actual criteria for delineating the eligibility of project assistance will be worked out by individual districts, in consultation with national and provincial agencies concerned, according to district specific conditions and within the framework of applicable government regulation on irrigation and relevant government decrees.

Following the approval of the IMP, a PIMA is formulated and agreed to for each scheme between the district government and the WUA. The PIMA incorporates the approved IMP and define the role and responsibility of the WUA in participating in O&M of the scheme, as well as the technical services to be provided by the district government. An agreed mechanism for conflict resolution is to be included.

3.3.2 WUA/WUAFS participation in SID of Rehabilitation of Irrigation Infrastructure

Rehabilitation of irrigation infrastructure aims to allow more efficient water management, in

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45In Bahasa Indonesia: KSP: Kerja Sama Pengelolaan
particular re-activation of the land-use of parts of existing irrigation systems that have become fallow due to shortcomings in the irrigation infrastructure. The works include restoration or replacement of hydraulic gates in weirs or hydraulic structures and/or installation of cross drainage or canal slope protection requiring technical analysis. The involved irrigation services will ensure availability of suitable technical expertise, preferably from the private sector or provincial sources, to provide support in the preparation of the survey, investigation and design (SID) for these works. The districts relate to the relevant Basin Water Management Units (Balai) information on river basin flows.

The planning, design and implementation of the rehabilitation works will be carefully checked to ensure that it is needs-based, economically, environmentally and socially sound, based on clear technical principles and provides value engineering. Guidelines and criteria in selecting schemes for rehabilitation include:

i. application of participatory SID including walkthrough and accompanying meetings at pre-design, preliminary and final design stages;

ii. appropriate surveys to clearly and accurately represent the design works on the ground including hydraulic analysis of new or altered canals systems, with detailed design calculations;

iii. proposals for replacement or replacement of weirs that will increase water diversions should be agreed with other water users and WUA further downstream, and water availability confirmed and agreed to by the district irrigation services;

iv. the improved irrigation management change increase crop production and socio-economic benefits especially for the poorest members of the community; and

v. The WUA resolve internally all land acquisition and compensation issues or obtain adequate government assistance from other sources.

Participative SID are prepared for the approved proposals. Participative SID are carried out interactively with the WUA and with involvement of the water resources services’ specialised design and water resource units (or the Balai if necessary). A summary of a subproject report will cover:

- a detailed layout map, accompanied by water balance and economic analysis of the proposed improvements and of any viable alternatives and details and requirements to address particular technical problems;
- an update of the scheme irrigation management plan including an improvement implementation program and costing schedule;
- confirmation on consultation with potentially affected persons within the scheme and in other schemes relying on the same water resource;
- documentation of the WUA agreement to the proposal, including willingness to undertake the responsibilities involved in construction and subsequent O&M, (subject to the WUA later agreement on the final design and financing arrangements);
- Confirmation of consistency with the IPIDM.

With regard to involvement of the WUAs in this SID process, standard procedures call for the application of a sequence of three (3) FWUA/WUA meetings.

### Table 6. Standard Procedures for WUA involvement in SID

<table>
<thead>
<tr>
<th>JOINT DESIGN / WUA ACTIVITY</th>
<th>RECORDED ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least three consultations with the WUAs/WUAFs</td>
<td>Results of these meetings:</td>
</tr>
<tr>
<td>1. Plenary meeting 1, PPISP introduction and principles of participatory irrigation</td>
<td>(i). an agreed upon list of main relAImr works to be designed (first meeting); farmers understand objectives of ETESP and their role, election of WUA representatives for the PSETK46, election of</td>
</tr>
</tbody>
</table>

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PSETK: Social, economic, technical, institutional profiling by the WUA to promote awareness and motivation. To be developed by the KPL and by the Consultants into the subproject AIP.
The districts prepare the survey and investigation documents by force account or alternatively recruit short-term local technical support by qualified WUA to prepare these works. These reports should clearly explain the involvement of WUA representatives and prioritization of the works by the IC. The reports should also be sent to the provincial and/or district agency offices responsible for design quality assurance.

### 3.3.3 WUA/WUAFS participation in SID of Rehabilitation of Irrigation Infrastructure

Rehabilitation always includes unskilled labor inputs (e.g., canal desilting, cutting weeds, earthworks to restore canal shape) which are to be undertaken by qualified WUAs through direct contract (SP3) of in force account. The technical capacity of WUA to implement required civil works is determined by the WUA itself, with assistance of district agencies and project consultants, during the process of selection, planning and design of works. The civil works contracts, which are beyond technical capacity of WUA, are classified as rehabilitation works and are implemented by contractors with WUA participation under a KSO (operational work-sharing agreement).

### 3.3.4 WUA/WUAFS Responsibility for Tertiary Systems

The Government also supports WUA in the rehabilitation of poorly functioning tertiary irrigation and drainage systems on a demonstration scale. This activity is limited to the schemes for rehabilitation for which a proper participatory and integrated SID will be made as part of the designed improvements to rehabilitate the main system facilities. The activity will be implemented under SP3 contractual arrangements with qualified and legalized WUA. The Government provides provision of materials and labor below market rate or farmer contribution.

### 3.3.5 WUA/WUAFS participation in O&M of Irrigation Infrastructure

After completion of improvement works, routine maintenance of the primary and secondary level irrigation system is financed by the Government, yet implemented by WUA. Maintenance of tertiary level systems is wholly financed and implemented by WUA. IMP includes an action plan identifying the responsibilities of each party in financing and implementing O&M within an agreed timeframe.

For schemes larger than 3,000 ha, for which the national government is financially responsible, the task to manage these O&M tasks is delegated to lower water resources services through TP. For schemes larger than 1,000 ha but smaller than 3,000 ha, the O&M arrangements will be guided by a separate agreement between a district and a province concerned. The IMPs and PIMAs prepared for each scheme will include a plan showing to what extent and for which tasks the WUA will be involved in actual scheme operation and/or implementation of routine and/or deferred maintenance either in SRR schemes or rehabilitation schemes. Such activities include de-silting, cutting weeds, earthworks to restore canal shape, etc.

### 3.4 Condition for Successful WUA participation in PPSI

The main conditions for successful PPSI in the Indonesian context are:
3.4.1 Create, maintain and increase sense of ownership and responsibility of WUA

Until the decade of 1980 irrigation management and development in Indonesia showed the dominant role of the government almost in every phase and level of management, even in tertiary irrigation schemes where the farmers have responsibilities. Initially the government forced took over rehabilitation works of tertiary systems as the farmers did not carried out it. However, this measure made worse when the farmers lost their sense of responsibility and sense of belonging. Based on some research findings and experts’ recommendations the government then start to improve the way and the approach in developing and managing the irrigation schemes by adopting participatory principles\(^47\).

3.4.2 Socio-technical process

Coincide with growing of participatory awareness, concept of irrigation as socio-technical process emerged and spread among experts and adopted by the government\(^48\). Contrast with conventional view of irrigation system which perceive irrigation system merely a technical process, the new concept revealed social and cultural aspects embedded in every irrigation systems. It implies there are many values, norms and actors have roles and impacts to functionality of an irrigation system whereas engineers and bureaucrats with their rules and regulation just part of it. In order to bring success and sustainability of irrigation system management the all elements of irrigation system should be invited together and given access to perform their roles proportionally. Ignoring social and cultural aspects of irrigation system will make the system fail to function effectively or not sustain as evident in many cases in past years.

3.5 Condition for Irrigation Infrastructure

Despite a large increase in output, the maintenance and replacement budgets of existing irrigation systems are perennially in short supply as shown below in Table 7.

<table>
<thead>
<tr>
<th>Central Government</th>
<th>Irrigation Area Condition (Ha)</th>
<th>2010</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Good</td>
<td>1,250,100</td>
<td></td>
<td>2,047,999</td>
</tr>
<tr>
<td>✓ Slightly damaged</td>
<td>300,950</td>
<td></td>
<td>106,055</td>
</tr>
<tr>
<td>✓ Moderately damaged</td>
<td>648,200</td>
<td></td>
<td>367,560</td>
</tr>
<tr>
<td>✓ Severely damaged</td>
<td>115,750</td>
<td></td>
<td>129,994</td>
</tr>
<tr>
<td>Province</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Good</td>
<td>555,057</td>
<td></td>
<td>515,099</td>
</tr>
<tr>
<td>✓ Slightly damaged</td>
<td>170,787</td>
<td></td>
<td>181,820</td>
</tr>
<tr>
<td>✓ Moderately damaged</td>
<td>526,592</td>
<td></td>
<td>182,575</td>
</tr>
<tr>
<td>✓ Severely damaged</td>
<td>170,787</td>
<td></td>
<td>225,987</td>
</tr>
<tr>
<td>District or City</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Good</td>
<td>1,676,141</td>
<td></td>
<td>1,500,610</td>
</tr>
<tr>
<td>✓ Slightly damaged</td>
<td>698,392</td>
<td></td>
<td>671,758</td>
</tr>
<tr>
<td>✓ Moderately damaged</td>
<td>698,392</td>
<td></td>
<td>691,270</td>
</tr>
<tr>
<td>✓ Severely damaged</td>
<td>419,035</td>
<td></td>
<td>799,539</td>
</tr>
</tbody>
</table>


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\(^47\)LP3ES, op. cit page 8
4 OBSERVED IMPACTS OF PIM

4.1 Water Allocation and Service Delivery

4.1.1 At River Basin Level
A water allocation plan at river basin level is prepared every year for each river basin by the RBO with reference to the guidelines established by the Minister of Public Works and the involvement of the community through the basin council. The prepared annual water allocation must be approved by the minister of public works/governor/regent/mayor in accordance with their authority.

So far, the guidelines for the preparation of water allocation plans have not been approved by the relevant authorities. The Director General of Water Resources issued a circular, No. 04/SE/D/2012, on the preparation of technical guidelines for the implementation of water balance and water allocation to support large river basin organization/river basin organization to prepare the water allocation plans.

The limited ability of human resources in the management unit of the RBO is one of the causes of annual water allocation plans not being able to pass through the screening prior to being approved by the authorities. The fact that no formal water allocation plans exist negatively affect the efficiency of water use and causes conflicts between the water users and between regions.

4.1.2 Irrigation Scheme Level
In Indonesia rotation of water delivery in rotation forms in already practiced for hundreds of years. The best example is the Subak system as applied in ancient Bali, in which the irrigation distribution was managed by the villages and also made part of the religious agenda. Also, due to this the level of enforcement of the distribution calendar was very high.

During the conical time rotation of water delivery was made standard with a most extreme version that of the ‘cultuur-stelsel’ in which during day-time the sugar cane plantations received the available water, while the villagers received water only at night. To allow for these distribution colonial engineers developed very precise measuring/control gates, such as the Romijn gate and the ‘Crimo-de Gutter gate’ which are still being applied today in modern irrigations schemes in Indonesia. In later years Indonesia moved to a more ‘equal distribution’ rotation system, as a result of which in many division gates the measuring devices are no longer being operated.

4.1.3 Tertiary Level
At tertiary level the farmers have organised themselves in a Water User’s Organisations and distribute the available irrigation water over the tertiary unit as they see fit.

4.2 Cost recovery

4.2.1 Irrigation Service Fee
Cost recovery of irrigation was first introduced in Indonesia in 1987 as ISF and was applied for a period of 10 years until with the mayor reforms of 1997/1998 were abolished again for reasons that is was regarded as an addition burden to the villages, while also the 1945 basic law in article 33 regards water as a social good.

In 1992 two important legislation supporting PIM were issued by the Ministry of Home Affairs (MOHA), on Irrigation Service Fees (PPs No. 6/1992 and No. 19/1992) indicated the government’s determination to raise revenue from the water users to provide funds for maintenance above the tertiary turnouts and place more responsibility on the farmers to care for the supply system. Responsibility for the collection of the ISF was placed on the local revenue service (DISPENDA) whose task was to raise the revenue directly from the WUAs. The amount to be collected complicated issue,
as it was individually assessed by Chief of District (Bupati), having, in the theory, taken regard of a number of location specific factors, such as the socio-economic condition of the area, the condition of the existing water supply and the actual calculated requirement. Following an initial attempt to implement the new ISF procedures, the program was abandoned during the REFORM era due to Law No. 25 of 1999 on Fiscal Balancing.

4.2.2 Costs of Water

Indonesia has two systems for charging water users for water services: service fee for water resources management (SFWRM) and fee for processed drinking water by water utility (PDAM). The SFWRM is applied when there are efforts to conserve water resources and facilitate utilization of water through the development of infrastructure, such as dams and canals, by which the dammed water can be delivered continuously to the water users. The users include farmers (irrigation), PDAMs, industries, and hydropower generators (for dams). However, SFWRM is not applied to small farmers (< 2 ha land holding) and households using water for domestic use. When the raw water is processed into drinking water by PDAM, the fees to be charged to customers are regulated in MoHA Regulation (Permendagri) 23/2006 regarding The Technical Guideline and Procedure of Water Tariff for PDAM.

4.3 Water use efficiency

In Indonesia at scheme level water-use efficiency is not very high for the following reasons:

- Irrigation distribution based on 2-weekly planning which does not consider effective re-infall
- Most distribution structures at primary and secondary level can only distribute but not measure water flows
- As in Indonesia the application of geo-spatial information systems in irrigation management is not common yet the exact size of the irrigated area per tertiary block is not known
- Because of the relative poor status of the embankments in most cases when the irrigation system is filled up with 80% of the design discharge, at several places overtopping occurs with irrigation water flowing directly into the drains.
- Due to the small landholdings most farmers are ‘part-time’ farmers and are not present during the entire growing season.

However due to the very large number of village irrigation schemes, in nearly all cases in area downstreams of a government irrigation scheme farmers have constructed semi-permanence devices in drains aimed to re-use this drain water. As a result in the dry season from nearly all of the major rivers on Java there is no outflow to the sea, indicating on a basin basis a high efficiency.

4.4 Increase in Economic Water Security

4.4.1 General

Water is used in productive economies mainly in the agriculture, industry, and energy sectors. Industrial demand is generally included in the assessment of domestic demands as industrial areas are almost always located in the vicinity of towns and rely on the water supply system of towns.

When the projected demands are compared with available water resources, it is evident that the available water resources exceed the demands. However, local and temporal differences exist. This will be discussed in more detail for Java, Sumatera, and Sulawesi.

The river basins for Java, divided into sub-basins where 2030/2035 demands for irrigation; domestic, municipal, and industrial use; livestock; and fisheries exceed the 80% assured river flow in any month. The available flow is corrected for existing and planned reservoirs, and for Java it is corrected also for inter-basin transfers identified in the Java Water Resources Strategic Study. Water shortages are

PP 42/2008 regarding Water Resources Management, Article 116(1).
concentrated in the eastern part of Java and the southern part of Sulawesi.

However, the analysis of demand curves shows that in Java water demand is maximized for all months with surplus water. This is not yet the case in Sumatera and Sulawesi, indicating the lack of infrastructure or connection between irrigated areas and available resources resulting in a lower cropping intensity. To assess the potential additional rice harvested area if additional water storage would be made available (using existing paddy field area), the highest monthly water demand is used for the whole year. In Sulawesi, the existing paddy field areas could potentially increase their harvested area with 840,000 hectares, or almost a factor of 2. In Sumatera, more than 1.1 million hectares could be harvested, an increase of approximately 1.8. The highest potential additional harvested area can be achieved in the Saddang, Jeneberang, and Walanae-Cenranae river basins of South Sulawesi. In South Sumatera, the highest gains can be achieved in Seputih-Sekampung and Musi-Sugihan-Banyuasin basins.

4.4.2 Measures

Improvements in economic water security can be achieved by effective water resource allocation prioritizing industry at the same level as that of domestic use. The contribution of industry to both gross domestic product and employment per cubic meter of water used is higher than that of agriculture, and industries can generally use the same infrastructure as the agricultural sector. Although some prices are quoted in US dollar ($), the cost-benefit calculations are made in Indonesian rupiah (Rp). Official exchange rates are used to convert $ (or euro [€]) prices into Rp: $1 = Rp12,400 and €1 = Rp13,050. The key numbers on costs and benefits as used are presented in Table 8. A more detailed account of assumptions and rationale of the economic assessment is given in Annex 1 of the extended country water assessment report.

| Table 8. Unit Costs and Benefits of Measures Used in this Study (Rp million) |
|------------------|------------------|------------------|------------------|------------------|
| **Unit Costs (2014)** | **Benefits** | **NPV** | **IRR (%)** |
| Electricity (no escalation) Capita | 6.88 | 8.36 | 1.48 | 15 |
| Electricity (with escalation) Capita | 6.88 | 13.35 | 6.47 | 21 |
| Land conservation/rehabilitation Hectare | 12.75 | 15.64 | 2.89 | 13 |
| Urban sanitation Capita | 4.76 | 5.54 | 0.78 | 13 |
| Rural sanitation Capita | 2.38 | 2.64 | 0.26 | 12 |
| Urban DMI supply Capita | 1.77 | 2.31 | 0.54 | 14 |
| Rural DMI supply Capita | 1.69 | 1.89 | 0.19 | 12 |
| O&M DMI supply Capita | 0.94 | 1.38 | 0.44 | 16 |
| Irrigation-new development Hectare | 177 | 157 | (20) | 6.33 |
| Irrigation-heavy rehabilitation Hectare | 117 | 157 | 40 | 33 |
| Irrigation-moderate rehabilitation Hectare | 107 | 157 | 50 | 63 |

DMI = domestic, municipal, and industrial; IRR = internal rate of return; NPV = net present value; O&M = operation and maintenance; Rp = rupiah. (Source: Asian Development Bank. 2014)

4.4.3 Economic rate of Return

Time value of money dictates that time has an impact on the value of cash flows. In other words, a lender may give you 90 cents for the promise of receiving $1.00 in a month’s time from now (resulting in an interest of 10% a month), but the promise to receive that same $1.00 20 years into the future (resulting in an interest of 10% over 20 years) would be of much less worth then to that same person.

To make future cash flows comparable, these payments are discounted (on the basis of a minimum required interest rate) to their present value. The net present value is defined as the sum of the present values of incoming and outgoing cash flows over a period of time (benefit and cost cash flows).

The (economic) internal rate of return is the interest rate (or discount rate) for which the net present
value equals 0; that is, the present economic value of all cost and benefits are equal.

The relative importance of investments in different provinces per sector has been established earlier. The strategy proposed by this study to develop water resources in river basins cannot be done without assessment of the detailed basin situation as well as consultation with the relevant stakeholders. This strategy has four main elements: infrastructure investments, demand management, interpectoral coordination, and O&M.

Infrastructure investments received most emphasis in the recent mid-terms plans and in the Pola and Rencana. They are perceived as the most important strategic components to achieve sustainable water resources for the development of Indonesia. Also, in the plans of the new government, the item related to the number of new dams receives most attention. As described earlier, the development of water storage has been lagging behind population growth since independence.

Demand management has not been at the forefront of government plans until recently, but possibilities for intensifying cultivation of rice are being explored. The previous assessment has shown that efficiency in this regard is not yet very high.

Interpectoral coordination refers to whether efforts of different ministries or levels of government are synchronized to achieve optimal results. Horizontal coordination has always been a challenge due to unsynchronized targets and budgets, but more so after the decentralization of the vertical coordination between central, provincial, and kabupaten /kota level ministries/governments.

The manner in which strategic objectives of governments are formulated has a direct impact on the selection of priority measures. If the government emphasizes the measure, for example, development of new dams (as the present government does), rather than the outcome, for example, improved food security, the resulting strategy will be affected.

An optimal selection of interventions requires an outcome-based log frame with selection criteria to guide the individual measures. Regarding the midterm development plan (National Medium-Term Development Plan, Rencana Pembangunan Jangka Menengah Nasional), it is strongly recommended to use outcome-related indicators. This will not only guide the most efficient interventions but also allow monitoring as to whether objectives are achieved, whereas the present input-oriented indicators only show whether the decided number of dams has been built, without indicating the impact on food security.

4.4.4 Funding of O&M

Operation and maintenance has not received the needed priority and funding resulting in deterioration of infrastructure and loss of functionality or reduction in the life span of infrastructure requiring high investments for rehabilitation of the existing or purchase of new structures. At present, the kabupaten and provincial levels underperform in terms of O&M. PDAM performance also shows undervaluation of O&M.

When the harvested area is used as an indicator for irrigation production, interventions such as rehabilitation of existing irrigation schemes, system of rice intensification (SRI) and other demand management approaches, and proper O&M become much more attractive than merely building new dams as can be seen from the internal rate of return (IRR) to develop 1 hectare. The IRR of new development is 6.3%, whereas moderate rehabilitation has an IRR of 63%. Similarly, O&M of domestic, municipal, and industrial infrastructure has a higher IRR than the development of new resources.

After the decentralization in Indonesia, many of the interventions require investments by regional governments. When the interventions discussed in previous paragraphs are compared with the
revenues of these province, it is clear that certain provinces face a much heavier burden than the others. It must be realized that this assessment only includes water and energy investments, whereas in reality provinces are faced with other investment needs as well. Obviously, the investments will not be IAMd for directly in a year from these revenues, but the comparison gives an indication of the capacity of the provinces to fund part of the investments. Also, there is a disparity between the different types of investments. Actual gaps that will need to be filled one way or the other, such as drinking water and sanitation, are not the same as the more politically motivated objective of food security.

The involvement of the central government in funding of infrastructure should consider the willingness and capacity of regional governments to fulfill their share, especially regarding O&M, which is often a regional responsibility. The central obstacles to financing infrastructure are management and guarantee of cost recovery through tariffs. These obstacles are overcome with time through pressure of praising and exposing, greater transparency, accountability, monitoring, benchmarking, and tariff-payer involvement.

**Outlook Summary**

Using the facts and analyses in the preceding sections, we formulate a vision of how national water security may be achieved or maintained for the future, balancing the competing needs for food and energy.

The main components of this vision are as follows:

- Implement demand management in all water-related sectors to reduce the exponential growth in water demand related to population growth and increased economic wealth. The cost to save a cubic meter of water is much less than the costs related to generating a cubic meter of additional water resource.
- Optimize the use and life span of existing systems and infrastructure providing or regulating water resources. Ineffective or inefficient use of existing systems reduces the amount of water actually used for beneficial purposes. The cost of properly managed operation and maintenance per cubic meter of water is much less than the costs related to rehabilitation of or rebuilding the same facility. Still, rehabilitation is much more cost and time effective than developing a new infrastructure.
- Develop new resources where the added investment will create net added value. Life cycle
costs and benefits should be considered including operation and maintenance, not only of the facility or infrastructure itself but also of all related measures. In case of dam development, for instance, social and environmental considerations and adaptations are not only part of the equation but also are needed for upstream catchment restoration or conservation to assure the long life of the reservoir with little sedimentation.

- Move toward transparency in data and information. The population, who pays for all costs directly either through a tariff or through the tax system, is the ultimate stakeholder or has a right to have an insight into how his or her money is being spent. At the same time, a transparent sharing of data will reduce the costs of monitoring by eliminating the many redundant systems and at the same time constitutes one of the best methods to ensure an honest and corruption-free management.

- Revitalize the institutional setting to transform it from a theoretical system into a system focused on practicality working coherently and efficiently for the optimal development and provision of services to the population while at the same time protecting the natural system for generations to come. The annulment of the water law creates an opportunity to harmonize legal instruments in line with bureaucratic reforms.

5 CHALLENGES

5.1 Water Allocation and service delivery

5.1.1 Water Footprint
The average water footprint (defined as the total amount of water that is used to produce goods and services) in Indonesia in relation to consumption of crop products is 1,131 cubic meters per capita per year (m³/cap/year), but there are large regional differences. The provincial water footprint varies between 859 and 1,895 m³/cap/year. The average provincial water footprint consists of 84% of internal water resources. The remaining 16% comes from other provinces (14%) or countries (2%). All island groups except Java have a net export of water in virtual form. Java, the most water-scarce island, has a net virtual water import and the most significant external water footprint. This large external water footprint is relieving the water scarcity on this island (Figure 4).

The water footprint of rice is about 3,500 cubic meters (m³) per ton, but there are large differences between provinces. Java accounts for 56% of the total rice production. Besides Java, major rice-producing areas are Sulawesi Selatan with a water footprint of rice of 3,800 m³/ton and Sumatera Utara with 3,900 m³/ton. These values are higher than the average water footprint of rice on Java, which is 2,800 m³/ton. The reason for the low water footprint of rice on Java is the combination of relatively high yields (5.3 tons per hectare [ha]) and moderate evapotranspiration (4.6 millimeters [mm] per day). The other two regions do not have this combination of high yield and moderate evapotranspiration.

The interprovincial virtual water flows are primarily caused by trade in rice. The products such as cassava, coconut, banana, and coffee have the largest interprovincial water flows relative to water use for production. The biggest amount of virtual water from provinces or countries goes to Java, the only main Island in Indonesia with a net virtual water import of about 2000 * 10⁶ m³/year between 2000 and 2004, as it is densely populated and the production of crops is not sufficient to satisfy the total consumption. Sumatera’s contribution is the largest in the virtual water export. The provinces that have the highest imports of water in virtual form from other provinces are DKI (DKI Jakarta, West

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51 Daerah Khusus Ibukota (DKI) = Special Capital Region.
Java, Riau, and Banten. These provinces account for 55% of the total interprovincial virtual water import. Because of the high consumption quantity and/or the low production of crops, these provinces have a high virtual water import. This paragraph illustrates that strategic development of water-dependent products in areas that have abundant water resources will increase water security in the country provided the interisland transport is efficient.

5.1.2 Water for Agriculture

The combination of abundant rainfall and fertile soils make many areas of Indonesia ideal for farming. In 2010, the Government of Indonesia estimated (Statistics Indonesia) the total agricultural land to be roughly 40.7 million ha, or 22% of the total land area in the country. The major crops produced in Indonesia include, but are not limited to, rice, oil palm, sugarcane, cassava, coconut, corn, banana, rubber, mango, orange, chili, sweet potato, soybean, and peanut.

![Virtual Water Use of Indonesian Islands and Food Crops Import and Export, 2011](image1)

**Figure 4. Virtual Water Use of Indonesian Islands and Food Crops Import and Export, 2011 (million m³)**

![Regional Rice Production in Indonesia](image2)

**Figure 5. Regional Rice Production in Indonesia**

The agricultural environment in Indonesia is divided largely by geography and altitude (Figure 5), with intensive food crop production occurring on the inner islands (Java, Bali, Lombok, and Madura), whereas less intensive perennial cropping systems (estate crops such as oil palm, sugar, rubber, cacao, coffee, tea) predominate on the outer islands of Sumatera, Kalimantan Sulawesi, and Papua. Natural soil fertility is highest on the inner islands, whereas lower-fertility acid soils predominate on the outer islands.

Indonesia has a rice (paddy field) area of 7.8 million ha (including irrigated rice area of 4,417,582 ha), whereas the harvested area of rice in 2011 was around 13.1 million ha (Table 9).

Rice is grown by approximately 77% of all farmers in the country (25.9 million) under predominantly subsistence conditions. The average farm size is very small at less than 1 ha, with the majority of farmers cultivating landholdings between 0.1 and 0.5 ha in size.

<table>
<thead>
<tr>
<th>Corridors</th>
<th>Area of paddy field (ha)</th>
<th>Harvested area of paddy (ha)</th>
<th>Intensity in a year (%)</th>
<th>Production (ton)</th>
<th>Crop yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatera</td>
<td>1,997,054</td>
<td>3,427,651</td>
<td>1.72</td>
<td>15,686,847</td>
<td>4.58</td>
</tr>
<tr>
<td>Java</td>
<td>3,251,694</td>
<td>6,165,079</td>
<td>1.90</td>
<td>34,404,557</td>
<td>5.58</td>
</tr>
<tr>
<td>Bali-Nusa Tenggara</td>
<td>464,814</td>
<td>765,848</td>
<td>1.65</td>
<td>3,516,824</td>
<td>4.59</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>1,068,491</td>
<td>1,147,648</td>
<td>1.07</td>
<td>4,574,149</td>
<td>3.99</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>939,834</td>
<td>1,481,260</td>
<td>1.58</td>
<td>7,280,888</td>
<td>4.92</td>
</tr>
<tr>
<td>Papua-Maluku</td>
<td>58,582</td>
<td>75,555</td>
<td>1.29</td>
<td>293,639</td>
<td>3.89</td>
</tr>
<tr>
<td>Indonesia</td>
<td>7,780,469</td>
<td>13,063,041</td>
<td>1.68</td>
<td>65,756,904</td>
<td>5.03</td>
</tr>
</tbody>
</table>


5.1.3 Water for Irrigation
The total water requirement of agriculture in Indonesia is estimated to be about 3,500 billion m³ per year, or 11,000 cubic meters per second (m³/s). However, most agriculture is rain fed. Only about 17%—20% of agriculture relies on irrigation. The irrigation water demand is estimated to be 5,441 m³/s. Water productivity, expressed as constant $2,000 GDP per cubic meter of total freshwater withdrawal, rose from 1.5 in 1990 to 3.5 in 2011. About 1% of irrigation water is drawn from groundwater and 12% from reservoirs. The main part (87%) is diverted from rivers without a large structure, making the irrigation schemes vulnerable to variations in river flow.

According to Indonesia’s Ministry of Public Works in 2012, approximately 84% of total rice area in Indonesia is irrigated, whereas the remaining 16% relies on rainfall. Rice is grown throughout the year, with some farmers being able to cultivate three crops within a given 12-month period. The Food and Agriculture Organization of the United Nations estimates that approximately 70% of total lowland rice area produces two rice crops each year. About 60% of the total rice production occurs in the first crop cultivated during the wet season (November-March), while two smaller harvests occur during the dry season (see the crop calendar in Table 10).

Besides food crops, other important annual crops such as palm oil, rubber, cacao, and coffee are cultivated across the country, especially on Sumatera. The crops are generally managed in large plantations by private farmers, state-owned enterprises, or private companies. The crops generally do not require irrigation; however, water is very important for the processing industry such as palm oil extraction. In 2013, the total area of oil palm plantations in Sumatera was about 6.5 million ha with a total yield of crude palm oil of almost 20 million ton. It is estimated that every ton of crude palm oil requires 6.7 m³ of water for processing.
Table 10. Seasonal Rice Crop Calendar

<table>
<thead>
<tr>
<th>Crop</th>
<th>Month</th>
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</thead>
<tbody>
<tr>
<td>First</td>
<td>Jan</td>
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<td>Second</td>
<td>Feb</td>
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<tr>
<td>Third</td>
<td>Mar</td>
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<td></td>
<td>Apr</td>
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<td>May</td>
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<td>Jul</td>
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<td></td>
<td>Oct</td>
</tr>
<tr>
<td></td>
<td>Nov</td>
</tr>
<tr>
<td></td>
<td>Dec</td>
</tr>
</tbody>
</table>

- **Planting**
- **Mid-season**
- **Harvest**

Source: Ministry of Agriculture, Indonesia 2012

Figure 6. Irrigation Water Demand per River Basin

$m^3/s = \text{cubic meter per second}$


5.2 Method and Mechanism for Determination of Cost Recovery and Water Charges

In Indonesia in particular on Java rainfall is relative abundant as a result of which Indonesia has no history of efforts to determine cost recovery and/or charge for water. Also in the 1945 constitution water is regarded as a social good for which no charges are allowed. However with regards to cost-sharing for future development in non-irrigation sectors Indonesia has developed the following vehicles.

5.2.1 SFWRM

In order to build, operate, and maintain new infrastructure, the SFWRM fee can be utilized. For this purpose, organizations such as the Technical Implementation Unit (UPT/Balai) BUMN/BUMD (government-owned enterprises) or a special purpose PT/Limited Company is formed. The fees are used for covering of the costs comprising (i) depreciation costs, (ii) amortization and interest rate in case of a loan, (iii) O&M costs, and (iv) development costs (as regulated by PP 42/1998 regarding WRM). These fees are not used to cover the capital investment costs when the infrastructure is financed by the government as sunk cost. The SFWRM is calculated as the total operating costs divided by the volume of water produced.

5.2.2 Tariff of PDAM

Water supply by PDAMs generally serves 55% of the urban areas, and the remaining 45% is catered to
by shallow wells. The source of raw water of PDAMs is mostly the surface water (river/canal) but sometimes deep wells as well, sourced through electric pumps. In rural areas, the provision of drinking water (sourced mostly from rivers, shallow wells, and water springs) is sometimes done by the community-based organization (CBO). As of now, tariff charged by the CBO for drinking water is not regulated. The tariff charged by the CBO is determined with the consent of the users.

5.2.3 Tariff for Sanitation
A few cities have regulations for the management of septate and charge fees for solid waste/sanitary service and septic tank desludging services. In reality, however, these regulations often do not provide proper wastewater and septate management. Palembang neither has septate treatment plant nor an official septage disposal facility. The tariffs for septage collection are Rp60,000-Rp80,000 per cubic meter, and Rp30,000-Rp40,000 per cubic meter for disposal by truck.

5.3 Engineering challenges
In Indonesia, the engineering challenges for the irrigation and lowland sector are enormous.

5.3.1 Storage Dams
In Indonesia, less than 10% of the irrigation area has secured water supply from a storage dam, with the 90% depended on ‘run-of-the-river’ weirs, but with global warming and deforestation of the catchment this is not a sustained situation. The present government plans the development of 49 new dams but the construction of these have many challenges, ranging from pure technical to social.

5.3.2 Geo-spatial Approach
To support food security, agricultural production, especially rice production, can be enhanced by rehabilitating deteriorated irrigation schemes and reservoirs and ensuring that full required O&M is conducted on all schemes. In this respect, special emphasis and support need to be given to Kabupaten or Kota and selected provincial government departments to raise awareness and increase the available water capacity. Funding arrangements need to be reviewed to ensure that regions are self-sustained to fund the activities under their responsibility.

5.3.3 Low land Development
As the vast majority of Indonesia’s rice producing area is on Java while Java is also the center of national industrial development, the size of the irrigated land on Java island is reduced with around 50,000 ha/year. To compensate for this loss the Indonesian government will have to invest in opening up new rice estates in the tidal low-lying lands of Sumatra and Kalimantan, and possibly Papua.

5.4 Possibility of Public Private Partnership (PPP) for financing and improved service delivery
In Indonesia, community participation in financing and development of water resources in Indonesia is still very limited. This is mainly caused by a lack of clear and unambiguous legislation towards this and lack of knowledge and understanding of communities and businesses in the development and management of water resources. However, for irrigation sector which is still expected to support the national food security in one hand and increase farmers income in other hand, the government tend to apply subsidy policy. Due to the absence of the legal basis and the subsidy policy, the WRM and irrigation institutions are not encouraged to enter into PPP arrangements. Community participation in the development and management of water resources financed by the Government on the other hand has already been practiced for many years, as described in paras above.

A key factor contributing to the problem of risk overload is the common perception within Indonesia that PPPs are simply financing instruments. Opportunities for private sector investment through PPPs are typically only conceived of within the context of the funding gap, that is, the gap between infrastructure needs and the financing capacity of the government. Hence, if the PPP modality is being
considered, the default setting is to assume a full concession model, with most, if not all, demand and other risks being transferred to the private sector. The opportunity to use PPP to obtain a higher value for money through more efficient or higher-quality services has not received much emphasis in Indonesia as yet, although the use of PJT can be considered as one.

Community and business involvement in WRM is very important as the need for public services is likely to increase. The role of the corporate RBO and implementation of service contracts for O&M should be considered using legal entities formed in local communities. Progress in engaging the private sector in the delivery of infrastructure services in the water and sanitation sector has been slow. Factors that constrain public-private partnerships (PPPs) include institutional coordination and leadership issues, land clearance problems, poor project identification and preparation, and continuing regulatory uncertainty.

PPP is, in principle, possible at every phase of development (construction, operation, service delivery) and for a wide scope of activities. Presidential Regulation 67 and its amendments govern the PPP process related to water supply projects; Decree No. 16/2008 facilitates PPP for the development of domestic wastewater management. Presidential Decree 38/2015 creates a mechanism for performance-based annuity schemes. Key success factors for Indonesia’s water sector PPP are the following:

- Strong support from Parliament is needed for priority projects as well as those considered as strategically important in the development plan. Commitment on tariff and capability to gain traction from public is essential. Fiscal commitment is sometimes required to address residual risks. Short-sighted interests should not disrupt objective policy and project decisions.
- Robust project preparation. A technical viability analysis of raw water is required including demand, needs, and options analysis; as well as legal, environmental, and social analysis. Suitable PPP modalities should be selected (Build-Operate-Transfer, concession, or other?).

In all sectors, including domestic water use, nonrevenue water, energy use, and water use in agriculture, opportunities for demand management should be explored and stimulated with incentives (progressive pricing, benchmarking, tax deductions, consumer education, etc.) enhancing self-regulation.

Coherent plan and policy at all levels. Consistency between central, provincial, and local plans are needed, facilitated by an effective coordination forum.

5.5 Issues in up-scaling PPSIP

The main policies and strategies are presented in the long-term development plan 2005-2025 (RPJPN) that functions as the direction in the preparation and the national medium-term development plan (RPJMN), which is further detailed in the annual plans. A few relevant components are as follows:

- Economic development is directed to the use of environment-friendly services that do not accelerate degradation and environmental pollution. Restoration and rehabilitation of prioritized environmental conditions are targeted in an effort to increase the carrying capacity of the environment to support sustainable development;
- stimulate the economy by strengthening the domestic economy to be globally oriented and competitive; and
- Adequate and modern infrastructures.

Specifically, for the management of water resources, the government set a Presidential Regulation (PERPRES 33/2011) on the national policy of water resource management from 2011 to 2030.

As can be expected, there are gaps between UU 11/1974 with the existing regulations related with water governance. It is, therefore, necessary to develop fast and simple regulations that can facilitate
the bridging between UU 11/1974 and other laws related to the governance of water resources. Definitions are also a problem as there are some different terms used in UU 11/1974 compared to the terms used in the existing other legislation relating to the water governance.

5.6 Capacity Development

In the period directly following the KRISMON up to 2012 the Indonesian Government at all levels has applied a policy of restriction or moratorium on the acceptance of civil servants over all sectors, and only the last few years is this changed. This policy is mainly related to the government policy of focusing only on the role of the regulator and the facilitator, whereas the role of the operator is entrusted with the public and private sectors. However, in the irrigation sector this policy had had a devastating impact on the management of water resources, especially in the O&M of water resources, including irrigation with a very large part of the field positions not fulfilled.

Following the Grand Design of the Bureaucratic Reform 2010-2025 and the implementation of the Mental Revolution put forth by Joko Widodo, the President of Indonesia, through intensive public and media monitoring, it is expected that the government apparatus will improve its integrity, neutrality, competency, and professional performance.

Following up on the legislature on IWRM, members of the Parliament are responsible for providing political support to the allocation of appropriate budgets for the implementation of IWRM plans and strategies.

- Through a community and business development program, the community and businesses will have an active role as operator or service provider serving the various needs of the community, in line with the government’s role as the regulator and facilitator.
- According to the 2005-2025 long-term vision (Undang-Undang 17/2007), the role of the government is manifested as a facilitator, regulator, and development catalyst, who increases the efficiency and effectiveness of public services.
- Water resource management activities are to be entrusted with state-owned and locally owned enterprises, as well as cooperatives. To achieve this, the government will endeavor to further develop Perum Jasa Tirta by increasing the work area of the existing Perum Jasa Tirta I to cover more basins; and enhance transformation of river basin organizations into corporate river basin organizations.
- To strengthen decentralization and regional autonomy, efforts are needed to make decentralization consistent. The central government needs to follow up with the provision of adequate resources and funds to the regions. In addition, the complexity of the system should be reduced. This will improve interaction between resource operators and the retail operators. The central government remains responsible for wholesale services, whereas the provincial and district governments are responsible for retail services.

6 WAY FORWARD AND RECOMMENDATIONS

6.1 Best Practices for Replication

6.1.1 WUA/WUAF Participation in Irrigation Scheme Rehabilitations

As applied in many projects, WUA/WUAF participation in irrigation scheme rehabilitations has improved quality, increased cost efficiency and strengthened WUA/WUAF institutions. Participation in the design process opens opportunities for WUA/WUAF to give local and specific information, farmers’ need and technical matters relevant to their capabilities so that the design will match farmers’ aspirations and hence ensure its feasibility. Participation in the construction process encourages WUA/WUAF involvement in supplying labors and materials needed for construction even
voluntary works which add to the total volume of works. There are three types or models of WUA/WUAF participation in the construction works i.e. the agency force account, the WUA/WUAF direct-contract and the WUA/WUAF sub-contract. WUA/WUAF participation in irrigation scheme rehabilities have applied at least in more than 300,000 ha of irrigation area, involving more than 2 000 WUAFs.

6.1.2 WUA/WUAF representation in the Irrigation Commission
Since 2006 with enforcement of the PP No 20/2006, Irrigation Commissions have been undergone some reforms regarding their tasks, responsibilities, working area and membership. For membership, the WUA/WUAF representations are now included together with other users so that they can participate in the decision process taken by the Commission. The WUA/WUAF representatives are chosen by and from all WUA/WUAFs in a district or a province in a proportional number fit to the total member of the Commission. At least now more than 100 units of Irrigation Commission have been established in the district level and about 14 units in the provincial level.

6.1.3 Application of the Integrated Plan for Irrigation Development and Management (IPIDM)
In this situation of complete lack of structured coordination in the ‘irrigated agriculture’ subsector, in the early 2000s BAPPENAS initiated the introduction of the IPIDM planning instrument, through the 2 irrigation loan projects which were conceived and started in that period, i.e. the World bank funded WISMP project and the ADB supported PISP project. In the documentation of the WISMP project the IPIDM is referred to as the KIMDP (Kabupaten Irrigation Management and Development Plan), while under the PISP project documentation it was referred to as the DIMP (District Irrigation Management Plan), but basically the same being a joint data-base/planning tool in which all aspects of ‘irrigated agriculture’ are combined.

The IPIDM embodies a joint database for all irrigated areas calculating a) the standard costs for Operation and Maintenance and b) a rough overview of potential for increase/decrease of the irrigated area. The involved data are:

- The irrigation infrastructure asset management (IAM) data from the Department of Public Works in which all aspects of ‘irrigated agriculture’ for which PU is responsible are described/assessed, being ii) the availability of irrigation water and the discharge of drainage water out of the scheme, ii) the condition of the intake and the primary and secondary canals and structures, and iii) the total coverage of the irrigated area per tertiary block. In addition, the IAM also compiles data on supportive and related aspects as O&M field staff, WUA condition and total size of irrigated area per tertiary block.
- The legal/institutional condition such as status of public awareness, the irrigation coordination KOMIR committee, the kabupaten irrigation bylaw (Perda Irigasi), all of which for which the Department of Home Affairs is responsible,
- The data on agricultural production (areas, cropping intensities and yields), extension-services, inputs including credit, seeds, and fertilizers, and marketing of both the irrigated areas and its immediate surroundings. This info is within the domain of the Agricultural agencies, but only the problem is that their data-structure follows the administrative set-up in which the irrigated areas do not appear as special sub-units.
- The land status of the irrigated areas and immediate surroundings in the kabupaten spatial plan, in which all productive irrigated areas by law should be assigned protected land status LPPB, for which the kabupaten Dinas Spatial Plan are responsible.

6.2 Future plans
The current presidency of President has an ambitious program for national development in the RPJMN 2015 -2019 embracing 9 main development goals referred as the ‘NAWACITA’ program form the Sanskrit word for nine ‘Nawa’, in which irrigation plays a large role as only already on the island of
Java some 50 million persons depend on irrigation as their main source of income. The relevant matters for the irrigated agriculture sector are the goals of food self-sufficiency in 2018, the development of 1 million ha new irrigation, the rehabilitation of 3,000,000 ha, the construction of 49 new storage dams, (iii) the adoption of sustainable approaches to farming on rehabilitated upland areas; (iv) the development of farm roads; and (v) increased adoption of environmentally friendly technologies for food crops,

Meeting these targets and realizing the irrigations sectors contribution to poverty reduction will require an integrated approach focused on rehabilitation, revitalization and modernization of the existing infrastructure and increased productivity and efficiency through irrigation modernization. To meet these targets the Sector Plan for Water Resources from 2015 to 2019 calls for an overall investment of US$ 24.68 billion nationwide with 3 concerts, a) rehabilitation of irrigation infrastructure, b) revitalization towards modernization and c) actual modernization.

a) **Rehabilitation:** Rehabilitation of irrigation infrastructure focuses on maintaining function and condition of irrigation infrastructure.

b) **Revitalization:** Instead of rehabilitation, revitalization is a comprehensive approach to maximize and optimize the effectiveness and efficiencies of irrigation management and infrastructure. The concept of revitalization of the irrigation sector as shown below.

**Table 11. Irrigation Revitalization Concept**
# 2nd Pillar: INFRASTRUCTURE

<table>
<thead>
<tr>
<th>PILLAR Nr</th>
<th>TOPIC</th>
<th>ISSUE</th>
<th>STRATEGY</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td>a. Deleterious of Irrigation Infrastructure</td>
<td>a.1. Irrigation Infrastructure Rehabilitation</td>
<td>a.1.1. Water Rehabilitation</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>a.1.2. Main System Rehabilitation</td>
</tr>
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<td>a.1.3. Tertiary System Rehabilitation</td>
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<td>a.1.4. Water Gates Replacement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Low level of Specification/Technology of the Irrigation Infrastructure</td>
<td>b.1. Improvement of Irrigation Infrastructure Standards</td>
<td>b.1.1. Irrigation Gates Motorisation</td>
</tr>
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<td>b.1.2. Conveyance System Lining</td>
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<td>b.1.3. Drainage Canal Capacity Improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Low Level of Completeness of the Irrigation Infrastructure</td>
<td>c.1. Development of the Main Irrigation Infrastructure</td>
<td>c.1. Installation of discharge measuring device</td>
</tr>
<tr>
<td></td>
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<td>c.2. Development of the Tertiary Irrigation Infrastructure</td>
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<td>c.3. Development of the On-farm Irrigation Infrastructure</td>
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<td>c.2.1. Flood Levee Construction</td>
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<td></td>
<td>c.2.2. O&amp;M Facilities Construction (Housing, office, communication, transportation, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Sediment load of the Irrigation Water</td>
<td>d.1. Reduction of sediment entering the river</td>
<td>d.1.1. Watershed management</td>
</tr>
<tr>
<td></td>
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<td>d.2. Reduction of sediment entering the irrigation canal</td>
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<td>d.3. Reduction of sediment on irrigation canal</td>
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<td>d.3.1. Sediment removal</td>
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</tbody>
</table>

# 3rd Pillar: IRRIGATION MANAGEMENT (1)

<table>
<thead>
<tr>
<th>PILLAR Nr</th>
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<th>ISSUE</th>
<th>STRATEGY</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>a. Lack of Data on Water Availability</td>
<td>a.1. Improvement of hydrological data management (collection, processing, and information system)</td>
<td>a.1.1. Installation of Rainfall Intensity and water level Device.</td>
</tr>
<tr>
<td></td>
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<td>a.1.2. Hydrological data collection</td>
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<td>a.1.3. Data Analysis</td>
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<td>a.1.4. Development of Hydrological Information System</td>
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<td>b. The cropping pattern is not prepared based on water availability and selection of crop species yet to consider the crops economic value</td>
<td>b.1. Revitalize the role of irrigation commission</td>
<td>b.1.1. Water Balance and Water Requirement Calculation</td>
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<td></td>
<td></td>
<td>b.1.2. Intensifying activities for discussions at irrigation commission</td>
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<td>b.1.3. Strengthening the capacity of irrigation commission</td>
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<td>b.2. Development of Information System on Market assessment on high economic value crops</td>
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<td></td>
<td></td>
<td></td>
<td>b.2.1. Development of Information System on Water use productivity</td>
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<td>b.2.2. Improvement of Flow data information</td>
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<td>b.2.3. Demonstration plot development</td>
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<td>c. Inefficient irrigation water use</td>
<td>c.1. Increasing the efficiency of irrigation water use</td>
<td>c.1.1. Distribution of irrigation water use as needed</td>
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<td>c.1.2. Strict Control on Water Distribution</td>
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<td>c.1.3. Improvement of the water use productivity information</td>
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<td>d. Slow response in Irrigation Operating System (Operation equipment still out of date)</td>
<td>d.1. Improvement of Irrigation Operating System</td>
<td>d.1.1. Development of Information System for Irrigation Operating System</td>
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<td>d.1.2. Installation of Telemetry Irrigation Device</td>
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<td>d.1.3. Installation of Motorized/Telecontrol Irrigation Structure</td>
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### 4TH Pillar: INSTITUTIONS

<table>
<thead>
<tr>
<th>PILAR Nr</th>
<th>TOPIC</th>
<th>ISSUE</th>
<th>STRATEGY</th>
<th>ACTIVITY</th>
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</table>
| 4       | INSTITUTIONS              | a. Low level of Commitment of the Irrigation Management Institutions | a.1 to improve irrigation management commitment to the duties and responsibilities | a.1.1 Establishment Irrigation Management Unit  
 a.1.2 Improve irrigation institutional capacity building  
 a.1.3 Increase budget allocations for operations of irrigation management institution  
 a.1.4 Introducing performance based incentive  |
|         |                           | b. Lack of coordination institution or weak coordination institution | b.1 to improve Irrigation coordination                                    | b.1.1 Establishment Irrigation Commission  
 b.1.2 Revitalize the Irrigation Commission Capacity  
 b.1.3 Sufficient allocation of funds for irrigation commission operation  
 b.1.4 Developing coordination mechanism among institutions  
 b.1.5 endorsement of irrigation commission  |
|         |                           | c. Low level of participation of the Farmers                          | c.1 Increased involvement of farmers                                       | c.1.1 Establishment WUA/WUAF  
 c.1.2 Strengthening the capacity of WUA/WUAF  
 c.1.3 Providing incentives for active WUA/WUAF  |
|         |                           | d. Low level of capacity of the water using farmers                   | d.1 Improved water user training                                          | d.1.1 Determination instructor of WUA/WUAF  
 d.1.2 Provide counseling to member of WUA/WUAF  |
|         |                           | e. Low level of Coordination implementation between the Irrigation management Institutions | e.1 Improvement of coordination among agencies and irrigation             | e.1.1 Synchronization program  
 e.1.2 To coordinate the implementation of irrigation management  
 e.1.3 Evaluating irrigation management implementation together  |
c) **Concept for Irrigation Modernization**: In the last decades before entering 21st century, many countries of the world have been facing critical issues in terms of less food production, limited energy availability, and inappropriate water resources management. Besides these issues, however, other phenomena dealing with emerging new technologies, especially in the information and communication, social and economic changes, also occurred in the community. Climate change to some extent has also affected people in some aspects. In the developing country such as Indonesia, environmental load in terms of increasing population rate has been occurring tremendously. Irrigation development as a part of water resources management was considered as a tool to overcome the problems, especially in raising food production. However, in some extent conventional irrigation management was considered not enough to be applied to enlighten the problems. It is needed more developments in the specific aspects. In 1995, FAO introduced a Modernization of irrigation policy in the special workshop and since the time it spread globally faster.

In 2011 the Government of Republic of Indonesia accommodated to launch The Indonesia Irrigation Modernization Policy with two main objectives which were: increasing level of irrigation services to farmers and improving irrigation management efficiency and effectiveness. The policy was considered on improvement of five pillars of irrigation, i.e. water availability for all farmers, good performance of irrigation infrastructures, well performed irrigation operation and maintenance system, adaptive and strong irrigation institutions, and capable human resources. Moreover, The Modernization of Irrigation of Indonesia Policy has three core characteristics which are participatory approach, defined-real time applications, and on demand irrigation management basis instead of supply basis. The policy had been implementing gradually using six steps, started from setting up the policy, measuring modernization of irrigation readiness index (IMRI), developing irrigation system planning, public consultation, irrigation infrastructure rehabilitation and development, and monitoring and evaluation. Recently, modernization of irrigation policy had been implemented in seven irrigation schemes.

### 6.3 Recommendations

#### 6.3.1 General

The 11 main recommendations for the improvement of the irrigated agriculture in Indonesia are listed below:
Table 12. The main recommendations for the improvement of the irrigated agriculture in Indonesia

<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PROPOSED INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Water Resources Management</td>
<td>Per river basin set-up of detailed water monitoring and scheduling system in which all water demands are assessed and honoured based on agreed LOS (Level of Services)</td>
</tr>
<tr>
<td>2 Regional Autonomy</td>
<td>Strict delineation of the responsibility of water management between the various levels of government with no more vague and ambivalent mandating arrangements</td>
</tr>
<tr>
<td>3 Fiscal Budgeting</td>
<td>Introduction of legal requirements for all levels to provide sufficient budget for water resource management including participatory irrigation management</td>
</tr>
<tr>
<td>4 Agriculture Extension</td>
<td>Introduction of special agricultural extension agency for the irrigated agriculture areas with educated and dedicated staff also involved in input- and output supply support and active policy to introduce crop diversification</td>
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<tr>
<td>5 SDA Data Gathering</td>
<td>Strict requirement for SDA services to implement Irrigation Asset Management, Irrigation Data Water Availability and Irrigation Development and Management and plan investments based on the IPIIDM recommendations and available water</td>
</tr>
<tr>
<td>6 WUA/WAUF and KOMIR Empowerment</td>
<td>Strong government support both technically and financially for active participation of water users in all phased of irrigated agriculture (Socio, Economic, Engineering and Institutional Irrigation Scheme Profile, WUA, Irrigation Commission)</td>
</tr>
<tr>
<td>7 Irrigation and Drainage System improvement</td>
<td>The irrigation and drainage system should allow for effective water scheduling to allow for crop diversification in all seasons</td>
</tr>
<tr>
<td>8 Land Consolidation</td>
<td>Due to very small size of farmers’ land holding in average (&lt;0.5 ha), it is recommended to apply a land consolidated model of farming in the form of corporate farming and integrated farming.</td>
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<tr>
<td>9 Single Irrigation Management</td>
<td>To eliminate many unsynchronized and over lapping of tasks and responsibilities regarding irrigation management and activities among government agencies, the government will apply a single irrigation management that will let all irrigation related activities under responsibility of the Public Works and Public Housing Ministry.</td>
</tr>
<tr>
<td>10 Irrigation Management Unit</td>
<td>For irrigation systems under central government responsibility, it is recommended to establish an Irrigation Management Unit under the Balai who will execute day to day activities of irrigation management. The unit will have personnel and facilities for carrying out O&amp;M activities to ensure effective, efficient, productive and sustainable irrigation management.</td>
</tr>
<tr>
<td>11 Irrigation Knowledge Management Centre</td>
<td>For sustainability of irrigation development and management, it is recommended to establish irrigation knowledge management as an institution to maintain irrigation knowledge and develop new irrigation knowledge including standard, method etc. The knowledge centre to manage knowledge of all irrigation stakeholders both from government and non-government and equipped by sufficient technology and communication units</td>
</tr>
</tbody>
</table>

6.3.2 Infrastructure Development

Developing additional storage and connecting existing irrigated areas to additional resources are the most effective ways to increase the harvested area when targeting existing irrigated areas where irrigation schemes are not implemented effectively. Southern Sulawesi and South Sumatera are most promising in this respect. However, it still remains to be explored whether geographically suitable locations actually exist. Priority should be given to those areas where a higher economic production can be achieved without developing new irrigation areas and, if possible, without developing new reservoirs.

South and North Sumatera and Aceh are areas where the most can be achieved in terms of increasing
the harvested area on existing irrigated areas through rehabilitation, O&M, and connections, not necessarily through developing additional reservoirs.

For Java and South Sulawesi and Lampung, additional reservoirs can provide additional potential to existing irrigated areas. For Java, the Java Water Resources Strategic Study identified additional potential for water conservation through dams as follows: Citarum (raising Cirata Dam), Citanduy (Matenggeng), Pemali Comal, (Ki Gede Sebayu), Jratunseluna (Panohan, Dolok), Lukulo-Bogowonto (Bener, for interbasin transfer to Yogyakarta), and Bengawan Solo. Jragung Dam could be potential if catchment conservation (especially improved agriculture management) results in less erosion. Jipang needs careful assessment, especially concerning social and environmental issues. Other dams especially in Jratunseluna and Bengawan Solo. For the development of water for energy, areas with relatively low connection to the electricity network and/or high-water potential and high expected demands are most promising. In this respect, Papua, Riau, North Sumatera, and provinces on Java show most potential.

6.3.3 Introduction of Real-Time Irrigation

In those areas with a storage facility, further improvements in operational management of irrigation water systems can be found by linking operational /SCADA systems with the free remote sensing data that are nowadays available. The remote sensing data can be used to monitor the crops, show when land is inundated to start the crop cycle and follow closely the crop stages and estimate crop production. Nowadays the best approach is a combination of visible / infrared and radar sensors (Primary: Sentinel-1, PALSAR-2; Secondary: TerraSAR-X, Sentinel-2, Landsat-8, and WorldView-3). A Multi-source rice crop monitoring approach will allow to map crop type extent, crop status, crop dynamics, crop inundation, crop calendar, harvested area, and condition risk using geospatial mapping tools. Combination with crop growth models and operational level hydrological models will help improve the operational management of scarce water resources by allowing accurate bottom up calculation of water demand/supply, instead of the current usual top-down practice.

**Objectives**

Provide near real-time crop monitoring using ESA, JAXA and NASA free data to provide maps every 6 days in support of the pilot modernization study of:
- Near real time status of crop stages, crop biomass and crop type
- Hydro-period (inundation for irrigation) to show when irrigation starts so we know when peak water demands are there
Derive the number of crops in a season (cropping intensity) and harvest area statistics.

Using automated GIS overlays with the irrigation area and golongan map we can follow the crop stages for areas of interest for PMMJIS

**Methodology**

Apply the existing Rice Decision Support System used for Myanmar and the US to the Binong pilot area of PMMJIS. The Rice DSS was developed for performing large scale data processing on satellite imagery based on open source and custom programming that streamlines automated ingestion, pre-processing, resampling, analysis, and management. The toolset library is made up of a component written in C++ and Python. Automation of processing is done by setting up the command line utility as a cron job to run on any newly acquired tiles.

**Source Data**

Primary: Sentinel-1, PALSAR-2; Secondary: TerraSAR-X, Sentinel-2, Landsat-8, World View-3

**Expected Outcomes**

- Map active and fallow crop extent at fine scale
- Characterize inundation status every 6 days (in near real time) at 10m spatial resolution
- Characterize hydro period (duration, frequency, timing) for paddy monitoring and assessment
- Characterize crop intensity (single, double, triple) and calendar (flood date, sowing, peak biomass, harvest)
- Map irrigation infrastructure (ponds, on farm reservoirs, major irrigation canals)
- Map condition (risk) and growth stage in near real time at 20m spatial resolution
- Deliver raster maps on web-GIS and/or ftp for local analysis and access
- If desired, tech transfer and capacity building can be performed as we use open source tools

**6.3.4 Increase in Routine O&M funding**

Regarding operation and maintenance (O&M), all regions can benefit from the improvement of services and the reduction of losses. The high-priority areas that require high investments to reduce the NRW are South Sumatera (NRW 81%), Lampung (NRW 61%), Riau (NRW 70%), and Aceh (NRW 56%) (Figure 8). As no prediction can be made regarding O&M needs in 2035, this is not included in the analysis.

![Figure 8. Investment Needed in Operation and Maintenance in Provinces with the Present Nonrevenue Water Level Higher than 45%](image)

*Note: Estimate here assumes the NRW is reduced from present levels to 33%; Asian Development Bank (2015)*
ABSTRACT

Irrigation development in Iran has been started since 1961. From 1961 up to now, about 2 million hectares modern irrigation networks have been constructed, but are not performed very well. From 1991 Irrigation Management Reforms (IMRs) have been initiated in Iran. It was evidenced; the results of IMRs would be obtained through long-term program and its process. The final results and sustainability of achieved outputs have more dependency on the level of active participation of local communities and governmental body in the process and their trusts to natural and inherent of participation. In this context, the active participation in the process follows the assurance of the empowering and institutional capacity building for the construction of further Participation Irrigation Management (PIM). In fact, the new built capacities are the main sources for the principle evolutions and reforms. In this article, IMRs’ constraints have been reviewed and lesson learned obtained from 25 years experiences in Iran. The reviewed IMRs’ constraints indicate that PIM has a high dependency to awareness of the executive team to this approach and their skills to conducting participatory methodology, transparency of national policies and strategies for IMRs, plans for principle evolution on community managing abilities, their trusts to local government, etc. Based on this experience, adaptation of IMT/PIM plan with farmers’ perceptions is the key element of success and defined practical bylaws to conduct in actual situation as well. Execution of IMT/PIM in national level needs holistic plan for enhancing the institutional capacities (including: GOs, NGOs, private sectors and local communities) at all level and local managerial empowerments. Today in Iran, the government face the challenges of find out the proper model to carry out the IMT as fast as possible. However, the lack of proper methodology for such attempt and lack of mutual understanding about IMT process, among the different related governmental sectors was known as the main reasons for these challenges. However, over the three categories of intensive efforts, a number of policy adjustments on modern Irrigation networks’ management that had been carried out in Iran. Such efforts are devolving the responsibility of irrigation management to users, but with inapplicable legislations for transferring the authorities. In addition, lack of methodology and clear IMT/PIM process to key staffs was main constraints on IMT/PIM process within the past 25 year’s efforts. This paper describes those efforts, constraints, lessons learned and issues for the future. Keywords: Management reforms, strategies, IMT/ PIM, Iran.

1 INTRODUCTION

We have passed more than half century efforts to solution of social and management constraints of Irrigation system through irrigation management transfer (IMT) and participatory irrigation management (PIM). Now it is clear to us farmer participation on Irrigation operation and maintenance is a part of solution of weak performance of the irrigation systems in the world.

Recent researches focusing on reforms of institutions made clear to us; there are more constraints, which have had no solution in short-term reforms. Lack of proper capacity in local community and local government for irrigation management transfer, is not such a small constraint, which could have been solved in a short-term plan.

Now the question is: how could be ensured about the sustainability of the reformed irrigation management through transfer the responsibility for O&M to the users, without transferring the
sufficient authority and proper capacity building in local level? Of course, in this situation there is no any guarantee to increase water efficiency and to improve system performance.

Today in Iran, the government face the challenges of find out the proper model to carry out the IMT as fast as possible. However, the lack of proper methodology for such attempt was known as one of the reasons for these challenges. But it is clear that the transfer of irrigation management from the government to local level constituent (both in public and private sector) and forming irrigation participatory management, which are involved in organizing the operational and maintenance of irrigation network and administrative as well, needs a long-term program.

Irrigation management reforms, if not implemented well, can lead to further constraints rather than improving irrigation performance (Kendy, et. al. 2003). From 1960s, many practices have been done on participation as one of key element of irrigation improvement, but the paradigm of such an approach could not have been understood as well, and caused a failure to achieve intended result. First model based on public participation in the 1980s and 1990s were developed (Burkey, 1993; Chambers, 1997; Khanal, 2003). This reform has been happened through local management by users’ organizations, referred to water users’ association (Vermillion & Sagardoy, 1999; Meinzen-Dick et al., 2002). IMT is the full or partial transfer of responsibility and authority for the governance, management and financing of irrigation systems from the government to water users’ associations. At present WUAs, progressively take over responsibilities and the role of government, irrigation agencies and WUAs (Vermillion, 2003; Peter, 2004), objected to solution of world challenges on Irrigation management and development.

Irrigation development in Iran has been started since 1961, from 1961 up to now, about 2 million hectares modern irrigation networks have been constructed in Iran, but are not yet performed very well. These problems causing the system of irrigation networks are unable to fully provide acceptable water efficiency and productivity. Under three groups of intensive efforts, a number of policy adjustments on water resources had been performed.

In this context, various policies, law, regulation and bylaws were approved by the government of Iran through congress, aimed at improving efficiency of water use and its productivity. Such policies are devolving the responsibility of irrigation management to users, without clear legislations for transferring the authorities. In addition, lack of methodology and clear IMT/PIM process to key staffs were main constraints on IMT/PIM process in Iran.

This paper describes the Iranian experience on IMRs and the issues from these exercises, and also reviews the results of IMT/PIM on some pilots of Irrigation networks in Iran.

2 A SUMMARY OF TRADITIONAL MANAGEMENT REVOLUTIONS ON IRRIGATED AGRICULTURE IN IRAN

Iran is situated in the Middle East region of the South-Western Asia and is located between 25° and 40° in the north, 44° and 63° in the East. The Climatic conditions are arid and semi-arid, and about two-thirds of the country receives less than 250 mm of precipitation per year. It means that optimised use of water resources is very important in this country.

Regarding water management capacity, Iranian rural communities have a history of accumulated knowledge and experiences. From many years ago, there were no water resource management legislations, but non-written bylaws had been accepted by the local communities. Hence, there were enough reasons for farmers to adapt themselves to such bylaws for proper management and efficient water use. In other words, there was no recurrent dilemma between the adaptations of farmers to
the local bylaws and social context versus the implementation of the necessary managerial changes imposed by local elders or leaders.

In other hand, under accepted definitions of local land attribution and water distribution, they had traditional water control and measurement structures. It should be noted here that, there was no any considerable conflict or struggle in water distribution and Irrigation systems’ maintenance. On those times, the farmers could manage their own traditional irrigation system even in water shortage during draught years.

The land reformation in 1962 changed the local social structures of water management and disturbed the traditional cooperation and social cohesion gradually. Governmental organizations and the relevant agencies (GOs) as external players became the active players in the economic and social life of the villages. Therefore, local community became passive in decision-making on main part of their daily activities. Therefore, the gradual weakening of traditional cooperation could be seen in the rural area.

From that time, the government has developed dam construction and Irrigation networks as fast as possible. Development of water resources could have been considered as an advantage and increasing the financial burden on the government as an effect, which is caused by this phenomenon. Through this phenomenon, the authorities responsible for water resource management progressively distanced themselves from the local communities. Further to such planning and development revolutions in water resource management, which emphasized the “top-down” approach, the entire management on irrigation networks tackled to the government, with very limited involvement of the farmers (in minor units).

Today the agricultural development could be seen in this country. Out of 37 million hectares of potential area for agriculture, about 8 million hectares is under irrigation. For this command area, more than 85 billion cubic meters of available water is consumed (more than 70% of supplied water is used for irrigation). It means the efficiency of Irrigation water is not acceptable. This also is the other effect of that phenomenon.

In the other hand, from 17 billion cubic meters of available water of the large dam is consumed on the 1.8 million hectares. After 30 to 40 years from the large dam construction, about one million hectares irrigation networks (including the tertiary and minor units) were have been completed in the dams’ down streamside.

From two past decades, the limited budget for construction, the conflicts between social perceptions and the designed schemes are the main constraints in these projects. Hence, continuous increasing financial burden lead to inabilities of government to fully provide the operation and maintenance costs and development as well. Moreover, inappropriate management of irrigation has contributed to environmental problems, operational and maintenance constraints caused the social problems and physical deterioration. Within the five years ago, the increased budget for construction of Irrigation network could not be the real solution for the proper operation and maintenance of Irrigation network.

Within the two past decades, the migration of rural population to the capital and urbanization has increased the domestic demand for water, which has put enormous pressure on the agriculture sector to reduce its consumption of water. Consequently, the concept of participation became the most important pre-condition for the development plans. However, the farmers’ participation in irrigation management, were not possible, with having understood that the government should take the full authorities for developing and O&M of irrigation networks.
From three past decades (1990), Iran initiated the first 5 years programme for the economic, social and cultural development (5YDP). During two past decades Government also initiated the exercise of management reforms in the modern irrigation systems. This paper describes those management reforms’ exercises on Irrigation networks and water resource development as well.

3  IRRIGATION MANAGEMENT REFORMS IN IRAN

In early 1990, the first 5 years programme for the economic, social and cultural development (5YDP) is initiated. The general trend of the 5YDP was toward privatization. Irrigation networks development was a part of this programme, but more focused on budget sharing. According to 5YDP policy, farmers had to pay the majority of Irrigation networks’ construction costs.

On those times, strategies of Irrigation Management reforms were not clear and the government was not succeeding in budget sharing policy for irrigation development. In addition, because of highly bureaucracies’ constraints and inadequate maintenance of irrigation systems, has led government to divert most of its roles to the private sector. In this context, three groups of events could be classified as follow:

3.1  Privatisation on Operational of Modern Irrigation Systems

In 1991 the government of Iran sought to provide more independence of operation and maintenance practices from public sector, in the management of the Irrigation networks, and decided to establish a new private company - the Operation and Maintenance (O&M) of Irrigation Networks Company (OMIC) - as an autonomous body under the Ministry of Energy (MOE). In this year a multilateral agreement signed by Ministers of Jihad-Agriculture Ministry (JAM), Ministry of Energy, Management and Planning Organization (MPO). With the establishment of OMIC, the decision was made to make part of its mandate the transfer of the operation, maintenance and administration of the Irrigation network (INet) to local communities. Each OMIC had concession of performing O&M in each INet.

The New Irrigation management policy enacted in 1991 rationalizes O&M responsibility, which is assigned to three administrative levels (Central / Province/local) with the designation of responsibility. OMIC establishment could be the origin to the Irrigation Management Transfer (IMT) program in Iran, but could not so.

In early 1992 up to number of 20 OMICs were established aims to perform following tasks:
- Improving the quality of Operation and maintenance of Irrigation networks;
- Increasing water use efficiency;
- Improving the efficiency of water fee collection;
- Irrigation agency structure’s reforms and reducing the number of employees;
- Improving the water users’ structure, in order to promoting the Irrigation management systematically;
- Enhancing the collaboration and communication between water users and related public sectors;
- Developing the participatory Irrigation management.

At the beginning, the ownership of OMICs should be shared between water users (51%) and governmental organizations (495 for JAM & MOE). In reality, this kind of shared stocks was not applicable (e.g. deteriorated Irrigation network and reluctant of the farmers to tackle). Actually, 100% of ownership shared between GOs.
Although in most of the INet, the quality of O&M improved and communications as well, but government body became bigger and water users’ management structures weaker. In addition, most of the initial objectives have been forgotten.

In fact, it could be said: there were acceptable incentives to transfer of responsibilities in the related GOs, but there were no sufficient incentives in local communities, unclear bylaws for transferring the needs’ authorities to the water users, insufficient capacities in the local communities, improper structures to perform such responsibilities. Hence, according to this policy water users couldn’t initiate and play own real roles on O&M and administrative affairs as well. Looking for solution on above-mentioned constraints made an extra force to the OMICs to perform the following policies.

3.2 Supportive Laws and Intensive Policies for Optimized Use of Agricultural Water

The backgrounds of these policies were as following:

- Due to part Ta note 19 from second 5YDP (1995 to 1999), the government approved the related bylaws. This note emphasis on Optimised Use of Agricultural Water (OUAW). In code 5 of this bylaw, the provincial part of JAM is responsible for establishment of water users’ formal groups.

- Increasing the constraints of financial burden, limited employees, budget, insufficient equipment etc. in the Irrigation networks under OMICs management.

- Article 107 from third 5YDP (2000 to 2004), emphasis on participation of landowners and water users’ groups in soil and water resources management. Article 17 from fourth 5YDP (2005 to 2009) also emphasises on this material.

- Article 35 under chapter five from Agriculture and Natural Resources Engineering Authority (ANEA) law (NGO).

Based on the above-mentioned supportive laws and intensive regulations, water users’ groups should be organized by the provincial parts of JAM with the participation of provincial parts of MOE and Ministry of Cooperation (MOC). In this regard, the Water Users Groups (WUG) as a formal type of Community Based Organization (CBO), but in the form of Cooperatives agency (WUC), presented in the Iranian water resource management literature for the first time in the 1996.

According to code 5 optimised use of agricultural water’s law, the JAM should organize the WUG within the maximum two years and introduce the representative of each WUG to the OMIC for each intake of secondary canal, who one is responsible for water distribution among each tertiary unit users.

In these intensive regulations and bylaws, main conflicts between two organizations (JAM & MOE) were as follows:

JAM had no a formal department or section with defined budget for these kinds of responsibilities and it was not interested to them as important as for OMIC. In fact, those constraints were daily problems to MOE, but the responsibilities were on the other side (JAM). There were no any defined communications or relations between JAM and WUGs in this regard. In reality, most of the agreements had no any guarantee to perform by JAM or other related GOs. There are many examples in this regard; the first exercise in Ghazvin Irrigation network, which has been happened between 1997 and 2002, is a good example.

Qazain Irrigation Network (QINet), with 50,000 hectares area under cultivation, is located in the northwest of Tehran. Due to above-mentioned atmosphere (article five and constraints in OMIC management), the first IMT exercise is started by OMIC under high supervisory of MOE (at the capital) and on the basis of Consulting Engineering Plan (CEP) in 1997.
Although from the beginning of the Irrigation network operation, farmers had their own managerial structure to distribute water among each other, but for solution of some constraints on O&M, Irrigation management reforms should be performed. According to CEP, the secondary unit L2 selected as a pilot. 12 WUCs and one Federation were constituted within the two years efforts. These WUCs and its Federation have been alive for three years and with only five-month activeness.

The results of Rapid Diagnosis (RD) on IMT in QINet, which has been done by Iranian PIM working group (IRPIM) in 2002, are as follows:

A) Main constraints
- Unclearness and unwell defined shared responsibilities to the majorities of the farmers;
- Transfer of responsibility to the WUCs with insufficient authorities;
- Financial Burden on WUCs with undefined budget sources;
- Insufficient capacity of WUCs to carry out such transferred responsibilities;
- Poor legality to carry out the responsibilities;
- Related local governments left the WUCs, just after establishment and has been disappeared any co-ordination among them;
- Finally, the majority of water users, which have to play the main roles, had no sufficient incentives.

B) Lessons learned
- In transitional time segment, more expenses will result to the farmers to carry out the new responsibilities, looking for the solutions of such constraints should be paid before WUCs’ constitution;
- After the WUCs were constituted, the local GOs (JAM&MOC) should pay continuous attentions to WUCs with respect to authorized them;
- WUCs should be supported (not as a charity, not as a subsidy, but as a real means of participatory) and strengthened for a transitional time segment, while it is necessary;
- IMT has own defined process, which should be passed as well as possible.

In this regard, the local department of JAM had no enough sensitive to WUCs’ constitution. Particularly, they had different model in their hands (Rural Production Cooperative = RPC) and trying the new model was not interested to them (e.g. Novin Dez RPC in Khozestan province, Mahidasht RPC in Tehran province). In fact, such intensive regulations couldn’t have any positive impact (except Lesson learned) and acceptable performance until 1999.

Due to suggestion of MOE, in order to find the solutions of above-mentioned constraints, the OUAW bylaw’s committee at two levels (capital and provinces) was established in 1999. This committee includes the representatives of MOE, JAM and MOC.

The committee had conducted several meetings and had several outputs. The first bylaw for instruction of WUCs was the most importance one. This bylaw was approved by MOC and ordered to Province to establish the WUCs as fast as possible.

According to this bylaw, many WUCs were established, but most of them never met the success. The main constraint of this performs were lack of sufficient incentives, lack of defined position for WUCs on decision-making and WUCs’ institutional weakness to play their roles. Besides WUCs, the RPC also couldn’t find own institutional capacity to perform OUAW law and plays basic roles in 1990 decade. Gillan experience is a good example in this regard.
In early 2002, the OUAW bylaw’s committee suggested to Gillan’s OMIC transfers a part of O&M responsibilities (e.g. fee collection) to Rural Consumption Cooperatives (RCC) and RPC. Negative impacts were their performance within the five years.

In some Irrigation networks, establishment of the WUCs was not on their plans. Those OMICs chose the different strategy and performed the improved traditional management. Varamin Irrigation network experience was a good example in the late 1990, in this regard.

From the beginning of the Varamin Irrigation network (VINet) operation, farmers had own management model. In this model, the representatives of WUGs in each secondary unit were responsible for operation and maintenance of lower part of main canals with developed cooperation. During the drought years and water shortage such cooperation have been enhanced. According to article five from OUAW’s bylaw, such cooperation enhanced up to villages (includes several secondary units) and participation grew up faster. At the moment, Secondary units CW and CNZ covers 14 and 50 villages respectively and 300 front representatives have been reduced to 150 representatives.

The results of Rapid Diagnosis (RD) on IMT in VINet, which has been done by Iranian PIM working group (IRPIM) in 2003, are as follows:

A) Main constraints
   – Lack of legal recognition of WUGs by provincial and local government.

B) Lesson learned
   – Adaptation of IMT plan with farmers’ perceptions is the key element of success. In this case, it could be thought about farmers’ financial supports to the IMT.
   – In some irrigation networks, which were not any external force on WUC’ constitution, capacity and power of the WUGs have been enhanced for the management reforms. Those reforms were compatible to the administrative legislations and social conditions and have been imposed on less constraint.

However, in VINet, WUGs could delegate the responsibility for the O&M of secondary units to main canal, depending on their abilities and willingness to participate of each of them. Given the positive experience and clear benefits of good water management practices seen over the past years, the OMIC and the WUGs are prepared and ready for whatever the new legal arrangements will bring (e.g. WUCs), and hopefully the outcome will lead to further improvements to the objectives of OUAW.

In addition, there are many examples in this regard, which have been related to Iranian civilization on water management. For example; from the beginning of operation of Mojen Irrigation network, the WUGs have been equipped themselves for management of Irrigation network. It means, they had never thought about sharing responsibilities with external players. They developed their indigenous knowledge and improved their institutional capacities. In early 1960, they constituted the MOjen Agricultural and Irrigation Ltd to better management of Irrigation system. At the moment, they perform all related duty of O&M and administrative affairs as well, without any governmental support and intervention.

With regard to Article 107 from third SYDP (2000 to 2005), landowners and water users’ groups’ participation on soil and water resources management became highlight again. To preparing a bylaw for this article, the OUAW bylaw’s committee conducted several meetings and the first draft of participatory plan was its output in 1992, but never approved by MPO. However, with conducting those meeting had some more positive impact on the front line of decision-makers in MOE and JAM.
In addition, up to 10 Article and note from third 5YDP, Article 35 under chapter five from Agriculture and Natural Resources Engineering Authority (ANEA) law (NGO) had more pressures to pay some more attention on social-economical formal structured farmers’ business groups and marketing.

According to Article 35, JAM had a mission for maximum 6 months to provide the constitution of agricultural activities. In the introductory draft, WUA has a position at the core of all different agricultural constitutions. At the moment, this model for agricultural constitutions activities is under the test in Gazvin Irrigation network.

As a summary of this chapter of efforts, it could be say that there were a lot of efforts on agricultural constitutions and valuable lessons learned came up from such efforts, but the strategies haven’t been approved yet. Most of the articles in third and fourth 5YDP, not yet officially implemented since the required bylaws have not been prepared giving important constitutional discrepancies regarding agricultural water use and management. Additionally, a set of reforms on the National Water Law and natural resources are waiting for approval by Congress.

3.3 Supportive Laws for Financial Support (National & International)

In the first 5YDP (1990-1994), budgets’ sharing was one of the strict requirements for construction of irrigation networks. Funds for construction of tertiary units must be shared among farmers. However, the policies were in transition and some costs were still being covered by government funds. Under those regulations, the primary financial responsibility for irrigation construction of the main and secondary canals and infrastructures for the scheme rests with the central government.

According to the first 5YDP, country’s development should have increasing rate. There were not enough budgets for such plan of developments. Using of financial supports was necessary and loan from internal and external banks was a part of the first 5YDP policies.

Although, when we are talking about IMT, we referring to management of O&M and administrative in constructed systems under the GOs’ management, so budgets’ sharing for construction of irrigation networks has a different story. But this story had influences on IMT in IRAN. Supportive laws and Financial Support has been described as below:

- National supportive laws for irrigation development

Before the second 5YDP, there was an agreement between the government side and agricultural bank about special loan (credit) for soil and water development with low interest rate. Note 3 was one of the yearly budget’s law for this purpose (e.g. using loan for traditional canal lining). These agreements have been improved from second to fourth 5YDP as following:

In note 26 from the yearly budget’s law (1994-95), farmers were responsible to provide 75% budget of irrigation networks construction.

Note 76 from second 5YDP (1995-99) with improved the government’s share up to 30%. Part A article 106 from third 5YDP (2000-2004) and part Ta article 17 from fourth 5YDP (2005-2009) have been the continued credit’s facilities from past decade.

Individual farmers have used these financial facilities from 1994. Beside of individual farmers, constitutional arrangement was required in some main and secondary canals. Three types of arrangements carry out in this regard as following:

- Under responsibility of Villages’ Islamic Council (VIC) such required arrangement for collecting shared budged were approved (in most of the developed irrigation canal).
- New Short-term constitution, including Sar-Abbyaran (traditional canal operators) or/and communities’ leader was established for such required arrangements (e.g. Karaj irrigation network).
- New permanent WUCs or RPC were established (e.g. Sufie-chai network). 17 WUCs have been established before 1995 in East-Axarbaiejan province.

In objected to canal construction and objectives of budget lines most of them (above three categories) were succeed, but with regard to development of PIM, some constraints could be recognised as follows:
- Lack of clear legal position for WUCs in decision-making on water resource management;
- Improper GOs’ constitutions for administrative and technical support of WUCs;
- Lack of clear strategies for enhancing the WUCs’ capacities and empowering.

The IRPIM surveys indicate that uncompleted process of PIM’s development is the main causes for most of the constraints.
- International financial support for Irrigation improvement

Irrigation improvement project was a joint project between government of Iran and World Bank (WB). This project was on MOE Irrigation program in 1991, but one of the main conditions to gain the WB financial support was to understand about legal position of WUGs in the Irrigation systems. The project has been approved and started in four irrigation networks (Moghan; (MINet), Behbahan; (BINet), Tajan; and Zarriene-rud) in 2000.

Improvement of MINet and BINet has been performed and Tajan is under construction.

The project was succeeding in order to physical improvements (MINet and BINet), but in order to Irrigation Management Improvement (IMI) there is a doubt.

In Moghan, according to intensive study and field works, the secondary canal DC6 selected as a better condition for IMT pilot. In coordination of local government (MOE and JAM), more efforts performed and Pishro’s WUC was constituted for IMT on 1000-hectare command area in late 2001. It could be said; WUC received enough technical and financial support from local government sectors (JAM and MOE), but such supports never could sustain the Pishro’s WUC.

The results of Rapid Diagnosis (RD) on IMT in MINet, which has been done by Iranian PIM working group (IRPIM) in 2003, are as follows:

A) Main constraints
- There was no any incentive for IMT in both side (local governments and communities);
- In the local government and communities’ points of view, the physical improvement objectives were well defined, but the IMI not;
- There was no any agreement in order to indicate the shared responsibilities.

B) Lessons learned
In Moghan, the close coordination between local authorities, technical and financial supports to the WUC had a picture of the successful story, but this cooperative was not sustained for a long time. In the short time (a few months), the conflict between cooperative board and the members put an end on another IMT exercise. This exercise indicates; if there is no any common incentive between GOs and water users with regard to IMT, it could be say nothing happened with regard to IMT.
4 SUMMARY OF IRRIGATION MANAGEMENT REFORMS IN IRAN

4.1 Constraints

- Transfer of responsibility to the WUCs with insufficient authorities;
- Insufficient capacity of WUCs to carry out such transferred responsibilities;
- Unclearness and unwell defined shared responsibilities to the majorities of the farmers;
- Lack of defined common incentives between GOs and water users with regard to IMT;
- Lack of clear legal position for WUCs in decision-making on water resource management;
- Lack of practical bylaws, which could be conducted in actual situation.
- Lack of acceptable methodology for IMT process, as a notional model. According to variation of the local condition.
- Lack of mutual understanding about IMT process, among the different related governmental sectors.

4.2 Lesson Learned

- In transitional time segment, more expenses will result to the farmers to carry out the new responsibilities, looking for the solutions of such constraints should be paid before WUCs’ constitution;
- Adaptation of IMT plan with farmers’ perceptions is the key element of success. In this case, it could be thought about farmers’ financial supports to the IMT;
- IMT out of PIM and its whole process has no meaning in the reality. It means the WUCs’ constitution is one of the tools for PIM, but is not PIM’s objective;
- In IMT/PIM process, if there is no any defined common incentive between GOs and water users, it could be say nothing happened with regard to IMT/PIM.
- Without the mutual understanding about national integrated program for IMT, there is no any guarantee for IMT succeed.

4.3 Conclusion

- IMT is a part of water resource management reforms in Iran;
- Three parallel efforts have been conducted for IMT/ PIM in Iran and have more positive impacts on front line of decision-makers’ attitude and have more lessons learned for future plan;
- Past two-decade experiences have a few positive impacts on local communities;
- There are four classified constituents in the PIM process (by author). These constituents are as follows:
  - Participatory Diagnosis
  - Participatory planning and implementing
  - Up scaling and out scaling
  - Participatory Monitoring and evaluation
- Only a part of the second one has been taken into the considerations by the IMT/PIM executive teams in Iran.
- There is more institutional capacity for IMT in private sectors (OMICs & RPCs & RCCs), but no one was reconstructed for this mission;
- At the moments, more paying attention of front line of decision-makers (government & congress) have made several wide channels to flows the IMT/PIM in the Gos body and the private sectors;
- Current national plan of Irrigation management reform has no providence for IMT.
5 ISSUES FOR THE FUTURE

Execution of PIM in national level needs holistic plan for enhancing the institutional capacities (including: GOs, NGOs, private sectors and local communities) at all level and local managerial empowerments. In this regards we need some more investments.

To carry out the PIM process or to combine the traditional and modern form of participatory management needs a special knowledge and specific skills. Due to insufficient professional experts and lack of proper methodology adaptable to different social-physical characteristics of Irrigation networks, to conduct any plan of PIM in Iran needs a mid-term program in some pilots. Let’s say 10 pilots for 10 different social- physical characteristics to test and development.

Such mid-term pilots test could help us to develop the methodology compatible to the Iran social conditions, out scaling and up scaling through participatory monitoring and evaluation (PME) for long-term plan.

With this suggestion, the opportunities will be provided for; increasing the common incentives and trusts between stakeholders, enhancing required capacities, time left for learning by doings and training of trainer for long-term program, sufficient times for clear definition and designing the accepted plan of PIM (objectives, strategies, levels, how? where? Whom? etc.). Of course, in reality, awareness and continuous communication between different stakeholders (related GOs and local communities) could be enhanced through Participatory Monitoring and Evaluation in the short-term plan as well.

6 REFERENCES


INTRODUCTION

In its long history of more than 2,000 years, agricultural water usage (irrigation and drainage systems) in Japan has been consistently protected and grown by the efforts of farmers and other people involved in agriculture in each era. It is these efforts and financial investment that have created the agricultural irrigation and drainage facilities of Japan, including the agricultural waterways that expand a total of about 400,000 km. While repeating numerous conflicts and struggles, and through finding solutions for the conflicts, not only those between the canal sectors, but also those between the sectors of different types of water usage, as well as rationalization of the canal sectors themselves, water usage management has developed the ordered and socially accepted status of today.

The multidimensional functions of irrigation and drainage systems are not limited to their contribution to the long-term food security realized by their ensuring of irrigation water, which is indispensable to a stable supply of food. The irrigation systems form aquatic areas consisting of ponds and rice paddies, which are connected to each other to create large areas of canal networks and ultimately sound aquatic environments for the whole rural area. The return water from rice paddies or other types of fields have functions to stabilize the river flow and recharge the ground water, thus playing important roles to maintain and strengthen the healthy circulation of the drainage basin. The irrigation and drainage systems have now become an essential national asset (social common capital) of Japan to supply food to the nation and ensure multidimensional functions of agricultural and rural communities.

Construction of irrigation and drainage systems in Japan after World War II has been conducted in land improvement projects that are based on the Land Improvement Act of 1949. Under this legal regime and project systems, farmers (i.e., beneficiaries) voluntarily organize land improvement districts (LID), submit applications for a project, and maintain and manage the land improvement facilities. The central and local governments play a role of assessing the validity of the project applied for and support the applicant in planning, designing and construction of the project. When advanced technologies are needed for the project, the government may carry out the project for the beneficiary by sharing the costs with the beneficiary.

More recently, however, structural changes in agriculture have been bringing about large changes in the environments surrounding agricultural water use, and thus influencing agricultural water management. The structural changes include changes in agricultural society, such as the aging and declining number of farmers, urbanization, and increase of mixed settlement of farmers and non-farmers, as well as changes in agricultural production and advancement of agricultural land consolidation. Also, the agricultural irrigation and drainage facilities, which have been ensuring stable supply of agricultural water with its capital value of 32 trillion yen, are rapidly aging, which requires proper renewal of facilities. At the same time, further improvement of efficiency and energy-saving properties of water management are in demand. In response, the government has been taking measures for strengthening of management regimes, use of ICT in water management, and improvement of energy conservation properties. To support the agricultural communities to play a role in maintenance and management of agricultural irrigation and drainage facilities, a direct payment system has been implemented and used.
For other countries, Japan has been involved in a number of overseas technical cooperation projects using the experience in water management conducted by LIDs. Specifically, farmer-participation water management has been introduced to developing countries, and the Japanese government will keep making proposals to those countries to make the farmer-participation style of water management take root in their culture.

2 SYSTEMS UNDER THE LAND IMPROVEMENT ACT

2.1 Land Improvement Districts (LIDs)

Land improvement districts (LIDs) are corporation farmers found under the Land Improvement Act with a purpose to implement land improvement programs based on the Act. As the procedure to establish a district, the Act stipulates that 15 or more people who are qualified under the Article 3 of the Act (e.g., land owners and those who benefit by using the land) shall designate a certain area; agreement shall be acquired from two thirds or more of people qualified in the same manner (farmers, etc.) in that area; application shall be submitted to the governor of the prefecture; and authorization is given. When an LID is established, all of those who are qualified for the prescription in the Article 3 of the Act become members of the LID. LIDs established under the authorization of a prefectoral governor possess corporate status, while organizations and corporations that have not completed the procedure may not use the term of “land improvement district.”

LIDs must set up articles of corporation and designate executive members and auditors. The executive members (five or more) and auditors (two or more) are elected by the district members and serve for terms of four years in principle. A general assembly meeting is organized as the highest decision-making body, except for LIDs with more than 200 members, where a meeting with representatives from each area can replace the general assembly meeting.

As of 2016 (end of March 2016), there were 4,646 LIDs, including many large-scale LIDs, as seen in the case of Nishi-Kanbara LID in Niigata Prefecture with an area of 19,678 hectors, 14,302 farmer members, and 155 staff members.

2.2 Operation of LIDs

Based on the articles, LIDs can impose payment of money, labor, goods, and/or membership fee on the members in the district to spend on the operation. LIDs can also collect part of the costs needed for the land improvement program from those who benefit from the land improvement program authorized by the prefectoral governor within a given limit.

When a member diverts the use of the beneficiary land in the district to non-agricultural use, the LID can collect a settlement fee. When a member falls behind in payments of the imposed fee, etc., the LID may send a demand notice; if the member who has received a demand notice does not complete the payment within the time limit, the LID may request the municipal government to conduct the collection.

LIDs are under the supervision of the prefectoral governor, and their management and operations are inspected on a regular basis. Election of the president is conducted under the supervision of the prefectoral election administration commission. In cases where an illegal act is found (an executive member or the president receiving a bribe, for example), a term of imprisonment is imposed as is the case for government employees. As seen in these cases, a highly public status of a corporation is given to LIDs.
2.3 Implementation of Land Improvement Projects

Land improvement projects are public projects that are initiated by the voluntary initiative of beneficiaries. Thereby, the Land Improvement Act stipulates that its implementation must be environmentally friendly, contribute to comprehensive development and conservation of national resources, and meet the development of national economy.

Land improvement projects stipulated in the Act include the construction, management, abolishment, or changes of agricultural irrigation and drainage facilities, agricultural roads and other facilities necessary for maintenance or use of agricultural lands (land improvement facilities); land readjustment; and recovery of agricultural lands or land improvement facilities from disasters.

Legal procedures for land improvement projects are stipulated in the Land Improvement Act for each project operator. In any case, however, it must be based on application and agreement of the beneficiaries. The scale of the project decides who is going to be the main body to implement the project (national government, prefectural government, municipal government, or organization, etc.), and the Act stipulates the rate of subsidies from the national government according to the main body.

Legal procedures for land improvement projects by the national or prefectural government can be summarized as follows:

- A person who is qualified according to Article 3 of the Act (“Article 3 qualifier”) or municipal government, etc. makes a public notice of the summary of the plan for the land improvement project (purpose, area to implement the project, approximate costs, etc.).
- Agreement shall be made by at least two thirds of the Article 3 qualifiers in the area to implement the project (signature and seal of each person are needed). Fifteen or more of the Article 3 qualifiers or the municipal government, etc. submit the application to the national or prefectural government.
- The national or prefectural government decides whether the plan will be implemented as a land improvement project and notify the applicant of the decision.
- The national or prefectural government finalizes the national or prefectural land improvement project plan.
- When there is no request for a review within 15 days after the completion of announcement /inspection (for 20 days or more) and inspection period, or when a request for a review is ruled, the national or prefectural land improvement project plan shall be finalized.
- Construction begins.

These procedures are stipulated based on the Act and are highly transparent.

2.4 Management of Land Improvement Facilities

Any agricultural irrigation or drainage facilities constructed by the national government or a prefectural government following an application by farmers belong to the national or prefectural government as its property. As the property right holder of the facility, the government or prefectural government takes responsibility of management. Daily management of the facility, however, is principally commissioned to the LID, which is the beneficiary group organized by the farmers. This is due to the fact that (1) farmers are the ones who directly benefit from the facility and (2) most efficient and proper management can be done by those who use and benefit from the facility. As exceptions, in cases where the facilities are in a small scale and its functions influence only a relatively small area, and thereby voluntary management by the beneficiary group is considered suitable (tertiary canal, small-scale pumping facility, etc.), the property right is granted to the LID.

As mixed settlement grows in rural areas, consideration to disaster prevention measures in the case of flood and use of the facility for non-agricultural purposes, as well as complicated and advanced
facility management, such as coordination with other types of water use management, has become necessary. In these cases, where commissioned management of LIDs is not necessarily appropriate from the perspective of capabilities of the LID in technical aspects, management responsibility, and coordination with non-agricultural use, management is entrusted to the local government (prefectural or municipal). In the case of a large-scale facility that benefits two or more prefectures, for example, its water supply and drainage functions give highly public features and special technical consideration is needed for management. In such cases, the national government directly manages the facility.

3 FACILITY MANAGEMENT FOCUSED ON LIDs

3.1 Facility Management Conducted by LIDs

When a land improvement program is completed, the LID is entrusted by the national or prefectural government with the maintenance and management of the facilities constructed in the area. Maintenance and management of land improvement facilities include operation of water supply and drainage plants, monitoring of canals (including operation of floodgates, etc.), and mowing of the areas around canals. The costs of these activities are paid from membership fees, in the form of labor service, or by other means. LIDs may receive a subsidy from the national or local government for a part of the maintenance and management costs.

3.2 Sharing Mechanism for Irrigation and Drainage Operation Costs

The LID collects membership fees for maintenance and management in the form of irrigation and drainage management fee (ordinary charge) from the members based on the article. The fee is determined based on the size of the farmland owned by the specific member and other factors. When a member falls behind in payment of the imposed fee, etc., the LID may send a demand notice; if the member who has received a demand notice does not complete the payment by the time limit, the LID may request the municipal government to conduct collection. The amount of the fees are decided at the annual meeting of general assembly (or the annual meeting with representatives).

3.3 Public Support for Irrigation and Drainage Management

As mentioned above, facilities constructed in national projects can be more efficiently managed by local LIDs, who directly benefit from the use of such facilities and can manage them in a way to meet the actual conditions of usage. Thus, the management in these cases is in principle entrusted to the LIDs. When a facility is managed by a local government and the scale and area to be affected by the facility is large, and if the facility is highly public (e.g., the operation of the facility influence the management of a river, or the facility has a function to prevent flood damage on non-agricultural lands), part of the management cost is subsidized by the national government from the perspective of public importance. The national government also supports facilities managed by LIDs in proper maintenance of the functions and exercising multidimensional functions.

4 CURRENT CONDITIONS OF WATER MANAGEMENT BY LIDs

4.1 Water Allocation and Labor Service

Irrigation to rice paddies is usually conducted by the block rotation method. This allocates the water to each block in a previously decided order, and the necessary operation of the land improvement facilities is conducted by LID members. Operation of irrigation and drainage facilities, etc. managed by an LID is conducted by LID staff following operation regulations. Monitoring of tertiary branches of canals (safety inspection), mowing of the areas around canals, removal of soil on the bottom of the
canals, and other management work are conducted in a form of cooperative settlement activities (labor service) of farmers and non-farmers in the settlement.

4.2 Improvement of Water Usage Efficiency

While the development of agricultural irrigation and drainage facilities enabled the mechanization of rice paddy farming and independent irrigation and drainage systems for each parcel of land, new challenges have arisen as part-time farming and the aging of farmers’ progress. Specifically, measures against the concentration of water consumption at peak times, automatization and labor-saving improvement of management of land improvement facilities, and energy-saving measures for agricultural irrigation and drainage facilities are needed. In water basins located in extremely populated large cities, where the facilities have a large impact on the water supply to meet the water demands unique to urban areas in the time of drought, LIDs cooperate with the local governments to coordinate water usage in the basin.

5 FUTURE ISSUES

5.1 Changing Conditions Surrounding Agricultural Irrigation and Drainage Facilities and LIDs

The Basic Plan for Food, Agriculture and Rural Areas (approved by the Cabinet in 2015) requires systematic and efficient implementation of the acceleration of agricultural structural reform and the development of agricultural production bases for national resilience. At the same time, the rapid aging of agricultural irrigation and drainage facilities requires stable execution of facility functions now and in the future. To this end, we need to promote strategic maintenance and management to thoroughly improve the life of the facilities and reduce the life-cycle costs through systematic and efficient repair and renewal works by conducting proper risk management through inspections, functional diagnosis, and monitoring. At the same time, measures must be enforced to prepare for unexpected events, such as a sudden accident in an agricultural irrigation and drainage facility due to a cause of age-related facility degradation.

Meanwhile, the agricultural irrigation and drainage facilities constructed during the period of rapid economic growth after World War II are expected to face rapid deterioration due to aging. This should increase the costs needed to deal with sudden accidents or to repair facilities to maintain their functions. Also, as mentioned above, the management costs of agricultural irrigation and drainage facilities are paid from the member fees and labor services from farmers. This means, as the farmers are aging and the number of farming households is declining, maintenance and management of facilities may receive adverse effects. Another concern to be noted is that the concentration of farmland to a fewer number farmers may result in a heavier burden of management costs of agricultural irrigation and drainage facilities to these farmers. Another issue is the energy costs of pumping facilities for water supply and drainage, as pumping facilities account for 60% of the land improvement facilities constructed by the national government. As the major energy used in these facilities is electricity and 30% of management costs are paid for through electric power charges, reduction of management costs through energy-saving measures and private power generation (e.g., small-scale hydric power generation for agricultural purposes and solar power generation) is desirable.

5.2 Maintenance and Management of Facilities Meeting the Needs of the New Era

Agricultural water supply systems can play a full role only when the whole series of facilities—from the main facilities to tertiary facilities—function in a united form. For high-quality farmlands to remain as high-quality farmlands and sustainable operation of agriculture to be realized, these series of facilities must be properly maintained and managed. While measures for rapidly aging facilities have become an urgent issue in recent years, the national and local governments, and farmers must share
their responsibilities and cooperatively work together for enforced measures, and efficient and assured maintenance and management of the facilities.

For the maintenance and management of land improvement facilities, specifically, management with maximum use of locally owned capabilities is most efficient. In this light, management by LIDs and other locally oriented organizations should be the basis of the management scheme while the national and local governments support their activities.

In order to effectively and continuously use land improvement facilities, energy-saving measures and other measures to deal with new issues must be taken. The mechanism to facilitate efficient implementation of these measures by LIDs as part of their cooperative work of maintenance and management should be developed and enforced. In addition, information must be shared with involved parties, including municipal governments and local residents, regarding the roles and conditions of land improvement facilities, including benefits to the public, in efforts to gain understanding and cooperation regarding the maintenance and management of the facilities.

5.3 Measures with Technological Innovation

In agricultural field improvement projects, farming plots are reshaped or enlarged, or dispersed farm lands are united, as part of land readjustment projects of rice paddies and other farmlands. In addition, tertiary canals are innovated from the existing open-ditch style, to pipe lines to allow operation of automatic valves or other types of operations to greatly reduce energy consumption in water management, realize reductions in water consumption, and lower maintenance and management costs. While agricultural field improvement projects are completed in about 64% of rice paddies in Japan, measures to deal with the anticipated conditions, where the number of farming households involved in local agricultural irrigation and drainage facilities, and their maintenance and management, should be taken. Such conditions will be brought about due to an increase in part-time farmers and aging of farmers, as well as population decline in rural areas and concentration of agricultural operation to small numbers of farming families. For example, ICT and other types of technologies may allow remote monitoring of the water level of each farmland and irrigation and drainage canals on mobile devices and remotely control valves or other equipment. Such new technologies should be used to further develop energy-saving and efficient water management, and advanced usage of water.

5.4 Requirements to Continue Sustainable Water Management

Large-scale renewal of irrigation and drainage facilities that requires huge cost has become difficult. Consequently, LIDs have to obtain information on the health of facilities with a diagnosis of their functions, while engaging in the routine facility management. In response, information has been organized and technician training has been provided for LIDs. Also, preventive measures should be taken to minimize the possible damage on land improvement facilities in the case of large-scale earthquakes and other natural disasters.

To respond to the aging of farmers and concentration and integration of farmlands to a fewer number of farmers, conventional methods of facility maintenance and management as well as cost allocation must be flexibly reviewed in order to continue sustainable water management.

5.5 Structural Reform of LIDs to Meet the Needs of the Times

The conditions surrounding local agriculture and LIDs are changing, while roles demanded for LIDs have become more diverse and complicated. Against this backdrop, and when the conditions of financial foundation, such as member fees and savings, and human resources including executives and officers are concerned, small-scale LIDs are facing the possibility that they cannot survive in the status quo. Thus, each prefectural government is to generate a plan to integrate and organize LIDs and
support activities to merge LIDs aiming for an ideal status of LIDs with their required roles in the future, and for the ideal organization and to promote the integration and organization of small-scale LIDs. About a half of the prefectures of the nation have completed a plan to integrate and organize LIDs.

5.6 Direct Payment System Concerning Maintenance and Management (Multifunctional Grant System)

While management of main canals and other major parts of agricultural irrigation and drainage facilities is the responsibility of LIDs, maintenance and management of tertiary canals (i.e., those at agricultural field levels) are conducted by cooperative activities of individual farms and settlements. With the recent decline in the functions of settlements, which are caused by the advancement of depopulation in rural areas, aging of farmers, and more mixed settlement (between farmers and non-farmers), multidimensional functions of agricultural irrigation and drainage facilities, which have been supported by the cooperative activities of local communities, are facing a concern in the ability to excise their functions. Moreover, the burden of the small number of farming households with maintenance and management of facilities is feared to increase.

Against this backdrop, the national government started the “multifunctional grant system” to financially support the local communities in their cooperative activities to conserve local resources (e.g., removal of soil on the bottom of the canals and mowing of the areas around canals) and activities to repair and renew facilities to increase their life. This is to maintain and efficiently use the multidimensional functions owned by agriculture and farming communities. Up to 9,200 yen (about 83 US dollars) per 10 acres of rice paddy is granted under this system.

6 PROPOSALS FOR THE FUTURE

6.1 Ideal Conditions for Sustainable Management

As mentioned above, management of agricultural water and agricultural irrigation and drainage facilities in Japan will continue to be conducted mainly by LIDs while measures for a variety of issues are taken. The national and local governments will prop up such activities. The governments also continue supporting the cooperative activities of local communities to maintain and manage agricultural irrigation and drainage facilities in order to ensure that the activities are continued without facing big problems. In other parts of the world, efficient water use to deal with the shortage of water resources is needed along with water management to deal with more frequent occurrences of drought and floods due to global climate change and abnormal weather patterns, and measures against disasters caused by rain storms and floods. To this end, continuous introduction of farmer-participation types of irrigation management and the stable use of such management systems are expected to remain as ongoing issues.

6.2 Issues in Farmer-Participation Irrigation Management in Developing Countries

Farmer-participation irrigation management has been tried in many developing countries since the 1990s with the cooperation of international organizations, namely the World Bank, FAO, and IWMI. The feasibility of the system, however, is still controversial. Introduction of irrigation facilities brings increased food production to each farming household. However, as irrigation facilities can work fully only when the cooperative work of groups in maintenance and management is properly conducted, development of capabilities of farmer organizations in water allocation, as well as in maintenance and management, along with increased appealing capabilities to attract farmers to the organization, is essential when starting farmer-participation irrigation management.

In many of the developing countries, no farmer organization that can manage facilities exists to begin with, or even when such organizations exist, they are hardly functioning. Concerning these issues,
many researchers of Japan have been pointing out issues and problems regarding farmer-participation water management as follows:

1) To establish farmer organizations (organizations for water usage) and strengthen operations (to ensure transparency and fairness as an organization),
2) To clearly define support schemes for the farming organizations and allocation of roles,
3) To grant incentives to farmers,
4) To firmly transfer technologies to government officers and farmer organizations, and
5) To develop laws, schemes, as well as technical manuals for promotion.

6.3 Characteristic Programs by Japan in Farmer-Participation Irrigation Management Technology Transfer (Example Cases)

Japan has been fully involved in technology cooperation projects in the field of irrigation and water management since around 1970. Although the initial focus was on technology transfer to technicians on site, the farmer-participation style of agriculture and rural area development (soil erosion prevention, village development, etc.) started around 1990. JICA has been fully working on technical transfer in farmer-participation irrigation management since around 2005 to developing countries based on the experience and technologies accumulated by LIDs in Japan. Starting with Vietnam in 2005, JICA has been operating a total of 20 projects in 17 countries (on-going projects are included). The list below shows cases where JICA took measures for the issues described above in its technical cooperation projects.

1) To establish farmer organizations (organizations for water usage) and strengthen operations (to ensure transparency and fairness as an organization):
   - Sri Lanka: Established four groups (irrigation group, rice paddy group, home garden group, and livestock group) in a farmer organization and strengthened their operations.
   - Laos: Established a production group (study group) in a farmer organization.
2) To clearly define support schemes for the farming organizations and allocation of roles:
   - Established taskforces as a support scheme for farmer organizations in many countries. Examined role allocation between the government and farmer organization.
   - Tanzania: Established a council for information sharing composed of government officers, prefectural officers, and a model association for water usage members, and strengthened their cooperation.
3) To grant incentives to farmers:
   - Sri Lanka: Established a revolving fund for milk or fruit production. Started joint purchase and joint sales.
   - Morocco: Started contract-based cultivation.
4) To firmly transfer technologies to government officers and farmer organizations:
   - Morocco: Introduced drop irrigation systems as a water-saving type of irrigation.
5) To develop laws, schemes, as well as technical manuals for promotion.
   - Tanzania: The government voluntarily developed the Irrigation Law and stipulated lower-level regulations under the Irrigation Law based on the comprehensive guidelines that have been generated and implemented by technological cooperation projects.
   - Egypt: Established a roadmap that includes an implementation plan for the next 10 years. Ministerial approval is to be obtained.

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**South Korea Country Paper: Institutional Reforms in Irrigation Sector for Sustainable Agriculture Water Management, Including Water Users’ Association**

1 INTRODUCTION

South Korea is located at the far-east of Asia, while it has a quite sound condition for agriculture with four vivid seasons and moderate temperatures (Figure 1). It was reported from excavated relics that rice cultivation started about 1,000 BC.

South Korea is in the monsoon area so that the wet and dry seasons repeat every year with seasonal variation of precipitation requiring irrigation and drainage systems for stable agricultural activities (Figure 2). Usually, June through August is the wet season, while most of yearly rainfall occurs during this period, and the other 9 months have about 30% of the annual rainfall (Figure 3). Most crops are cultivated during March to October, except for protected farming and winter crops.

Rice is still the most important grain as the staple food of Koreans since rice has been introduced (Figure 4). Table 1 shows the cultivation areas of rice paddy and dry crops from 2006 to 2015. Table 2 shows the standard ponding depth of transplanting method during rice cultivation (Jung et al., 2014). At present, the direct seeding types covers up to about 11 % (110,000 ha) of the total paddy areas. Now, the average rice production is 5.0 tons/ha. However, the consumption of rice has been decreased by the change and diversity of food tastes (Figure 5). Figure 6 shows the area of vegetable greenhouse by type from 2005 to 2014. The paddy areas were occupied by the greenhouse expansion during 1990~1999 subsidy program of central government and the greenhouse on paddy still consistently increases. The farmers graying and the greenhouse farming increase of young farmers is now accelerating the decrease of rice cultivation. Under the situation, the direct payment to paddy rice farmers was introduced since after the 2001 WTO DDA (Doha Development Agenda). South Korea in the present days (2016) has 17,401 agricultural reservoirs, 7,890 pumping and drainage stations, and 44,848 weirs covering 440,807 ha, 193,087 ha, and 113,901 ha respectively (Figure 7). The enhancement of agriculture and irrigation of paddy fields have been a principal responsibility for governing the country in Korean history. When the country was faced with hardship accompanying destabilizing social movements or starvation due to natural disasters, such as droughts and floods, the government has attempted to ameliorate these disasters by constructing new irrigation systems or rehabilitating existing ones.

As one of the information and communication technologies (ICT) leading countries, the use of ICT applications for agricultural water resources management has been made due to its benefits in terms of efficiency improvement and cost effectiveness. Since 2001, the MAFRA (Ministry of Agriculture, Food and Rural Affairs) and the government agency KRC (Korea Rural Community Corporation) has invested in reservoir water level monitoring project, which targets at nationwide 1,570 agricultural reservoirs, 7,890 pumping and drainage stations, and 44,848 weirs covering 440,807 ha, 193,087 ha, and 113,901 ha respectively (Figure 7). The project has been completed at 37 irrigation districts since 2001 will be invested until 2021 with total $0.5 billion. Recently during 2009 to 2015, total 113 agricultural reservoirs were rehabilitated to secure 0.28 billion tons of water for flood and drought prevention including stream management flow as part of four major river restoration project ($2.7 billion).

In this country paper, to provide understanding of irrigation sector in South Korea, the history of agricultural policy, institutional and organizational change, the present effort of PIM (Participatory
Irrigation Management) and the future direction of irrigation and drainage for sustainable agricultural water management.

Figure 1. Seasonal Climate Characteristics of South Korea (http://web.kma.go.kr/eng/biz/climate_01.jsp)

Figure 2. Yearly normal mean temperature (°C) and precipitation (mm) of South Korea (http://web.kma.go.kr/eng/biz/climate_01.jsp)

Figure 3. The monthly normal mean temperature (°C) and precipitation (mm) in Seoul (http://web.kma.go.kr/eng/biz/climate_01.jsp)

Figure 4. The present cultivation areas in South Korea
Table 1. The trend of cultivation areas of rice paddy and dry crops from 2006 to 2015 (MAFRA and KRC, 2016)

<table>
<thead>
<tr>
<th>Cultivation Area (1,000 ha)</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1,800</td>
<td>1,782</td>
<td>1,759</td>
<td>1,737</td>
<td>1,715</td>
<td>1,698</td>
<td>1,730</td>
<td>1,711</td>
<td>1,691</td>
<td>1,679</td>
</tr>
<tr>
<td>Rice Paddy</td>
<td>1,084</td>
<td>1,070</td>
<td>1,046</td>
<td>1,010</td>
<td>984</td>
<td>960</td>
<td>966</td>
<td>964</td>
<td>934</td>
<td>908</td>
</tr>
<tr>
<td>Dry crop</td>
<td>716</td>
<td>712</td>
<td>713</td>
<td>727</td>
<td>731</td>
<td>738</td>
<td>764</td>
<td>748</td>
<td>757</td>
<td>771</td>
</tr>
</tbody>
</table>

Figure 5. The consumption of rice from 1988 to 2015 in South Korea (http://kostat.ko.kr)

Figure 6. The area of vegetable greenhouse by type since 1971 (unit: ha) (MAFRA and KRC, 2016)

Table 2. The standard ponding depth of transplanting method during rice cultivation (Jung et al., 2014)

<table>
<thead>
<tr>
<th>Date</th>
<th>5/11–5/31</th>
<th>6/1-6/30</th>
<th>7/1-7/31</th>
<th>8/1-8/20</th>
<th>8/21-8/30</th>
<th>9/1-9/10</th>
<th>9/10-9/20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing stage</td>
<td>Transplanting</td>
<td>Tillering</td>
<td>Panicle initiation/ booting</td>
<td>Heading/ flowering</td>
<td>Ripening/drainage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed ponding depth (mm)</td>
<td>132</td>
<td>50</td>
<td>34</td>
<td>58</td>
<td>86</td>
<td>38</td>
<td>74</td>
</tr>
<tr>
<td>Recommended by Government (mm)</td>
<td>60</td>
<td>40</td>
<td>0</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>
2 LEGAL FRAMEWORK

2.1 Review of Institutional and Organizational Aspects of Irrigation and Drainage Sector

Figure 8 shows the institutional and organizational transition of irrigation and drainage (I&D) sector of South Korea from 1906 to present. Historically, the modern irrigation management started with the establishment of the Jeonbuk Water Users’ Union in 1908. The beginning of I&D organization in South Korea was ‘Irrigation Union’. In 1938 after that, the federation of ‘Irrigation Union’ was founded as ‘Land Federation’. Another one, ‘Agricultural Land Corporation’ was launched in 1942 as a government agency by merging ULIA (Union of Land Improvement Associations, 1962~1970) and GDC (Groundwater Development Corporation, 1969~1970). The 3 organizations were modified by the government law in 1962, civil law in 1962, and agricultural community modernization promotion act in 1970 respectively. In 2000, the 3 organizations were unified with equal rights to KRC (Korea Rural Community Corporation) to enhance operational efficiency of I&D sector and to strengthen services to farmers. At that time, the KRC was in charge of two third parts of the total irrigation areas with about 20% facilities and the remains were to local governments. The KRC raised operation and management (O&M) funds through profitable business, such as sales of irrigation water, lease of facilities and disposal of assets together with supports from central government.

Since the KRC organization, the irrigation water was provided free of charge and the operation expenses of KRC were totally supplied from the central government. The yearly water charge before 2000 was 5 kg of rice per 10 are. The farmers union is now existed as ‘Managing Board of Representatives’ with central board (14 farmers) and branch boards (1,139 farmers) nominally. Thus, the Participatory Irrigation Management (PIM) by the FLIAs farmers was almost disappeared since 2000 and the irrigation responsibility was totally transferred to KRC as the Public Irrigation Management (called PubIM in our case). Figure 9 shows the present Public Irrigation Management Structure. Now, the farmers cannot participate in decision making for irrigation management in KRC areas and cannot elect union and regional office leaders. Because the KRC forms the boards, and nominates the central and regional representatives, now the farmers had no decision-making authority.

In 2000, even though South Korea has grown the GDP world ranking as 12th, the agricultural water use occupies about 65% with 35 % irrigation efficiency which is less than 38 % for the 93 developing countries in 1998. Under the particular situation of aging farmers, aging facilities, and pushback on the priority list by the government industrial policy, the KRC has strived to improve the management and operation efficiencies by introducing TM/TC (tele-metering & tele-control) technology.

2.2 Issues and Challenges Related to Land and Water

Before telling about the issues and challenges of our future land water, we need to understand couple of things which have been affected to agricultural land and water in South Korea.

Firstly, ‘Large scale project for integrated agricultural development’ started in 1969 acquiring loans from IBRD, ADB, and OECF. Together with the graduation of GATT-BOP in 1989, the on-going large-scale projects were continued with 100 % support of government subsidy. Almost the projects were conducted with land reclamation projects along the west coast. Presently still we have 2 large projects of Saemangeum (1991~) and Yeongsan (Phase I: 1972~1986, Phase II: 1976~2007, Phase III: 1985~; Phase 4: 2001~) river basin agricultural development (Figure 10 and Figure 11). With the aid of the projects, we accomplished 100% of rice self- sufficiency ratio by overcoming the population growth.
Figure 8. The Government Organization of Irrigation Management in South Korea since 20th Century

Secondly, as shown in Table 3 and 4, the government agricultural policy was turned to ‘rural community’ development from ‘agricultural infrastructure’ development since 1990 for farmers’ protection from the coming GATT-UR and FTA, and rural life quality improvement. The ‘Special Act for Rural Community Development’ was enacted in 1990, and in 1991, a comprehensive plan of a 42 trillion won investment and loan plan for the agricultural sector during 1992~2001 was established. Thus, the budget for agricultural land and water development has been decreased by finishing the pre-existing large-scale projects while the welfare budget for rural community development has gradually increased until present. The government legislated a Direct Payment Program for paddy field agriculture in 2000, a Direct Payment Program for compensation of income from rice in 2002, and a Special Act for Improved Quality of Life in 2005. At present, the rice and dry crop subsidies are about $850/ha and $360/ha respectively.

Thirdly, the environmental problem has become the social issue since 1990. The compensation for fishery rights by tideland reclamation, the value comparison between mudflat ecological system and agricultural land development impeded and retarded the project progress for a long time. In addition, the nonpoint source pollution from agricultural lands and point source pollution from rural
communities are still the critical issue to prevent the water quality decline by increasing investment in BMP and village-unit sewage treatment facilities.

Lastly, the climate change approached to agriculture as a big threatening factor. The 2001 spring extreme drought for 3.5 months and the mega flood by Typhoons of 2002 Rusa and 2003 Maemi provoked to re-plan the irrigation and drainage infra for future climate change adaptation and mitigation. The ICT application to I&D facilities has been the solution to implementation method.

With the above agricultural policy changes and factors to solve the future agricultural land and water problems, presently we need some new emerging issues and challenges for our national food security with safe, stable, and efficient I&D.

By the tendency of holding for rapid decrease of rice paddy area and gradual increase of dry crop area, we need some suitable irrigation system for cry crops using the existing irrigation networks and need to improve the irrigation efficiency by recommending drip irrigation system. For the increase of greenhouse cultivation by young generations, the farmers need all the year-round customized irrigation water under their own water supply facilities, for example, personal groundwater development. Because of this kind of groundwater abuse for warmth keeping during winter periods cultivation, we need to recharge the used warmth keeping groundwater. This also will help to solve the stream drying phenomena which have been a social problem since 2000 by the increase of winter groundwater use, temperature increase bringing earlier spring, and dry spell increase during spring periods.

Recently, the smart farming boom using the fully controlled environment with ICT has been created. We can foresee that the smart farming and further smart crop production factory would be alternative solutions for our limited land and water problems. The ‘smart’ cultivation can be an attractive job market by accomplishing one’s own little world water-food-energy nexus.

Figure 10. Saemangeum large scale project outline (www.isaemangeum.co.kr)

Figure 11. Youngsan large scale project outline (KRC and KCID, 2014)
2.3 Need for Institutional and Organizational Structure Reforms for Sustainable Water Management

The present agricultural water situation in South Korea can be summarized as follows. The irrigation water became free of charge since 2000 by the government policy. The KRC has been working steadily...
to raise the irrigated paddy areas and now they reached to 80.6 % (752,598 ha) in 2014 statistics. Among them, 60.1 % has the capacity to endure 10-yr return period of drought. However, by the 11 times droughts (2000, 2001, 2006, 2008, 2009, 2012, 2013, 2014, 2015, 2016, 2017) since after 2000, the agricultural reservoirs frequently fell far beneath the average in their original capacity at the right time of irrigation needs.

By the economic disadvantage compared to other industry reaching to limitation for hard-infrastructure development, environment priority over agriculture, and climate change attack for itself, the agriculture is placed in a dilemma between holding operations for the present organizations and making a breakthrough by new emerging technologies (for example, drone monitoring, self-driving tractor, big data computing etc.).

Now, the management organizations of agricultural water resources and watershed streams are separated to Ministry of Agriculture, Food and Rural Affairs (MAFRA) and Ministry of the Interior (MOI). For the integrated water resources management (IWRM) in agricultural sector, we need the organization unification of water management function between MAFRA and MOI to keep the always flowing streamflow from watershed to streams and secure the reservoir inflows for irrigation water requirements.

3 The Participatory Irrigation Management (PIM) in South Korea

3.1 The Need of PIM and its Approach

As mentioned earlier, the irrigation responsibility was totally placed on the government agency, KRC in 2000 by national law. Since 2000, the irrigation water has been converted to free of charge and the management and operation expenses of KRC were totally supplied from the central government. Thus, the Participatory Irrigation Management (PIM) chance was almost disappeared since 2000 and the remaining things are the irrigation channel mainly for branch channels and lateral turnouts employing rural peoples by KRC.

With this kind of situations, the irrigation water was supplied by the farmers’ requests from reservoir managed by KRC and local governments, and reuses the discharged water to the downstream by using pumping stations. Because of the free water and the low efficiency of irrigation water, the KRC has converted the earth canals to concrete canals and introduced the TM/TC irrigation control system to enhance the water conveyance efficiency. Even this kind of government investment efforts, there are still difficulties for managing the automated lateral turnouts because the farmers are struggling to supply water first to his/her field and eventually break the turnout function. This causes the low irrigation efficiency even though the government invested the modernization of irrigation system during the past couple of decades.

Since 1962, South Korea has focused on the self-supply achievement of rice as a national policy. By the reason, the irrigation system has been developed for rice paddies and the irrigation system for dry crops was not well developed by the reason of small cultivation areas and the difficulty for the water conveyance to hillslope areas from stream or reservoir. Thus, the dry crop areas are still remained as irrigation vulnerable areas especially for spring drought periods.

Thus, we need two tracks of PIM recovery for rice paddies irrigation and dry crops irrigation. For the rice paddy PIM among the many approaches, one of the South Korea customized PIM can be the introduction of incentive granting program for the good maintenance of turn out based on the affiliated farmers or district unit. For the dry crop PIM, the co-utilization of groundwater well can be one of the way. However, most of the dry crop farmers are small hold farmers, KRC need to develop the well, and the water supply system and almost the whole operation cost need to be supported by the government.
Now, the irrigation management transfer (IMT) from local government to KRC is an emerging social issue for better I&D service. The irrigation sector managed by local government has received relatively low quality of service by the insufficient financial support from local government compared to the KRC. Thus, there was a recent study (Choi et al., 2016) for the IMT with an extensive survey with structured questionnaires. The survey results showed that most of the farmers, KRC members, and local government officials agreed with the IMT from local government to the KRC. However, the transfer of assets revealed divided opinions for the farmers’ contribution to the maintenance of canals, including clearing water weeds and dredging ditches. In addition, some actions have to be implemented to improve irrigation management by encouraging farmers’ participation under the public irrigation management (PubIM) system. These actions include reorganization of the discarded water management committee to revive the concept of PIM and direct subsidies for loyal farmers as an incentive for their labour.

### 3.2 Water Use Efficiency and Cost Recovery

Irrigation canal and drain improvement is steadily implemented to increase irrigation efficiency. Earth, lined and flume canals are quite typical waterways for irrigation in Korea and drop, chute and gates are usually used for slope declining and water distribution in irrigation networks. Structured canal ratio has been increased due to the effort for irrigation efficiency improvement as shown in Figure 12. In addition, the use of ICT applications for agricultural water resources management is being made due to its benefits in terms of efficiency improvement and cost effectiveness.

Table 5 shows the constitution of irrigation management cost from water fee, subsidy from government, and revenue from FLIA (Farmland Improvement Association) before 2000 and Table 6 shows the transition of irrigation water fee from farmers. Since 2000, after the farmers’ water fee was exempted, the O&M costs were provided by the central government and KRC. The O&M cost increased from $214 million in 2000 to $339 million in 2013. The cost share in 2013 was 36.6% for government and 63.4% for KRC. The KRC requests more government funds with the maintenance cost share between central government: local government: KRC: farmer of 4:3:2:1. According to a survey conducted by the KRC in 2007, 39% of farmers were willing to pay water fees of $60 per ha, which was about 10% of the total maintenance cost (Lee and Kim, 2011).

![Figure 12. The changes of structured canal during 1990~2009 (MAFRA and KRC, 2012)](image)

Table 5. The constitution of irrigation management cost before 2000 (Lee and Kim, 2011)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard of IAF (per 10a)</td>
<td>Rice 26kg</td>
<td>Rice 10kg</td>
<td>Rice 5kg (89~95)</td>
<td>6USD (96~99)</td>
<td>-</td>
</tr>
<tr>
<td>Irrigation fee</td>
<td>66%</td>
<td>23%</td>
<td>13%</td>
<td>8%</td>
<td>-</td>
</tr>
<tr>
<td>Subsidy by Government</td>
<td>7%</td>
<td>45%</td>
<td>61%</td>
<td>21%</td>
<td>30%</td>
</tr>
<tr>
<td>Revenue by FLIs</td>
<td>27%</td>
<td>82%</td>
<td>26%</td>
<td>71%</td>
<td>70%</td>
</tr>
</tbody>
</table>
### Table 6. The transition of irrigation water fee from farmers (Lee and Kim, 2011)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Year</th>
<th>Irrigation fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1987</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Non Subsidy by Government)</td>
<td></td>
<td>- Establish Irrigation Association</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Collect Irrigation Association member fee (IAF)</td>
</tr>
<tr>
<td></td>
<td>1908</td>
<td>- Enactment for IAF (Farmers say not IAF but Irrigation tax)</td>
</tr>
<tr>
<td></td>
<td>1917</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1952</td>
<td>- Permission parallel payment of IAF (Cash, Goods)</td>
</tr>
<tr>
<td></td>
<td>1983</td>
<td>- Setting maximum of IAF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reservoir beneficiary area 25kg/10a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pumping station 30kg/10a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pumping &amp; Drainage station 8kg/10a</td>
</tr>
<tr>
<td>After 1987</td>
<td>1987</td>
<td>- Rejection and abolition demand by water user (farmer)</td>
</tr>
<tr>
<td>(Subsidy by Government)</td>
<td>1988</td>
<td>- Rapidly reduction of IAF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7.33 kg/a ≤ Supervision ≤ 8.11 kg/a)</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>- Change to Cash(6 USD/10a)</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>- Abolition of IAF</td>
</tr>
</tbody>
</table>

### 4 CHALLENGES

#### 4.1 Water Accounting and Auditing

The water accounting in agricultural sector of South Korea has not been properly treated. Since 2001, the MAFRA (Ministry of Agriculture, Food and Rural Affairs) and the government agency KRC (Korea Rural Community Corporation) has invested in reservoir water level monitoring project, which targets at nationwide 1,570 agricultural reservoirs having effective storage above 0.1 million ton in order to watch reservoir flow, alert flood and control storage water for drought in real time ([https://rawris.ekr.or.kr](https://rawris.ekr.or.kr)). KRC also has updated and modernized irrigation practices by introducing TM/TC (tele-metering & tele-control) technology. The project has been completed at 37 irrigation districts since 2001 will be invested until 2021 with total $0.5 billion. Recently during 2009 to 2015, total 113 agricultural reservoirs were rehabilitated to secure 0.28 billion tons of water for flood and drought prevention including stream management flow as part of four major river restoration project ($2.7 billion).

#### 4.2 Engineering Challenges

South Korea is now preparing the forthcoming 4th industrial revolution (4IR) age by strong soft-infrastructure building. As already mentioned, the keyword in private sector is ‘smart’ by introducing summarized ICT. Since the technology foundation of 4IR is ICT and pursues hyper-connection mutually, it is required to re-establish nationwide information linkage between a sector and other sectors. This means that the government side needs to reform or link the institutional and organizational structures in irrigation sector and the related sectors. South Korea has central government organizations for irrigation water management by KRC (Korea Rural Community Corporation, [http://eng.ekr.or.kr/ Kenpub/index.krc]), crop water management by RDA (Rural Development Administration, [http://www.rda.go.kr/foreign/ten/]), agricultural product distribution by aT (Korea Agro-Fisheries & Food Trade Corporation, [http://www.at.or.kr/home/apen000000/index.action]), and local government institutions at each city and provinces for providing agricultural technology and information ([http://agro.seoul.go.kr/](http://agro.seoul.go.kr/), [http://nongup.gg.go.kr/](http://nongup.gg.go.kr/)). If they are linked each other, they can provide alive information and knowledge contents from farming irrigation to food supply to personnel (from watershed agricultural water resources-water production-water supply-water consumption-crop yield-food delivery-food safety-to people’s welfare) (Figure 13).
4.3 The direction of Public Private Partnership (PPP) in South Korea

The irrigation management system of South Korea has been revolutionarily changed by the law in 2000 from private (PIM; Participatory Irrigation Management) to public (PubIM; Public Irrigation Management). From this change, there were positive and negative aspects for the water supply and use. The positive effects by PubIM were the stable investment of new I&D facilities and repairs, the systematic operation of I&D facilities, and the risk management for drought event by KRC. The negative effect was the full dependency of water supply from central and local governments. This resulted in the weakened and limited participation for irrigation works, and the abuse of water as a result with still less than 40% irrigation efficiency even though the O&M and branch channels have been modernized.

Therefore, we need to recover the partnership acceptable and executable with farmers for water saving and environmental conversation of their private controlled areas. For the farmers’ participation, the government needs to give incentives for the farmers’ efforts of saving and conservation, and financial supports for the new WUG (Water Users Group) organization and activities. For the partnership restoration between public and private, the KRC needs to give more rights and duties to the board of representatives in the KRC and government decision making processes. Among the rights and duties to be given and recovered, the most important and first thing is the reorganization of WUGs to revive the concept of PIM through the autonomously reinforced new type of WUGs. The second thing is that KRC needs to recover the rights of collecting water fees from the farmers for the better irrigation service adjusted by PPP between WUGs and KRC.

5 RECOMMENDATIONS

As described above, the PIM and the PPP concepts of South Korea were broken and could not be operated well by the government legal action of unification from 3 organizations (ALU, ALUF, and RDC in Figure 8) to government agency, KRC in 2000. After that, the irrigation management has been dependent on public side. Thus, we, first of all, should recover the function of PIM and PPP by reorganizing WUGs with decision making rights and water price duty for better water sharing and service.

Agricultural water management is so complex because it concerns different spatial and temporal scales and multiple stakeholders with varying goals. Information on the spatio-temporal variability of environmental parameters, their impacts on soil, crop, water, and other components of farming play
a major role in formulating the farmers’ strategy. Today, farmers and water-related stakeholders can utilize the convergence of several technologies including in-field sensors, geographic information system (GIS), remote sensing (RS), crop and water simulation models, prediction of climate and advanced information processing and wire/wireless communications (Panchard et al., 2006). As already mentioned, the information and communications infrastructure in South Korea is now well equipped for irrigation management applications between government and farmers. Thus, as the future irrigation water management of South Korea, it is necessary to build the bi- or multi-directional synchronous linkage of shared information for irrigation management. This is the direction of 4th industrial revolution preparation in agricultural activities.

The big problem to solve is the adaptation and mitigation of climate change impact on sustainable irrigation. The future climate trend certainly goes to become hotter and drier resulting in the difficult irrigation water management. Despite increased stress on agricultural water resources, many water users and managers are still unaware of practical, cost-effective irrigation water efficiency improvements they can make. Strategies or plans for irrigation water efficiency are largely lacking, both in the public and private sectors. The PPP for enhancing the irrigation water use efficiency in supplying and cultivation processes are very important. The irrigation water efficiency should be the indicator between the amount of water required for irrigation purpose and the amount of water used or delivered for irrigation (Vickers, 2001).

6 REFERENCES


***************
INTRODUCTION

Malaysia has a total area of 600,000 ha of paddy cultivated land of which 280,000 ha is mostly irrigated by the tertiary system, while the balance is without sufficient irrigation infrastructure. Of the irrigated area, there are twelve granaries area, located sparsely distributed in the Peninsular Malaysia, while the other two are located in Sabah and Sarawak. The development of these irrigated area started since independence in 1957, with the development of Muda Irrigation Project 96,558 ha, which uses gravity fed main system up to secondary level and the Kemubu Irrigation Project 29,450 ha which used the pump lift system at the main water intake. Since the completion of the pioneer two major irrigation project, another ten has been developed since then. The irrigation infrastructure density varies between 18 m/ha to 48 m/ha.

A total of almost 100,000 family farmers has benefited from this irrigated area project with the implementation of rice double cropping. The government provided incentives of subsidized fertilizer and also incentives for increase in yield production. The farmers’ income has increase from poverty level (income less than USD 500) in the 1970’s to more than USD 6,000 per year at present time. Other socio-economic activities were also carried so that the farmers’ income does not solely dependence on rice production only. A total of 70% of self-sufficiency level of rice production has been achieved for the country from all the granary areas. The balance 30% of the rice production is imported from neighbouring ASEAN countries.

With the ageing of the infrastructure facilities provided since independence and the “inappropriate” assumption in designing the tertiary system, the planned operation by modular water user group in the irrigation blocks has declined. The new approach of making use of Small Farm Units (SFU) in the irrigation blocks to revitalize the water user group in the irrigation blocks has shown success. This approach has been initiated by the federal agencies to be implemented in all the granary by rolling out a master plan in November 2015. It is envisaged that with the new approach of using the small farmers units as the basis to form the Water Use Association (WUA) in the Granary Area will derived positive results from the farmers.

From the rapid appraisal process (RAP) carried out in Muda Irrigation Area as the case study, the overall index of water user group (WUG) is 0.6, which is relative low compared to other countries where RAP was conducted. With the new approach of development off the Water User Group by leveraging on the strength and potential of the SFU’s, it is projected that the overall index of the water user group will increase to near unity.

The principle of good governance in water user association is applied in the irrigation blocks where adequate and reliable water supply, legal status and participation, organization within the hydraulics boundaries, water deliveries can be measured volumetrically and equitably collection of water charges from members of the WUA are imposed to all members and owners of land plots. With this implementation, the fifth National Mission of strengthening the institutional and implementation capacity of the farmers in the country will be realized.
1.1 Malaysia’s Development Plan

Development is the thrust of any nation building to uplift the quality of life of its people. Since life begins man needs to satisfy the physiological needs of human being to consume food as the most basic human needs. All developed and developing countries focus on providing food to its population, with some countries able to export for income generation and some needs to import to supplement their needs.

After independence, as a new nation, Malaya (then Malaysia) has charted its direction to fulfil its development goals. Major development programs were carried prior to independence and post-independence period. It started with First Malaya Plan (1956-1960) to the current Eleventh Malaysia Plan (EMP: 2015-2020). All the development plans gave emphasis on agriculture sector development with one of the latest was in the Ninth Malaysia Plan (2006-2010) to revitalize the agriculture sector as the third engine of economic growth. The emphasis is to promote New Agriculture which give priority to modernization and improve productivity.

In the Tenth Malaysia Plan (TMP: 2011-2015), Malaysia focus its economic growth efforts on National Key Economic Area (NKEA). An NKEA is defined as a driver of economic activity that has potential to directly and materially contribute a quantifiable amount of economic growth to the Malaysian economy. Agriculture is one of the twelve major NKEA identified. One of the strategies in the Agriculture NKEA is to set up agriculture cooperatives to commercially intensified paddy production in the granary area. The economics of scale of the farms size to be centrally managed is one of the factor taken into consideration.

In the current Eleventh Malaysia Plan (EMP: 2016-2020) the agro food and industrial commodity will be transformed and modernized into a high income and sustainable sector. This sector is expected to grow at 3.5% per annum contributing 7.8% to GDP in 2020. Industrial commodities will contribute 57% and agro food 42.4% to the total agriculture value added in 2020. Seven strategies have been identified. The first is to get the involvement of smallholders farming community to optimize production from agricultural land.

1.2 Irrigated Agriculture Development in Malaysia

The Government launched two major irrigation projects during the First Malaysia Plan (FMP: 1966-1970), after independence to increase production of rice, the nation staple food. In 1966, the Muda Irrigation Project (refer Figure 1) was initiated whilst the Kemubu Irrigation Project took off in 1968. These projects are integrated in nature, combining engineering infrastructure work and agriculture. The main objective of these projects is to provide sufficient supply of staple food for the nation’s population and to reduce poverty among the farmers by increasing their income.
The priority of development was to provide basic irrigation infrastructures which consist of a network of canals and drains, control structures and farm roads to areas producing staple food for the country. Initially Muda Area was provided with infrastructure at a density of 10m/ha only. Realizing the inadequacy of infrastructural density in Muda Area, about a third of its area was later provided with tertiary irrigation and drainage infrastructures with a density of 30m/ha. The other seven granaries were later developed with higher intensity between 35 to 50 m/ha.

Provision of infrastructural development in irrigation projects without addressing the human needs bounds to have problems of implementation. Thus, the need for irrigation extension was realized in the early stage of the implementation of the irrigated agriculture development. Participation from the farmers in the design, operation and maintenance of the tertiary irrigation and drainage infrastructures by conducting “kursus tempatan”. However, the voluntary participation of farmers to operate and maintain the infrastructures leaves much to be desired.

In the era before irrigation infrastructure were provided, farmers helped out each other in the single cropped paddy planting activities which is wholly dependent on the rainfall. When modern irrigation facilities were provided and double cropping introduced, farming activities like transplanting and harvesting were still labor intensive before mechanized land preparation was introduced.

2 LEGAL FRAMEWORK OF MUDA AGRICULTURAL DEVELOPMENT AUTHORITY (MADA)

After the completion of the Muda Irrigation Project, the Muda Agricultural Development Authority (MADA) Act (Act 70 of 1972) was enacted by the Parliament of Malaysia for the purpose of the operation and maintenance of the Muda Area with two main function:

a) To develop, promote, facilitate and execute socio and economic development in the Muda Area.

b) To plan and execute in the Muda Area any agriculture development that has been authorized by the State Government of Kedah and Perlis.

Administratively MADA serve the function of three (3) departments of the Federal Agency. The departments are the Department of Agriculture (DOA), Department of Irrigation and Drainage (DID) and the Farmers’ Organization (LPP). The administration for the operation and the operation and maintenance cover an area of 100,685ha is divided in four (4) region. Two main activities are carried out by MADA annually. The major part of the activity is planting paddy for double cropping and supply of irrigation water for the double cropping.

To serve the population of over 53,000 farmers, Muda Area is served by 27 Farmers’ Organization (FO) formally called locality. The Farmers’ Organization law was also enacted by the Act of Parliament, Farmers’ Organization Act 110 of 1973 (refer Figure 2). The main purpose of the Act is to help the socio and economic development of the farmers under one single organization. The FOs’ has a mandate to carry out business activities under its Act to increase the income of its members.

The Farmers’ Organization has its vital supporting element called Small Farming Units (SFU). There are 496 SFU under the care of the 27 FO’s. Each FO has an average of between 15 – 20 SFU each. The SFU have an elected committee which the members reside every two years to elect the Committee. The SFU is administered by a special “Procedure to Administer and Manage the Small Farming Units”. The highest authority of the SFU is the bi-annual general meeting or the Extra Ordinary General Meeting.

The farmers at the unit level are the main player for the double cropping of rice in the Muda Area. The main activities of paddy planting in Muda Area starts with mechanized land preparation, sowing either
in wet or dry condition, pest and disease monitoring, utilizing water supply from bulk supplier and harvesting by combined harvester is very well handled at the unit level.

For coordination purpose between the farmers’ organization and the MADA’s management a coordinating committee was set up. This coordinating committee has a representative from each region. The Coordinating Committee meet once a month with the MADA’s management to discuss issues related to the farmers welfare.

2.1 The Muda Area

The Muda Irrigation Project or now commonly known as Muda Area, is located in the North-west of Peninsular Malaysia (Figure 1), occupying a flat coastal alluvial plain straddling the states of Kedah and Perlis. This area is the oldest area being planted with paddy since the construction of an irrigation canal constructed by the Prime Minister of Kedah, Wan Muhammad Saman, completed in 1895. The canal still in use until now is 35 km in length, 7 m wide and 1.5 m deep run from the present state capital Alor Setar to the mountain range of Kedah Peak, where the water source comes from during the monsoon period.

The climate in Muda Area is tropical and the area is shielded from direct rain-bearing winds of the North-east Monsoon and the South-west monsoon the main range to the east and Sumatra to the south-west. Rainfall during the wet season is usually sufficient to maintain one crop of paddy per year. However, the “off-season” crop from May to September has to depend on irrigated water which has been impounded in three dams in the eastern part of the Muda Area some 100 km away.

The development of the project area has covers three distinct stage:

a) Early development which consist of basic infrastructure and reticulation system including two dams constructed from 1965 to 1975. Canal, drain and farm road density is only at 10 m/ha.

b) First phase tertiary system development from 1979 to 1999 which aims to increase the canal, drain and farm road densities to 35m/ha in 45 irrigation blocks only.

c) Second phase tertiary development system under the National Key Economic Area (NKEA) to increase the density up to 30m/ha in the remaining 128 irrigation blocks and to establish a centrally managed farm in 50,000 ha of the paddy area from 2011 to 2020.
Being the largest granary in Malaysia, Muda Area has been producing almost 40% of the National paddy production. The average gross yield is 6.3 ton/ha with a target to increase production up to 8 ton/ha in 2020 through modernization and technological input in paddy cultivation. Even though the national self-sufficiency level for rice is set at 70%, increasing production in the Muda Area will benefit the farmers directly through increase in paddy production and indirectly to the nation by reducing the imports of food bill.

3 PARTICIPATORY IRRIGATION MANAGEMENT (PIM) IN THE MUDA AREA

Paddy cultivation in the Muda Area has evolved from the traditional farming by using water buffaloes for land preparation in the pre-Muda era, to mechanized land preparation and harvesting by the combined harvester. Farmers tend to their plot with “berderau” spirit among the farmers in the same village. During this time irrigation is totally dependent on the monsoon rainfall and without proper irrigation and drainage infrastructure.

With the development of Muda Irrigation Project, farmers are encouraged to form group farming or “kelompok” in the definite irrigation blocks to cooperate among the members to carry out farming activities with the provision of secondary level infrastructure. After the First Phase Tertiary development, the “kelompok” based farming grew into “semi estate” entity through the Irrigation Service Area (ISA) which consist of three to four Irrigation Service Units. The objective of forming “semi estate” paddy farming is for the farmers to fully utilize the tertiary infrastructure provided at individual plot level. With the improved facilities in the tertiary irrigation blocks it was recorded increase in yield for farmers in the “semi-estate”.

The present NKEA initiated, centrally managed “paddy estate” is similar to the “semi-estate” except the management is carried out by the Farmers’ Organization. The Government also provide incentives for the farmers participation in proportion to the area of land owned by the farmers at the rate of RM2,500/ha. This NKEA “paddy estate” starts in 2011, with the objectives to form 50,000ha of paddy estate in 2020. The formation of the “paddy estate” since 2011 until 2016 is highlighted in Table 4: Basic Information of NKEA Central Management Paddy Estate.

Throughout the evolution of over 43 years of the different phases of farming activities i.e. “kelompok”, “semi-estate” and “paddy estate”, the most important condition to begin the planting season is the preparation on the irrigation schedule at the beginning of each season. The participation of the farmers is through their elected leaders from the unit to locality level and also through their representative in the Farmers Coordinating Committee.

Irrigation management in Muda Area is a consultative process. It normally starts with the meeting between the MADA’s management with Farmers’ Coordinating Committee from the Farmers Organization (FO). The purpose is to propose and agree to a planting schedule before each planting seasons starts. The consultative process can be summarized in Figure 3.

The consultative process takes place at four different levels, the headquarters, regional, locality and unit. The crucial process is at Step 1 to Step 4 (in Figure 3) where decision on the planting schedule starting date is made. At Step 5 and Step 6 the farmers at the locality and unit are informed of the planting schedule decision.

This consultative process for planting schedule is part of the procedure in the Quality Management System (QMS) Malaysian Standard (MS) ISO 9001 of MADA’s organization. The implementation of the QMS since the year 2001 has further encompassed Participatory Irrigation Management (PIM) in
Muda Area as the system mandatory requirement of customers’ satisfaction on irrigation management services included in the QMS.

Table 4. Basic Information on NKEA Central Management Paddy Estate

<table>
<thead>
<tr>
<th>REGION</th>
<th>AREA (ha)</th>
<th>Total Area (ha)</th>
<th>Number of Farmers</th>
<th>Data Source</th>
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<td>B</td>
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<td>E</td>
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</tr>
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<td>T</td>
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<td>124.123</td>
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<td>U</td>
<td>242.039</td>
<td>127</td>
<td>264.133</td>
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<tr>
<td>V</td>
<td>79.193</td>
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<td>5.018.285</td>
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<td>5.362.732</td>
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**Figure 3. Planting Schedule Consultative Process**

**Step 1**: Farmers Coordinating Committee Membership - General Manager, Chairman, Manager, Head of OFFICE, Head of District Services Division, and Regional office.

**Step 2**: Water Supply and Planting Schedule Meeting - Headquarters internal information dissemination: Irrigation and Drainage Services Division and Regional office. Task: To elaborate planting schedule proposals.

**Step 3**: Water Supply and Planting Schedule Meeting - Region.

**Step 4**: Water supply and planting schedule meeting MADA.

**Step 5**: Water Supply and Planting Schedule Meeting - Locality.

**Step 6**: Water Supply and Planting Schedule Meeting - Unit.

**Step 7**: Water Supply and Planting Schedule Meeting - Unit.
The meeting for the consultative process for the preparation of the irrigation schedule normally occurs twice a year before the starts of each season. The first season also known as the “off-season” normally starts in Mac with harvesting normally occur in August. The second season or the main season normally starts in August/September and harvesting starts as early in December the same year. This meeting serves as platform for direct feedbacks from the farmers’ to MADA’s management.

3.1 Water User Association (WUA) Approach of PIM in Muda Area

In the Muda Area, it is envisaged to have Water User Association (WUA) in all 172 irrigation blocks. Each irrigation block has its definite irrigation and drainage boundaries. The farmers’ representation in the irrigation block is through their elected leaders in the village called Small Farming Unit (SFU). An irrigation blocks may consist more than one small farming units. In an ideal case of a single unit in an irrigation blocks, the elected SFU committee can form the WUA committee. For irrigation blocks with more than one SFM, representative from the different SFU will be nominated or chosen to sit in the WUA committee at irrigation block level.

The structure in the SFU is the same as the proposed organization of the WUA is shown in Figure 4. It was strategized to form the WUA in the previously started group farming or “kelompok” and the “semi-estate” and NKEA “paddy estate”, projects carried out by the farmers. A study by Kamaruddin et. al. in 1997 suggested the formation of WUA in the Muda Area will benefits in the following forms:

a) The WUA will convene to establish their irrigation block schedule to carry out the farming activities.

b) The WUA association can reduce conflicts during the supply of irrigation water

c) The formation of WUA is to inculcate the awareness on water productivity among the farmers.

   The farmers will get incentives with the increase in yield and water productivity.

d) A more optimized water consumption will be translated among the farmers.

The purpose of the formation of the WUA is to have interaction between the committee of the WUA with the operational staff in the water management section at the locality office. Matters related to field water management, maintenance of waterways and operation and maintenance of tertiary level irrigation and drainage structures is handled by this combined unit called the Secretariat of the Water User Association (WUA).

![Figure 4. Water User Association (WUA) Organization Chart](image_url)

With the present approach of forming WUA based on SFU in the respective irrigation blocks, eight Water User Association (WUA) established up to year 2016 in the Muda Area. An intensified approach in 2017 is targeted to establish 19 more WUA in the selected irrigation blocks. The status of the
pioneer group farming and WUA is highlighted in Table 5: Basic Information of WUA in Irrigation Blocks. The WUA is located in irrigation blocks comprise of an area between 500 to 1000 hectares.

<table>
<thead>
<tr>
<th>Region</th>
<th>WUA Irrigation Block Area (ha)</th>
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<th>2016</th>
<th>2017</th>
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<td>III</td>
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<td>1153</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>136.99</td>
<td>512.33</td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,831.83</td>
<td>1,618.03</td>
<td>7,517.00</td>
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4 OBSERVED IMPACT OF PARTICIPATORY IRRIGATION MANAGEMENT (PIM)

The performance of the PIM can be assessed by the successful implementation of double cropping since the first double cropping in the Muda Area pilot project in Kubang Sepat took place in 1974. Double cropping has since been implemented annually except for the incidence of drought in 1978. One crop was cancelled in the incident.

The participation of farmer’s leaders in the consultative process of the planting schedule thus far has been the thrust well accepted. This process will continue in the future. The in-field water management practice needs more participation from the farmers. As what has been planned in the tertiary irrigation development, farmers are indecisive and reluctant to volunteer taking over the maintenance of waterways (tertiary canals and drains) on the basis that these infrastructures were developed by the Government.

The issues during the tertiary development phase, the concept of “neighboring in the farm” is difficult to practice among the farmers due to absenteeism among the farmers in the farm. This is due to the farmers tending their plot are not residing in the locality.

Proposals by the Authority for the farmers to operate tertiary irrigation structures for water supply also were not well received by the farmers. Situations arise, when irrigation turnouts and regulating structures were damaged probably due to unsatisfied individual farmer on water conflicts in the paddy field. The formation of Water User Association (WUA) in the irrigation blocks with local participation from the same and neighboring villages in Small Farming Units (SFU) are more acceptable to the farming community.

5 CHALLENGES OF PIM IN MUDA AREA

5.1 Management and soft approach – Internal Issues

5.1.1 Building capacity for capable Water User Association (WUA)

Building capacity for a capable water user group is based on the country fifth national mission, “to strengthen the institutional and implementation capacity”. It is envisaged that the formation of the WUA with the emphasis on in-field water management should arrest the issues of allocation, efficiencies, liberalization of economies, enhanced and enlarged participatory approach in decision making, irrigation management transfer and perhaps a new institutional arrangement.

The objective of building a capable WUA is finally to transfer the “ownership” of the operation and maintenance of irrigation infrastructure to the farmers themselves operated by a central management
farming community in a competitive liberalized economic environment. The Government should allow a conducive enabling environment for farmers’ organization to adopt themselves by introducing policy changes in managing the country water resources in a holistic manner.

As Muda Area is the major contributor/player of irrigated agriculture in the country, the options to manage the water resources available for water savings and conservation needs a policy review for the benefits of another consumer in the region. A comprehensive framework of a regulating charter should encompass an integrated approach which covers the inter sector of use of water resources, water efficiency and water conservation needs in the Muda Area.

5.1.2 Revisiting the present agronomic practice
The present wet seeding culture is widely practiced in Muda Area. It consumed almost 1600mm to 1800mm of water annually. This amount is considered high compared to another alternative of planting method especially direct seeding in standing water in the field. Direct seeding in standing water can reduce water consumption for paddy planting substantially. This will be a useful approach in water management to reduce the impact of water shortage in the Muda Area and the region.

Muda farmers start farming activities on their own capacity with their normal networking with the land preparatory who own tractors, to start their land preparation work to rotor the field with water inundated in the field. The seeding process for rice germination, dry or wet, starts after the land prepared earlier by the tractor is leveled by using power tiller which pulled a wooden bar to ‘crest leveled’ the field before the seed is broadcasted.

Prior to the seeding process, in wet direct seeding, water is drained out from the field to allow crop establishment. Water is then requested by the farmers after the seed established usually one (1) week after the seeds are broadcasted. A substantial amount of water is ‘wasted’ during the pre-process of germination of seed. Water is then supplied accordingly and correspondingly through the vegetative height of paddy plant until pinnacle initiation and right to the end before harvesting.

Direct seeding in standing water should be the water saving method of irrigated agriculture in the granaries of the country. By application of this method the water requirement for crop establishment can be reduced. Initial studies at MADA’s training plot shows that water seeding can save water up to 12% when compared to the wet seeding planting method. Emphasis on prudent water management in the paddy field is the key to water savings.

The new irrigation method should be the choice between water saving or water wastage method to be applied in the paddy field. The emergence of mechanical transplanting which also require no standing water to allow trans-planter to transplant the seedling does have some impact to the farming community in term of production cost and income. Additional cost in paddy production will be incurred if this new machine will be widely used in the Muda Area. Planting by mechanical trans-planter seem to be the same as wet direct seeding where MADA’s water management practice is concerned.

5.1.3 Integration and optimization of human and natural resources
Rice production in the Muda Area is water dependent on the four (4) major sources of water in the area. The rainfall in the field, uncontrolled flow from river tributaries downstream of catchments, recycled drainage water and releases from the dam were the priorities of water usage practice in the field. The MADA’s irrigation management practice is in collaboration with the farmers’ leaders when fixing the planting schedule for every season is concerned.

After the process has taken place between the management and the farmers, these messages is widely disseminated to all farmers through radio talks and extending the meeting result through farmers’
association staff and regional office staff. This process is also communicated through religious channel by informing the “jemaah” through the Friday prayer sermon.

Although the process of communicating on the planting schedule to the farmers is carried out extensively, delay in carrying out planting activities is bound to happen by at least two weeks. This delay although seemed a short period of time but the amount of water needed to be supplied is substantial if this delay is not checked.

A regulatory role in the form of guidelines with reference to the governance of MADA’s Act and the Irrigation Area Act should be implemented or guided to the farmers in relation to double cropping activities in the Muda Area. A centralized agronomic and water management concept in the formation of Water User Association (WUA) for the paddy cultivation as recommended in the formation of paddy estate needs urgent attention especially from the farming community and their institutions.

5.2 External Challenges/Issues involving Muda Area

5.2.1 Land Use Conservation in the Catchment

Land in the Muda Area encompasses two distinct area namely the plain where the rice double cropping is carried out. The area is almost continuously cultivated with paddy since double cropping started in the 1970’s. The catchments area of forest reserve for the three dams where dams where the source of water is drawn from the reservoir to supplement the rain fed paddy field.

The catchment area of the three dams Muda (980 km²), Pedu (171 km²) and Ahning (122 km²) sum up to a total of 1277 km². Muda catchment being the largest has generated a lot of interest because of its valuable natural resources to be derived from logging activities. Besides the area has been identified as one of the richest in Malaysia in terms of wildlife containing 109 species of mammals, 174 species of bird, 54 species of reptiles and 33 species of fishes.

The State Executive Council has principally approved a reduced impact logging (RIL) i.e. Helicopter logging with the condition of an approved Detailed Environmental Impact Assessments (DEIA). The comprehensive studies on the impact of logging initiated by MADA with the collaboration of Drainage and Irrigation Department (DID), Forest Research Institute of Malaysia (FRIM), Malaysia Institute Nuclear Technology (MINT), Agriculture University Malaysia (UPM), National University of Malaysia (UKM), University Technology Malaysia (UTM) and University Science Malaysia (USM) proves valuable in examining the DEIA report commissioned. With the comments of all parties involved the Federal Government decision to forbid further logging in catchments area is a wise decision indeed.

With the preservation of the catchments, not only domestic water supply to the northern part of Kedah, Langkawi and Perlis are fulfilled but also perhaps the supply of domestic water especially, to the central and southern Kedah and Penang are also safeguarded.

The issues related to the development of Pedu Lake Resort in the Pedu catchments area in the early 1990 was amicably solved. The development level of chalets should be above the maximum storage level whence the construction was carried out far below the maximum storage level due to difference of opinion of the project’s consultant that the reservoir seldom reaches its maximum storage level. Nevertheless, after the resort was completed, Pedu Reservoir reaches its maximum storage level after a year upon completion causing the chalets below the maximum storage level to be submerged under water. The fact that the maximum storage level is important to retain the reservoir as per designed to make full use of the storage available for the supply of water for irrigation and as well as for domestic. Thus, a prudent management decision is taken by the authority to safeguard the interest of the public at large.
5.2.2 Planned Urbanization

The impact of Muda Project on the social and economic status of the farmers is obvious and already had been quantified. This lead to the development and expansion of urbanization in the Muda Area since the inception of the project. The demand of land for development is increasing because of land scarcity around the township.

In keeping with the aspiration of the Kedah and Perlis State Government, MADA has allowed the towns and growth center to be expanded to reflect economies and social achievement of the states. The policy adopted by the management is that all development must be well planned and confined so as to cause minimum disruption on the operation and maintenance of infrastructure in the Muda Irrigation Project.

To achieve that goal MADA has initiated several urbanization studies with the Local Authorities as well as the Town and Country Planning Department as early as 1979 and a series of development zone has been agreed upon not only in towns like Alor Setar, Kangar, Jitra and Kota Sarang Semut but also small towns like Kodiang, Air Itam, Jerlun etc. As a result, urbanization in the Muda Area more than 3,000ha of paddy land had been used up and converted for commercial and housing development.

6 WAY FORWARD AND RECOMMENDATIONS

The National Transformation Program (NTP) plan to develop Malaysia into a “high income nation economy” requires managing resources efficiently which will definitely contribute to Malaysia’s environmental endowments. In the New Economics Model (NEM), inclusiveness and sustainability is the key indicator of transformation. Inclusiveness is the participation of all levels of farming community to participate in a proper planning for a sustainable management of water resources in paddy cultivation.

This paper proposed a model to support the implementation of commercialization of paddy farming as strategize in the agriculture component of the National Key Economic Area (NKEA) specifically can be carried out in the Muda Area and to other IADA’s granary.

6.1 The Transformation Model

6.1.1 The Enabling Environment – Government Policies

The desire to transform should be understandable to all level of the “rakyat” especially the farmers which are involved in the paddy industry. The Ten Big Ideas behind the Economic Transformation Program (ETP) should be made known to the Farming Community which comprises the landowner, the tenant, the farming service provider, the millers and the consumer. Four of big idea, transforming to high income through specialization, concentrated growth & inclusive development, supporting effective and smart partnership and valuing our environmental endowments should be the guiding principle in this national transformation program.

In the context of the country National Mission, thrust five of the mission viz strengthening the institutional and implementation capacity should be the mission of the Farming Community in the development of agriculture sector in the National Key Economic Area (NKEA). Strengthening the institution means to reinvigorate the capacity of the present Farmers’ Organization to be a self-sustainable and profitable farmer’s business arm. One can imagine what will be the capacity of the Farmers’ Organization if their business is put in high profitability.

The development of agropolitan in the major granary area to inject economic growth for a higher income to the farming community to increase paddy production will be the target of the transformation model.
6.1.2 The Enablers – the Organization

The situation to enable this economic transformation shall be taken by the Government agencies involved in the agriculture water management. Agencies like the Division of Agricultural Irrigation and Drainage, Integrated Agriculture Development Area and Farmers’ Association must play the management role for the commercial farming group. By providing the leading management tools for the group commercial farming will ensure efficiency and productivity growth in the paddy sector.

6.1.3 The Model

The model recognizes the needs for continuous capacity development where knowledge management forms the basis of its development. The practical aspect of this model is in its implementation where the management team plays an important role in the successful implementation of commercial group farming. The Farmers’ Organization should take this leading role into transforming their role to hinge on commercial paddy farming to be turned into their success business arm.

The relation of the management team or system managers and the Water Users’ Association (WUA) shall be further enhanced to provide “hands-on” and “in-service” capacity development approach in the country. This will expedite the Irrigation Management Transfer by creating one commercial group farm in one irrigation block as envisaged in this paper. The schematic of the model is as illustrated in Figure 5 below.

![Figure 5. Model of Capacity Development for Agriculture Water Management Transformation](image)

The proposed transformation is based on works carried out by International Commission on Irrigation and Drainage (ICID). Three levels or domain for capacity development needs to be addressed:
- enabling environment
- organization
- individual

In the context of Malaysian Granary Area, the Government as the enabling environment, supports in term of relevant policies is important to allow the farmers to aggressively participate in the New Agriculture initiated in the Ninth Malaysia Development Plan. Malaysia is a country which has good track record in development since independence. Nonetheless the Self Sufficiency Level (SSL), as spelt out in the National Agrofood Policy, of local paddy and rice production which was set at 70% may need to be reviewed.

The second level or domain viz organization, in this transformation context is proposed to “change functional role as service provider” for bulk water provider by the Integrated Agriculture Development Area (IADA) and paddy growers - farm operators by the Farmers’ Organization. This transformation
requires change management role of the two organizations which the Farmers’ Organization must take the leading role to aspire as the “Tuan Padi Tuan Beras” notion propagated by the politician.

The New Agriculture to commercially produce high yielding paddy with technology based inputs at farm level will generate higher income to the farmers. With high production levels, the country may be able to export quality rice with the application of Green Technology. The country can be self-sufficient if all the resources are fully utilized in the Granary Area.

The IADAs’ will distribute water at the irrigation block level and the internal reticulation is controlled by the Farmers’ Organization. Water distribution at the field level will be coordinated and managed by the Farmers’ Organization. This will enhance water management at farm distribution level. This will facilitate the farmers grouping into large scale commercial farming.

Emphasis of the model should be at organizational and individual level. The two groups are the enabler of the model which actually translates the implementation of the group commercial farming with high yield target for the agriculture industry. Knowledge generation, management and dissemination are increasingly important features which require the authority concern for successful capacity development.

6.1.4 The Indicators
Target indicators for success of capacity development should be measurable. Results from Rapid Appraisal Process (RAP) carried out in two major granaries can be use as reference is set out for the capacity development of this new approach and “inclusive development” propagated by the Government. A simple matrix indicator index to the enablers of the development is proposed as shown in Table 6 below.

| Table 6. Indicators for the Enablers Group |
|-----------------|-----------------|
| **Enablers Group** | **Indicators** |
| The Bulk Water Provider (IADAs”) | ~ Operation Efficiency |
| | ~ Conveyance Efficiency |
| | ~ Distribution Efficiency |
| | ~ Field Application Efficiency |
| The Paddy Grower (Special Purpose Vehicle) | ~ Output per Crop Area |
| | ~ Output per Unit Irrigation Supply |
| | ~ Water User Association (WUA) |

6.2 Future Direction
Water User Association (WUA) exists in the Muda Area although without the legal organization setup. The successful implementation of double cropping and production of nearly 40% of the nation rice production from the Muda Area is a testimony to itself. This effort is difficult to implement without the full cooperation of the farmers or entrepreneur farmers in this “Rice Bowl of Malaysia”.

The implementation of a formal WUA must be streamlined with the country’s fifth national mission to strengthen the institutional and implementation capacity. This mission is a national agenda. A framework for irrigation water governance is required to complement the National Water Policy. In this way, the natural resources of the country can be managed efficiently and holistically. This requires the capacity building of human resources involves in the rice production of the country.
As the country is rapidly moving towards TRANSFORMATION for a high-income nation, agricultural development specifically paddy production should be the driving force of the Nation Agriculture Policy by providing sufficient food for the people and provide “new spin off” industry to the farming community. The capacity development no doubt will be complex and demanding task for the authority to pursue nonetheless it is indeed crucial to be carried out for successful TRANSFORMATION.

Knowledge generation, management and dissemination are important to ensure the success of capacity development. The knowledge pool covers not only policy and matters related to agriculture but also in water management and environment. This will develop farmers whom are aware of our nation environmental endowments. With the increasing importance of governance in water sector the knowledge acquired will definitely equipped our farmers in development of high income rice growers in the country which will be truly INCLUSIVE in nation building.

7 REFERENCES

9. Shafie A.G, Loh K.M., K. Dahuli (2003), Role of Irrigation and Drainage in Raising the Living Standard of Farmer in The Muda Area,

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MEXICO COUNTRY PAPER: REFORMS IN THE ADMINISTRATION OF IRRIGATION SYSTEMS — MEXICAN EXPERIENCES

ABSTRACT

A brief description is presented of the process and impact of the transfer of the infrastructure, management, and operation of Irrigation Districts in Mexico from the State to farmers. It begins with an overview of the present and future conditions of the hydro-agricultural sector in the country, and goes on to discuss the social background and the legal framework under which the transfer process was planned and carried out, highlighting the participation and the organizational framework adopted by the users, which not only remains in force, but has been consolidated, giving rise to a social organization that constitutes an example nationwide. It also underscores the linkage that has been established between different government agencies and user associations for the sustainable development of the hydro-agricultural sector, which has given rise to a series of programs aimed at the modernization and conservation of hydraulic infrastructure and to the efficient use and management of water at the on-farm level, all of this with the ultimate aim of increasing agricultural production per unit area and the volume of water used in this important sector. In addition, a series of major challenges, problems, and opportunities that need to be addressed in order to meet the current and growing food demand prevailing in the country are discussed, as is the importance of the role of technological research and development institutions within this frame of reference. In closing, a reflection is given on the importance of the legal framework on water and its impact on the agricultural sector, highlighting the need to have a General Water Law that is applicable both to the three tiers of government that exist in Mexico and to society at large; an action currently in progress.

1 CLIMATOLOGICAL AND WATER CONDITIONS OF MEXICO

Mexico has a land area of 1,964 million km². In the north, it borders with the United States and in the South with Guatemala and Belize; to the east and the west, it borders the Atlantic Ocean and the Pacific Ocean, respectively, with a total of 10,000 km of coastline. It is located within the strip of the great deserts of the world, as are Algeria, Libya, Egypt, and Saudi Arabia (Figure 1).

Due to its geographical location, Mexico is naturally exposed to a dry climate and recurrent droughts (Figure 2). The effects of these conditions are magnified in the north central part of the country, with the occurrence of severe and extreme droughts (National Water Commission, 2017). Given this condition, within these areas, agricultural production is subject to the availability or creation of water supply sources for irrigation purposes.
This location notwithstanding, due to its coastline borders and the consequent presence of meteorological and climatological phenomena at different scales, Mexico has an average annual precipitation (1981-2010) of 740 mm (Figure 3), equivalent to 1,449 km³ (CONAGUA, 2016. “Atlas del agua en México 2016”). Adding to these factors the national orography, which includes two great mountain ranges and several plains, the country displays a great variety of climates, and within its extensive territory precipitations range from 50 mm/year in the north, to more than 4,000 mm/year in the south. In addition, it should be noted that precipitation is not uniformly distributed throughout the year, with peak values recorded in the months of July to September and the lowest between February and March, when demand for irrigation water is the highest.

Within this framework of reference, it’s important to note that each year tropical cyclones transport large amounts of moisture from the oceans to the continental zone, and that through precipitation they contribute to the natural replenishment of surface- and groundwater sources (Figure 4). However, it is also necessary to note that they are the cause of significant damages, due to flooding in population centers and in agricultural production areas that are vulnerable and exposed.
In this respect, it is estimated that 162,000 km² of the national territory are susceptible to flooding for a probability of a 40-year return period. While this represents less than 10% of the national territory, the socioeconomic impact has become very high as it affects large agricultural and urban areas, mainly due to their vulnerability and resilience.

With respect to its population, Mexico is an increasingly urbanized country. In 2015, there were 119.5 million inhabitants (INEGI, 2015), 75% living in urban areas and the rest in rural areas, Therefore, as in most developing countries, the population engaged in agricultural and livestock activities is becoming increasingly less. Moreover, 77% of the population demanding water and food resides in the north and central part of the country, where only 33% of water resources are found (Figure 5). This generates a lot of pressure on water resources, with the consequent overexploitation of watersheds and aquifers.

Regarding political organization in water issues, Mexico has a set of institutions to carry out, in conjunction with users, the distribution and management of water, as well as the development, maintenance, and management of hydro-agricultural infrastructure. In this context, the Federal Government has the Secretariat of Environment and Natural Resources; the Secretariat of Agriculture, Livestock, Rural Development, and Fisheries; the National Water Commission, the Mexican Institute of Water Technology, the Secretariat of Energy, and the Federal Electricity Commission, among others (Figure 6).
In order to perform an adequate management of available water resources, taking into account the hydrography and the political division, Mexico has been divided into 13 Hydrological-Administrative Regions (Figure 7), which in turn encompass 37 hydrological regions and 728 river basins. (CONAGUA, 2016 "Atlas del agua en México").

2 HYDRO-AGRICULTURAL ORGANIZATION AND LEGISLATION

As regards the legal and normative aspect, the current legislation has its origins in the Constitution of 1857, from which came a series of laws and regulations to manage and regulate the administrative and economic operation of water resources (Box 1). These instruments, including the Political Constitution itself, have been reformed and improved on a number of occasions. The present Constitution, which originated in 1917, is the basis of a set of general, national, and local laws in which water is considered as an asset that is owned by the nation and its use in the hydro-agriculture sector has the highest social priority (COLMEX, 2017). Both the Constitution and the laws that emanate from
it are subject to a process of revision, updating, and continuous improvement. For example, the legislature is currently tasked with drafting a new law, the "General Water Law", which will regulate the actions of the three tiers of government (federal, state, and municipal), and will incorporate, among other aspects, the human right to water and food.

**Box 1 Water Laws and Regulations**

<table>
<thead>
<tr>
<th>Water laws and regulations</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political Constitution of the United Mexican States</td>
<td>1857</td>
</tr>
<tr>
<td>Federal Jurisdiction Water Utilization Act</td>
<td>1910</td>
</tr>
<tr>
<td>Political Constitution of the United Mexican States (articles 27 and 115)</td>
<td>1917</td>
</tr>
<tr>
<td>Federal Public Water Utilization Act</td>
<td>1917</td>
</tr>
<tr>
<td>Irrigation with Federal Waters Act</td>
<td>1926</td>
</tr>
<tr>
<td>Land and Water Allocation and Restitution Act, regulatory of Article 27 of the 1917 Constitution</td>
<td>1927</td>
</tr>
<tr>
<td>National Property Water Act</td>
<td>1934</td>
</tr>
<tr>
<td>Irrigation Act</td>
<td>1946</td>
</tr>
<tr>
<td>Federal Water Law and Bylaws</td>
<td>1974</td>
</tr>
<tr>
<td>National Water Law and Bylaws</td>
<td>1992</td>
</tr>
<tr>
<td>General Water Law (in process)</td>
<td></td>
</tr>
</tbody>
</table>

Regarding the management of the hydro-agricultural sector, Mexico has a long history of organization and legislation, which is reflected in the evolution and the level of importance given to the various federal agencies that have governed the use of water resources and their application in agricultural production (Box 2). For example, in 1891, the Secretariat of Promotion was created, which evolved into becoming, in 1989, the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food and the National Water Commission, two great institutions under which the Federal Government serves the national hydro-agricultural sector. (CONAGUA, 2009 "Semblanza histórica del agua en México).

**Box 2 Federal Institutions in the hydro-agricultural sector**

<table>
<thead>
<tr>
<th>Federal Institutions in charge of the Hydro-agricultural sector</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secretariat of Promotion</td>
<td>1891 - 1917</td>
</tr>
<tr>
<td>Secretariat of Agriculture and Promotion</td>
<td>1917 - 1926</td>
</tr>
<tr>
<td>National Irrigation Commission</td>
<td>1926 - 1946</td>
</tr>
<tr>
<td>Secretariat of Hydraulic Resources</td>
<td>1947 - 1976</td>
</tr>
<tr>
<td>Secretariat of Agriculture and Hydraulic Resources</td>
<td>1977 - 1989</td>
</tr>
</tbody>
</table>

**3 IRRIGATION INFRASTRUCTURE**

The national agricultural land surface is about 22 million hectares, of which 15.5 million hectares correspond to rainfed areas and 6.5 million to irrigation areas (Figure 8). It is interesting to note that the agricultural frontier of Mexico is of the order of 32 million hectares, which means that virtually 70% of the area with agricultural potential is in production, leaving 30% for expansion; that is, 10 million hectares, so there is an important strategic reserve for food security. (Hinojosa, 2016).
Mexico has 86 Irrigation Districts (IDs) and more than 40,000 Irrigation Units (IUs) distributed throughout the national territory (CONAGUA, 2016, “www/siga.cna.gob.mx/Mapoteca/Regionas Hidrológicas”). Fifty percent of the national agricultural production is harvested on irrigated land, producing 2.4 times more, per unit area, than in rainfed areas. After the Revolution of 1810, Mexico established as a political priority the development of irrigation infrastructure (Figure 9), which was enhanced, as of 1926, with the construction of large storage dams, reaching growth rates of 100,000 ha/year between 1946 and 1989. (Ramos V. C.O. 2017, “Seguridad hídrica en la producción de alimentos”, CICM). It is important to note here that in order to meet the food demand in Mexico by 2050, with an estimated population of 150 million inhabitants, coupled with a significant increase in the consumption of calories, it is foreseeable that the growth should be adjusted to the order of 40,000 ha/year.

Figure 8 Agricultural Areas

Irrigation units, also known as "small-scale irrigation", are run by 960,000 users. For agricultural production, they use an average of 35,000 hm³/year of irrigation water, and their average water productivity is estimated at 2.29 kg/m³ (CONAGUA, 2016, “Estadísticas agrícolas de las unidades de riego”).

For their part, the 86 Irrigation Districts, also known as "large-scale irrigation" zones, are managed by 557,381 users, accredited as irrigators. For agricultural production, an average of 30,000 hm³/year are

Figure 9 Evolution of irrigated areas in Mexico

Historic evolution of irrigated areas in Mexico

[Graph showing the evolution of irrigated areas from 1926 to 2017 with a growth rate of 26,300 ha/year from 1989 to 2017]
used, and their average water productivity is of the order of 1.69 kg/m³ (CONAGUA, 2016, “Estadísticas agrícolas de los distritos de riego”).

At the global level, in terms of availability of hydro-agricultural infrastructure, Mexico ranks seventh. As part of this infrastructure (Figure 16), for example, Irrigation Districts have 139 storage dams and 345 diversion dams, 664 pumping plants, 2,760 deep wells, 50,069 km of canals, 31,164 km of drains and 70,156 km of roads (CONAGUA, 2015, "Inventario de obras de infraestructura de distritos de riego").

As already mentioned, all of this infrastructure began to be constructed more than a hundred years ago; an example of this is the "La Boquilla" dam, which dates back to 1910. This multipurpose dam, located in the north of the country, in the state of Chihuahua, generates electricity and covers the water needs of 75,200 agricultural hectares in ID 005 "Delicias" (CONAGUA, 2016, "Características de la presa La boquilla", DR 005 Delicias Chihuahua).

Irrigation Districts are quite diverse in terms of size (Figure 10), so that, depending on the availability of soil and water, there are relatively small irrigation districts, with surface areas around 10,000 hectares, to very large districts exceeding 100,000 hectares. Among the latter are ID 014, Valle de Mexicali, in Baja California, and ID 075, Valle del Fuerte, in Sinaloa (CONAGUA, 2015, "Inventario de obras de infraestructura de distritos de riego").

![Figure 10 Dimension of irrigation districts in Mexico](image)

**Figure 10 Dimension of irrigation districts in Mexico**

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### 4 IRRIGATION DISTRICT TRANSFER

Among the major transformations and reforms promoted in the hydro-agricultural sector in Mexico, the "transfer of irrigation districts to users" stands out (Box 3). This transfer began in 1988, and has represented a fundamental change in the administration, distribution and delivery of water at the on-farm level. The initiative is supported by the Federal Water Law of 1974 and its consolidation is fully based on the National Water Law of 1992. Thus, the administration and operation of the districts, except for supply sources and headworks, become responsibility of the users (Trava, 1996).
The transfer of Irrigation Districts drives a series of processes that give rise to a productive reconversion in Mexico (Figure 11). This reconversion was initially conducted by the former Secretariat of Hydraulic Resources in 1988 and was consolidated in 2010, already under the responsibility of the National Water Commission, securing the transfer to the users, including not only the physical infrastructure, but also the responsibilities for the operation, conduction, distribution, and delivery of water for irrigation.

**Box 3 Process of transferring irrigation districts in Mexico**

<table>
<thead>
<tr>
<th>Year</th>
<th>Beginning of the process of transferring irrigation districts to users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>The administration, operation, and conservation of irrigation districts and their infrastructure depended on the Federal Government and were executed by the Secretariat of Hydraulic Resources.</td>
</tr>
<tr>
<td>1989</td>
<td>The National Water Commission (CONAGUA) is created.</td>
</tr>
<tr>
<td>1990</td>
<td>CONAGUA plans the delivery of the hydro-agricultural infrastructure to the users in order to lead them to financial self-sufficiency and enhance water and land productivity.</td>
</tr>
</tbody>
</table>
| 1992 | Transfer of irrigation districts to users begins:  
• Their training and organization is enhanced  
• The regulations for the creation of irrigation modules and limited responsibility societies, with their rights and obligations, are established. |

**Figure 11 Productive reconversion process in Mexico**

Thus, the main objective of the water reform in terms of water resources management in irrigation districts is achieved by transferring the hydraulic infrastructure and its integrated management to the users, which implies for them taking on the responsibility of making an efficient and sustainable use of water resources (Trava, 1996).

As part of the process of transfer of irrigation districts, the creation of the so-called Irrigation Modules (IMs) was conceived as a central figure for the administration and social organization of users. At the same time, integrating several modules, other administrative entities, known as Limited Responsibility Societies (SRLs) were created (Trava, 1996).

Irrigation district transfer process is described as follows:

- Creation of irrigation modules and limited responsibility societies (SRL’s)
  - Integrated by users representing small property and ejidos
- Irrigation modules manage, operate and maintain the hydro-agricultural infrastructures assigned to them
  - Irrigation modules contribute 50% of the investments for rehabilitation and modernization, which are complemented with 50% of federal support
  - Each irrigation module receives a volume of water according to their surface area and to the annual availability in the storage source

The transfer of the 86 irrigation districts involved the creation of 474 irrigation modules and 16 LRSs in order to manage an area of 3,495,085 hectares. These administrative structures are made up of 557,381 irrigation users. The area per module varies between 5,000 and 15,000 ha. Small owners are 139,345 in number compared to the 418,036 ejidatories (communal land holders).
Each irrigation module is managed by a board of directors that is periodically renewed, and which usually consists of a president, a supervisory council and three major areas: administration, operations, and conservation. For the implementation of these structures, the State supported the modules with technical and administrative training (Figure 12). These support mechanisms for strengthening the modules have had continuity and, in a certain way, have allowed to consolidate the organization of users (Trava, 1996).

![Figure 12 Organization chart of an Irrigation module](source)

It is important here to reiterate that the State, through the National Water Commission, maintains the control and management of the headworks in the irrigation districts, that is, of the supply sources (Figure 13). Thus, dams and other bodies of water, as well as the series of wells, are managed and operated by the National Water Commission (Trava, 1996).

![Figure 13 State of the National Water Commission](source)

This form of management has made it possible to organize both small and large irrigation districts in the country. For instance, in Irrigation District 075, Valle del Fuerte, the National Water Commission is responsible for operating and managing the water available at the Miguel Hidalgo and Luis Donaldo Colosio dams ("Huites"), which constitute one of the largest hydraulic systems in the country and one of the main sources of water for agriculture in Mexico (CONAGUA, 2010).
5 IRRIGATION DISTRICT DEVELOPMENT PROGRAMS

In order to enhance the technical and administrative management of Irrigation Districts, the State, together with the users developed the "Master Plans for Irrigation Districts" (Figure 14). These plans consider and prioritize the needs of economic investment and the technical actions to be taken in each irrigation zone, based on a diagnosis that includes an analysis of the current situation and the pending problems, as well as a ranking of alternative solutions. The impact of investments and actions is evaluated through a set of social, technical, and economic indicators within a framework of action aimed at the sustainability of Irrigation Districts.

Among the actions that the Mexican Government has prioritized through institutions such as the National Water Commission, together with the users, a series of programs have been promoted for the rehabilitation, modernization, and technification of irrigation districts; the efficient use of water and energy; the reimbursement of payments for block water supply; the technification of gravity irrigation; the recovery of saline soils with on-farm drainage; and the training of users on water resources management and agriculture (D.O.F., 2016).

Hydro-agricultural infrastructure support programs:
- Rehabilitation, modernization and technification of irrigation districts
- Equipment provision for irrigation districts
- Efficient use of water and energy
- Reimbursement of payments for block water supply
- Technification of gravity irrigation
- Recovery of saline soils with on-farm drainage
- Training of users on management

Therefore, through the Modernization and Rehabilitation Program for Irrigated Areas, the State contributes up to 50% of the investments for high- and low-pressure irrigation systems, as well as for the technification of gravity irrigation.

Modernization and rehabilitation of irrigation areas:
- Executive projects of collective networks (low- and high- pressure) and of irrigation systems, such as multigate, spray and micro-spray systems.
- Technification of gravity irrigation by means of furrow alignment, land leveling, and the measurement, delivery and fee collection of the water volume provided to the user in order to increase the efficiency of water use at the on-farm level

With regards to upgrading the machinery for the conservation of hydro-agricultural infrastructure, support is provided for the acquisition of various pieces of equipment, among which stand out

![Diagram](image-url)
brushcutters, backhoes, leveling tools, tractors and long arms. Thus, the users are in better conditions for carrying out maintenance and rehabilitation works in canals, drains, and roads within irrigation zones (D.O.F., 2016).

Upgrading of machinery for the conservation of hydro-agricultural infrastructure:
- Decrease in the cost of conservation work on hydro-agricultural infrastructure
- Selection of machinery according to the characteristics of the infrastructure

Due to its impact on the operation, special attention has been given to the integrated control of aquatic weeds, such as lily, algae and tulle, which obstruct water flow in both main canals and in the secondary network, which is why programs and actions for biological control have been promoted and supported by using neochetina and grass carp, as well as for mechanical control, i.e. by direct extraction of aquatic weeds.

Due to the exploitation of agricultural land in soils with a certain degree of salinity, combined with the effects of evapotranspiration and the application of irrigation, among other factors, in no less than 600,000 ha there have been salinity problems and elevated water tables, the control of which requires soil washing and the installation of on-farm drainage.

Remote sensors to identify soils with salinity and drainage problems:
- Using satellite imagery, electronic sensors, and soil and crop sampling, the system irrigation are calibrated and statistical models are obtained
- Soil salinity maps in large areas of irrigated agricultural land
- The analysis includes estimation of crop yields and impact of salinity on the economics of the irrigation zone

In order to address this problem, the Program for the Rehabilitation of Solis with Salinity and Poor Drainage Problems was implemented at the national level. Thus, to date, on-farm drainage has been installed in more than 100,000 ha, with production capacity being restored and even increased.

In order to increase productivity per land area unit and cubic meter of water used for irrigation, the Program for the Technification on Irrigation Districts and Units was established. With this program, which involves investments shared at 50% between the Federal Government and the users, to date, irrigation systems have been installed or improved in more than 850,000 hectares.

Technification in Irrigation districts and units:
- Irrigation systems with frontal advance, hose reel, central pivot
- Spray and micro-spray irrigation
- Drip irrigation, localized irrigation
- Greenhouses, moldboards, tunnels, shade mesh
- Technification of gravity irrigation

Upon considering the process described, there is a natural interest in knowing what have been the achievements and positive impacts of the reforms promoted by the Federal Government through the transfer of irrigation districts to the users. In this regard, it should be recognized that very positive changes have been generated in the legal field, which have been reflected in the National Water Law, which regulates Article 27 of the Political Constitution of the United Mexican States. These instruments have made it possible to consolidate and formalize the transfer of Irrigation Districts. On the other hand, mechanisms have been established to promote and capitalize investments shared between the State and the users in favor of improvements in the technification of agricultural land and, consequently, in the hydro-agricultural productivity within the 3.5 million hectares under their responsibility. In this same regard, the knowledge and skills for the technical and administrative
organization of users have increased, which give them a greater level of competitiveness in international markets, an aspect that is enhanced by the increase in production in the 850,000 ha where irrigation systems have been modernized.

Achievements and impact of irrigated agriculture:

1. **Legal**
   - Laws and regulation on national waters
   - Transfer of irrigation districts to users

2. **Construction and technification in irrigated agriculture**
   - Hydro-agricultural infrastructure in 6.5 million ha
   - Federal support programs for hydro-agricultural infrastructure

3. **Transfer of science and technology to the Mexican countryside**
   - Irrigation technification in 850,000 ha
   - Increase in agricultural production
   - Permanent training for irrigation users

The positive effects and impacts of these reforms (*Figure 15*) are visible and quantified in a tangible way through the evidence associated with the construction of new dams to increase water availability for irrigation purposes; the construction and lining of canals to increase their conduction efficiency; the opening and piping of drains to drive surplus flow outside the irrigation areas, to lower elevated water levels, and to control salinity; the installation of wells and pumping plants to aid irrigation; and the transfer of irrigation technology itself, such as the Program for the Technification of Gravity Irrigation from which 200,000 ha have been benefited.

![Figure 15 Technology developed by Mexican technicians](image)

Due to the need to have a series of indicators that reflect the progress of the reforms and especially the transfer of Irrigation Districts to the users, the Federal Government, through the National Water Commission, implemented the Annual Agricultural Statistics in irrigation districts and units, as well as in technified rainfed districts (*Box 4*). These documents contain data on the production in each of the irrigation zones and their evolution over time, as well as statistics on irrigated and harvested land, and the volumes of water used by each crop and by irrigation district, among other parameters of interest (CONAGUA, 2015 “Estadísticas agrícolas de los distritos de riego, año 2013-2014”).
From the agricultural statistics of irrigation zones, the evolution of water productivity, expressed in kg/m$^3$, is derived. It can be observed how this productivity has been increasing, from 1.1 kg/m$^3$ in 1990 to 1.83 kg/m$^3$ in 2014 (Figure 16). These results constitute one of the best evidences of the benefits derived from the reforms to irrigated agriculture in Mexico (CONAGUA, 2015 “Estadísticas agrícolas de los distritos de riego, año 1990 al 2015”).

It should be noted that the government institutions that oversee agriculture and irrigation in Mexico continue to provide ongoing training for users, with the aim of bringing them up to date and optimizing their integrated management of irrigation agriculture (Figure 17). To that end, priority has been given to the following topics: irrigation and drainage, operation, administration, and conservation.
CHALLENGES FOR THE IRRIGATION SECTOR

One of the main challenges for the irrigation sector in the short, medium and long terms is water and food security for the Mexican population. Among the elements that justify its prioritization are the negative effects associated with climate change, as well as the need to increase agricultural productivity and the opening of new irrigation zones in the south-south-east of Mexico, and the urgent need to optimize the sustainable use of available water resources, and to promote governance and governance within the hydro-agricultural sector. To this end, it is necessary to create a "General Water Law" that includes the human rights to water and food with a high degree of priority, under a joint and inextricable approach.

Challenges for the irrigation sector:
- Water and food security in the face of climate change
- To increase agricultural productivity in irrigated areas
- Opening of new irrigation zones in southern Mexico
- Sustainable optimization of water resources
- Greater technological transfer to the Mexican countryside
- To promote governance in hydro-agricultural management
- Application and adaption of the National Water Law and its bylaws

The Mexican Institute of Water Technology, through its Irrigation and Drainage Division, plays an important role in the development of the country’s hydro-agricultural sector, since it is responsible for carrying out research, developing technology, training human resources, and providing highly specialized technological services in order to contribute to the sustainable development of this important sector. To this end, it has several laboratories and equipment and, especially, highly qualified human resources, which account for more than 30 years of institutional experience.

Functions of the Mexican Institute of Water Technology:
- Conduct scientific research
- Develop, adapt and transfer technology
- Innovate in the sustainable management of water resources
- Train human resources
- Provide consulting services and dissemination of scientific knowledge at national and international level

In Mexico, it is necessary to analyze, determine, and plan the best sustainable alternatives to the effects of climate change, which look negative for the hydro-agricultural sector, since projections indicate that there will be less availability of and increased demand for water resources for agricultural production. Given this scenario, it will be necessary to adopt and develop better and new technologies and productive practices, with a preventive approach, to adapt the sector to the new conditions that will prevail, and thus avoid, as far as possible, the affectations and even the damages caused by ever increasing extreme events, such as droughts, frosts, and floods, as well as the affectations derived from the gradual, but continuous precipitation decreases and temperatures increases shown by forecasts.

The increase in agricultural production required by Mexico, as in the rest of the world, to meet the demands of future generations, must be achieved through an increase in productivity per land area unit and through an extension of its agricultural frontier. This is expected to be on an 80%/20% ratio, which means that 80% of incremental demand will have to be absorbed through higher productivity per land area unit and the remaining 20% through new agricultural areas. Thus, in order to increase
agricultural productivity in the areas currently under irrigation, agriculture using precision irrigation should be promoted, such as greenhouses, while a better and more efficient management of irrigation water should be done. This must be accompanied by an adequate control of pests and diseases, the selective planting of crops, and the installation of more and better irrigation systems, giving priority to collective networks and automated drip, sprinkler and micro-sprinkler systems.

Mexico has a great water potential in its southern and southeastern regions, as precipitation in these areas reaches 2,000 mm/year, and there are large bodies of water and rivers, including the Usumacinta River, one of the most abundant rivers in the world. Adding to this wealth is the availability of large arable areas, estimated at more than 3 million hectares, for the production of forest, fruit, and vegetable species. To exploit these areas in a sustainable manner, it will be necessary to introduce systems to control excess moisture and in other areas to drill wells to harness groundwater for irrigation purposes, and it will even be necessary to develop and design new irrigation infrastructure for diverting and using the water from the multiple and large rivers.

In the context of the sustainable use and management of available water resources, efforts should be made to increase the overall efficiency with which irrigation water from surface sources is managed, distributed, and supplied, with the aim to increase it to values no lower than 50%; and, on the other hand, attention must be paid to controlling and reducing the overexploitation of aquifers. There are now more than 106 overdrafted aquifers, largely due to poor irrigation practices and excessive water withdrawals compared to allocated volumes in the hydro-agricultural sector. This is a complex problem, the solution of which requires both technical interventions and the correct and strict application of the National Water Law and its bylaws, as well as reconsidering electric energy subsidy programs for agricultural wells in over drafted aquifers.

Government agencies are collaborating with research institutions and with users to promote the development, adaptation, transfer, and especially the appropriation of state-of-the-art technology for the benefit of the Mexican countryside. The lines of action include projects oriented towards the measurement of irrigation water, real-time irrigation forecasting, the availability and use of meteorology in irrigation planning, the use of drones in agriculture, irrigation automation, agro-climatological forecasting, studies on the temporal variations of precipitation patterns by regions, and the effects of climate change on agriculture. In all these thematic fields, the Mexican Institute of Water Technology has open lines of research and technology development, and has the personnel and installed capacities to provide highly specialized services in support of addressing and finding solutions to the great challenges posed by the sustainable development of the hydro-agricultural sector.

Finally, and without a doubt, some of the most important challenges are to improve governance and to consolidate the governability of institutions within the hydro-agricultural sector. This requires a broad and permanent participation of users, who are responsible for the administration of hydro-agricultural infrastructure and who should be considered as having voice and vote, from the stating of the problem to the processes of selection and approval of solution alternatives. This does not imply that the institutions responsible for water and land resources will lose leadership; on the contrary, it requires them to maintain a close relationship and collaboration with the users, who are ultimately the beneficiaries of the decisions and actions that are taken and carried out.
7 ENHANCEMENT OF IRRIGATION DISTRICT MODULES AND LIMITED RESPONSIBILITY SOCIETIES

Not all the challenges of the sector are technical in nature. In parallel, there are a series of challenges to continue with the enhancement of irrigation organizations (Box 5); they will have to seek integration in order to have a shared vision throughout the hydro-agricultural sector in order to achieve the joint sustainability of irrigation districts, irrigation units, technified rainfed areas and normal rainfed areas. Facing this challenge, among other things, will lead to a model of integrated management and an orderly process in view of the necessary conversion of certain areas from rainfed to irrigated areas, as well as the introduction of changes in economic activities, crop patterns and the application of clear and equitable rules for water distribution; all this backed by the promotion of technology adoption.

As a result of these transformations, it can be concluded that, in general terms, users now have a more entrepreneurial mindset and that their priorities are focused on the search for financial and technical self-sufficiency; on increasing hydro-agricultural productivity; on the care, utilization, conservation, and extension of the useful life of the infrastructure under their control; and, of course, on the consolidation of organizations with a business approach that may guarantee the sustainability of the national agricultural sector.

8 CONCLUSIONS

In summary, with the transfer and reforms that have been implemented, Mexico has the bases for achieving water and food sustainability and security. To this end, as has already been mentioned, priority has been given to social, technical, economic and environmental aspects. It should be noted that these decisions and actions emanate from the guidelines and mandates established in the Political Constitution and the laws that derive from it, especially the National Water Law and its bylaws. However, we must recognize that, in order to continue making progress on water-related issues and to ensure sustainable development, Mexico requires a General Water Law for ensuring water sustainability and security in the national hydro-agricultural sector; that is, a law applicable to all three tiers of government, to society as a whole and, of course, to all productive sectors, especially the hydro-agricultural sector.
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1 INTRODUCTION

Out of 2.7 million hectares of agricultural land in Nepal, only 1.4 Mha have irrigation facilities. The majority of irrigation systems are small and medium scale, which also includes groundwater irrigation. Agriculture is a mainstay of the economy of Nepal, providing about 33% of the gross domestic product (GDP) and supporting the livelihoods of most of the population. Livelihoods based on agriculture are vulnerable due to the vagaries of monsoon climate and the topography.

There is a need to both improve agricultural productivity and make it more resilient to climate uncertainty and changes in general. Recent increases in floods and droughts have raised concerns that the climate is changing rapidly and that existing arrangements for irrigation design and management may need to be reconsidered.

2 BACKGROUND OF IRRIGATION SECTOR IN NEPAL

Public sector irrigation development in Nepal took place only in 1950s. Only two public sector irrigation systems were constructed before 1950. One is known as Chandra Nahar which was constructed in 1923. The other is Judha Nahar which was constructed in 1940s. Hence, Nepal is known more for her thousands of farmer managed irrigation systems scattered in the mountains, river valleys and Tarai.

In 1950s, many farmer managed irrigation systems were rehabilitated in Kathmandu valley which used to be one of the fertile valleys of Nepal because of its elaborate network of irrigation systems. The Department of Irrigation was established in 1952. Many of these irrigation systems which were constructed in 1960s and 70s were made agency managed systems. Even the rehabilitated farmer managed systems were converted into agency-managed systems. The irrigation systems were then considered more as technical and hydrological proposition. Human aspect of irrigation management was not taken into consideration. It was felt that government alone will be able to manage the irrigation systems. The role of the farmers was not duly recognized in agency managed irrigation systems.

In 1980s, the farmer-managed irrigation systems were recognized by the government. It was ironical not to have due recognition of them before 1980s. For example, the First Five-year Plan of Nepal (1956-60) recognized only the existence of 14,000 ha irrigated land in Nepal. These figures indicated the existence of only government managed irrigation systems.

In mid 70s, Nepal embarked on the construction of large scale surface irrigation systems in southern part of Nepal from the World Bank and Asian Development Bank loans. During this time, the concern of Irrigation Department was much more toward the physical construction of irrigation infrastructures. Institutional development did not receive due consideration.

In later part of 1980s, agencies providing support to irrigation development got amalgamated into one. The Ministry of Panchyat and Local Development (MPLD) supported irrigation component and Farm Irrigation Water Utilization Division (FIWUD), under the Ministry of Agriculture were merged with Department of Irrigation. However, the Agriculture Development Bank was allowed to carry on
its role on irrigation development through the provision of loans. The reform was to make only one agency to be made responsible for different types of irrigation development all over Nepal. It is now Irrigation Department which has mandate for irrigation development all over Nepal. The amalgamation of these different agencies was necessitated in order to increase agriculture output to meet the basic need fulfilment of people policy by the year 2000. Hence, irrigation plays important role in increasing agriculture production.

2.1 Changes in the Approaches, Scope and Management of Department of Irrigation (DOI)

The amalgamation brought changes in the approach, scope and management style of the Department of Irrigation. Irrigation units at 75 Districts were established. The responsibility of providing assistance to farmer-managed irrigation systems also came within the jurisdiction of the Department of Irrigation. The thrust on participatory irrigation management was made. Irrigation Working Policy was brought out, emphasizing farmers’ participation from planning to implementation of small and medium irrigation schemes. Necessary amendments in Irrigation Rules were made. Besides, emphasis was put on the management improvement of the already completed irrigation systems.

Irrigated agriculture holds great potentiality to meet the development challenges and key to increased agriculture production to feed the growing population of Nepal. Besides, increasing the agriculture production, irrigation helps promote Green Revolution, contributes for poverty alleviation and helps promote rural growth, and ensure food security of the country. Dilapidated irrigation systems affect on all these fronts of development issues. In order to meet these challenges, the important question is: how can irrigation sector be revitalized? It is, therefore, necessary to revitalize the irrigation sector to feed growing population, to ensure livelihood and poverty alleviation and maximize the benefit of available natural resources like water to get more production from limited land availability.

The existing irrigation schemes of Nepal are now getting old and they require to be improved and modernized to raise food productivity from irrigated agriculture. It is often found that state built and managed irrigation systems can be made better performed, so they need to be revitalized. Similarly, farmer managed irrigation systems (FMISs) in Nepal also have greater potentiality for increasing agriculture productivity. Hence, the improving irrigation systems to meet the food demands of the future are to be considered in an integrated manner consisting infrastructure rehabilitation, investment to raise productivity from irrigated land and promotion of appropriate institutions and innovative management modes.

2.2 Historical Perspective of Irrigation Organization Development in Nepal

The involvement of government in irrigation development started with the enactment of the National Statute (Muluki Ain 1854), which provided a legal foundation for the development of canal irrigation in the Tarai and made the District Revenue Offices responsible for the construction, operation and maintenance of irrigation system. However, government’s involvement, real sense, began in 1923 when Government constructed Chandra Nahar Irrigation Project applying the then modern engineering techniques. The project was planned, designed and constructed by British Engineer. It was followed by development of few irrigation facilities till 1951 under the supervision of the then Public Workd Department. A bureaucratic movement in planned irrigation development started with the creation of Canal Department (1952) with a chief engineer, two civil engineers and few support staff was established in Sighadurbar, then Administration Building of Government of Nepal, with just two rooms. Gradually the scope and activities of the Department were continuously expanded. A number of organizational reforms took place before the Canal Department was developed into a full-fledged Department of Irrigation (DOI) in December 1987. The Canal Department was expanded to Department of Irrigation and Water Supply under the Ministry of Works and Transport and Communication. Later on, further change was made in forming Department of Irrigation, Hydrology and Meteorology (DIHM) under the Ministry of Water and Power. After sometimes, this Department
was brought under the Ministry of Irrigation and Agriculture, from 1972 to 1980. Afterwards, the DIHM, which became DOI later on, was under the newly created Ministry of Water Resources until 2009. During this time, Ministry of Irrigation was established by splitting Ministry of Water Resources into Ministry of Irrigation and Ministry of Energy. Though this Department has gone through many transformations. However, there has been steady capacity development of DIHM’s technical staff since 1970s.

During the initial stage of government intervention in irrigation activities, the department would establish individual offices for specific projects, many of these offices were transformed later on into divisions and sub-divisions to take care of the maintenance of completed projects along with implementation of other projects in the vicinity. Following major administrative re-structuring of the country making four regions in 1974, Regional Irrigation Directorate (RID) was established in each region. The divisions and sub-divisions came under the administrative control of these directorates. In 1983 the Far-Western Region was split into two and named Mid-western and Far-western regions. However, implementations of large projects were carried out under direct supervision of DOI. This practice is still continuing even today.

In 2015, the Department of Irrigation has been further expanded by establishing a 57 Division and 16 Sub-division offices for the implementation of medium sized irrigation systems. Irrigation Management Directorate has also been created with the overall objective to improve the irrigation management of the large irrigation systems. Under this directorate, 10 number of Irrigation Management Divisions and three number of Sub-division offices have been established. Groundwater Irrigation Directorate along with 10 Groundwater Irrigation Divisions have been also been established to plan and develop groundwater shallow and deep tubewells.

3 EVOLUTION OF GOVERNING POLICY, LEGAL FRAMEWORK, RULES AND REGULATIONS

Farmer managed irrigation systems have been traditionally governed by the social norms and collective decisions. Although legal instruments like Sanad, Sawal, etc. were issued by the then Rana Rulers to regulate the operation and maintenance of State built and operated irrigation systems. The farmer managed systems were under operation and management of the beneficiary farmers guided by the social norms and values of the community.

3.1 National Statute of Nepal, 1854

Muluki Ain (National Statute of 1854, Land Cultivation Section) was the only governing law at that time. Some of the provisions of the Muluki Ain are as follows.

- One who constructed the canal should get priority in receiving irrigation water
- Lands in lower reach shall not receive water until lands in the headreach are irrigated
- Irrigation canal in the upstream from an existing canal in a river can be constructed only when it has no effect on the availability of water in the existing system in the downstream
- Farmers should first try to rehabilitate a canal themselves, if it is damaged by the national calamities. If it was not possible to rehabilitate by themselves, they may request the government for grant of fund required for the rehabilitation

3.2 Irrigation Act, 1962

In fact, until beginning of planned development 1956, government policy of irrigation development is non-existent. Nepal introduced the Irrigation Act for the first time in 1962. Some of the features of Irrigation Act 1962 were:
Costs of construction and maintenance of Field Channels including the land occupied by the channels are to be borne by the farmers, however, the higher order canals are to be constructed by the government.

Permission to use irrigation water is granted either for a crop season or for a year, which is however renewable.

Water use right is not transferrable without permission of the Canal Officer. However, the water right can be transferred to the cultivator authorized to use the land for cultivation.

Water use permission is transferred along with the land entitlement.

Water right cannot be established merely getting permission to use the canal water.

Farmers are entitled to receive compensation, if the irrigation water supply is interrupted without a valid reason.

Provision to award penalty to anyone who misuses canal water.

Water-cess is collected by the Land Revenue office along with land tax on annual basis.

3.3 Canal and Electricity and Related Water Resources Act, 1968

The Irrigation Act was later replaced by Canal and Electricity & Related Water Resources Act, 1968. Some of the features of the Act were as follows:

- Provision was made to obtain license for water use for commercial purpose, including for irrigation and right to collect irrigation service fee by such private agency.

- Provision was made restricting any activity which results into adverse impact on environment while developing such project.

3.4 Irrigation Working Policy, 1988

In late 1980’s, there was a major policy shift in irrigation development and management approach in Nepal. The government introduced Irrigation Working Policy which emphasized on participatory planning development and management of the irrigation systems. Irrigation Regulation, 1988 and Irrigation Directives were also brought out by the government in sequence. The Irrigation Directives, 1988 provided detailed procedures for the formation of Water User’s Association (WUA). Some of the features of the directives were:

- Involvement of Water Users Groups (WUGs) in construction and operation and maintenance of tertiary canals, field channels and drainages of large Agency Management Irrigation Systems.

- Water allocation and distribution by the agency in an irrigation system in coordination with WUA.

- Provision was made for the formulation of Constitution of WUG/WUA defining its roles and responsibilities.

- Irrigation Service Fee (ISF) is to be paid by users and ISF is to be determined by the Government based on the criteria stipulated in the Regulation.

- WUG/WUA receives incentives for facilitation in collecting the ISF.

- Issuance of license to use water for irrigation or any other agricultural use to a formally registered Water Users Association.

- Provision was for registration of WUAs under Association Registration Act, 1978 in respective District Administrative Office.

- Formation of WUAs consisting of 5 to 11 members including a representative from Irrigation Office of the government.

The formation of WUA was mainly meant to involve the beneficiaries in the construction and operation and maintenance of the systems.
3.5 Irrigation Policy, 1992 and Subsequent Amendments

Irrigation Policy in Nepal was formulated in 1992. One of the six objectives set forth in the policy was to provide continuity to the Nepali farmers’ traditions and managing their irrigation systems as autonomous entities in the private sector by making it more stable and extensive. The policy had categorized the irrigation systems into the following four groups:

- Irrigation systems operated by water users or to be operated by them in future
- Government irrigation systems to be turned over to the Water Users’ Associations
- Irrigation systems under the Joint Management of the government and WUAs or irrigation sub-systems under the multi-purpose project/systems as per national requirement
- Private irrigation systems

The policy mentioned that the recognition should be granted to the Users’ Associations. They should be made self-reliant and strengthened gradually. No investment would be provided until there is a registered WUA in place. Sharing of construction cost by the users is made mandatory. However, the amount of construction costs to be borne by the beneficiaries depends upon the type of the irrigation systems, as mentioned above, as per the Policy. Modalities for the intervention to the farmers are as follows:

- There could be agency intervention only if there is a formal request from the majority of the farmers
- In the implementation of such demand driven projects, there should be full participation of organized users from the very beginning. The full responsibility of operation and maintenance of the system after completion of the construction should be shouldered by the users’ association according to the agreement made with the user’s association

Besides, the users should have provided all lands, required for the construction, rehabilitation and improvement of such systems, free of cost. Different provisions were set forth for different types of irrigation systems regarding cost sharing.

3.5.1 Irrigation Policy Amendment, 1997

The Irrigation Policy was later revised in 1997. The revised policy had the following features:

- Irrigation system owned by the farmers would be governed by the irrigation policy
- Institutional development of farmers to be promoted to make irrigation systems more productive
- Formation of WUAs should be towards a multipurpose organization working for the farmers
- Responsibility of WUAs should include planning and implementation of schemes
- Involvement of farmers is envisioned in project identification, selection, construction, operation and maintenance, monitoring and evaluation
- WUAs of FMISs could raise the funds in cash or kinds from the users required for the operation and maintenance of the systems

3.5.2 Irrigation Policy amendment in 2003

In 2003, Irrigation Policy was further revised and it had following important features:

- An Irrigation System has been defined as “all infrastructures built for irrigation purpose and all units including irrigated area. This provision refers the completed irrigation system which is in operation.”
- The maintenance, rehabilitation and reform of the system constructed/operated by the users’ association and traditional irrigation system managed by farmers shall be rehabilitated with the farmers’ participation upon their request. Users’ association shall be made competent for the sustainable management.
- For the purpose of management of irrigation systems, following classifications have been made:
• Operated by the users
• Traditional irrigation systems
• Systems transferred by government and non-government agencies to the users’ association
• Operated by the government
• Operated in joint management by the government and the users’ association
• Operated in joint management by the local bodies and the users’ association
• Operated by private sector

– Irrigation systems rehabilitated/improved on the demand of users’ and operated by them shall be managed by the users’ associations
– GON shall invest in the project only after having formal agreement with the users’ association by clearly defining the functions, duties and rights of the Department of Irrigation and the users’ association by adopting a transparent method in relation to construction, operation and management of the project
– Users’ associations may claim for compensation in cases where one faces losses due to non-fulfilment of the responsibility by GON under the agreement
– Capital contribution from the users is based on the average size of the landholding and it varies from 3% to 15% of the total estimated cost of the rehabilitation of the scheme

3.5.3 Irrigation Policy Amendment, 2013
In the year 2013, the Irrigation Policy was revised and it has following features:

– Irrigation Master Plan based on Integrated Development and Management of River Basin shall be prepared at the National as well as District Level
– The Government of Nepal shall declare Irrigated Area where the irrigation facilities are made available and use of such land other than for agricultural purposes shall require prior approval of the government.
– Coordination and partnership between the stakeholders shall be promoted to enhance the productivity in the irrigated area
– Appropriate Irrigation Technology suitable to particular geographical location and topography shall be promoted
– Irrigation projects shall be planned based on Integrated Water Resources Management (IWRM) principles
– In order to provide round the year irrigation from existing seasonal irrigation systems, reservoirs, rain water harvesting and ground water irrigation shall be developed
– Priority shall be accorded to develop large reservoir and inter basin water transfer type of projects
– Private sector, cooperatives, communities shall be involved in the development, operation and management of irrigation systems
– In order to address the impact of climate change in the irrigation systems, programs related to adaption and mitigation measures shall be implemented

The Irrigation Policy of the government has been made effective by the enactment of Water Resources Act, 1992, Water Resources Regulation, 1993 and Irrigation Regulation, 2003.

3.5.4 Proposed Irrigation Act, 2074
Irrigation Bill 2015 has been drafted by the Ministry of Irrigation and has been tabled in parliament for the approval. Features of Irrigation Bill 2015 are as follows:

– A person or organization planning to survey and develop irrigation system shall have to obtain the license
– Government of Nepal may collaborate with private sector for identification, selection, construction, implementation, operation, maintenance, improvement or management of
irrigation system on the basis of public private partnership (PPP) modality. Similar modality regarding multipurpose project which are commercially viable for operation would also go to PPP model

- The Government of Nepal can handover the irrigation systems constructed, developed or managed by it to the Water Users Association, Farmers cooperatives, Management Board in accordance with the prescribed procedures
- The Government of Nepal by publishing in the Nepal Gazette can declare an irrigated area that has fulfilled the prescribed requisites as special irrigated area, where use of land for other purposes, without permission of the Government, shall be prohibited
- The related Users willing to develop, use, maintain and protect any irrigation system can form Water Users Association by following the prescribed provision.
- The functions, responsibility and authority of the Water Users Association shall be following:
  - To update and protect the asset of an irrigation system under the responsibility of Water Users Association
  - To repair, maintain or reconstruct the structures of the irrigation system if damaged
  - To plan and implement sustainable irrigation service and distribution management
  - To prepare list of the users of the concerned irrigation system
  - To collect irrigation service fee as per the regulation prepared under this Act.
  - To implement local level irrigation development programs in coordination with the concerned agencies.
  - To prepare standard and action plan for protection of canal infrastructure and irrigation water and implement them.
- The Government of Nepal can form an Irrigation Management Committee for sustainable development and effective management of each of the large and major irrigation systems developed. The Committee shall have the representation from water users, central government, provincial government and local government.
- The Government of Nepal will establish a Central Irrigation Development Fund by publishing notice in the Nepal Gazette from the prescribed date for overall development of irrigation systems and their sustainable management. The Fund Board shall be headed by Secretary, Ministry of Irrigation. Following amount will be deposited in the Fund:
  - Amount received from the Government of Nepal
  - Amount received from national or international agencies and organizations
  - Amount received from interest, profit or other fees and taxes earned from the investment of the amount of the Irrigation Development Fund;
  - Other amounts as prescribed
- The users of the irrigation system shall pay the prescribed irrigation service fee. Irrigation services shall be ceased for those users failing to pay the Irrigation Service Fee.

4 POLICY AND STRATEGIC FRAMEWORK FOR IRRIGATION DEVELOPMENT

The Government of Nepal (GON) attempted to address the issues of increasing the performance and potentialities of irrigation sector through the Water Resources Strategy (WRS) initiated in 2002 (WECS 2002). It defined short to long-term institutional and physical targets and activities to be undertaken based on Integrated Water Resources Management (IWRM) principle including irrigation sector.

4.1 Place of Irrigation Development in Water Resources Strategy of Nepal

Besides other Water Sector Issues, the strategy document highlights Irrigation Issues as follows:
- Reorientation of supply-driven approach,
- Poor performance of irrigation systems,
- Lack of effective implementation of Agriculture Perspective Plan (APP),
Farmers’ dependency syndromes and sustainability,
Problems of river basin management,
Weak institutional capability,
Symbiotic relationship between agriculture and irrigation (weak linkages), and
Strengthening of WUAs

4.2 Water Sector Objectives

Water resource development, like other national development agenda, should aim to contribute to improving the quality of life. Besides other objectives, the objective is to increase agricultural production and productivity, ensuring food security of the nation is prominently highlighted. Water Resources Strategy outputs will contribute to this goal through the achievement of short, medium and long-term purposes. These purposes have been defined as follows:

- **Short-Term (5 Year) Purpose**: Implementation of the comprehensive Water Resources Strategy provides tangible benefits to people in line with basic needs fulfilment, supported and managed by capable institutions of all stakeholders.

- **Medium-Term (15 Year) Purpose**: Water Resources Strategy is operationalized to provide substantial benefits to people for basic needs fulfilment as well as other increased benefits related to sustainable water use.

- **Long-Term (25 year) Purpose**: Benefits from water resources are maximized in a sustainable manner. To achieve these purposes, the Water Resources Strategy has defined ten strategic outputs. One of the specific outputs of the irrigation sector is to make: “Appropriate and efficient irrigation available to support optimal, sustainable use of irrigable land.” National Water Plan (NWP), 2005

The National Water Plan (NWP), 2005 was prepared in order to implement the provisions of the Water Resources Development Strategy approved by the government in 2002. It guides stakeholders to implement and manage resources and water related services including irrigation services in an integrated manner. The NWP recommends the short-term, medium-term and long-term program and project planning along with investment projection and institutional reorganization (Gurung 2007; Dhungel 2007).

4.3 Irrigation Policy and Agriculture Policy

The Agriculture sector and the irrigation sector as a whole, with the collaborative effort of both public and private entities, have to respond to translate those short-term, medium-term and long-term objectives of the National Water Plan. Agriculture Policy proposes to implement the Agriculture Perspective Plan (APP) by adopting more effective, liberal and market-oriented economic policies in the agriculture sector by promoting active private sector participation in agriculture inputs like (a) chemical fertilizer, (b) shallow tube wells and (c) micro-credits along with improvements in agriculture inputs, policy reforms and institutional restructuring. However, the time frame for the APP was implementation until 2015. Government of Nepal has formulated Agriculture Development Strategy, a long-term vision for agriculture development.

4.4 Agriculture Development Strategy

One of the issues to address the periodic plans is the preparation of district/ river basin-based irrigated agriculture development strategy. The District Irrigated Agriculture Development Strategy (DIADS) as a tool for planning and selection of district level agriculture strategy was proposed, but the exercise on DIADS could not take place. This exercise aims at getting the information of natural resources of the district for agriculture and irrigation planning.
5 IRRIGATION INSTITUTIONS

It occupies substantial share of annual investment in the national budget. Along with the World Bank (WB), Asian Development Bank (ADB) and other donors, the Government of Nepal (GON) has substantial share of investment in irrigation sector of Nepal. This is an important driver to promote irrigated agriculture, which occupies important place in domestic production as well as rural employment in Nepal.

There are different agencies, which influence the irrigation sector of Nepal. The National Planning Commission (NPC), Ministry of Irrigation (MOI), Ministry of Finance (MOF), and Water and Energy Commission Secretariat (WECS) are responsible for initiating appropriate policy on irrigation development in Nepal. Recently, the GON has shifted towards mega-irrigation projects and inter-basin water transfer projects as well. However, the micro-irrigation like non-conventional irrigation systems, small and medium irrigation systems also contribute to ensure food security. These policy-making bodies have to take comprehensive approach incorporating all these resources (mega, medium and micro systems) to decide on the investment, choice of appropriate technology, water right issue on different water sectors, allocation of water resources to different sectors keeping in view of integrated water resources management program, direction towards management types and governance modes, etc.

Irrigation development and management is undertaken by different agencies of the government and private sector in Nepal. The institutions that are contributing for irrigation development in Nepal are: (a) Department of Irrigation (DOI), (b) Department of Agriculture (DOA), (c) Ministry of Local Development (MOLD) through DOLIDAR (Department of Local Infrastructure Development and Agricultural Roads), (d) Ground Water Resources Development Board (GWRDB), (e) ADB/Nepal (f) farmers’ community, and private sector organizations (e.g., NGOs such as International Development Enterprises (IDE), SAPPROS/Nepal (Support Activities for Poor Producers of Nepal), etc.).

Similarly, the educational and research institutes like agriculture and engineering colleges and the National Agriculture Research Council (NARC) are also important players to contribute for the better performance of irrigated agriculture. Among these different agencies involved in irrigation sector development, the DOI has a major share in promoting and managing the irrigation systems in Nepal. The DOI is involved in multi-facet aspects of irrigation development. Prominent among them are surface irrigation system of all sizes above 25 ha (small, medium and large), ground water development by shallow tube well (STW) and deep tube well (DTW), and lift irrigation systems, including non-conventional irrigation techniques in water distribution.

6 FOCUS ON REVITALIZATION OF IRRIGATION SYSTEMS IN NEPAL

The National Water Plan (NWP) 2005 puts a set of physical targets in irrigation sector for increased agriculture production. These targets are for round the year irrigation, increased irrigation efficiency, increased cropping intensity as well as increased irrigation facilities in the potential irrigable area.

Taking the irrigation facility base as 1.2 million ha in 2011, by 2027 (within 15 years) 442,000 ha irrigated area is to be added if 97% of irrigable area is to provide irrigation facility. This will require adding about 30,000 ha irrigation facility each year for next 15 years according to NWP of Nepal. On top of that, effort is to be made to increase cropping intensity, agriculture productivity and irrigation system efficiency. In order to meet the above-mentioned targets to increase agriculture productivity and irrigation facility, revitalization in the irrigation systems is to be undertaken. The revitalization of irrigation systems should include (a) physical improvement, (b) increased irrigated agriculture productivity and (c) institutional reforms.
Case studies of Irrigation Management Transfer (IMT) and FMIS of different sizes are referred. It is important to mention here regarding the annual loss of irrigated land caused by flood, river bank erosion, landslides, unfriendly weather condition affecting the destruction of the crops, housing developments in the prime lands and sand mining in the rivers, etc. However, there is no comprehensive record which can help make a comparison of the newly added irrigated land with that of land loss by natural disaster and unplanned man-made developments.

6.1 Improvement of Agency Managed Irrigation Systems (AMISs) through Management Transfer (IMT) Program

It is reported that agency managed irrigation systems (AMISs) have poor performance and there are potentialities for their performance improvement through appropriate type of Irrigation Management Transfer (IMT). IMT means a process in which some functions and responsibilities of management, formally exercised by a state agency, are transferred to an organization of the users of the irrigation system. Appropriate IMT with well-defined objectives to the users address the issue of increasing agriculture productivity and better irrigation infrastructure performance. Hence, IMT attempts to address the problem of below capacity performance, poor O&M, negligible cost recovery, inadequate funds for the management of irrigation systems and finally the problem to increase agriculture production. IMT is one of the important methods of revitalization of irrigation systems.

It is recognized that there is scope for performance improvement of AMISs by
- improving the service delivery through responsibility division between the agency personnel of DOI and water user associations (WUAs),
- support to strengthen the WUAs,
- the agency needs to consider that IMT is not only physical improvement; and
- it includes the institutional reforms and agriculture productivity improvement.

These components have to go together. One of the important features of IMT in the new approach adopted in Nepal is the signing of agreement between the farmers group and the agency with the responsibility division between DOI taking charge of maintenance and management of headwork and main canal, and WUA taking charge below the main canal. The agreement thus signed between these two parties includes the provision of penalty for failure to comply the terms of agreement by either party.

6.2 Modernization of Large Scale Farmer Managed Irrigation Systems (FMIS)

It is estimated that 70% irrigated area in Nepal fall in the category of farmer managed irrigation systems (FMISs) (Pradhan 1989b)). FMISs have greater potentiality for management improvement and increased agriculture production. Recognizing the potential for improvement of these systems, the
Nepal government has mobilized funds from donor agencies for improvement of these systems.

Two interesting Nepal examples are presented here: the farmer managed Rani, Jamara and Kulariya Irrigation Systems (RJKIS) of Kailali District and the Rajapur FMIS of Bardiya District. Both of them are each of about 15,000 ha and over a hundred years old systems. Both of them have the Karnali River, one of the big river systems, as the source of water of RJKIS is the Karnali and that of Rajapur is the Geruwa, a bifurcation of the Karnali River. The water flow fluctuation in the river ranges from 173 m$^3$/s during dry season to 16,000 m$^3$/s during monsoon (HMD 2001). The farmers have organized themselves to get irrigation water under the huge fluctuation of river water. Within those 15,000 ha, there are several systems, but the command area is physically contiguous.

The Rajapur Irrigation System has potentiality for increased agriculture production. The objectives of the rehabilitation of Rajapur Irrigation System are: (a) increasing agriculture production and farm income, (b) protection of land erosion through flood, (c) reduction of environmental degradation through less reliance on forest products for repair of irrigation systems, and (d) strengthening institutional base and technical capability of WUA members.

The loan covenant of the Asian Development Bank (ADB/Manila) stipulates that the farmers will get timely access to necessary agriculture support services. The completion report of ADB states that the absence of integrating these two elements (agriculture and irrigation) with the project has hindered farmers taking full advantage of improved irrigation facilities to increase agriculture production (ADB 2003).

Drawing lesson from the Rajapur Irrigation Rehabilitation Project, Rani, Jamara and Kulariya FMISs of about 15,000 ha command area of Kailali district located on the opposite side of Rajapur Irrigation System, the modernization of this system is designed in two phases with four components (WB 2011). They are: (a) physical rehabilitation called scheme modernization, (b) strengthening water users’ associations, (c) agriculture production support, and (d) project management.

They have great potentiality for increasing agriculture production. Both these systems are flood irrigation types, not having any water control structures for proper water distribution in the command area. In the Rajapur Irrigation System as well as in the Rani, Jamara and Kulariya system at the first phase, it is proposed to have control structures at the intake point of the system. The stages of irrigation development can be characterized as, firstly, flood irrigation (capture the water when there is flood in the water source.) The second stage of irrigation development is the establishment of control structure at the intake point so that water flow in the system can be regulated. The third development of the irrigation system is the installation of number of control structures and field channels in the command area so that water can be made available where water is in need for crop growth. The fourth stage is the automation of the regulators to let the water flow according to the size of the command area and demand of the users. Finally, the irrigation system will be designed in such a way that water distribution will be regulated by computer programming based on the moisture requirement to the crop roots. Many irrigation systems have come to third stage development in Nepal. However, government made the policy clear that the farmer managed systems will remain most parts of a system under the management of farmers even after major rehabilitation.

6.3 Towards Medium Size FMIS

FMISs are owned and managed by the farmers themselves. At present, about 40% of food requirement of the country come from these irrigation systems. Hence, they have an important role for food security as well their contribution to the Nepalese economy. There have been many modes of intervention in the FMIS in Nepal (Ostrom, Lam et al 2011; ADB 2006; WB 2007). Irrigation and Water Resources Management Project (IWRMP), a project funded by the World Bank and Community Managed Irrigated Agriculture Sector Project (CMIASP) funded by Asian Development Bank have the
objective to improve agriculture productivity of existing small and medium size FMIS suffering from low productivity and high poverty incidence and help enhance the livelihoods of the poor men and women. These objectives shall be translated by providing improved means for WUA empowerment, improving irrigation facilities, promoting agriculture extension, targeting livelihood enhancement to build human capital of the poor and strengthening policies, plans and institutions for more responsive service delivery.

6.4 Other Types of Irrigation Systems and Their Implications

Other important segment of irrigation sector which is unorganized yet contributes substantially to the food security of Nepal and helps alleviate the poverty is the small irrigation systems below 25 ha, utilization of groundwater through individually owned STW, and micro-irrigation systems utilizing small local sources of water and different technologies. This sector deserves special attention to revitalize and consider this sector from the approach of physical improvement, support system for increasing agriculture production and policy and institutional arrangement and governance mode whereby users can derive benefit out of this sector. It is estimated that this sector covers thousands of hectares of agriculture land and millions of users both in plain area of Terai for STW as well as in the difficult inaccessible remote hill and mountain areas (Upadhyaya 2000; Chapagain 2000). Recently, there has been consideration of multiple use of small source of water for drinking purpose as well as for economically productive activities (Pant, Sakya and Adhikary 2006). Except for ground water utilization, there is no strong institution to promote and protect this category of irrigation systems with different technologies.

6.5 Multiple Approach in Irrigation Development

Out of those case studies, one finds that there are still potentialities to derive enormous increased agriculture productivity benefit from the revitalization of different types of irrigation systems in Nepal. With appropriate physical improvement and improved governance mode empowering the users group, the agency managed systems bring out their potentiality and improve under-performance. Similarly, appropriate physical improvement activities along with proper institutional arrangement and agriculture production promotion program would generate positive results to feed the growing population as well as meet the challenges of water scarcity. There is need to have considerations for the revitalization of small and micro-irrigation systems. The approaches of revitalization of this sector have to be unconventional irrigation rehabilitation and intervention program. The focus of revitalization of this sector of program has to be more of people and their way of managing natural resources within the community. The physical improvements of irrigation systems cost substantial investment. Hence, the Department of Irrigation and Ministry of Irrigation take into consideration while undertaking physical revitalization from poverty alleviation, gender concern, regional balance and inclusiveness.

Increasing agriculture production is the important agenda behind the revitalization of the irrigation systems. There are tremendous potentialities of increasing agriculture production through appropriate mix of better water management and agriculture improvement technologies and market oriented agriculture production. Rice production occupies major share of irrigated agriculture. Out of 1.4-million-hectare rice production area, about one million hectares has irrigated rice cultivation. Rice yield/ha is very low in the region, amounting in an average of 2.79 ton/ha (Uprety 2007). However, records of production from agriculture research farms show that there is potentiality for increasing production of 6 ton/ha of rice. Similarly, pilot experiments of the adoption of the System of Rice Intensification (SRI) in Nepal show the yield of 6-10 ton/ha (Uprety 2007; Uphoff 2007). Other crops also have potentiality to increase yield.

The governance of irrigation management is important. The centralized management system of irrigation systems has proven that it is not conducive for better water management, resource
mobilization and agriculture production. There is a big debate going on whether bureaucracy or community should be managing irrigation systems. There are even debates going on stating neither state nor private sector but the community can better manage the irrigation systems (Ostrom 1994). Therefore, revitalization of irrigation systems has to have multi-dimensional features to address resources (water), physical infrastructure (canal and other control structures) as well as placing the farmers in the driver’s seat and creating appropriate governance procedures (irrigation institutions) (Ostrom, Lam et al 2011).

A central agency is necessary for planning, investment, monitoring, and evaluation of the sector in the larger context. At present, one feels the absence of such a central agency to oversee the overall irrigation sector encompassing all sizes, types and technologies as the national resource to ensure the food security.

7    CHANGES IN THE PRIORITY OF THE IRRIGATION SYSTEMS AND INVESTMENT PORTFOLIO

Over period of time, investment in irrigation sector through public funding has increased. In late 70’ and 80s, large scale systems were developed. Nepal has now 1.4 million ha of irrigated land out of 1.76 Million ha potential irrigable area. Now irrigation facility development in the remaining potential irrigable area calls for higher level technical and financial challenges. Now Department of Irrigation has changed its role from constructing and managing the surface and some ground water irrigation systems to new adaptation of non-conventional irrigation technologies. DOI has changed its role from irrigation water management to water resources distribution for the benefit to the marginal farmers and deprived group of farmers. Non –Conventional irrigation systems like drip, sprinkle, solar pumps, traddle pumps were promoted where water scarcity prevail or water availability has been a major problem.

Department of Irrigation has change its role from only infrastructure development to socio-economic change agent through making irrigation water equitable distribution among all sectors of people both rich and marginal farmers to better cultivated land to marginal lands as well. Department of Irrigation is making effort in its policy and program to have inclusive policy and gender equality. They are very appreciable directions that DOI is moving forward yet there are many challenges that DOI has to face.

7.1    Changes in irrigation Agency

Water resources management is a dynamic process which is influenced now by the climate change and population growth. Water resources are getting scarce and the allocation of water in irrigation sector is also comparatively decreasing to meet for the expansion of irrigated area and cope with increasing food production for growing population.

Department of Irrigation now has entered into high level multi-sector water resources management approach through inter-basin water transfer for expansion of irrigated area and hydropower generation through the head gain from the water transfer from one basin to another. One inter-basin water transfer project called Bheri-Babai Diversion Multipurpose Project is under construction and another project called Sunkoshi-Marin Diversion Multipurpose Project for Bagmati Basin is under final study which will have both irrigation facility development as well as hydropower generation. Organization is yet to be decided whether DOI is also looking after hydropower management or only take the royalty for department by assigning the management to another agency. This also may ask whether the Basin transfer program be handled by the existing DOI or need to create another entity to consider basin transfer program separately with an approach of integrated basin water resources management. Besides, as per the Constitution Nepal, part of functions carried out in the past by DOI
as a central organization, will be devolved to provincial and local government. Thus, role of DOI in the future will be limited to plan and develop the large irrigation and multipurpose projects.

Within five decades of Department of Irrigation history, it has gone through many change cycles. Every time, it has proven that it can accept new challenges. Along with these changes, Department of Irrigation now should develop its own a strong Research wing and linkages with other research institutions within Nepal and elsewhere.

7.2 Changes in farmers organization

7.2.1 Conditions for a functional Water Users Association (WUA):
At the very heart of any effective WUA is a functioning water share distribution system. The water share arrangement should ensure that each member of the irrigation community has a legitimate access to water within the arranged rules, and it confers an obligation to contribute an agreed-upon share of the cost of managing water in the system. The concept of water shares unites two essential aspects of organizational operations — resource acquisition for operation and maintenance and water allocations along the canals (Freeman, 1992). Members of the irrigation committee should be irrigators who represent the various reaches of the canal system and are fully accountable to their fellow irrigators.

7.2.2 WUA Dependency Syndrome
Almost all schemes of management transfer suffer from a dependency of the new organizations upon the government. Pradhan and Bandaragoda 1997, quoting a regional study of WUAs in South Asia, put the problem as follows: “Water Users’ Associations have not been effective because they did not reflect the multiple needs of the farmers, rather they work as an extension of the irrigation department in many places. Water Users’ Associations should develop a self-reliant basis for their functioning, in their areas of jurisdiction, while they pursue an interdependent relationship with the government agencies.” This pattern of dependency on the promoting agency has been reported frequently, and from many different types of economic and political environment.

The core of the problem is that the new organizations are initially accountable to the promoting agency of government. The direction of accountability must change, so that they become accountable to their own membership. If this does not happen, they are not likely to become sustainable as independent organizations. So, when Pradhan and Bandaragoda say that the organizations must "develop a self-reliant basis," we should recognize that development of self-reliance does not depend only on actions and behaviour of the organizations and their own leaders. It will be decisively influenced by actions and behaviour of the promoting agency, and of agency officials who are in frequent contact with the water users’ or irrigators’ organisation (Abernethy, 2001).

7.2.3 Definition of Success
We can define our concept of success in a management transfer operation relatively simply. Success is achieved when we have genuinely independent organizations, which choose their own objectives, make and amend their own rules, select their own leaders, raise and spend their own funds, and ensure rule-compliance through their own internal processes. If an organisation exhibits these characteristics, it is likely that some of the government objectives will also be achieved, and that the dependency syndrome will be brought to an end.

This condition of independence is defined well in the three conditions quoted by Pradhan and Bandaragoda 1997: the organisation should become "self-governing, self-regulating and self-supporting." It is evidently necessary, as one of the first steps in the preparatory phase, to undertake consultation among the putative future members of the new organisation, to discover their objectives. It is not very likely that members will want to pursue a set of official objectives. However, if the WUA
pursues objectives that its members do see as important, they may be amenable to making adjustments, so that some of the official objectives will also be addressed.

7.2.4 Transition from Agency to Farmer Management

It is important to understand the distinctive differences between agency management and farmer management in terms of their intrinsic values. The irrigation infrastructure in agency–managed irrigation systems (AMIS) is designed according to conventional engineering and agronomic practices. By contrast, irrigation infrastructure in farmer management system does not follow standard engineering design.

7.2.5 Department of Irrigation for Better Functioning WUAs

(i). Wide participation of the members of the system and equal distribution of stakes among head, middle and tail-end farmers make for a strong organisation.

(ii). Mutual dependence between head and tail farmers due to difficulty of water acquisition or resource mobilization. Social cohesion leads to a more equal distribution of benefits.

(iii). Transparency of activities, as demonstrated at the annual general assembly meeting of the WUA. Rules, regulations, statements of income and expenditures should be discussed. Elected members of the WUA should be accountable to the general assembly.

(iv). Resource mobilization based on equality. Cash, in-kind and labour contributions must be recorded properly. Accounts should be open to all members for inspection.

(v). If water is to be considered as a community resource, the rules for its distribution must be agreed by all members. Decisions on water distribution should be made collectively and enforced by the committee. Punishments for non-compliance with the water distribution rules must be clear and understood.

(vi). Water rights should be clear and linked to obligations, including mobilization of resources.

(vii). The Executive Committee, formed on the basis of the voice of member farmers gives room for wider representation. It should be accountable to the general body.

(viii). The General Assembly should meet at least twice a year to approve rules and regulations for the management of the system.

These are general features of effective WUAs. However, the functioning of WUAs in practice is influenced by the availability of otherwise of water, the procedures for acquiring water rights and water distribution. The relationship of the WUA with the government agency and other external agencies is also very important.

8 TOWARDS SELF-MANAGEMENT OF IRRIGATION SYSTEMS IN NEPAL

A farmer from Sindhupal chowk district of Nepal once told to us that "the irrigation channel up there cannot stand in that fragile terrain only by iron rods and cement concrete, it is our organisation which kept the irrigation channel functioning"

What the farmer is talking about here is the social capital and farmer organisation which have helped better utilize the physical capital like channel and natural capital like irrigation water. Individuals usually derive the benefit of physical and natural capital but social capital, in contrast, is expected to produce goods that are more collective than just for individuals. The mutually beneficial collective action of farmers makes irrigation system perform better. This mutually beneficial collective action, in order terms, is the self-management of irrigation systems.

The typology of irrigation management broadly categories the agency managed and farmer managed irrigation systems. The self-managed irrigation systems imply the implementation of management activities of irrigation systems by the irrigators themselves. They are also called farmer managed irrigation systems. Hence, the self-management of irrigation systems undertakes "fundamental tasks by irrigators themselves on the basis of accumulated local knowledge and filling all of the necessary
positions for among the irrigation systems from small multi-individual and community system that irrigates few hectares to thousands of hectares. The self-managed irrigation systems can hire technical manpower to help manage the irrigation systems as well as the employment of irrigators themselves for management.

It requires the change of the role of the government from implementers to facilitator. The government takes the responsibility of helping the farmers build up their management capacity and carry on further improvement activities through the WUA. The role of the organised group of the farmers becomes important. Hence, appropriate form of WUA becomes important. Such program helps promote self-management of irrigation systems.

8.1 Farmers Organization as focal point for Self-management

The intelligence of the farmers is to be recognized and respected by the officials. Of course, many farmers are illiterate but not necessarily idiot. We must have faith on them and help develop their capacity to manage hence, the WUA formation needs to be carefully handheld. It is necessary to the farmer’s community to discuss about WUA. It needs to develop trust among themselves and sense of cooperation. Reciprocity and mutual understanding among the farmers themselves are important conditions for proper functioning of WUA. With these conditions, social capital within WUA develops. This social capital will complement to physical and natural capital to increase their agriculture productivity. They come only through frequent interactions among themselves.

8.2 Conditions for WUA Formation

It will be useful to consider establishing WUA on hydrological basis. These criteria will make easy to identify the members of the irrigation systems who are water users. Consequently, resource mobilization for O&M and other purposes will be easy. List of the water users and size of landholding is to be prepared before the formation of WUA/ WUG. Based on the list, meeting of members of WUA has to be organised by the facilitator and inform about the role and responsibilities of the WUA. Based on water distribution system, sanction for non-compliance, resource mobilization based on the land holding has to be encouraged and incorporate in the constitution for the WUA.

8.3 Impact of Participation on Self-Management

Participation of the farmers during rehabilitation is important for institutional development as well as for good quality physical infrastructure construction. Externally imposed WUA would not be effective. Usually, the irrigation agency attempts to introduce "uniform" rules in all irrigation systems without recognizing the diversity inherent in the irrigation systems. They are different from region to region. Even within a system, there are differences from area to area. Imposing prototype rules and regulations of WUA in the irrigators community would take away the opportunity of the irrigators community crafting institution suitable to their specific situation and ecological conditions. The level of passive participation allowed in this process would deny the people the opportunity to make "Collective choice" appropriate to their condition and environment. Because of low level participation in the process of rehabilitation and assistance to FMIS, the social capital development does not take place. If we take the rules and regulations as one of the attributes of social capital development formation, it is important to see how their rules and regulations as "structured social capital" have evolved. They have to evolve based on understanding, negotiations and cooperation among the users. Imposition of prototype rules and regulations to govern the irrigator’s community would not contribute to promote social capital, which should act as glue to bring together the members of the irrigator's community and help promote self-management of irrigation systems.

In analyzing 102 irrigation systems of Nepal from Nepal Irrigation Institute Data Base (NIIS Database) stored in Workshop in Political Theory and Policy Analysis at Indiana University, on the impact of farmer
participation in economic and technical efficiency, physical and agriculture condition, it is found that the systems with high level of farmer participation perform better, Joshi et al. 2000. The table given below clearly shows that the system with high level participation has good result on economic and technical efficiency. The physical conditions are considered much better. The difference of cropping intensity between head and tail is less. The water supply in head and tail is not much different. On the other hand, systems with low level participation have poor performance in economic and technical efficiency. The physical condition of the large percentage is not good, water supply between head and tail is different making scarce supply at the tail end.

<table>
<thead>
<tr>
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<th>High-level Participation</th>
<th>Moderate-level Participation</th>
<th>Low-level Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Economic Efficiency</td>
<td>82.4% (16/19)</td>
<td>31% (21/66)</td>
<td>33% (9/27)</td>
</tr>
<tr>
<td>Highly Technical Efficiency</td>
<td>73% (12/19)</td>
<td>13.6% (9/66)</td>
<td>22% (6/27)</td>
</tr>
<tr>
<td>Difference between head and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tail cropping intensity</td>
<td>2.5% (15/19)</td>
<td>3.5% (37/63)</td>
<td>6% (7/26)</td>
</tr>
<tr>
<td>Water supply at the tail end</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Adequate and Predictable)</td>
<td>78.9% (16/19)</td>
<td>58.7% (37/63)</td>
<td>26.9% (7/26)</td>
</tr>
</tbody>
</table>


The study shows clearly that the investment in physical infrastructure alone does not produce positive results. The formation of social capital compensates even in weak infrastructure. However, in the absence of social capital, permanent structures also would be less productive. Therefore, the social capital helps towards the self-management of irrigation systems. With such management type, the important issue of equity, participation of the farmers, accountability and transparency are institutionalized.

8.4 Towards Self-management of Irrigation Systems

It is to encourage the irrigator's community to take the responsibility of management of irrigation systems. Since there has been change in the management of state affairs and less importance to state control of management of public enterprises and natural resource management, the community of irrigators have proved that they can manage system through self-management mode. In order to make self-management effective, active participation of the irrigators, polycentric mode of governance, effective water users associations and social capital development have to take place. Hence, DOI is implementing WUA towards self-management.

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SUDAN COUNTRY PAPER: INSTITUTIONAL REFORMS IN IRRIGATION SECTOR FOR SUSTAINABLE AGRICULTURE WATER MANAGEMENT, INCLUDING WATER USERS’ ASSOCIATION

1 INTRODUCTION

Irrigation projects are considered major components of development plans in many developing countries. This is because of the food security issue; in addition, they produce commodities for export to earn foreign currency and also producing raw materials for local industry. Many other benefits are obtained from irrigation projects like offering jobs for rural inhabitants, reducing poverty, and thereby achieve rural development in general context. Urban centers are also benefitting through receiving agricultural products and got relief from the influx of villagers’ invasion seeking marginal jobs.

Sudan as an example of developing countries started irrigation projects early last century with the Gezira Scheme, and through the years many other irrigation projects were constructed in different parts of the country. Today the irrigated areas exceed four million Feddans (about 1.68 million hectare) second to Egypt in the African Continent. The largest irrigated scheme, the Gezira Scheme is chosen as a representative for other irrigation schemes in the country.

Because of the vast benefits from irrigation projects, most financial institutions and international lenders are ready to offer finance after finalizing the needed documents and obtaining guarantees.

In fact, the agricultural sector plays a pivotal role in the economy of the country. The irrigated schemes represent only about 10% of the total cultivated areas; however, it contributes to about 50% of the agricultural production and 42% of the GDP of the country. It also involves about 70% of the population.

Figure 1. Sudan Map after Cessation of the South
2 LEGAL FRAMEWORKS

2.1 Issues and challenges related to land and water

Today the total money invested in the water sector in the governmental projects in Sudan may reach up to Nineteen (19) billion dollars. These include the major dams (Sennar, Rosaires, GushmElgirba, and Merowe) and the irrigation schemes in the Gezira, New Halafa, Rahad and Suki. If we add the Sugar schemes in Genaid, Sennar, New Halfa, Asalaya, Kennana and White Nile Sugar Project; their infrastructure may amount to one (1.0) billion dollars. The scattered pumping irrigation schemes in the While Nile, Blue Nile and Main Nile with an area about 400.000 Feddans (0.168 million hectare), their infrastructure with the prices of today may amount to another 1.5 billion dollars. So, the total investment in the infrastructure of the water Projects in Sudan may exceed 22.0 billion dollars.

Sudan has a comparative advantage in vast irrigable lands, easy to irrigate and in the 1996 Food Summit in Rome was considered one of four countries capable of providing sufficient food to feed the world population. Agriculture consumes about 90% of the country water uses.

Table 1. Summary of the available water resources in Sudan (rainfall is not included)

<table>
<thead>
<tr>
<th>Available Water Resources</th>
<th>Quantity (BCM)</th>
<th>Constraints</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan share from the Nile (measured at Sennar dam)</td>
<td>20.5</td>
<td>Seasonal pattern coupled with heavy silt affecting the storage capacities.</td>
<td>Nile waters</td>
</tr>
<tr>
<td>Wadis Waters</td>
<td>6.0</td>
<td>Highly variable, short duration flows difficult to monitor or harvest. The major ones are shared with neighbours (Gash, Baraka, etc.)</td>
<td>Mainly Non-Nileotic waters</td>
</tr>
<tr>
<td>Renewable Groundwater</td>
<td>4.0</td>
<td>Deep water entailing high cost of pumping. Remote areas of weak infrastructure.</td>
<td>About 30% Nile waters</td>
</tr>
<tr>
<td>Present Total</td>
<td>30.5</td>
<td></td>
<td>8.8 (BCM) Non-Nileotic</td>
</tr>
<tr>
<td>Others (depend on cooperation with South Sudan)</td>
<td>4.0</td>
<td>Capital intensive with considerable social and environmental costs</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Groundwater estimates in Sudan is about 564 BCM, however the major part is found in the Nubian Sandstone Aquifer (NSA) which is located in the North-West part of the country and shared with Chad, Libya and Egypt. NSA is connected to the Nile system, especially in the areas north of Khartoum. There are other aquifers covering most part of the country like Umm Ruwaba, Bagara, Gezira aquifers. Gezira aquifer is charged and connected to the Nile system as well. The estimates are very rough, and there is no detailed study showing the amount of groundwater in each aquifer.

2.2 Review of institutional and organizational aspects of irrigation and drainage sector

The responsibility of water resources monitoring, assessment, development and management in Sudan was not under one institution. The major part after independence in 1956 was under the responsibility of the then Ministry of Irrigation and Hydroelectric Power which later became the Ministry of Irrigation and Water Resources (MIWR). In 2011 the irrigation part became part of the Ministry of Agriculture (MOA) reducing the ministry to be the Ministry of Water Resources (MWR). Less than six months later, in 2012 that ministry was attached to Electricity and Dams to be the Ministry of Water Resources and Electricity (MWRE). In 2015 a Presidential decree No.32 brought back
the O/M Directorate from Ministry of Agriculture to the mother ministry, currently became Ministry of Water Resources, Irrigation and Electricity (MWRIE). Now the MWRIE is entrusted for monitoring, assessment, planning and development of the water resources: surface water, groundwater and drinking water and sanitation at the national level. Drinking water at the state level is the responsibility of the states. Measurement of evaporation is the responsibility of the Meteorological Department which is part of the Ministry of Defence. There is coordination between the MWRIE and the Ministries of Agriculture, Environment and Forestry, Industry, Meteorology and related institutions.

2.3 **Needs for institutional reform**

Institutional reform coupled with legal enforcement bodies are needed to meet the challenges ahead. The challenges range from internal disagreements over text, to institutional overlap, unclear mandate and lack of capacity. Increased vertical and horizontal coordination is required to achieve targets in a planned project. Recently there is awareness for the role of the stakeholders’ involvement in planning and decision-making. This was reflected in moves which resulted in the formulation of the Gezira Scheme Act (GSA) of 2005 and the development of Water Users Associations (WUAs) in the Gezira Irrigation Scheme (GIS). It was thought wise and appropriate to take the stakeholders on board for the success of both rehabilitation and modernization of a project. In a federal system, one might find centrifugal forces pulling regional considerations away from national ones generating concerns over policy coherence. This could be seen in developing water projects without reference to the Federal Government. In other cases, there is un-satisfaction between the centre and the regions about delegated authority or responsibilities that are not matched by financial capacity because the centre may be reluctant to let go of national regulations.

3 **PARTICI liquidity irrigation MANAGEMENT (PIM) AND IRRIGATION MANAGEMENT TRANSFER**

3.1 **Need and objectives of PIM**

If we take the GIS as an example the main organizations involved in the water management at the scheme are the MIWR, Sudan Gezira Board (SGB) and farmers as Water Users Associations (WUAs). The irrigation responsibility used to be under the MIWR, however, different combinations from the above organizations were tried. A study done by a researcher (Ahmed El Shaikh, 2016) about the performance evaluation of these organizations and based on the data of water supply and cultivated areas for the period of 44 years from 1970 to 2014. The data was statistically analysed for each period, then the outputs were compared with the reference value based on design criteria of the scheme and Crop Water Requirement (CWR). The results show that MIWR period was the most efficient era with only 1% difference from the base value, while the worst period was found after the involvement of the SGB when water supply increased by 61%. The other periods include: The Irrigation Water Corporation (IWC), WUAs & MIWR and SGB & later the WUAs exclusively on which these periods witnessed an increase in water supply by 13%, 44% and 53% respectively. It could be said that, the changes of polices and institutional arrangements, clearly, have an influence on the irrigation management performance. Figure2 below shows the flows to the Gezira Scheme in the period from 1981 to 2013. It is evident that after the adoption of the WUAs in 2005 the flows increased without any increase in the cultivated areas. It can be seen from the same Figure that the flows delivered to the Scheme in 1992 was only about 6.0 BCM while the area cultivated was about 1.7M Feddans, the largest in all recorded areas in the mentioned period.
4 OBSERVED IMPACTS OF PIM

4.1 Water allocation and service delivery

GIS had witnessed a significant decrease in water management performance and agricultural productivity which led to many institutional changes aimed to put the system on the right path (Ahmed 2009; World Bank 2010). Nevertheless, the situation did not show any progress as shown above and conversely it became worse. There are many studies conducted to evaluate the policies related to the irrigation water management in Gezira scheme. Adam et al. (2003) studied the impact of farmer’s participation in water management in Gezira scheme. Ahmed (2009) explored the challenges that facing the operation and the performance of irrigation management Gezira. The World Bank (2010, 2000) discussed development issues and sustainability of water management in the scheme. The irrigation management challenges and opportunities in the Gezira scheme were studied by (Babiker 2014), while Osman (2015) conducted research focus on the effects of system operation and maintenance on the sediment and water management.

The irrigation management of the Gezira scheme was used to be run under three institutions: Sudan Gezira Board (SGB), Ministry of Irrigation and Water Resource (MIWR) and the farmers. SGB historically was responsible for adopting agriculture management Rules and Regulations (R&R), while MIWR was implementing irrigation system Rules and Regulations. The farmers were managing and irrigating their farms at the field level (World Bank 2000; Babiker 2014). The SGB officials at the beginning called liaison officers where they act between the water providers (MIWR) and the beneficiaries (Farmers). Later the SGB agronomists became responsible from the operation of the minor canal while the MIWR engineers are responsible from the maintenance of the minor canal.

When the Gezira Scheme Act of 2005 adopted and the WUAs were formed and given responsibility of maintaining the minor canals and water delivery to their farm, the situation became worse and it is really a disaster (Figure 3 below shows how the flows to the scheme increased while the cultivated areas were decreased.

Recently a mission from the World Bank visited the country offering a salvation program: Rehabilitation and Modernization to the irrigated sector starting with the Gezira Scheme. This program is under preparation.
4.2 Cost recovery

The modern irrigated agriculture started with the Pumping Scheme in Zaidab, Northern Region. The water charges used there was adopted later in most irrigation schemes in the northern part of the country. The water charges adopted at that time amount to about 50% of the net profit. A similar system was used in the beginning of the Gezira Scheme between the Sudan Government (SG) and the British company, Sudan Plantation Syndicate (SPS); a system known as Joint Account (JA) where the net profit was shared between the two partners (50% each).

Later in season 1981/1982 with the advice of the World Bank, the Individual Account (IA) was adopted and the irrigation water charges were introduced to encourage the farmers to increase their productivity. However, the implication of this change is the reduction of revenue to the SG, because the farmers and the Agricultural Boards were reluctant to pay the government those charges. Consequently, the SG ability to finance the irrigation department is hampered and consequently the irrigation operations to deliver water were severely affected. The water charges mechanism was based on the actual expenses of the departments involved in the irrigation water delivery and the total amount was distributed on the cropped areas on a flat rate and proportional to the delivery time. For example, cotton crop needs water for 6 to 8 months while wheat crop needs water for 4 months, so the water charges for these crops are based on these factors. Last year MWRIE assigned to one of its companies the collection of irrigation water charges and the latter succeeded to collect almost 80% of the charges and this will be reflected in the level of finance from the Federal Ministry of Finance in the future.

5 CHALLENGES

5.1 Water accounting and auditing

The system adopted for water delivery makes it difficult to run a water accounting and auditing on an individual water user. This is main cause of the inefficient water usage. The irrigation system needs to adopt a metering system to charge the farmer according to his abstraction. In view of the vast areas and the cultural behavior of the farmers, a sophisticated metering method will not be advisable. The actual amount of water delivered at the head of a minor for a group of farmers may be calculated and water charges may be divided equally between them. This may be the most practical method at hand.
5.2 Engineering challenges

The GIS is a gravity irrigation scheme where most of the scheme is commanded from Sennar dam on the Blue Nile River. The land is very flat and it was very easy to monitor the irrigation network through a system of regulators and weirs and command the whole scheme.

Due to the recent developments when the WUAs were responsible from the maintenance and operation of the minor canals, a lot of excess digging occurred which resulted in deeper channels, so gravity irrigation could not be practiced and many farmers are now obliged to use pumps in order to irrigate. The GS may be obliged to abort the positive command system and adopt the negative command system like Egypt. This resulted in extra costs to the farmers. Also, due to water shortage in some areas the farmers practiced vandalism and damaged many cross regulators and weirs to secure water for their farms. Now it becomes a major challenge for the irrigation engineers in controlling and regulating the water in the various canals.

5.3 Financing the Irrigated Schemes:

With the introduction of irrigation in the GIS last century the Sudanese Department of Finance used to finance the Irrigation Department, while the Sudan Plantation Syndicate and later the Central Bank used to finance all the other agricultural activities through credit which will be reimbursed at the end of the season. The same system was applied to other irrigation schemes.

In 1992 the SG adopted a major economic reform and introduced liberal economy, where all the government irrigated schemes were to be financed through a consortium of banks (mainly private banks) which were instructed to finance agriculture in the country. The interest of the Banks’ credits was extremely high in the beginning (about 70%) in comparison to the facilities offered earlier by the Central Bank, finance without interest. This system resulted in a severe setback to the whole agricultural production. The consortium of banks doesn’t have the experience in financing agriculture and also doesn’t have the sufficient resources; so, this situation resulted in reduction of cultivated areas and lower productivity.

5.4 Possibility of Public Private Partnership (PPP) for financing and improved service delivery

Due to the new government policy, more private sector are becoming involved in the irrigated sector. Various forms of finance are introduced varying from sharing the costs and revenue, or securing the finance through bank guarantees and land leasing. Other forms of private sector partnership through agreements with a group of farmers, as shown in this Memorandum of Agreement between Albasanta Group of Farmers and a South African Company as an example.

Box 1. Memorandum of Agreement between Albasanta Group of Farmers and a South African Company

<table>
<thead>
<tr>
<th>1. Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 To promote agriculture industry through technical and financial capacity</td>
</tr>
<tr>
<td>1.2 To develop Sudan agriculture farmers in terms of human capital</td>
</tr>
<tr>
<td>1.3 To provide agriculture exchange information between South Africa and Sudan</td>
</tr>
<tr>
<td>1.4 To improve agriculture trade relation between South Africa and Sudan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Parties To Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albasanta Group Farmers Co-Op, herein represented by Mr. A/ziz Mustafa Elbodi, duly authorized in his capacity as Representative.</td>
</tr>
<tr>
<td>And</td>
</tr>
<tr>
<td>African Kholom Holdings Pty Ltd, herein represented by Mr. Bheki Thamsai, Shangdeduly authorized in his capacity as Executive Director</td>
</tr>
</tbody>
</table>
6 WAY FORWARD AND RECOMMENDATIONS

6.1 Best practice for replication

The Memorandum of Agreement signed by a group of Farmers and a private company from South Africa is planned to be implemented next season, will be a good example to change the agricultural practices in Sudan. If it is a success it may be replicated in other parts of the schemes as well as other schemes. In fact, last year another example for finance with improved seeds was offered by the Arab Organization for Development and Agricultural Investment to a mall area in the GS and was very successful and it was repeated this year in a larger area (20,000 and 30,000 Feddans).

6.2 Recommendations

- Sudan is endowed with vast agricultural lands and has good experience with irrigation. In view of meagre financial resources, it is recommended that the government should make the proper polices and adopt the PPP concept and introduce it gradually in the irrigated sector.
- Recently the World Bank sent a mission to assist the Sudan Government in rehabilitating and modernizing the irrigation sector. The water management inefficiency is a major problem and needs to be addressed. It is recommended to start with small areas and gradually expand,
- It is recommended to encourage the private sector to invest more in agriculture with the government support in the form of taxes breaker.
- It is high time to charge the irrigation water by volume and not as a flat rate.
- Awareness campaigns designed to farms need to be started and put them on board.

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Chinese Taipei Case Study: Institutional Reforms in Irrigation Sector for Sustainable Agriculture Water Management, Including Water Users’ Association

1 Introduction

An irrigation system is a common-pool resource whose size or characteristics makes it costly, but not impossible, to exclude potential beneficiaries from obtaining benefits from its use. Especially, when the water supply is scarce and unpredictable, allocation of water is necessary to ensure that water is distributed equitably and used productively. With this concept to share the scarcity of water, development of rotational cropping and irrigation in Chinese Taipei, particularly during the period of 1950s to 1980s had fulfilled its designated contemporary goal of producing adequate food to meet the need of that era with comparatively small amount of water. This achievement might attribute to the technical renovation on water management and heavy investment in the improvement of irrigation facilities. Contemplatively, this practice had enabled water controllers to convince water users that the scarcity of water is being distributed equitably to a maximum extent so that the use of water in the field could maintain orderly, of which might ascribe equally or even more than the technical amelioration and heavy investment to the success and sustainability of water management.

Chinese Taipei arguably has some of the best-performing irrigation systems in the world, which have made significant contributions to the country’s economic development (Williams 1994; Chen 1997). Prior research suggests that the excellent irrigation performance can be attributed to the design of the country’s irrigation institutions. Irrigation in much of Chinese Taipei is governed by seventeen Irrigation Associations (IAs) – parastatal organizations collectively owned by farmers, supervised by governments at multiple jurisdiction levels, managed by professional managers, led by local politicians chosen by farmers, and supported by a network of Irrigation Groups (IGs) through which farmers organize collective action for irrigation operation and maintenance (PIM) at the local level. This design combines professional management and government support on the one hand, and farmer participation and self-governance on the other.

Since the early 1980s, Chinese Taipei’s irrigation has been facing substantial challenges as agriculture lost its economic importance; the decline of agriculture has come with drastic changes to the country’s social-political contours. As a result, irrigation in Chinese Taipei has taken on new features including a dominance of part-time farming, an increasingly heavy reliance on groundwater, and a growing integration of irrigation into the national water management regime; all these have reduced farmers’ incentives to engage in self-governing activities for irrigation management. Since 1993, the government has been paying membership fees to the IAs on farmers’ behalf. As the irrigation sector is getting more and more reliant on government subsidy, the government feels obliged to impose tighter control to make sure that public monies are appropriately spent which result in many irrigation groups are no longer as active as before. However, coordination in actual water delivery in Chinese Taipei is maintained not by a grand plan or a pacemaker, but by an array of institutional arrangements that encourage local problem solving on one hand, and local mutual adjustments on the other. Farmers in disparate situations can decide on how much effort they want to put in irrigation management, and their best ways to do it. The flexible institutional arrangements in Chinese Taipei depends on the willingness of a small group of IG leaders who serve as the bridges connecting up farmers.

The worsening of climate change in recent years has brought the hydrological conditions into more extremes, and threatens the water sectors. Especially for irrigated agriculture, the irrigation land is
always forced to conduct fallow in order to transfer the water to other sectors, which may introduce
the deficit risk shift to irrigation sector and food security problem. That is, traditional irrigation
practices are no longer capable for the normal operation of water resources distribution, and hence
new ideas are needed. The role of the IG has become increasingly important for the coordination
with variability on field level. The IAs are surely aware of the situation, and have adopted measures
to beef up the support and incentives for the IG leaders. In addition to find the sustainable
development of Irrigation Associations, the Irrigation Associations should not confine themselves on
the single service of irrigation. Instead, through diversification of the businesses by making better
use of the facilities, land assets, and human resources, the financial situation of the Irrigation
Associations should be significantly improved.

2 LEGAL FRAMEWORK

2.1 Issues and Challenges related to land and water

Chinese Taipei, 142 km in width and 383 km in length, is an island oblong in shape and located in the
West Pacific Ocean, east of the Chinese mainland with an area of 35,961 km². Being situated in both
of the tropical and subtropical oceanic zones and also in the Asian monsoon region, and with a large
ratio of mountainous lands on the island (Figure 1), the climates in Chinese Taipei are greatly
influenced by the monsoons as well as the land forms.

Subtropical climate characterized by high temperature, heavy precipitation, and violent winds.
Annual precipitation over the island averages 2,610 mm, which far exceeds the world average of 650
mm/year. However, the rainfall pattern in Chinese Taipei is mostly concentrated torrential with short
duration, and the sediment yield per unit area of the rivers is about 64 times of the world average.
The annual availability of water resources from precipitation varies from 60 billion m³ to 120 billion
m³, of which about 20 to 25 per cent of them were utilized in the last 10 years. In terms of depth, the
annual average precipitation of Chinese Taipei is the third highest in the World~ but per capita
precipitation being used is about 4,030 m³/person/year, contrarily this amount is the third lowest
compared to the lowest and 2nd lowest of Egypt and India at 951 and 3,795 m³/person/year
respectively (Ko, 2002). Uneven distribution of precipitation in space and time, together with the lack
of suitable storage dam sites due to weakness in geological land formation coupled the difficulties in
water utilization in Chinese Taipei. The precipitation utilization rates in the last ten years varied from
22% to 14%. Of the utilized water resources, only 24 to 28 per cent of them were taken from the
existing 41 small reservoirs. The shares of water utilization to the sectors of agriculture, domestic
water supply, and industry, in the Year of 2015 for example, are about 71.5%, 17.7% and 11.8%
respectively. In the same year, paddy rice irrigation, fishery and animal industrial sub-sectors shares
83, 16 and 1 per cent of the total of agriculture respectively (COA, 2013).
Those features induce the damage of flood and drought is very frequently in Chinese Taipei. The development of agriculture is highly depended on the large-scale irrigation and drainage projects. Given the above-mentioned unfavourable precipitation distribution, water shortage for irrigation almost reoccurs once every five to seven years during the dry season of winter; however, the temperature and soil conditions in Chinese Taipei are in favour of growing two crops of paddy rice wherever and whenever water resources are available. As rice is the staple food of the local inhabitants, traditionally, farmers would grow paddy rice as possible as they could when Chinese Taipei was still in the subsistence agriculture. Non-rice crops might be grown after harvesting irrigated paddy at the beginning of dry season. Those non-rice crops, which consumed much less water than paddy, would absorb the residual moisture in the soil after irrigation for germination; then they would grow in the semi rain-fed condition. Once or twice of irrigations depending upon water availability would be given to upland crops. When water resources are sufficiently for growing paddy rice, farmers would grow rice; otherwise the upland crops would be their second choice. This rotational and diversified cropping pattern has prevailed for hundreds of years in Chinese Taipei. There were some cases, when upland crops could not receive sufficient water from irrigation or rainfalls, they would produce lower yield or even being suffered from damages. Farmers practicing this kind of rotational or diversified cropping were usually aware of the existence of risk; however, through their long-term trial-and-errors process, they eventually would gain sufficient experiences to undertake the most profitable diversified cropping in the long run.

2.2 Review of Institutional and Organizational Aspects of Irrigation and Drainage Sector

The island of Chinese Taipei, formerly known as Formosa, was inhabited by Chinese Taipei’s aborigines before the 17th century, when Dutch and Spanish colonies opened the island to mass Han immigration. After a brief rule by the Kingdom of Tungning, the island was annexed by the Qing dynasty, the last dynasty of China. The Qing ceded Chinese Taipei to Japan in 1895 after the Sino-Japanese War. Following the end of World War II in Asia in 1945, the Republic of China took control of Chinese Taipei. According to the historical data, the course of irrigation development in Chinese Taipei that has lasted for over 400 years since its inception can be divided into two stages as indicated in Figure 2 (COA, 2009), which can be summarized below.

2.2.1 Free development / Foundation lying period (before 1945)

There were few irrigation projects established before 1680s. Most of the irrigation organization were organized by private sector. Because of severe financial constraint, few significant irrigation works were developed in the beginning of this period. As the immigrants from the Mainland China to Chinese Taipei increased in 1680s, the private sector began participation in development of irrigation projects, invested by either the singles or the partnerships. At that time, most irrigation facilities had been constructed and managed by the private irrigation groups, and in order to manage these equipment, they would either recommend or invite a reservoir supervisor to inspect, repair the canal,
distribute water, and water thieves. Instead of taking an active role in managing the irrigation facilities the government authority merely played the role of issuing permits (canal licenses, admonitions, and seals) or acted as the judge and law enforcer when there was a dispute.

Until the end of 1894, the total area of paddy fields in Chinese Taipei exceeded about 200,000 ha, of which around 110,000 ha were irrigated by the canal water which sources included stream flows, rainwater stored in ponds and groundwater abstracted from wells. The irrigation systems were developed and operated totally by the water users, i.e. a real and whole participatory irrigation management (PIM). The people that channelled water would pay the water supervisor with grains of rice. When there was canal damage, they were required to fix it. These irrigated areas were ever supplied water from several canals, which were then expanded and upgraded afterwards till nowadays and hence still exist presently. These canals are among others the Liugong Canal at Taipei area in the north, Babao Canal at Changhua area in the central and Caogong Canal at Kaohsiung area in the south of Chinese Taipei.

As a showpiece “model colony” of Imperial Japan since 1895, the Office of the Governor-General of Chinese Taipei had made much effort to improve the island’s agriculture, industry and public works. After adopting mass rice production as the policy for foreign exchange earnings or savings, and food self-sufficiency or food security in 1908, the Government of Japan became involved deeply in the development and management of irrigation systems. Since then, irrigation development and operation has never got rid of Government’s different levels of control. From 1901 to 1921, the private irrigation groups were integrated into the Public Irrigation Assemblies and controlled by the government authority through series of government regulations. On the other hand, the large-scale irrigation and drainage projects were launched by government in the same time. The most famous one is the Chia-Nan irrigation project. In spite of the construction of irrigation structures, the irrigation association are also reorganized by the government. Until the end of 1944, the 180 Private Irrigation Groups and public reservoirs/canals were combined into 50 Irrigation Assemblies when the irrigation area increased to about 370,000 hectares.

2.2 Mature/ Degradation period (from 1946)

Following the end of World War II in Asia, in 1946, 50 Irrigation Assemblies were renamed as Farmland Irrigation Association by present government who take over the management from Japanese. The government authority only played as a moderator or a supervisor in the beginning of this period. Instead of designating by government officials during Japanese colonial period, the association chairman was elected by the election committee members in this period. In 1948, the government regrouped Irrigation Association into Irrigation Committee which made the irrigation institution can be easier to be controlled by the government. However, due to the absence of law enforcement, the irrigation committee was like a government agency in form but was still generally viewed as a private group. It was neither a public nor a private organization. In 1956, the 40 irrigation committees in the nation were combined into 26. These irrigation associations were entitled to corporate rights, were allowed to exercise governing rights but did not fall under the jurisdiction of government agencies.

As a result of rapid industrial development and fast urbanization in Chinese Taipei since 1970s, the arable lands including irrigation lands have been converted to non-agricultural purposed lands. Later on, finance and personnel related problems were frequent occurrences due to corruptions. The government was forced to propose a comprehensive plan intended for irrigation associations in 1975. Member elections were terminated temporarily. The chairman was directly appointed by the provincial government and the irrigation associations were combined into 16 in number. It was not till 1982 was the autonomy of public juridical persons restored and the irrigation associations were separated into 17 in number. After the election system was restored, local factions manipulated the system and tampered with election results. Based on the food security reason at that time, the
government started to take on an increasingly heavy role in irrigation management. Since 1993, the government has been paying membership fees to the IAs on farmers’ behalf, and the chairman and committee members were amended to be selected by the government. The “committee representative system” was changed into the “foundation system”. The following year, irrigation associations in the nation under Ministry of Economic Affairs were relisted as under Agriculture Committee. The chairman was directly appointed by the government to minimize interventions from local factions. The government hoped to change all irrigation associations into public agencies. However, after 2002, the chairman was again elected by committee members. Strictly speaking, irrigation associations were only ostensibly called public agencies.

Up to the year of 2015, the irrigation area of Chinese Taipei reduced to around 387,346 ha, of which about 368,576 ha were serviced by the existing 17 irrigation associations in all. According to the inventories of the irrigation systems in the year of 2015 compiled by the Joint Irrigation Association of Chinese Taipei, an organization with its members being all the existing irrigation associations, quantities of the main items of facilities, with an overall length of about 44,061 km of irrigation canals and 25,604 km of drainage ditches (TJIA, 2016).

2.3 Institutional and Organizational Structure for Sustainable Water Management

Chinese Taipei’s irrigation systems used to be reportedly among the most effective in the world. In a study comparing the water delivery efficiency in different rice-growing systems in Asia, Levine (1977) estimated that the basic water requirement per crop in Chinese Taipei was 1,000 mm, as compared to 2,500 mm in the Philippines and 1,400 mm in Malaysia. In the Tou Liu system in Chinese Taipei (currently part of the Yunlin Irrigation Association), the requirement was even as low as 650 mm. The effectiveness, however, is not confined to the high levels of efficiency in water delivery. Water delivery and distribution in Chinese Taipei’s irrigation systems are generally organized in an orderly manner, and the physical structures are kept in relatively good condition.

2.3.1 Organizational structure of irrigation institution in Chinese Taipei

In general, an irrigation system consists of diversion works, conveyance canal and distribution system in Chinese Taipei. Owing to the large commanding area, conveyance as well as distribution of water and irrigation work must be separated so that the system can be managed clearly defined. Figure 3 shows the division of an irrigation and drainage system and its management. As of a small system, it can be simplified according to actual need.

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**Figure 3. Division of Irrigation and Drainage System and its management**
Division of irrigation area varies with irrigation methods. In general, a conveyance system (lateral or sub-lateral) is considered as a division unit, or, the system is divided into several division of area depends on the canal capacity of the conveyance and distribution system, discharge of water source, soil permeability, and growth stage of paddy, so sizes among areas are widely different.

2.3.2 Adopts environment & socioeconomic change through rotational cropping and irrigation

Scarcity of resources does not cause problem more serious than inequity in distributing such resources to the public. With this concept to share the scarcity of water, development of rotational cropping and irrigation in Chinese Taipei, particularly during the period of 1950s to 1980s had fulfilled its designated contemporary goal of producing adequate food to meet the need of that era with comparatively small amount of water. This achievement might attribute to the technical renovation on water management and heavy investment in the improvement of irrigation facilities. Contemplatively, this practice had enabled water controllers to convince water users that the scarcity of water is being distributed equitably to a maximum extent so that the use of water in the field could maintain orderly, of which might ascribe equally or even more than the technical amelioration and heavy investment to the success and sustainability of water management.

A) Practice of rotational irrigation: In general, water delivery for irrigation in Chinese Taipei is not based on the demand of individual farmers. Irrigation usually follows a precise schedule recognizing farmer needs. The method is called rotational irrigation. Rotational irrigation is an intermittent application of irrigation water at a regular time interval and with specified water depths. The amount of water applied to each cycle of the rotation is based on the actual need of crop’s consumptive use and irrigation requirement according to the different growth stages of paddy. This method will result in one or two days without water standing on the field. It permits a periodical aeration of the root zone, which is considered to be beneficial to a better growth and production of paddy rice.

This concept and practice in Chinese Taipei had already prevailed about two hundred years ago. Especially after the restoration of Chinese Taipei in from 1945, systematic research on water application methods for paddy rice was conducted in the Chianan Irrigation Association. Information from these experiments coupled with actual demonstration experiences in the new canal system gave confidence to the irrigation engineers to develop the specifics of "Rotational Irrigation." It has been rapidly displaced the conventional continuous irrigation. The above-mentioned experiments and demonstrations found that the rotational irrigation compared to the conventional irrigation has the following advantages. They are:

- Rotational irrigation has shown to achieve water saving by 20-25 percent as compared with conventional continuous irrigation in the long-term.
- Most cases indicate a higher yield with rotational irrigation.
- Rotational irrigation decreases irrigation disputes and helps the development of cooperative atmosphere and order in the practicing irrigation in the rural areas.
- Rotational irrigation encourages the use of the common irrigator, by which the farming time on irrigation by individual farmer can be saved resulting in farming efficiency.

As for rotational irrigation, the area should be divided into rotation blocks and rotation units according to the irrigation system and in considering the natural boundaries such as farm roads, waterways and other ground implements. In general, an area of rotation block shall be of about 50 ha. The rotation block, based on the distribution system, is subdivided into several (4-6) rotation units, each of about 10 ha in size. The rotation unit is the basic unit for rotational irrigation. Water distributed into rotation block shall be properly rotated at a certain interval among the rotation units, the rotation process shall be repeated all over again.
Division according to rotation block and unit in a land consolidation area is shown in Figure 4b, while the division of an irrigation system is shown in Figure 4a.

![Figure 4. Division of Irrigation system and rotation block](image)

**B) Practice of rotational cropping pattern:** One of the most sophisticated rotational cropping patterns designed in Asia is also located in the Chianan Irrigation system situated in the south of Chinese Taipei. This amount of rainfall should have been sufficient to grow two crops of paddy annually. Unfortunately, the about 91 per cent of annual run-off concentrates in the raining season from May to September each year, and the geological condition is neither in favour to build water storage facilities. As a result, the developed water resources were only sufficient to grow one crop of paddy rice in the monsoon season in the one-third of the total newly developed area. Consequently, a "three-year rotational cropping pattern" was developed and practiced.

The preliminary rotational cropping pattern was firstly operated in 1927 during Japanese colonization. After the end of World War II in Asia since 1945, more water resources were developed to produce more rice to meet the increase in populations. As of the now there are six kinds of cropping pattern prevailing in Chinese Taipei. They are:

1. **Double Paddy Cropping Pattern:** rice grows in the both wet and dry seasons each year.
2. **Single Paddy Cropping pattern:** rice grows only in wet season each year.
3. **Two Paddy Rice Crops Each Two Years Pattern:** rice grows in wet season in the first year and another rice crop grows in dry season the next year.
4. **One Rice Crops in Three Years:** rice grows in the wet season once out of three years.
5. **Two Rice Crops in Three Years:** rice grows only in wet seasons twice out of three year; and sugarcane or upland crops during the remainder of three years.
6. **Modified Two Rice Crops in Three Years:** rice grows once in wet season and other in the dry season of another year out of three years.

For enabling the irrigation schemes to carry out "Three-Year-Rotational Cropping Pattern", the entire newly developed irrigation areas were divided into 150-hectare unit each, namely rotational cropping unit; each unit is further subdivided into three sub-rotational units with 50 hectares each. Three major crops, namely paddy rice, upland crops, and sugarcane were grown in each sub-unit by turn within three years as a rotational cycle. The layout of irrigation and drainage canal either on-farm or off-farm system was so designed to fit the practice of the rotational cropping. In this
connection, each rotational unit with three sub-units has their own individual off-take gates. In particular, for the design of irrigation system, among all rotation units or sub-units, canals in different units would never be connected or mixed among them.

As above-mentioned, for instance, when one of the three sub-units would receive water sufficient for producing one crop of paddy rice in the summer; the second sub-unit would be given irrigation water only in the dry season of winter or spring for the need of growing sugarcane; while the third sub-unit, growing miscellaneous crops, would receive only the surplus water whenever is available, or frequently no irrigation at all. The next year, the second sub-unit would be given water to grow rice; the third to grow sugarcane and the first to grow miscellaneous crops, and so on. Thus, the differential water supply is applied to the three sub-units on a three-year rotation basis.

To ensure the success of rotation cropping, farmers’ irrigation groups and sub-groups were organized according to their units and sub-units. The main task of the organization includes: a leader for each group would be elected through common election for a three-year service term; and three sub-group leaders would be assigned by the elected group leader. The responsibility of group leader would mainly serve as the followings:

- Conducting fixed term and temporary group meetings for discussing irrigation and cropping schedule related affairs;
- Conveying farmers’ view regarding irrigation, cropping pattern, water fee and matters relevant to the system controllers i.e. the irrigation association;
- Conveying the message from the irrigation association to the farmer; and
- Other relevant matters entrusted by the Government or the irrigation Association

In the early stage of the implementation of rotational cropping pattern, the willingness of farmers to follow was not encouraging. The Government had provided a strong support and intervention to make sure the success of rotational cropping pattern. For the most cost effective the use of water at that time, the Government usually gave the first priority to paddy rice, the second to sugarcane, then upland crops the third. It has taken about six years on trial-and-error approach to make the arrangement of rotation cropping pattern to be mature.

3 PARTICIPATORY IRRIGATION MANAGEMENT (PIM) AND IRRIGATION MANAGEMENT TRANSFER (IMT)

3.1 Need and objectives of PIM

In the implementation of water distribution in an irrigation system duties and functions between canal water distribution and farm irrigation should be separated to avoid discrepancies in irrigation time and irrigation implementation which may cause uneven water distribution. Only in a small system can both be served concurrently by the management technicians. Canal water distribution should be carried out by the canal working station or canal management technicians, while irrigation area (rotation unit) should be managed by irrigation working station or irrigation management technicians. Common irrigator may be employed for each rotation unit. In case there is no common irrigator, it may be operated by the irrigation group (PIM). Farm practices can be done by the common irrigator or the member farmer themselves in accordance with the irrigation schedule.

Rotation block and unit are the end system for water distribution. In general, irrigation water in the rotation block is properly rotated with a certain irrigation interval among the rotation units. Except that the turnout gates of rotation blocks are regulated and farm irrigation practices in rotation units supervised by the management technicians of the irrigation associations, water management in rotation blocks currently adopted in Chinese Taipei are of following system:
3.1.1 Implementation of common irrigation system by hiring common irrigators
Inside a rotation block (about 50 ha), one or two common irrigators may be hired by the members within the block. After practical training in water distribution, they will be responsible for execution of water distribution in the rotation block according to the irrigation plan. The advantages and disadvantages of this system are as follows:

**Advantages:**
- Entrusting execution of water distribution to common irrigators may save labour of farmers so that they may have enough time to develop other side jobs.
- Each farm plot can be irrigated evenly with the skill of common irrigators, no matter how different are the water sources.
- Water distribution done by common irrigators may reduce meaningless disputes.
- Common irrigators may also take charge of the maintenance of farm ditches during his spare time to save labour for maintenance.
- Common irrigators may gradually be transformed into specialists by experience and training with the ability to raise the standard of irrigation and also promote the following cropping system in (1) Establishing common seedling bed, and (2) implementing joint-operation; furthermore, in facilitating joint cultivation, joint pest and insect control, cooperative farm machinery, and cooperative production and marketing on the basis of rotation block. This is most idea method in promoting rotational irrigation.

**Disadvantages:**
Although labor can be saved, farmer must pay the cost for common irrigators. If the farmers have no other side job, this cost will become a burden to them.

3.1.2 Water distribution by member farmers on duty in turn
This method is suitable for the rotation block where there are surplus labors or cultivated area of each farmer is large. The irrigation group will arrange the time for its members to go on duty in turn according to the size of farmers’ land. Water distribution in a rotation unit shall be operated by the members outside the unit, even it is its turn.

**Advantages:**
- Farmers need not pay the cost for common irrigators.
- Farmers’ surplus labour can be adequately utilized.
- It may help farmers thoroughly understand the operation of water distribution and promote their experience.

**Disadvantages:**
- It is easy to be discontinued if the farmer member in turn cannot go on duty.
- Operation of water distribution by farmers may not be as fair and skilful as that done by a common irrigator.
- The irrigation group leader needs to supervise at all times and places.
- Changing shifts wastes time for coming and going.
- Size of cultivated land of farmers are different, accurate calculation and just allocation of work are difficult.
- It is difficult to implement this system in an area where water is abundant.

3.3.3 Water application by member farmers themselves during their turns
This is similar to the operation of continuous irrigation. Member farmers irrigate their farms by themselves according to the irrigation schedule.
Advantages:
- Farmers need not pay the cost for common irrigators.
- Farmers may do some of his field work while on duty.
- It can be done by women, elders or children in the daytime

Disadvantages:
- Unauthorized water use may easily occur.
- Uneven application of irrigation water may occur when the discharge from the water source varies.
- Farm ditches have to be protected and maintained by free labors.
- Irrigation of farm plot should be done and handed over according to schedule.
- It wastes time and labor for farmers to go back and forth between his own farm and the operation spot.
- Irrigation may not be specialized and farmers are difficult to take up some side job.

3.2 PIM Approach

A major feature of Chinese Taipei’s irrigation institutions is that they provide arenas and logistic support for problem solving by farmers at the field level. Farmers are organized into self-organized Irrigation Groups (IGs), which are responsible for irrigation operation and maintenance (O&M) in the field. Farmers in an IG elect an IG leader, who is given the mandate to coordinate and liaise with the IG members concerning O&M activities. In some IGs, common irrigators (water guards) are hired to help on water allocation and minor maintenance works. A major feature of the IGs is that they are organized on the basis of hydraulic boundaries. By matching the boundaries of the IGs with hydraulic areas, the task of irrigation management is effectively compartmentalized into subtasks; more importantly, farmers in each IG are in effect assigned to coordinate among themselves with reference to the management of the subtask. That farmers at the local level are allowed to work out solutions to cope with the “localized” irrigation problems enable better utilization of local information. The IG arrangements, by nature of its proximity to local community, can effectively draw upon social capital that has already been developed in local community to attain coordination in the O&M processes (Lam, 1996, 2004, 2016).

Coordination at the sub-lateral level with the IG as the basic problem-solving unit by itself is inadequate. Some of relative researchers have found that allowing a small number of random links developed between individuals can provide the glue that drastically shortens the social distance between individuals belonging to different communities. In irrigation management, cross-community coordination is very importance to irrigation efficiency. There are two institutional arrangements are implemented to connect the clustered groups (IGs) in Chinese Taipei. The first is the irrigation plans worked out by Irrigation Associations (IAs) every year as the blueprint for water delivery. While the plans are so meticulous that even the exact amount of water allocated to a particular patch is specified, they are frequently not strictly followed in actual water distribution. In fact in systems where the major source of water is rivers and creeks, irrigation plans are made but seldom used. Yet these irrigation plans do serve a very important coordination function. The amounts of water to particular field as specified in these plans are considered farmers’ entitlement of water. They serve as the yardstick around which adjustments be made. So disparate IGs have a rough idea about the overall picture of how water should be distributed, which could impose the bounds within which the IGs can make mutual adjustments. In a way, these plans provide a mental map for farmers to engage in mutual adjustments.

Second, random links are applied to provide bridges linking up the IGs and the working stations. The working stations hold regular IG leaders’ meetings twice a year, usually scheduled for the time right before irrigation starts. Other than these regular meetings, ad hoc meetings will be held to cope with
emergencies. Whether these meetings can provide an effective communication for decision making and deliberation has been subject to question. Anyone who has observed these meetings would note that they are more like social gatherings and largely dominated by IA officials. Despite of the attendance rate is always low; these meetings still serve the important function of weak ties linking up the IGs. Other than meetings, IG leaders are engaged in activities of several kinds organized by the IAs. For example, every year an irrigation festival is organized at which some “model IG leaders” will be given awards; also, an IG leader is entitled to an “overseas field trip” during his term of service to explore his knowledge. All these seemingly trivial and irrelevant activities help sustain the connection among the IG leaders. Random links are also built in by rotating working station staffs from time to time. A major characteristic of the IAs is that, through a network of working stations, the IA staffs are stationed in the field for a relatively long period of time so that they are made embedded in the communities they serve. Unlike in South Asian countries where irrigation officials are often posted to particular positions for a short period of time, IA staff usually spend a prolonged period of time in a station. The prolonged stay, however, is not like that in Japan where the small size of Farmland Improvement Associations has basically locked in irrigation staff to a particular locale for their careers. The IA staff usually have a number of postings during their careers. The infrequent yet regular movement of staff helps creating links between officials and farmers across communities.

Coordination in actual water delivery in Chinese Taipei is maintained not by a grand plan or a pacemaker, but by an array of institutional arrangements that encourage local problem solving on one hand, and local mutual adjustments on the other. While such a mode of coordination seems not forceful, and certainly does not fit neatly with the engineering image of orderly water allocation, it is tremendously flexible and robust. It allows farmers in disparate situations to decide on how much effort they want to put in irrigation management, and their best ways to do it. The flexibility of the institutions can cope with the low incentive mode of agriculture on one hand, and retain a certain level of vibrancy in irrigation management on the other. The viability of the flexible institutional arrangements in Chinese Taipei depends on the willingness of a small group of IG leaders who serve as the bridges connecting up farmers. Although many IGs are no longer as active as before, the role of the IG leaders has become increasingly important for the purpose of coordination. The IAs are surely aware of the situation, and have adopted measures to beef up the support and incentives for the IG leaders.

4 CHALLENGES

In the 1950s and the 1960s, the Chinese Taipei government adopted policies to tax the agricultural sector to help launch industrialization. By a series of exploitative measures such as barter of fertilizer for rice and compulsory rice purchases, the government was able to extract surplus out of agriculture to support industrialization by providing affordable food and necessary financial transfers to the industrial sector. In the late 1970s, Chinese Taipei’s industry took off. Ironically, the efficiency of the agriculture sector has made the sector particularly vulnerable to the process of industrialization. While agriculture lost its economic viability, the cross-sector reallocation of resources issues occurs in Chinese Taipei.

For food security reason, the government has maintained a grain reserve that is sufficient for the population consumption for 3 months. More importantly, the government has promulgated strict zoning laws, restricting changes of land use of paddy fields to maintain the agricultural potential. However, the government has also provided a variety of subsidy programs for the compensation of the farmer, including guaranteed procurement of grains at preferential prices, subsidies for fallowing, and substantial rural infrastructure projects. As the vibrancy of irrigation infrastructure is essential to the maintenance of agricultural potential, the government has been subsidizing the irrigation sector quite substantially. Other than the food security concern, another aspect of the political economy of
agricultural policy in Chinese Taipei concerns with votes and elections. The rural populace in Chinese Taipei constitutes a substantial voting block that no political parties in the country could afford to ignore. As of 2016, the 17 IAs in Chinese Taipei have a total membership of more than 1.56 million (TJIA, 2016). Assuming that each member household has four people eligible to vote, the IAs can influence almost 6 million votes. Unlike in many other Asian countries, Chinese Taipei’s rural populace is highly organized, an unintended consequence of the government’s effort to control the rural population through a network of semi-governmental organizations, including the IAs. When the interest of these organized groups is challenged, they won’t hesitate to defend themselves.

However, if the agricultural sector had been able to diversify production, the government’s food and agricultural policies would not have affected agriculture too adversely. Unfortunately, the structure of Chinese Taipei’s agriculture is not helpful to diversification or change. A major problem is the small landholding size, which is largely a result of the land reforms so successfully implemented in the early 1950s. Since 1990, the average landholding size of farm households in Chinese Taipei has been less than 1 hectare. The small landholding size does not allow effective use of machines and, more importantly, renders infrastructure investment uneconomical. Farmers simply cannot make a living on farming. As farming turns unprofitable, farmers in other countries might well sell their farmlands and move to cities. Chinese Taipei’s farmers, however, are generally unwilling to do so. Farmers’ bond of land might explain part of the situation, but material incentive might be a more important factor. Many farmers expect that someday their lands might be rezoned, which would mean a substantial increase in land value. For farmers who derive a major part of income from non-farm activities, they could afford keeping the lands and wait.

The political economy of agriculture as described has impact on irrigation management at two levels (Lam, 2016). At the field level, farmers face little incentive to engage in irrigation management. Unlike in good old days when irrigation water very much determined farmers’ income, and so farmers had strong incentives to get involved in irrigation operation and maintenance (O&M), farming nowadays is considered a supplementary economic activity which, in some circumstances, is not even for profit-making but simply for keeping the lands cultivable. Such a low-incentive mode of agriculture poses serious challenges to Chinese Taipei’s irrigation management which is grounded upon farmers’ participation and farmer-government synergy.

At the sectoral level, the change has posed to the government the difficult question of how to restructure its relationship with the irrigation sector. Given that farmers are trapped in agriculture by government policies and do not have much incentive to invest in irrigation maintenance and operation, the government finds itself taking on an increasingly heavy role in irrigation management (TJIA, 2003). Since 1993, the government has been paying membership fees to the IAs on farmers’ behalf, in addition to the large infrastructure maintenance subsidy that also comes out of the government budget. As the irrigation sector is getting more and more reliant on government subsidy, the government feels obliged to impose tighter control to make sure that public monies are appropriately spent. Interestingly, that the government has put in increasing amounts of resources in the irrigation sector does not mean that all the IAs are facing financial difficulties. The IAs that are located near urban areas have in fact been accumulating much wealth through the sales of lands and properties that ceased to serve irrigation purposes (AERC, 2001). Because farmers are no longer enthusiastic about getting involved in irrigation management and hence the operation of the IAs, the government finds herself taking on the role of the monitor to prevent the IAs from turning into some private clubs of IA staffs and local politicians who control the IAs.

Despite the government’s intention to tighten control, putting effective control in place is no easy task (CAEA, 1995). First, the IAs are formed and owned by farmers. It is not clear as to how the government could square the concept of private property with the process of nationalizing the IAs. Second, how to manage the IA staff is another thorny issue. Currently the IA staff do not have the civil servant
status; in fact, the majority of the older generations of the staff have received only limited formal education. Third, the IAs are important political mobilization machines. Politicians who have a strong hold in these organizations are unlikely to give in easily.

Another dimension of the challenge at the sectoral level is concerned about water resource allocation and utilization across sectors. As agriculture is no longer a major economic activity, many people argue that water rights should be reconsidered so that more water could be diverted to domestic and industrial uses. To irrigation officials and the IAs, they need to address two issues. First, they need to provide justifications for their defence of their water rights. Second, they need to come up with policy recommendations that allow effective utilization and flexible allocation of water across sectors. The challenges at both the operational and sectoral levels have impact on the operation and management of irrigation systems in Chinese Taipei.

5 WAY FORWARD AND RECOMMENDATIONS

The worsening of climate change in recent years has brought the hydrological conditions into more extremes, and threatens the water sectors. Especially for irrigated agriculture, the irrigation land is always forced to conduct fallow in order to transfer the water to other sectors, which may introduce the deficit risk shift to irrigation sector and food security problem (Y.C. Chang 2007). That is, traditional irrigation practices are no longer capable for the normal operation of water resources distribution, and hence new ideas are needed.

In addition to find the sustainable development of Irrigation Associations, the Irrigation Associations should not confine themselves on the single service of irrigation. Instead, through diversification of the businesses by making better use of the facilities, land assets, and human resources, the financial situation of the Irrigation Associations should be significantly improved. The example of Chia-Nan Irrigation Association in southern Chinese Taipei is a successful case. Besides traditional irrigation and drainage, Chia-Nan Irrigation Association also engages in: 1. power generation by setting up a power plant, yet under the condition that water conveyance is not affected, 2. renting the canal network to other sectors for water conveyance, 3. constructing business buildings for commercial use, and 4. establishing water-friendly parks or entertainment parks beside the waterways. The management of sustainable diversification without selling properties by the Chia-Nan Irrigation Association is definitely a model example in Chinese Taipei.

6 REFERENCES


***************************
INTRODUCTION

1.1 Geography

Turkey is located between 26°-45° eastern longitudes and 36°-42° northern latitudes. Turkey has an area of 78 million ha, of which about 1.1 million is inland lakes and forms an elongated rectangle roughly. The east-west direction is 1,650 km and the north to south is 1,000 km. Turkey’s average altitude (1,132 m) is higher than that (1,050 m) of Asia and three and a half times higher than that (330 m) of Europe. The elevation rises from the west to the east. The altitude of Ulus, the centre of Ankara, is 875 m. The altitude of plains in the eastern region is up to 2,000 m. Turkey’s highest point is Ağrı Mountain 5,137 m) in. eastern region. Turkey forms a bridge between Europe and Asia, with t 3% of its land (The Trace) in Europe.

1.2 Population

According to the results of the Address-based Population Registration System, the population of Turkey is 80 Million in a total of 81 provinces as of 2016. Population growth rate is approximately 1.8% per annum. The average population density is 95 km/person. Turkish Statistical Institute (TÜİK) has estimated Turkey’s population as 100 million for the year of 2030. Agricultural contribution to total GDP constitutes 8% of GDP.

Table 1. Turkey’s Profile (2016)

<table>
<thead>
<tr>
<th>Population</th>
<th>80 Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Population</td>
<td>30%</td>
</tr>
<tr>
<td>Urban Population</td>
<td>70%</td>
</tr>
<tr>
<td>Annual Increase</td>
<td>1.5%</td>
</tr>
<tr>
<td>Population Density</td>
<td>95 people/km²</td>
</tr>
<tr>
<td>GDP (Total)</td>
<td>US$ 850 billion</td>
</tr>
<tr>
<td>GDP /Capita</td>
<td>US$ 11,000</td>
</tr>
</tbody>
</table>
1.3 Climate

Turkey has a semi-arid climate with some extremities in temperature. Turkey is surrounded by seas on three sides and high mountains stretching along the Black Sea coast in the north and along the Mediterranean Sea coast in the south. On account of its geographical features, Turkey has four distinctive seasons. Variation in altitude up to 5,000 m causes different climatic conditions in the same season. Distance from sea and fluctuations in altitude result in climatic variance within short distances. Temperature, precipitation and winds vary based on climatic features. The difference in the north to the south latitude (6°) also plays a role in this temperature change.

2 WATER INSTITUTIONAL SET-UP

The first important irrigation project to utilize river and lakes in Ottoman Period started in Konya Plain. The first modern irrigation facility in Anatolia dates back to 1908-1914 (Ottoman period) as “Çumra Irrigation and Drainage Project.” This irrigation did not last long since the importance of irrigation water quality and drainage was not known enough. Agricultural areas were lost due to wrong irrigation caused in saline soil. Swampland areas were desiccated to combat against malaria and to extend agricultural areas in the first years of the Turkish Republic. Then some small irrigation projects were introduced. The construction of large-scale irrigation and drainage networks started by the establishment of State Hydraulic Works (DSİ) in 1954 as per Law No. 6200.

The General Directorates of Rural Services (GDRS) and Agrarian Reform were established to ensure efficiency in irrigation by on-farm development and land rehabilitation projects. The water resources having a flow of more than 500 liter per second fell within the mandate of the DSİ while smaller surface flows fell within the mandate of the GDRS which was dissolved in 2005. SPAs (Special Provincial Administrations) have taken over the responsibilities of GDRS.

In order to estimate the electricity demand of the Country, as well as to make surveys and investigations to cover such demand through hydroelectric or other energy sources, abolished EIE (The Electrical Power Resources Planning and Survey Administration) worked from 1935 to 2012 in which DSİ has taken over its responsibilities. The first dam built after the establishment of Turkish Republic in 1923 is the Cubuk-I Dam constructed from 1930 to 1936 to meet water need of Ankara. The rate in dam construction has increased tremendously after 1950’s, especially after the establishment of DSİ (State Hydraulic Works) in 1954.

2.1 Inventory of Agencies Involved in Water Resources Development

A brief inventory of agencies involved in water, directly or through delegated subnational departments:

<table>
<thead>
<tr>
<th>National Agency</th>
<th>Water-Related responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Development</td>
<td>Responsible for national development planning matters, and this is undertaken through five-year plans in cooperation with the line ministries.</td>
</tr>
<tr>
<td>Ministry of Forestry and Water Affairs</td>
<td>DSİ is the primary executive state agency responsible for development of the Turkey’s overall water and relevant land resources in a sustainable manner. As a public agency, DSİ was established by Law No. 6200 setting out DSİ’s 4 major task which are: to supply domestic and industrial water to accommodation areas, to take measures against flood hazards, to realize irrigation projects, and to develop hydroelectric energy potential.</td>
</tr>
<tr>
<td>General Directorate of State Hydraulic Works (DSİ)</td>
<td>WMGD’s main duties are; to prepare River Basin Management Plans, to determine the specific provisions for drinking water sources, to determine water quality standards at</td>
</tr>
<tr>
<td>National Agency</td>
<td>Water-Related responsibilities</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Water Management General Directorate (WMGD)</td>
<td>basin level, to establish an effective monitoring system for water quality control, to constitute a database for water resources, and to prepare flood and drought management plans.</td>
</tr>
<tr>
<td>Ministry of Forestry and Water Affairs Meteorological Services General Directorate (MSGD)</td>
<td>Around Turkey, It makes observations, weather forecasts, early warnings and monitor climate changes. It provides meteorological services for all sectors.</td>
</tr>
<tr>
<td>Ministry of Forestry and Water Affairs Turkish Water Institute (SUEN)</td>
<td>SUEN’s aims at contributing to the development and implementation of Turkey’s strategies on water politics at global, regional and national levels, promoting interdisciplinary scientific research and international collaboration in water sphere, organizing water related international events and developing national/international projects.</td>
</tr>
<tr>
<td>Ministry of Environment and Urbanism Directorate General of Environmental Management</td>
<td>Its duties are; to prevent and control all contamination of the factors influencing the environmental pollution for providing a livable environment, to protect air quality; air pollution, to implement the necessary measures related to global climate change, the depletion of the ozone layer and support the use of clean energy, particularly the area of renewable energy sources.</td>
</tr>
<tr>
<td>Municipalities</td>
<td>State Hydraulic Works (DSI) General Directorate design and construct water supply purposed water storages (dam, small dam, and regulator), conveyance lines, and water treatment plants. The operations of these facilities are transferred to the related Municipalities who construct inner city distribution lines them manage, maintain, and collect water charges combination of investment and operation cost.</td>
</tr>
<tr>
<td>Ministry of Food, Agriculture, and Husbandry</td>
<td>Its mission is; to ensure the sustainable use of agricultural and ecological resources, to increase standard of living in rural areas; and to ensure access to safe food and high-quality agricultural products needed by Turkey and world markets Groundwater activities used to be carried out by DSI and defunct GDRA (General Directorate of Rural Affairs. Groundwater activities now carried out by DSI and Provincial Administrations.</td>
</tr>
<tr>
<td>Ministry of Energy and Natural Resource Energy Market Regulatory Agency (EMRA)</td>
<td>In recent years, DSI has started tendering Hydroelectric Power Plant Projects HEPPs on water usage contract basis, which requires the private sector to obtain license from the Energy Market Regulatory Agency (EMRA) according to the Law No 4628 and invest for the building of the dams and hydroelectric power plants on certain locations designated by DSI. According to this regulation DSI started to make tenders to select the companies to give Water Use Right by making agreement. The company who get WUR from DSI applies for Generation License to EMRA.</td>
</tr>
<tr>
<td>Ministry of Health</td>
<td>Responsible for the monitoring quality of domestic water.</td>
</tr>
<tr>
<td>Interior Ministry</td>
<td>The supervision of WUOs’ managerial and fiscally is carried out by the General Directorate of Local Administrations under the Ministry of Internal Affairs.</td>
</tr>
</tbody>
</table>

### 2.2 Coordination of Water Resources Management

Since Water Use of Rights are granted by DSI; Coordination for Water Resources Management involving agencies, water users’ association and other water users is carried out by State Hydraulic Works General Directorate (DSI) having 26 DSI Regional Directorates established in provincial and district levels. DSI Regional Directorates coordinate Water Resources Management which wholly
located in a district. For a cross provincial areas schemes, State Hydraulic Works General Directorate (DSI) has Department of Operation and Maintenance prepares operation procedures of water storages.

State Hydraulic Works (DSI) General Directorate is an authority responsible for water allocation from surface and groundwater for single and multiple purposes. The mission of DSI is to take measures against losses of flood and droughts, and develop water resources taking into account scientific and technical principles. DSI has been authorized for planning and executing the Hydroelectric Power Plants (HEPPs) projects while the abolished EIE (The Electrical Power Resources Planning and Survey Administration) worked from 1935 to 2012 in which it was abolished and DSI has taken over its responsibilities was responsible for investigation and planning of HEPPs.

The General Directorates of Rural Services (GDRS) and Agrarian Reform were established to ensure efficiency in irrigation by on-farm development and land rehabilitation projects. The water resources having a flow of more than 500 liter per second fell within the mandate of the DSI while smaller surface flows fell within the mandate of the GDRS which was dissolved in 2005. SPAs (Special Provincial Administrations) have taken over the responsibilities of GDRS.

Figure 2. DSİ Regional Directorates and command areas

3 WATER LEGAL INFRASTRUCTURE OF DSİ

The DSİ General Directorate carries out its task pursuant to following laws No 6200, 167, 1053 (Amendment Law No 5625).

3.1 Law No. 6200 enacted on 28th February 1954 on Establishment & Duties

Law No. 6200 empower DSI to; constitute flood control facilities, set up irrigation facilities, draw plans and maps of the entire existing plots, or parts of the plots, and conduct cadastral survey, generate energy from water, survey, endorse, and inspect the projects of water supply and sewerage, and secure to get in operation the above-mentioned facilities (Operating, maintenance, and repair).

Decree Law No. 662 enacted 11.10.2011 amended the Law No. 6200 on Establishment and Duties of DSİ. The Decree law has shifted DSI from general and annexed budget administration to special budget administration. Decree Law enacted on restructuring DSİ has come into effect since it was published on 2nd November 2011 at the repeated edition of Official Gazette numbered 28103.

3.2 Law No. 167 enacted on 16th December 1960 on Groundwater

Law No. 167 empower DSİ to: conduct surveys of groundwater and drill deep wells or have them drilled, transfer or lease deep wells, protect and record groundwater, and grant licenses for survey,
use, rehabilitation and modification of wells.

3.3 Law No. 1053 enacted on 03rd July 1968 on Domestic and Industrial Water Supply to Ankara, Istanbul and Cities with Populations over 100,000.

Law No. 1053 empower DSI to; construct dams and transmission lines, set up water storages and pump stations; build water treatment plants. The Article 10 of Law No 1053 has been amended and revoked city population criteria of 100,000 as well as extended the duties of DSI till Municipal level. After that, DSI has been authorized for domestic and industrial water supply of 3225 settlements having Municipality Administration over all Turkey. The Law stipulates that, if necessary, DSI could give priority to waste water treatment plants in progress at present.

3.4 Soil Conservation and Land Use Law No 558 dated 19/07/2005

As per the Article 17 of Soil Conservation and Land Use Law No 558 dated 19/07/2005 as to added article as per Article 4 of Law No 5578 dated 31/01/2007 with the Regulation of “Agricultural Land Use and Land Consolidation” prepared by the Ministry of Agriculture and Village Affairs and put into effect on 24.07.2009, DSI has been authorized to execute land consolidation in the irrigation areas developed by DSI.

3.5 Law No. 6172 put into effect on 22nd March 2011 on Water User Associations

Law No. 6172 on Water User Associations. (WUOs) delineates duties and responsibilities of WUAs and DSI. Together with executive board of WUAs, Inspection board has been established.

4 SEASONAL WATER AVAILABILITY

Annual mean precipitation in Turkey is 574 mm, which corresponds to 501 Bm$^3$ (billion m$^3$) of annual water volume in the country. A volume of 274 Bm$^3$ water evaporates from water bodies and soils to atmosphere. 69 Bm$^3$ of water leaks into groundwater, whereas 28 Bm$^3$ is retrieved by springs from groundwater contributing to surface water. Also, there are 7 billion m$^3$ volume of water coming from neighboring countries. Thus, total annual surface runoff amounts to a volume of (158+28+7) 193 Bm$^3$ of water.

Including 41(69-28) Bm$^3$ net discharging into groundwater (covering safe yield extraction, unregistered extraction, emptying into the seas, and transboundary), the gross (surface and groundwater) renewable water potential of Turkey is estimated as 234 (193+41) Bm$^3$. However, under current technical and economic constraints, annual exploitable potential has been calculated as 112 Bm$^3$ of net water volume, as 95Bm$^3$ from surface water resources, as 3Bm$^3$ from neighboring countries, as 14Bm$^3$ from groundwater safe yield.

In 2016, 54 billion m$^3$ water was consumed in various sectors in Turkey; 40 billion m$^3$ in the agriculture, 7 billion m$^3$ in the water supply, 7 billion m$^3$ in the industry. This sum accounts for development of only 48% of the available exploitable potential of 112 billion m$^3$. Turkey aims at using the available potential by 2023, which is the centenary of Turkish Republic.
5 LAND RESOURCES

Turkey’s surface area is 780,000 km², namely 78 million hectares (Mha). Excluding the total area of reservoirs and lakes, Turkey’s land area is 769,600 km². With her diverse geological, climatic, vegetation and topographical features, Turkey rooms in most of large land groups found on the earth today. Besides, this richness also makes it possible to raise a diversity of crops, many of which are high in their quality.

Table 3. Turkey’s Land Resources

<table>
<thead>
<tr>
<th>Land Resources</th>
<th>Million ha (Mha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey’s Surface Area</td>
<td>78</td>
</tr>
<tr>
<td>Arable Land</td>
<td>24</td>
</tr>
<tr>
<td>Irrigable Land</td>
<td>12</td>
</tr>
<tr>
<td>Rainfed Agriculture</td>
<td>17.6</td>
</tr>
<tr>
<td>Economically Irrigable Land</td>
<td>8.50</td>
</tr>
<tr>
<td>Presently Irrigated</td>
<td>6.4</td>
</tr>
</tbody>
</table>

5.1 Topographical features, rivers, and lakes

Excluding mountainous areas which cover a little more than half of the total land area, Turkey has plains, plateaus, steep and rugged land, and flat hills. Plains of different altitudes covered with alluvium amount to 19 Mha. Plateaus cover 8 Mha. The total area of plains and plateaus is equal to 27Mha, which is 30% of Turkey’s land. Rugged terrains with flat, wide hills amount to 10 Mha. Since
agricultural operations are often relatively easy in these types of rugged terrains, 10Mha might be added to 27Mha as flat lands. Therefore, Turkey has about 37Mha of flat lands.

Turkey has about 120 natural lakes, including small lakes in the mountains. The largest and the deepest lake of Turkey located in the Eastern Anatolian region is Lake Van with a surface area of 3,712 km² and an altitude of 1,646 m from sea level. The second largest lake is Lake Tuz in central Anatolia. Being shallow (0.5 m) and very salty, Tuz Lake at an altitude of 925 m has a surface area of 1,500 km².

Most of the lakes of Turkey are shallow and contain bitter and brackish water. Some fresh water lakes such as Manyas, Beyşehir, Uluabat, İznik, Eğirdir, Eber, Akşehir can be used for irrigation purposes. There are 907 artificial lakes, that is, dam reservoirs in Turkey. Many rivers originate, flow and empty into seas within Turkey’s borders. Rivers can be classified in relation to the sea into which they empty.

5.2 Land Holding Situation

An important problem of Turkish agriculture is the small farm size agricultural enterprises. Just over 3 million agricultural enterprises exist in Turkey. 67% of these farms own between 0.1-5 ha each, (22% of total agricultural land), while only 33% of households own more than 5 ha-comprising 78% of available agricultural land. Therefore, farmers’ average income is low.

It is possible for Turkey to compete with other countries in agriculture by means of completing land consolidation work and increasing the crop yield per ha. While in EU countries, average farm size is 16 ha, it is only 6 ha in Turkey; this means that average farm size of 6ha in Turkey is not economical operational size. On the other hand, as far as agricultural farm size is concerned, having fragmented parcels are another problem, the number of parcels for each farm is over 6, and average parcel size is approximately 1 ha in Turkey whereas average parcel size is between 1.8 and 4 ha in EU countries.

5.3 Degradation of Catchment Areas

New bore holes for irrigation purpose have not been allowed in some watershed areas since excess usage of groundwater in drought years have caused environmental problems. Since groundwater usage has reached the groundwater allocation levels in terms of groundwater potential, groundwater licenses for new bore holes for irrigation purpose especially in most of the watersheds of Konya Closed, Meritsa–Ergene, Akaçay, Orontos, Ceylanpinar-Kızıltepe plains. The government has launched many programs to prevent and rehabilitate critical lands and watersheds but it seems still incapable to counterbalance the degradation rate. A more strategic approach should be integrated in the water and irrigation sector which include conservation and flood and drought management as part of water resources management.
As to water resources, 2 main water issues exist in Turkey; Flood and Drought. These natural disasters can result in social and economic damages. Scientific studies point out that as a result of the global warming and climate change, water related natural disasters experienced in many countries have been occurring more destructive with larger scales than those happened in the past. Impacts of global warming and climate change have been intensified with each passing day in the World and in our region. These unpleasant conditions add to the weight of water administration in the semiarid zones in which Turkey is located as well.

When we look at past years, we can notice that wet and drought years may continue as consecutive two or three years. Coastal areas in Turkey receive much more precipitation, e.g., annual precipitation in the northeast coast is 2,500 mm and hereby wet years may result in torrent disasters in coastal areas. However, inner part of Turkey receives least precipitation e.g., annual precipitation in the central areas is 250 mm hereby drought years may result in drought disaster in the central area. Torrent and drought may lead ecological degradation. Torrent may result in soil erosion which may shorten the life of water storage facilities. Thanks to flood mitigating structures that DSI has developed so far, 1.8 Million ha area is protected from flood disasters and from soil erosion in Turkey.

Excess rainfall may lead to flood disaster. On the other hand, lack of precipitation for a long time may lead to drought disaster. Drought disaster causes pressure in using ground water resources, reducing ground water table and even using fossil groundwater resources. This is the case in arid and semiarid countries one of which is Turkey. This indicates that much investment is necessary on water structures in order to mitigate damages of the flood and drought disasters.

Drought may arise from water shortage and from the situation that water amount could not meet the water demand. Water storage structures are major insurance facilities to mitigate adverse effects of drought disaster. Dams are important water storage facilities enabling to store during the wet periods and to use water during the drought periods.

6 GLOBAL CLIMATE CHANGE IMPACT

Preparation of climate change projections for all river basins and determination of groundwater budget and the change in surface water levels for all basins are outcomes of “Climate Change Impacts on Water Resources Project”. Thus, probable condition of water resources which is under pressure of climate change is projected until 2100.

Upon identification of negative impacts of climate change, sectoral impact analysis (for the main sectors of drinking water, agriculture, industry, ecosystem) of climate change with respect to water resources are performed. Turkey will be more ready to adapt to changing climate.
7 NEED FOR SURFACE WATER IRRIGATION FACILITIES

Rivers in Turkey have generally irregular regimes. The natural flows cannot be taken directly as usable sources. The average annual precipitation, evaporation, and surface runoff varies with respect to time and geography. Nearly, 70% of the total precipitation falls from October to March. There is little effective rainfall during the summer months in which agricultural sector needs water. Thence, it is absolutely necessary to have storage facilities, to ensure agricultural irrigation to meet domestic & industrial supply, and to generate hydroelectric energy.

81% of the irrigation water is derived from surface sources and the 19% from groundwater in areas equipped with irrigation in Turkey. Turkey can maintain sufficient crop production thanks to the significant increase of the national budget for agriculture sector. Since the 13 years, the government has been launching an acceleration program for development of 620 dams and 1.3 million ha new irrigation schemes throughout Turkey.

Box 1. Surface and Groundwater Irrigation Types

<table>
<thead>
<tr>
<th>Irrigations</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water Resources</td>
<td>81%</td>
</tr>
<tr>
<td>- Pumped</td>
<td>14%</td>
</tr>
<tr>
<td>- Gravity</td>
<td>67%</td>
</tr>
<tr>
<td>Groundwater Resources</td>
<td>19%</td>
</tr>
<tr>
<td>- Supplementary to Gravity</td>
<td>2%</td>
</tr>
<tr>
<td>- Groundwater by pump</td>
<td>17%</td>
</tr>
</tbody>
</table>

Box 2. Criteria to meet farmer’s irrigation needs

DSI evaluates prospective irrigation projects as per the following requirements:
- Farmers’ demand,
- Land, climate and ecological suitability
- Gravity irrigation in preference to pumping,
- Water resource availability
- Land consolidation works

Figure 7. Irrigation Water Sources

7.1 Irrigated Agricultural Sector

Turkey has richer endowment of agricultural resources in terms of cultivable land and availability of water than any Middle Eastern country. This abundance of climatic conditions makes Turkey one of the few nations in which such a variety of good quality crop and foodstuffs can be produced. Turkey is the largest exporter of agricultural products in the Middle East and North Africa (MENA) region.
Despite agriculture’s relative decline as a percentage of GDP (8.2), the sector played an important role in foreign trade. Turkey enjoys a comparative advantage in many agricultural products and exports cereals, pulses, industrial crops, hazelnut, fresh and dried fruits, and vegetables. Turkey primarily exports dried fruit and hazelnuts to European Union (EU) and United States of America (USA). Middle East countries primarily imports fresh fruit and vegetables from Turkey.

Agriculture is an important sector socially and economically in Turkey. As of 2016 rural population is 30%. Agriculture accounts for 8% in Gross National Product, 4% in exports, and 23% in employment.

About 60 million tons of grains and other crops, 28 million tons of vegetables and 17 million tons of fruits are yearly produced in Turkey. The vegetal production is primarily made up of cereals, pulses (edible seeds of various pod-bearing plants such as peas, beans, or lentils), industrial crops (crops needing industrial process e.g., olive, sunflower, sugar beet, barley, and maize) and perishables (e.g. fresh vegetables and fresh fruits). Of these, cereal crops occupy more than half of the cultivated land. The main species of cereal crops produced in Turkey are wheat and barley. The other cereals are oats, rye, maize, and millet. These crops are produced in most parts of the country with a heavier concentration in the central regions.

![Figure 8. Main Crop Pattern in Irrigated Agriculture](image1)

![Figure 9. Agricultural Crops Cultivated](image2)

7.2 Nature of Existing Surface Water Irrigation Schemes

As of 2016, Canal type ratio as per irrigated area are: 36% classic canal (lined open canal), 41% prefabricated irrigation networks canalettes-concrete raised parabolic flume), 23% pipeline irrigation
networks.

Approximately 77% of total area is irrigated by surface irrigation methods (furrow, border, etc.). The remaining part (23%) is irrigated with pressurized irrigation methods (sprinkler 15% and trickle 8%). About 850,000 hectares area is equipped with sprinkler irrigation system of hand-carried pipes which is widely used among farmers. About 450,000 ha area has been irrigated by drip irrigation. In DSİ irrigation projects, mainly fruit trees are grown by using sprinkler irrigation and mainly vegetables are grown by using drip irrigation. Slopping land necessitates a lot of water structures and water distribution problems are faced during the operation. Hence, low pressure pipe networks became necessary. Concrete low pressure pipes in irrigation networks were used in 1980s.

![Figure 10. Types and Lengths of Existing Irrigation Canals](image1)

![Figure 11. Present and Prospected Irrigation Canal Types](image2)
7.3 Limitedness of Irrigation Ratio

The reasons of low irrigation ratios have been studied in more than 1,000 ha irrigated areas in which DSI operates and areas in which management of the operation has been transferred to various Water User Organizations. The reasons for low irrigation ratios are; inadequacy of water resources (9%), insufficient irrigation structures (7%), high watertable (1%), salinity and alkalinity (2%), inadequate maintenance (2%), topographic conditions (3%), enough rainfall or some crop types with rainfed cultivation (30%), fallowing (11%), economic & social problems (21%), pasture land not irrigated (%4), irrigation areas converted to industrial & settlement areas (6%), and other reasons(4%). These results are obtained from the assessments of DSI irrigations, the size of which is more than 1,000 ha.

Table 4. Reasons for and Ratios of low irrigation ratios

<table>
<thead>
<tr>
<th>Reasons for low irrigation</th>
<th>Area not irrigated</th>
<th>Share in Area not irrigated</th>
<th>Area irrigated</th>
<th>Share in Area irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient water resources</td>
<td>77,292 ha</td>
<td>9%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Insufficient irrigation structures</td>
<td>59,453 ha</td>
<td>7%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>High watertable</td>
<td>8,005 ha</td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity and Alkalinity</td>
<td>14,516 ha</td>
<td>2%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>High watertable and Salinity</td>
<td>591 ha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate maintenance</td>
<td>14,516 ha</td>
<td>2%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Topographic conditions</td>
<td>21,704 ha</td>
<td>3%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Rainfed cultivation and no demand for irrigation</td>
<td>259,317 ha</td>
<td>30%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Fallowing</td>
<td>99,015 ha</td>
<td>11%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Economic &amp; Social Problems</td>
<td>180,400 ha</td>
<td>21%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Pasture land not irrigated</td>
<td>32,925 ha</td>
<td>4%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Converted to industrial &amp; settlement area</td>
<td>49,567 ha</td>
<td>6%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Other* (Pollution, terror, etc.)</td>
<td>33,181 ha</td>
<td>4%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>850,912 ha</td>
<td>100%</td>
<td>39%</td>
<td></td>
</tr>
</tbody>
</table>

7.4 Limitedness of Irrigation Efficiency

Population increase and migration from villages to cities raised water demand. Hence, construction of intermediate and high pressure pipes in irrigation networks saving water and allowing optimum
utilization from water resources have been utilized starting from 1990s thanks to the advancement in pipe technology.

Because of increase in fresh water demand, to save water is imperative in agriculture, which is the most water consuming sector. A typical example is the Southeastern Anatolia Project where long tunnels, expensive conveyance canals, high elevated pumps to convey water to irrigation areas raised the cost of the water so much that water economy have become compulsory. Water saving will become much more important due to increase demand for water.

Theoretically, there are operational (conveyance) losses 5% in main canals and 5% in the schemes, adding up to 10%. These losses amount more than this figure in practice. In large irrigation schemes, decreasing of these losses have greater importance. Pressurized pipe systems in newly developed irrigation projects increase water economy therefore modern irrigation systems are to be encouraged. To convey irrigation water and to use wild irrigation on farm is prodigality and raise cost due to construction of larger drainage canals.

Farm efficiency in traditional irrigation systems e.g., wild, border, or furrow irrigations is about 60%. If leakage, evaporation and operational losses are included, efficiency becomes 50%. In other words, 2 m³ is consumed to provide 1 m³ water which means wasting of limited water resources, constructing distribution and drainage schemes with bigger capacities, thus increasing costs and additional power consumption if system includes pumping.

If we add the cost of the water itself to abovementioned factors, it may be easily understood that water economy is really important. Because it is not possible to reduce water amount in crop water requirements, water economy could only be applied in water conveyance, distribution, and in modernization of on-farm irrigation systems. The most important factor is the increase of farm efficiency. Instead of traditional methods, if sprinkler and drip irrigation methods are utilized, sprinkler irrigation increases water efficiency from 60% to 80% and drip irrigation raises water efficiency up to 95%. It means 20% and 30% water economy.

To realize irrigation, land to be irrigated is to be efficient, water resource is to be sufficient, and water quality is to be acceptable. After these conditions are met, irrigation network to be used by farmer to convey water to the field as well as drainage network facility to move excess water away is necessary. Even all these facilities are exact and perfect, these are not enough for successful irrigation. Irrigation is lively job, its success depends on operation by administration as well as by farmer’s knowledge and skill.

<table>
<thead>
<tr>
<th>Table 5. Efficiencies of conveyance canals and on-farm irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distribution Efficiencies</strong></td>
</tr>
<tr>
<td>Classic layered systems</td>
</tr>
<tr>
<td>Concrete raised parabolic flume</td>
</tr>
<tr>
<td>Closed systems</td>
</tr>
</tbody>
</table>

7.5 Worn Existing Surface Water Irrigation schemes

The ages of 966 irrigation facilities constructed by DSI are as follows: 185 facilities (19%) are over 40 years old, 327 (34%) are 21-39 years old, 185 are (19%) 11-20 years old, 93 (10%) 6-10 years old, and 176 (18%) 1-5 years old.

Management of irrigation facilities are transferred to water user organizations, some of which are difficulty in financing maintenance services. Conditions of irrigation facilities:

- Irrigation facilities in poor quality have been transferred to WUOs.
Because WUOs could not repair and maintain, the conditions of irrigation facilities became worse.

Wear and tear condition of irrigation facilities is so poor in quality that they cannot be restored simply by repair and maintenance.

Urgent rehabilitation and rejuvenation of these irrigation facilities are needed not only to increase irrigation rate but also to raise irrigation efficiency.

Aims of rejuvenation projects are to: ensure full function of the irrigation facilities, continue the contribution of the facilities to the National Economy, ameliorate conditions in which farmers can benefit from facilities, secure the sustainability of the repair and maintenance, save water in irrigation, ease the repayment of investment cost of irrigation facilities, and achieve collaboration between DSI and WUOs.

Facilities have been worn and out of fix by adverse impact of climate and by passage of time. For that reason, DSI has initiated rejuvenation project which have been put into practice by “Ministerial Decree” for the irrigation projects developed by DSI and transferred to various water user organizations. Participation of beneficiaries and water user organizations is focal point in this Project. Rejuvenation criteria are considered in order to determine priorities in the rejuvenation applications. The rejuvenation criteria are given as:

- Duration in operation
- Water Resources and Project Area Hydrology Data Change Need in Irrigation System
- Maintenance and Repair Condition of the Facility
- Fiscal and Operational Structure of the Organization
- Cost benefit Rate in the Project Area and Plant Type
- Irrigation Rate, Irrigation Area
- Irrigation Efficiency, Facility Deficiency
- Condemnation Appraisal

<table>
<thead>
<tr>
<th>Rejuvenation Projects</th>
<th>Irrigation Facilities (Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finished</td>
<td>13</td>
</tr>
<tr>
<td>Under Construction</td>
<td>9</td>
</tr>
<tr>
<td>Constructions proposed</td>
<td>8</td>
</tr>
<tr>
<td>Constructions to be proposed</td>
<td>5</td>
</tr>
<tr>
<td>Project is over.</td>
<td>25</td>
</tr>
<tr>
<td>Project work in progress</td>
<td>52</td>
</tr>
<tr>
<td>Planning work in progress</td>
<td>56</td>
</tr>
</tbody>
</table>

### 7.6 Limitedness of Groundwater Irrigation Facilities

Groundwater potential of Turkey is determined, allocated, and conserved as per Groundwater Law No. 167. Studies are conducted to determine where groundwater is, how many meters in depth it is, and what is its quantity. Searching and using groundwater in and out of proclaimed groundwater operation areas depends on the permission given by DSI as per Code 167, Article 8.

In the same manner, permission documents for rehabilitation and alteration are also granted by DSI. Groundwater in Turkey is used for domestic and industrial water supply as well as irrigation. Groundwater irrigation projects were executed by DSI General Directorate and defunct Village Service
General Directorate (KHGM). But now they are implemented by DSI and Province Special Administration. There has been great demand to use groundwater recently. Safe yield amount of ground potential has already achieved in terms of groundwater irrigations. During drought years excess extraction of groundwater causes reduction of water table, settlements of soil, and degradation of land. Therefore, new groundwater irrigations are not considered. On the contrary, by constructing new surface water irrigations transferring water from other basins, DSI aim to reduce existing groundwater irrigations. The government initiated some measures to control the use of groundwater. To this end, some gauging systems have been necessary in order to measure the groundwater use.

As per the amendment in 10th Article of Law No. 167, the determination of the catchment areas in which the gauging stations are compulsory has been vested to Ministerial Board in order to control groundwater, to ensure its sustainability and to manage efficiently.

At the preliminary stage, gauging stations at all the wells regardless their purpose on Konya Basin and Ergene Basin, as well as at all industrial purposed wells in Turkey regardless of their basins have to be installed. The application of gauging stations on other catchments will be compulsory as per their intensive use of groundwater and relations to reservation-allocation. Since domestic water supply has priority, present groundwater resources are used for domestic water supply without waiting development of surface water resources. Some groundwater irrigations may be used until development of surface water resources.

In order to calculate rentability of the investment in groundwater irrigations, crop pattern and new crop pattern with irrigation are to be known. At present 10 l/s discharge of a well is rentable, but there are some cases which can be rentable below this figure. 10 l/s discharge of a well could irrigate 10-20 ha area depending on the on-farm irrigation method such as wild irrigation or closed system.

DSİ drills groundwater wells and provides irrigation schemes with equipment. After DSI construct groundwater irrigation schemes, the management of groundwater irrigation schemes are transferred to Groundwater Irrigation Cooperatives (GICs). Majority of Groundwater Irrigations are managed by Groundwater Irrigation Cooperatives (GICs). Some groundwater irrigations are still managed by DSİ. There are some combine irrigations where surface water is insufficient, groundwater extractions is supplementary tool for irrigation.

In the need of public institutions, mostly Agricultural Enterprises (TIGEM), DSİ drills groundwater wells and provides irrigation schemes with equipment on the cost recovery base. The operation of these projects is performed by related institutions. The share of GICs in total groundwater irrigated area is 73%, that of irrigations by DSİ is 14%, and that of public groundwater irrigations is 13%.

7.7 Nature of Existing Groundwater Irrigation Scheme

So as to save groundwater and contribute it to Turkey’s economy, the studies to shift open canal canals to closed canals have started. The transformation program has started by signing a protocol and pre-contract among Irrigation Cooperative-SPA-DSİ. 260 cooperatives have signed a protocol and pre-contract together with DSİ and Province Administration in order to shift open canals to closed system. Thus, 292,585 ha area has been included in the program for transformation. The rate of groundwater irrigation cooperation having the closed system is 58%.

8 INCREASING DEMAND FOR NON-AGRICULTURAL WATER

As consequences of population and economic growth and social developments, demands for non-agricultural water also increase either for urban, industries, domestic or recreations and so on. Turkey
is not a “water-rich” country as it is often presumed. To the contrary, the country could be vulnerable to facing water shortage problems in near future unless necessary interventions were made. This problematic status of the country in regard to water derives from several actors including the following: Difficulty of controlling resources as a result of a problematic topography; unbalanced regional distribution of resources and precipitation; and utilization of water resources through regional, discrete and short-term projects instead of long-term planning for integrated management on basin basis.

Per capita water usable is 1,600 m³. Looking at some other countries and the world average, Turkey will be among those facing water shortages in term of per capita usable water endowment. Today, it is accepted that a country should have annual per capita water potential of more than 5,000 m³ to be classified as “water rich.” Population of Turkey is expected to be 100 million in 2023. Per capita water potential will further fall to 1,125 m³ by that year. It is possible to figure out further pressures on water resources deriving from population growth and changes in water consumption patterns. All these estimates are based on the assumption that existing water resources and potential are transferred to coming generations. This indicates that Turkey has to utilize her water resources efficiently and rationally to safeguard future generations. Water for irrigated agriculture has been estimated at around 74 % and the rest 26 % has been utilized for domestic, industry and urban. In addition, it will also necessary to be more effective in coordinating all parties in using water either internally or cross-sectors. Coordination institutions in all levels need to be strengthened.

Table 7. Water Potential and Utilization and Annual Surface and Groundwater Demand

<table>
<thead>
<tr>
<th>As of 2016, Annual Water Utilization in Turkey</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Water</td>
<td></td>
</tr>
<tr>
<td>Water Consumed for Irrigation: 32 billion m³</td>
<td></td>
</tr>
<tr>
<td>Water Consumed as Domestic Water: 4 billion m³</td>
<td></td>
</tr>
<tr>
<td>Water Consumed for Industry: 4 billion m³</td>
<td></td>
</tr>
<tr>
<td>Total Consumed Water: 40 billion m³</td>
<td></td>
</tr>
<tr>
<td>Ground Water</td>
<td></td>
</tr>
<tr>
<td>Water Consumed for Irrigation: 8 billion m³</td>
<td></td>
</tr>
<tr>
<td>Water Consumed as Drinking Water: 3 billion m³</td>
<td></td>
</tr>
<tr>
<td>Water Consumed for Industry: 3 billion m³</td>
<td></td>
</tr>
<tr>
<td>Total Consumed Water: 14 billion m³</td>
<td></td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>54 billion m³ (48%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Water Potential of Turkey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Rainfall Amount: 501 billion m³</td>
</tr>
<tr>
<td>Annual Available Surface Water: 98 billion m³</td>
</tr>
<tr>
<td>Annual Available Ground Water: 14 billion m³</td>
</tr>
<tr>
<td>Annual Total Available Water: 112 billion m³</td>
</tr>
<tr>
<td>As of 2015, Development Status</td>
</tr>
<tr>
<td>Water Utilized for Irrigation: (74 %): 40 billion m³</td>
</tr>
<tr>
<td>Water Utilized as Domestic Water: (13 %): 7 billion m³</td>
</tr>
<tr>
<td>Water Utilized for Industry: (13 %): 7 billion m³</td>
</tr>
<tr>
<td>Total Consumed Water: 54 billion m³</td>
</tr>
</tbody>
</table>
9 IRRIGATION MANAGEMENT BY STATE

81% of the irrigation water is derived from surface sources and the 19% from groundwater in areas equipped with irrigation in Turkey. 97% of surface irrigations constructed by DSI transferred to Water User Organizations (WUOs). 86% of groundwater irrigations constructed by DSI transferred to Groundwater Irrigation Cooperatives and other public agencies. Only 3% of surface irrigations and 14% of groundwater irrigations are being managed by DSI.

DSİ applies 3 planned irrigation management works;
1) planning before irrigation,
2) monitoring water distribution during irrigation, and
3) evaluation after irrigation.

Maintenance and repair process contains preparation of the maintenance and repair program for facilities constructed and operated by DSI, Allocation of the budget of Maintenance and Repair, monitoring final account files, Preparation of the facilities identification dossier, Development of techniques of Maintenance and Repair, and Weed control. Sediment accumulation and weed on the canals hinder the water conveyance. Mechanical clearance is to be preferred to eradicate these problems. Before the irrigation season water structures (canals, check gate, gauging facilities, and intake structure) are to be prepared by maintenance.

For last 15 years in the irrigations operated and transferred irrigations, DSI annually executes average following maintenance and repair works; 4.4 million m$^3$ irrigation canal cleaning, 3.4 million m$^3$ drainage canal cleaning, 83,000m$^3$ concrete repair, 110 km canalette change, 40,000m$^2$ painting, 15 km service road maintenance, 370,000m$^3$ lying stabilizing material on roads.

9.1 Limitedness of State budget for irrigation management

In Turkey, State Hydraulic Works (DSI) is the state agency responsible for the construction, operation and maintenance of large-scale irrigation infrastructure. Historically, State Hydraulic Works operated the irrigation schemes through a top-down approach with very low levels of farmer participation. Cost-recovery rates for the irrigation projects were very low. In many cases, maintenance was not (and could not be) performed due to a lack of funds, and the long-term sustainability of these projects depended on significant changes being made.

Decentralization of irrigation system management has been achieved since 1993 which transferred irrigation management responsibilities to Water User Organizations (WUOs). The rationale behind this transfer is to encourage farmers to commit themselves to the IMT, ensure their active participation in irrigation activities and thus to reduce the financial burden of the State related to the costs of the irrigation management.

There is a need for community based water governance, because all effected parties should have an input on how and where to use water. Thus, there is to promote a collaborative decision-making process. There is greater interaction among stakeholders at local level, better service and affordable O&M costs, increasing transparency, enhancing self-control and stronger sense of ownership. There are less financial burdens on governments who have become regulatory bodies rather than investor. Community cohesion and empowerment is another nature of WUOs.

In 2016, 54 billion m$^3$ water was consumed in various sectors in Turkey; 40 billion m$^3$ in the agriculture, 7 billion m$^3$ in the water supply, 7 billion m$^3$ in the industry. This sum accounts for development of only 48% of the available exploitable potential of 112 billion m$^3$. Turkey aims at using the available potential by 2023, which is the centenary of Turkish Republic.
Table 8. Irrigations constructed by DSI

<table>
<thead>
<tr>
<th>Irrigations constructed by DSI</th>
<th>Unit</th>
<th>Net Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed by other agencies</td>
<td>30</td>
<td>17,285</td>
</tr>
<tr>
<td>Managed by GICs</td>
<td>1,440</td>
<td>489,585</td>
</tr>
<tr>
<td>Managed by Operated by DSI</td>
<td>176</td>
<td>130,587</td>
</tr>
<tr>
<td>Managed by WUOs</td>
<td>876</td>
<td>2,298,026</td>
</tr>
<tr>
<td>Total</td>
<td>3,692</td>
<td>2,935,483</td>
</tr>
</tbody>
</table>

Table 9. DSI Irrigation systems

<table>
<thead>
<tr>
<th>DSI Irrigations</th>
<th>Unit</th>
<th>Net Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed for Others</td>
<td>30</td>
<td>17,285</td>
</tr>
<tr>
<td>Groundwater Irr. Coop. GIC</td>
<td>1,440</td>
<td>489,585</td>
</tr>
<tr>
<td>Operated by DSI</td>
<td>176</td>
<td>130,587</td>
</tr>
<tr>
<td>Transferred to WUOs</td>
<td>876</td>
<td>2,259,022</td>
</tr>
<tr>
<td>Total</td>
<td>3,692</td>
<td>2,896,479</td>
</tr>
</tbody>
</table>

Table 10. Management and Types of Irrigations constructed by DSI

<table>
<thead>
<tr>
<th>Management of Irrigations constructed by DSI</th>
<th>Gravity Pumping</th>
<th>Groundwater Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed by DSI without tariffs</td>
<td>35 947</td>
<td>300</td>
</tr>
<tr>
<td>Managed by DSI with tariffs</td>
<td>73 907</td>
<td>94 340</td>
</tr>
<tr>
<td>Managed by WUOs</td>
<td>1 858 766</td>
<td>57 076</td>
</tr>
<tr>
<td>Managed by other agencies</td>
<td>47</td>
<td>17 285</td>
</tr>
<tr>
<td>Managed by Groundwater Irrigation Cooperatives</td>
<td></td>
<td>489 585</td>
</tr>
<tr>
<td>Total</td>
<td>1 968 667</td>
<td>564 099</td>
</tr>
</tbody>
</table>

Figure 13. Rates of Irrigation Types Managed by DSI

9.2 Participatory Irrigation Management

Until the decade of 1993 irrigation management and development in Turkey showed the dominant role of the DSI almost in every phase and level of management, even in tertiary irrigation schemes where the farmers have responsibilities. Initially the DSI forced took over rehabilitation works of tertiary systems as the farmers did not carried it out. However, this measure make worse when the farmers lost their sense of responsibility and sense of belonging. Based on some research findings and experts’ recommendations the DSI then started to improve the way and the approach in developing
and managing the irrigation schemes by adopting participatory principles. State provided reductions in water charges for Irrigation Communities who completed their maintenance work of irrigation facilities. These initial works provided successful transition to Irrigation Management Transfer.

9.3 Irrigation Management Transfer for Surface Water Irrigations

In the case of Turkey, the transfer of irrigation management to the associations progressed much faster than planned. In 1995 alone, the area transferred was three times that of the yearly plan. There was no opportunity to prepare an enabling law that would be the legal foundation for the associations. The associations were established using a patchwork of the Village Act (No. 442), the Local Government Act (No. 1580) and the Provincial Governance Act (No. 5442).

The associations are set up by the local authorities in an irrigation zone and apply to the DSI in order to sign the transfer agreement which gives them the right to collect fees and assigns them the responsibility to distribute water and maintain the canals.

Today irrigation unions maintain their facilities within the scope of this law and to provide participation of the farmers into the assembly of irrigation unions a special regulation has been conducted in 19th article. In current situation, the budgets of irrigation unions are put into force with the approval of Mayor soon after adopted by union assembly. DSI General Directorate has no sanction power legally over allocations regarding staff, vehicle, energy, maintenance and repair which are all required for running of the irrigation facility and over determination of irrigation wages which form nearly all income of the union for obtaining the allocation required. Intensive studies held between 2008-2011, 6172 numbered Irrigation Unions Law was put into force on 22.03.2011 soon after being published at Official Journal numbered 27882.1

Establishment process and founder members.

As per some Articles of WUO Law No. 6172, following topics have been amended by this law:

i. Establishment of assembly of WUAs
ii. Preparation of budget and coming into effect
iii. Determination of tariffs
iv. Personnel employment
v. Imposition of a penalty
vi. Auditing, and
vii. Special arrangements on energy consumption, repair and maintenance

Some important changes by this law can be set out as follows:

The running of unions shall be provided according to “Union Frame Main Status” which will be determined by DSI. Duty area is restricted with irrigation area. The union can be set up with the application of at least 4 persons utilizing from the irrigation and form Establishment Committee. The irrigation unions will only deal with irrigation facility. They will have the authority of the institution which takes over (DSİ) within the scope of transfer contract. At least 18 water user members are needed to become official as a union. Those who give up water user identity shall be excluded from the membership by Executive Committee and under other circumstances denoted at the Law, by Assembly decision. The number of assembly members is to be determined as per the irrigation area with at least two farmers as members at each accommodation site. Assembly members is estimated to be assigned for 4 years. Monitoring and supervision have been established to have auditing powers in terms of views, opinions, reporting, running, and maintenance issues as to facilities of union. Supervision and guidance as to facilities carried out by union and being among issues within duty area of the Ministry of Food, Agriculture and Husbandry. The assembly decisions will be taken by majority of the votes while the decisions regarding internal and foreign loans by the 2/3 votes. Water usage service cost shall be determined by Union Assembly not below the tariff determined each year by
Council of Ministers. Forming a SUPERVISORY BOARD out of Union Assembly thus inner auditing will be provided. The members of Executive and Supervisory Board will be appointed for 2 years and the Head for 4 years by the assembly. 30% of the fees in GRAVITY irrigations and the 15% in the PUMPED are to be spared for maintenance and repair and in case amount remains it is to be spared to the next year. The energy cost at least for the former year in PUMPED irrigations is to be added to the budget as expenditure and this money cannot be used for any other purposes. A balanced budget is to be prepared. After confirmation of DSİ Regional Directorate, the approval of the budget will be realized by Mayor. Debt stock cannot exceed the final budget incomes. The head and executive members who do not carry out the necessary procedures for collecting the debts in time and accurately, will be responsible for the damage during their period. The debts which cannot be collected in time shall be collected according to Bankruptcy and Enforcement Law. Staff expenditure is to be disciplined, staff will be employed as per Labor Law, staff charges cannot exceed 30% of the budget, under urgent circumstances this amount can be increased to 40% with the approval of Minister. Travelling expenses of union staff will be provided as per Travel Expense Law. The highest manager (director/engineer) employed will not be fired without the permission of DSİ Regional Director. It is given the authorization to apply BOT and other investment models to the unions. The unions’ areas to be audited by the commission formed by governorship. The Ministry will realize managerial and fiscal supervision. Unions can be audited by Turkish Court of Accounts directly. It is determined the utilization conditions of farmers who are not members of the union at the irrigation site. Those damaging irrigation facilities which union took over shall be punished as per criminal sentence of damaging the state property. Existing irrigation unions will adjust their positions to this law within 18 months. Existing permanent staff to other public agencies can be transferred by maintaining their acquired rights. Contracted staff will go on to work in existing positions without losing any rights.

Figure 14. Large Scale Surface Water Irrigation Management Transfer (IMT) started in 1993

9.4 PPIMIP Project for Surface Water Irrigations

Participatory Privatization of Irrigation Management and Investments Project (PPIMIP) has been developed to buy machinery and equipment needed by water user organizations taking over the responsibility of operation and maintenance services of irrigation facilities developed by DSI. Irrigation organizations financed 60-80% of cost of equipment by their own sources, and 20-40% by the project. The project also supported rehabilitation of irrigation facilities. 17 Irrigation Associations have performed modernization and rehabilitation in the whole of their schemes or in some parts with the condition of participating to the cost by 50%. The loan amounted 20 million dollars provided from the World Bank was used between the years of 1998-2004.

9.5 Water User Organizations (WUOs) for Surface Water Irrigations

WUAs in Turkey are non-profit organizations having the right to irrigate within their hydraulic
boundary within a range of 300 ha-35 000 ha. There are more than 300 WUAs in Turkey. Main responsibilities of WUAs according to the Law No. 6172, are setting water tariff together with DSI, implementing O&M activities, repaying the investment costs of irrigation facilities, planning the crop pattern in cooperation with the Ministry of Food, Agriculture and Livestock. Income of WUAs: water tariffs are financial penalties and donations. Water is not priced. O&M costs are charged to users. DSI provides training and monitors activities of WUAs.

The main decision-making body of a WUA is the Council. The Council, which has a four-year term, is composed of the local authorities who are permanent members (such as the village headmen and the mayor) and selected representatives from each village. The councilors elect the chair and the executive committee of the association. The general secretary of the association is responsible for the steering of the associations’ daily operations and coordination.

Assembly members of WUAs are elected by water users. They are composed of beneficiaries from each administrative irrigation zone. Their responsibilities are to monitor and check the activities of the president and the boards as well as accept the annual budget.

Governing board of WUAs are members elected by the Assembly members. Their responsibilities are registering new water users as members, collection of fees and financial penalties, preparing budget reports, preparation of budget for the Assembly’s approval and management of available budget.

Supervisory board of WUAs are members elected by the Assembly. Their responsibilities are checking the actions of the governing board and the president to report to the assembly. President of WUAs is elected by the Assembly, acts as the representative of the WUA, and proposes the budget to the assembly. President of WUAs has the final word on executive decisions.

Irrigation Management transfer in Turkey has been implemented according to “k” Article of the establishment law of DSI. Until 2011, there was no separate law related to WUAs. Water User Organizations have been established pursuant to: Local Administrations Law No. 5355, Village Legal Entities Village Act no. 442, Municipalities Municipality Act no. 1580, Cooperatives Act No. 1163.

WUOs have been established according to Law No. 5355, 1580 and 442, Irrigation Cooperatives (ICs) have been established according to Law No. 1163. Irrigation schemes serving the area of only one administrative unit, could be transferred to the Municipalities and Village Authorities. As of 2013, the transfer ratio of DSİ has reached 97%, which indicates the success of these transfer activities.

9.6 Water User Associations (WUAs) for Surface Water Irrigations

Irrigation Management transfer in Turkey has been implemented according to “k” Article of the establishment law of DSI. Until 2011, there was no separate law related to WUAs. Water User Organizations (WUOs) have been established pursuant to: Local Administrations Law No. 5355, 1580 and 442, Irrigation Cooperatives (ICs) have been established according to Law No. 1163. Irrigation schemes serving the area of only one administrative unit, could be transferred to the Municipalities and Village Authorities. As of 2013, the transfer ratio of DSİ has reached 97%, which indicates the success of these transfer activities.

Water User Organizations (WUOs) can be in several forms. If an irrigation network goes through one local authority area, the whole management of the irrigation network can be transferred to that authority (Municipality or village authority). However, the majority of irrigation networks goes through more than one local authority area or serves more than one administrative unit. Therefore, WUAs are necessary to take over the management responsibility. Even though irrigators are in charge of the management, technical staff is hired to carry out the operation of the system. The WUAs are in
charge of collecting the water demand forms before the beginning of each irrigation season (usually in April) and forwarding the total demand to DSI which is responsible for allocating the amount of water from the reservoir. The most common method of water distribution is the rotation system among different tertiary canals and a distribution ranking among farmers set by technicians. The number of siphons - which are pipes used in order to divert water from irrigation canals to the fields – farmers can use to divert water from the canal to their field is determined by the size of land they irrigate. The field technician is in charge of auditing the process, of patrolling the territory for infrastructural problems and for ensuring the smooth running of the water distribution process.

<table>
<thead>
<tr>
<th>Water User Organization</th>
<th>Unit</th>
<th>Unit Rate %</th>
<th>Net Irrigation Area (ha)</th>
<th>Area Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village Authority</td>
<td>200</td>
<td>21</td>
<td>36,751</td>
<td>1.6</td>
</tr>
<tr>
<td>Municipality</td>
<td>127</td>
<td>13</td>
<td>100,649</td>
<td>4.3</td>
</tr>
<tr>
<td>WUAs</td>
<td>377</td>
<td>39</td>
<td>2,041,994</td>
<td>87.5</td>
</tr>
<tr>
<td>Cooperative</td>
<td>251</td>
<td>26</td>
<td>134,031</td>
<td>5.7</td>
</tr>
<tr>
<td>Other</td>
<td>17</td>
<td>2</td>
<td>20,721</td>
<td>0.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>972</td>
<td>100</td>
<td>2,334,146</td>
<td>100</td>
</tr>
</tbody>
</table>

9.7 Groundwater Irrigation Cooperatives (GWICs)

They are set up jointly by DSİ and the abolished GDRS. Now, SPA (Special Provincial Administration) has taken over the responsibility of GDRS. Well-digging, electrification, and motor-pumps requirements of GWIC are carried out by DSİ, but irrigation network is completed by SPA. As per Law No. 1163 in order that State invest in groundwater irrigations, manage, maintain and repair, groundwater irrigation network, Groundwater Irrigation Cooperatives are to be set up if farmers want to use groundwater. Groundwater irrigations, originally, has been started by the protocol signed by DSİ and General Directorate of Soil-Water Conservation Services as well as Agricultural Bank. This protocol was revised in 1973.

10 COST RECOVERY OF IRRIGATION FACILITIES

10.1 Cost recovery of Surface Water Irrigation Facilities

The Code 6200 instructs that the whole actual operation and maintenance expenditures incurred by DSİ for irrigation investments are subject to be paid back by beneficiaries as operation and maintenance charges. Operation and maintenance charges are determined each year by Council of Ministers’ decree. Code 6200 authorizes Council of Ministers also to discount in operation and maintenance charges. Investment costs as well as expropriation cost for DSİ developed irrigation facilities are to be recovered by beneficiaries pursuant to Code 6200. Installments payments of cost recovery prices are updated in certain periods by Governmental Decrees. But the last update was made on 7th May 2001 with Prime Ministry Approval and annual investment cost recoveries were determined between 1,500 and 7,500 TL/ha. Recovery payment period is average 11 years.

10.2 Cost Recovery of Groundwater Irrigation Facilities

The abolished General Directorate of Rural Services (GDRS) used to perform the services and facilities
of the ground water wells on the free charge basis. However, the services and facilities by DSİ are subjected to repayment. The cost recovery of these facilities has been computed taking under no interest consideration, and facilities have been transferred to cooperatives in accordance with the "Transfer Contract" which prepared by DSİ, pursuant to the Decision of Council of Ministers. The Transfer Contract used to comprise 30 years of operational period, the first five years of being the grace period, and following 25 years containing the cost recovery schedule. During this 30 years period, operational ground water wells would be renewed just one once, but motor-pumps used to be renewed twice. However, with the decree of the Prime Ministry dated June 26, 1997, Transfer Contracts have been renewed for facilities constructed after this date. The cost recovery has been reduced to 15 years-the first three years being of grace period, and 12 years being regular cost recovery period which are subjected to annually equal payment installments.

Groundwater Irrigation Cooperation (GICs) prefers Special Province Administrations (SPAs) because there would be no reimbursement if the groundwater irrigation schemes were realized by SPAs. But farmers are in difficulty in using irrigation because of delays in realization of irrigation schemes since SPAs have the insufficient funds. For that reason, funds are transferred to SPAs via the protocol signed amongst SPAs, DSI, and GIC.

11 IRRIGATION SERVICE FEE

The WUAs’ council is responsible for the approval of work plans and the budget; determining/approving irrigation fees for the coming season; and the decision to acquire machinery and employ new personnel. Irrigation fees constitute the majority of the WUA revenues. The fees are set by each association and vary according to the crop that is cultivated. The associations depend on the collection of fees for survival – unlike DSI whose budget depended on transfers from the general budget. The budgetary autonomy renders the associations able to freely decide about their expenditure items.

12 OUTCOMES OF IMT

Before the establishment of WUAs, there were low ratio of billing and collection rates, high water consumption, no cost recovery for investment, and no interest by local farmers to protect the infrastructure. The transfer of Operation and Management (O&M) services to the Water User Organizations (WUOs) has had positive impact on the O&M issues both from the technical and financial point of view. The participatory approach by the users has generated a sense of responsibility that did not existed before, to better use the resources and the facilities and protect them. Water use is more reliable and equitable, the plots situated at the upstream or the downstream of the irrigated land are equally served. Farmers using water for irrigation are members of the WUAs are equally served as a member. Involvement of local stakeholders in water Governance process is a key element for efficient water use within countries’ water management policies. Increasing interaction among players results in better and rapid decision making and enables the acceptance of decisions. In irrigation sector, financial success of the process in Turkey is apparent. State expenditure for O&M decreased 80% in 15 years. With the establishment of WUAs all around the country, excessive use of water in irrigation decreased significantly. Accordingly, this resulted in protection of water resources and effected the soil and water quality (decrease in salinity). Improvement of O&M services enables the efficient use of irrigation water.

There is a mutual supervision mechanism, carried out locally on a continuous basis. On the whole, the collection rate has increased from 42% (irrigation by DSI) to more than 90%. Conflict management has been accomplished locally. Moreover, voting in a WUA assembly and having a chance to be a member of executive council encourage the people to participate and cooperate.
Irrigation efficiency has been attained. Overall, the area of irrigated land has increased for the same volume of water, a consequence of better operation and maintenance of the facilities provided by the local O&M (operation and maintenance) staff of the WUOs. Energy consumption of pump irrigation has decreased after the transfer.

13 RECOMMENDATIONS

Operation and Management (O&M) of DSI General Directorate is in the process of developing a new irrigation Management Information System (MIS) called SUTEM. O&M Department has implemented questionnaire for WUAs based on 84 indicators in 2016. The results indicate that 78% of WUAs are operating successfully. 13% are satisfactory and 9% are not satisfactory.

Generally, a WUO would manage irrigation cooperation, if the WUO has 5,000 ha agricultural area, the amount of which may vary as per the fertility and crop type of the land. WUOs having less agricultural area than 5,000 ha and WUOs having pumping irrigating may have difficulty in paying energy and maintenance cost. In order to reduce energy cost of WUOs having pumping irrigating, solar energy is considered. Solar panels have been installed one of the WUOs having pumping irrigating.

There are also some WUOs not managed well. Alternative operation models are being studied for the irrigations which were not able to transferred to any organizations or which are unsuccessful in their operations. One option is Transfer of Operational Rights to Municipalities. Another one is procurement of the operational services.

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UKRAINE COUNTRY PAPER: INSTITUTIONAL REFORMS IN IRRIGATION SECTOR FOR SUSTAINABLE AGRICULTURE WATER MANAGEMENT, INCLUDING WATER USERS’ ASSOCIATION

1 INTRODUCTION

In Ukraine, land reclamation is a major factor in adapting the agrarian sector of the economy to global climate change, providing high-performance management in adverse weather conditions, improving socio-economic and environmental conditions for rural population living and developing rural areas.

According to FAO estimates, Ukraine’s agro-resource potential makes it possible to produce agricultural products in quantities reaching 450-500 million people for food supplies.

Today, these opportunities are used by no more than a third, although Ukraine fully provides its food security, and is the largest producer and exporter of sunflower oil, the third world corn exporter, the fourth - barley, the sixth - soybeans, and the seventh - chicken.

2 LEGISLATIVE BASE


2.1 Challenges

As a result of climate change, the area of dry and very dry zone has increased by 7% and covers more than 29.5% of the territory or 11.6 million hectares (37%) of arable land. The area with excessive and sufficient atmospheric moisture, on the contrary, decreased by 10% and occupies only 22.5% or 7.6 million hectares of arable land. Thus, permanent irrigation in Ukraine requires 18.7 million hectares of arable land, 4.8 million hectares - periodic.

The existing state policy in water management area is ineffective because of the unresolved and unsettled nature of a number of issues, namely: the absence of a single independent authorized body that would be responsible for the development, monitoring and implementation of state water policy; The lack of a delimitation of the functions of water resources management and provision of water services to all consumers; Uncertainty of the status and authority of the basin councils; Unregulated participation of water consumers at all levels of water resources management and land reclamation, etc.

In order to meet the existing challenges and implement the existing potential of the country in the field of irrigation and drainage, it was decided to develop a Strategy for the restoration and development of irrigation and drainage systems in Ukraine by 2030 with involving into this project experts from World Bank.
2.2 Institutional and organizational aspects

In accordance with the Law of Ukraine "On Land Reclamation", irrigation and drainage infrastructure is divided into inter-farm and on-farm. Inter-farm reclamation infrastructure is state property, and it’s on the balance sheet and operated by the State Water Agency of Ukraine. On-farm reclamation networks in the Soviet period were and de jure still remain the property of the state, in spite of their transfer into communal ownership by the Government’s decree.

The financing of the irrigation and drainage sector in Ukraine is carried out through the State Water Agency at the expense of two sources: the state budget and revenues from the payment for water services. The total budget of the State Water Agency in 2016 amounted to about 2.2 billion UAH, of which 80% is attributed to irrigation and drainage. Water supply to consumers to the point of water outlet is carried out by the state water organizations on a contractual basis, according to which water users pay for the water supply services provided, including for the costs of operation and for consumed electricity.

The organizations of the State Water Agency are managed water complex, which includes 63 thousand rivers, 1103 reservoirs, including 172 large reservoirs with a total volume of 53 billion cubic meters, 48 thousand ponds with a total volume of 4 billion cubic meters, five large canals with a total volume of 10 billion cubic meters of water per year, 5.5 million hectares of reclaimed land, 45 thousand km of inter-farm canals, which provide water to industry, agriculture and other industries.

There are 250 legal entities in the system of the State Water Agency, including 9 basins, 16 inter-regional and 19 regional water resources departments, which implement state policy on the ground, 147 inter-district and district water management departments, 5 channels of service operation, 6 state water enterprises, 5 state design and survey institutes. More than 28 thousand people work in the system of the State Water Agency, most of which are held at the expense of the budget of Ukraine.

3 NEED IN INSTITUTIONAL REFORMS

Changes are necessary to bring the new market economy in line, to stop the decline of the irrigation and drainage sector and to increase its efficiency.

The existing management system of water resources and land reclamation in Ukraine is imperfect, inefficient, not cost-effective and incapable of attracting investment for modernization, reconstruction and development. The need for its reform is also due to:

- the growing of the problem of water supply for population and sectors of the economy by quality water in the required quantity, especially during periods of low water level;
- the deterioration of quality of surface and groundwater and the progressive degradation of environmental systems;
- the need for integrated management of water resources based on the basin principle, in accordance with international norms;
- lack of effective economic mechanisms for managing water resources and promoting sustainable water use;
- further deterioration of the state and the impossibility of effective use of state water-reclamation infrastructure, lack of economic levers of operation of reclamation systems.

The two functions of managing water resources and operating infrastructure should be separated because the roles are very different and there is a potential conflict of interest given the competing demands of other water uses and the impact of agricultural run-off on water quality.
Phase I will strengthen the “Water Resources Division” and “Water Operations Division” within State Water Agency, and begin a functional review of ancillary functions. The “Water Resources Division” consists of departments for each major river basin, each with a “Basin Council”, plus common supporting units. Further development of this division will involve reorganising resource-management staff in the current region and district water management units, to better reflect the basin approach.

Phase 2 will see the canals and drainage infrastructure moved out of State Water Agency into new regional bodies, leaving the State Agency to concentrate on water resource management in line with its name and its institutional location under the Ministry of Ecology. Water Agency ancillary services, such as design bureaux and training institutions, will be retained, restructured, relocated or privatised, as determined by the functional review.

Inter-ministerial coordination will continue under the Inter-Agency Commission for Water Resources during Phase 1, though with an independent chairman from outside SAWR. In Phase 2 it will be succeeded by a National Water Resources Committee to coordinate the activity of different ministries in the management and use of water resources.

Management and operation of local irrigation and agricultural drainage systems will be transferred to Water Users’ Organisations (WUOs), under a new WUO Law prepared in Phase 1. These will be non-profit bodies of public law set up and managed by their members to provide specified services in irrigation and drainage. They will employ professional management and must have sufficient scale to employ specialist staff, equipment and systems.

The creation of WUOs should precede the legislative settlement of the following issues:

- legal form of WUOs (public organization, not private law);
- the task of their activities, rights and responsibilities;
- the procedure for the elaboration and adoption of the Statute;
- the order of management and decision-making;
- Organizational structure and principles of activity, including budget formation.

According to the Strategy the modernization will be made on 1 – 1.5 million ha of irrigated lands and about 1 million ha of drained lands. And it will need total investments 4 – 4.2 billion US dollars.