Contribution of Agricultural Water to the Rural Development in Asia

Technical report of the Asian Regional Working Group Work Team

Asian Regional Working Group (ASRWG)
International Commission on Irrigation and Drainage (ICID)
The International Commission on Irrigation and Drainage (ICID), established in 1950 is a leading scientific, technical, international not-for-profit professional organization. The professional network consists of experts from across the world in the field of irrigation, drainage, flood management, and a wide spectrum of agriculture water management. The main mission is to promote ‘Sustainable agriculture water management’ to achieve ‘Water secure world free of poverty and hunger through sustainable rural development’. ICID is a knowledge sharing platform dedicated to issues that covers the entire spectrum of agricultural water management practices ranging from rainfed agriculture to supplemental irrigation, land drainage, deficit irrigation to full irrigation, etc. In addition, drainage of agricultural lands forms the core theme of commission’s activities. Floods and drought, the two extremes of increasingly variable climate as a result of potential climate change, also form the focus of activities.
PREAMBLE

Agriculture is the key for rural development and poverty reduction and water use for food production is a value-adding process. Irrigation play an important role in food security because water is crucial to food production and development and can ensure that enough food is available to all and can ensure access to sufficient food. However, in many developing and least developed countries, water is a major factor constraining agricultural output, and income of the world's rural poor. Improved agricultural water management can contribute to poverty alleviation and rural development. Assured water improves water productivity, enhances employment opportunities and stabilizes income and consumption. It encourages the utilization of other yield-enhancing inputs and allows diversification into high-value products, enhances non-farm outputs and employment, and fulfils multiple needs of households’ vis-a-vis rural development. The net impact of agricultural water management interventions on poverty may depend individually and/or synergistically on many approaches.

Improved access to water is essential, but not sufficient for sustained poverty reduction. Investments are needed in agricultural science and technology, policies and institutions, economic reform, addressing global agricultural trade inequities, etc. But how best to match the agricultural water management technologies, institutions and policies to the needs of the heterogeneous poor living in diverse agro-ecological settings remains a challenge.

The side event on “Agricultural Water Management for Sustainable Rural Development” was jointly organized by African-Asian Rural Development Organization (AARDO), Korean Rural Community Corporation (KRC), Korean Committee on Irrigation and Drainage (KCID) and ICID during 2nd World Irrigation Forum in November 2016 at Chiang Mai, Thailand, which deliberated on the best practices and requirements of various rural development interventions like development of social capital (gender sensitive approach), public private partnership (PPP) and technical options like water trade to deal with the emerging issues with focus on collaborative mechanisms so as to mutually support the interventions for optimal rural development.

The challenges implicit in the contribution of agricultural water to the rural development in Asia was the reason behind the International Commission of Irrigation and Drainage (ICID) establishing in 2013, a Work Team on “Contribution of Agricultural Water to the Rural Development in Asia”. The ICID Work Team on this subject has done a marvelous task of consultations and workshops during the past five years taking on board various country experiences and studies. It is through these deliberations that they have brought out the publication “Contribution of Agricultural Water to the Rural Development in Asia”.

We are convinced that this publication will serve its objectives in guiding National Committees and others on meaningful contribution of agricultural water to the rural development in a sustainable manner. The significant contributions by many lead experts in the ICID fraternity have made this publication possible and the members of the ICID Work Team deserve appreciation for their hard work. We are particularly indebted to Prof. (Ms.) K.S. Choi’s diligent efforts in bringing out this publication.

Eng. Felix B Reinders
President
International Commission on Irrigation & Drainage (ICID)
Agricultural water management (AWM) with a focus on irrigation water is envisaged as a primary way to fight household poverty and food insecurity and as such constitutes one of the important facet of rural development. Irrigation water enables not only in improving crop production but also serves many other agricultural activities such as the development of livestock and fisheries production and thus has a multiplier effect on the well-being and livelihood of rural poor.

The report has been prepared by the Asian Regional Working Group – Work Team (ASRWG-WT) of the International Commission on Irrigation and Drainage (ICID). The initiative to establish this ASRWG Work Team on “Contribution of Agricultural Water to the Rural Development in Asia” was taken in 2013 by Prof. Tai Cheol Kim from Korean National Committee while Prof. (Ms.) K.S. Choi who join the WG in 2015 finalized the report in the year 2017. The first meeting took place under the Chairmanship of VPH Dr. Karim Shiati in 2013.

Over the past five years, ASRWG-WT held several workshops and meetings in order to prepare the report. This task had the benefit of a very good cooperation of the specialists from various countries, including Indonesia; Republic of Korea; Japan; Myanmar; Philippines; Thailand; Turkey; Vietnam ; and Chinese Taipei where the rural development played an important role in the overall development.

The initiative to prepare a status report was very appropriate and timely and the results are most revealing. In the report, readers can find analysis of collected case studies from various countries as mentioned above. All the material has been brought together by the specialist and professionals from the participating countries. As such, the report presents a good overview of the status of knowledge and policies related to the relevant issues in Asia.

I would like to congratulate Prof. (Mrs.) K.S. Choi, the Chair of the ASRWG-WT and editor of the report and all the country contributors and authors for preparing this informative and useful report. Also thankful to the Korean National Committee of Irrigation and Drainage (KCID), Korea Rural Community Corporation (KRC), and Korea Ministry of Agriculture, Food and Rural Affairs for their kind support and cooperation. Although the publication is considered to be the final product of the Working Group, I hope that the Working Group can continue with its valuable work, as the contribution of water to the rural development will become more important in the future to meet the challenges of sustainable development and management under the pressures of population growth, urbanization and industrialization in densely populated countries.

Last but not the least, special thanks to Prof Karim Shiati (Iran) for leading the group activities as the Chairman of ASRWG and to Dr. Vijay K Labhsetwar, Director at ICID and other support staff for their dedication in bringing out this publication for releasing it during the 8th World Water Forum in March 2018 at Brasilia, Brazil.

I hope this report will be useful to all and many others who may refer to it in future.

Ashwin B Pandya
Secretary General
BACKGROUND

Agricultural water has been identified as a critical factor to drive rural development. Generally, water is regarded as natural resources in abundance and its contributions in the areas of conservation environment and biodiversity, domestic use, ecological system and energy sector other than for agricultural production cannot be overemphasized. When agricultural water is effectively harnessed, food production and crop yield are positively affected. Hence, rural development and a drastic reduction in poverty and hunger are achieved.

Agriculture plays an important role in rural development. Sustainable agricultural development cannot be achieved without the availability of agricultural water. The development of agricultural water use for food production is nearly equivalent to the rural development. Also, the rural development includes an increase in food production, income, rural economic diversification, labor cost saving, social economic development, farming convenience enhancement, industrial development, reduction in natural disasters and improvement on the standard of living.

However, Asia is currently facing acute water shortage, and water demand is expected to exceed supply in the future. Since the larger percentage of water is used for agricultural production, shortage of agricultural water will lead to food scarcity and increase in rural poverty and hunger. Agricultural production and food security which is a leeway to rural development has gradually been affected by the scarcity of agricultural water due to its competitiveness.

To address this situation, the Asian Regional Working Group (ASRWG) organized a Work Team (WT) for publication of a technical report on “Contribution of Agricultural Water to the Rural Development in Asia” at 20th meeting of ASRWG in Mardin, Turkey in 2013. The mandate of WT was to suggest the better directions and prospects of techniques and policies, and also suggest the sustainable water management on development and improvement of the livelihood of the rural community.

The WT consists of Korea, Iran, Japan, Chinese, Taipei, Thailand, Turkey, Malaysia, Indonesia, and Nepal members. Prof. Tai Cheol Kim who was the VPH of ICID and former Co-chairman of ASRWG proposed issue of the technical report and was appointed as a chair of WT, but resigned his position due to personal reason after the 22nd meeting of ASRWG in Montpellier, France in 2015.

I have since then taken over his role, and saddled with the responsibility of the WT. The most difficult part of this task was collecting appropriate papers from many countries, but fortunately most WT members contributed to this publication, and other papers were collected from ASRWG internal workshops, collaboration with PAWEES and INWEPF WG 2, and Side Event with AARDO (Asia Africa Rural Development Organization).

The technical report consists of two parts. The part I of the report centers on the background notes. This gives the importance of agricultural water vis-à-vis irrigation and drainage to food security and rural development. The part II of this technical report is on cases and experiences relating to agricultural irrigation, drainage and rural development in some selected countries across Asia. Each of these provides invaluable insights on issues and policies relating to agricultural water management.

I hope this technical report will serve as a framework for both the policymakers and stakeholders on the sustainable management of agricultural water for the rural development.

I would like to thank the chairman of the ASRWG, Dr. Karim Shiat and WT members for their supports, and many thanks to Mr. Naoki Hayashida, Dr. Gwo-Hsing Yu, Mr. Arthon Suttigarm, Dr. Aynur Fayrap, and Dr. Mochammad Amron, who contributed to the report. The efforts of authors apart from WT members, who submitted informative, useful and well researched papers, are sincerely appreciated.
This technical report would not have been completed without mentioning International Cooperation WG Task Force members of Korean National Committee of Irrigation and Drainage (KCID) including Dr. Sung Hee Lee, Dr. Young Duk Kim, Mr. Seung Won Lee and Ms. Jeong Min Ryu for their contributions and dedications in summarizing and editing the report.

I also appreciate KCID, Korea Rural Community Corporation (KRC) and Korea Ministry of Agriculture, Food and Rural Affairs for their financial supports on this publication.

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Chapter 1
Country Papers on Rural Development
Chapter I. Country Papers on Rural Development

Synthesis Report on Country Papers

A total of seven full papers were received for Background Notes. The papers are:

- "A way to achieve food security and reach an advanced status - Focusing on Korean experience" by Tai Cheol Kim (Korea), which was input of 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea
- "Irrigation and rural development: A changing relationship” prepared by Thierry Facon, which was input of 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea
- "Transition towards sustainable rural development in Thailand” prepared by Somkiat Prajamwong (Thailand) presented at 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea
- "The role of irrigation development in food security and poverty alleviation in Indonesia” prepared by Mochammad Amron (Indonesia) for 2016 ICID meeting in Chiang Mai, Thailand
- "Contribution of agricultural water to the rural development in Japan” prepared by Naoki Hayashida (Japan) and presented at the Side Event of 2016 ICID meeting in Chiang Mai, Thailand
- "Turkish experiences on irrigation improvement” prepared by Aynur Fayrap (Turkey) presented at 2013 ICID Meeting
- "Agricultural irrigation and rural development in Taiwan” prepared by Gwo-Hsing Yu (Taiwan) submitted in 2017

Asia represents about seventy percent of the world's irrigation but it is yet to give the desired results. Strategies of national food production and water use in the changing society will vary according to the rural and economic development. In general, it is expected that irrigation sector would have gone beyond its present level and reached development plateau. Agriculture in Asia is facing a complex dilemma to meet economic growth and sustainable development because it could have considered both elements together for economic development rather than focusing on only economic growth.

Thierry Facon from FAO presents challenging issues on irrigation and rural development to manage the agricultural water in a sustainable and equitable manner. FAO introduces its effort to provide a planning and management tool to meet the demand of sectoral reform and spreading of
integrated water resource management. Especially, agriculture water use is depending on the livelihood context in a given environment of its country. It is used for non-productive functions not to mention food production.

In this context, Naoki Hayashida from Japan introduces multifaceted and publically beneficially intangible advantages such as conservation of biodiversity, landscape, replenishing of groundwater and so on, which is so-called multi-functionality. He highlighted how important the Multi-functionality should be taken into account to evaluate water use for agriculture in Asia.

Some countries like Korea and Indonesia presented experiences and lessons to achieve food security through the irrigation and rural development projects. Since the 1960s when the national plan for food security have been undertaken, agricultural production and infrastructures developments were carried out for productivity improvement and food security that have resulted in the self-sufficiency of staple grain rice. Kim emphasizes, “Although the investment for food production declined, continuous interventions from the government are critical because agricultural water use can be extended for improvement of the rural living standard”. In addition, a bottom-up approach for sustainable development and multiple functions of agriculture in Asia were highlighted with the participation of residents and farmers.

Indonesia suggested challenges based on the current roles of irrigation development in food security and poverty eradication. The challenges are an increase of population, agricultural land conversion, degradation of watershed and climate change. Separately, he added options for sustainable irrigated agriculture management in general context. They include diverse approach not confining to irrigation management by itself, land consolidation, mechanization, post harvesting and empowerment.

Gwo-Hsing Yu from Taiwan introduces a subsidy program for the upland irrigation system, adopted in 2015, allowing the rural areas to access the national agricultural water resources, vitalizing the development of agriculture in the rural areas, improving the efficiency of agricultural irrigation, better managing the water and land resources and facilitating the overall development of agriculture. The strategy includes promotion of private upland pipeline irrigation and guidance to construct and operate public facilities since upland irrigation system may alleviate problems being faced in the rural areas and enhance the income of farmers.

General Directorate of State Hydraulic Works (DSI) and Ministry of Food, Agriculture and Livestock (MoFAL), Turkey encourage farmers to use sprinkler and drip irrigation methods. The drip (trickle) irrigation system has contributed to a marked increase of yield under open-field and greenhouse conditions in Turkey. Its use is increasing rapidly for vegetable and field crops. Greenhouse crops are also rapidly expanding in the Mediterranean region of Turkey.
Another interesting work is Group Agricultural Practices (GAP), a South-eastern Anatolia Project. GAP is a multi-sector and integrated regional development effort approached in the context of sustainable development. It aims to improve living standards and income of people to eliminate regional development disparities and to contribute to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector. The project covers approximately 10 % of Turkey’s area (7,800,000 ha).

Thailand rural development was shifted from a growth-oriented approach to the new model of holistic people-centered development and sustainable development. Public services in water domain not only deal with water provision for production, but also mitigate water-related natural disaster and hazards such as flood and drought. The Mae Yom Operation and Maintenance Project in Phrae province, northern Thailand is an example of an initiative to mitigate drought. Formerly, water conflicts in the project area were mediated on a case by case basis without implementing a comprehensive measure against drought. With a participatory approach involving relevant stakeholders and through a technology advancement and research-based management, the project could provide proactive drought relief measures. A better quality of farmers’ life has been considered as the greatest gift to project. For successful implementation of the project it is essential to integrate collaboration between public sectors and local people in order to sustain the quality of public services.

In conclusion, traditionally, agricultural water in Asia is deeply rooted in its culture and livelihood. Paddy farming has been performed over thousands of years all over the world, especially in Asia. Importantly, it is necessary to find a way to use agricultural water for production and environmental service at the same time for sustainable rural development. It is, therefore, clear that these studies give some insight on the role of agricultural water towards sustainable rural development. In addition, it is needed to share each experience with partnership and member countries to use the limited water resources wisely for sustainable rural development with poverty eradication to meet SDGs (Sustainable Development Goals).
1. Introduction

We are united in our commitment to land, water and food as well as irrigation, drainage and flood control. We are all trying to enhance global food security and farmers’ livelihood. Currently 20% of irrigated agriculture produces 40% of the world’s food crops. This justifies the importance of irrigation and its development for food production. Globally, it is needed to double food production by 2050 with scarce water and land resources, while protecting ecosystems under the growing concerns on increasing population, low efficiency of irrigation water, conflicts between water users, and climate change.

Over the last half-century, irrigation sector has greatly expanded to increase food production to meet the demands of growing populations and to raise incomes of the rural people. Some countries have achieved the goal of the irrigation project, but are still suffering from the gap between the rich and poor and the impoverished conditions of rural communities. Other countries are still in the process of transition, and suffering from food shortage and poor living standards of rural people. It is important to discuss and suggest the directions of irrigation policy and rural development considering the level of the economic transition.

In this respect, the irrigation policy executed in Korea might be a good lesson and a role model for developing countries. It is known that Korea is the only country in the world to have become an advanced/ developed country from a least developed country through achieving both economic and democratic growth. The practical experience could improve the irrigation policy, implementation and monitoring. Agriculture still remains an important foundation of the country in the 21st century, because of not only food security, but also the conservation of diverse bio-system, the maintenance of rural community and traditional culture.

2. Background

Korea was a poor, struggling, least developed country and in less than one generation it has become an advanced/ developed country partly with the help of foreign aid. We have firsthand
experience in how to escape out of extreme poverty and how to reach the status of the advanced country not only by food security but high-tech industry too.

Many developing countries recently want to learn lessons from Korea’s economic growth and Korea gladly shares its experience with them.

Meanwhile ICID has encouraged developing countries to participate in its activities, because water for food is the most impending issue to them. But it is not easy to attend its events because of high expenses and so they do not realize the importance of participation in ICID.

In that sense the Round Table meeting is organized to build up a cooperative network with global partners. Its theme is “Irrigated agriculture and rural development in developing countries” Irrigation experts are invited to provide developing countries with the opportunity to discuss the issues on food security and rural development and to share their own experiences to overcome their challenges.

3. Korean Experience in Irrigation and Rural Development

Agricultural water development can be achieved through constructing irrigation facilities and increasing efficiency of irrigation water use. Therefore, the infrastructures of irrigation such as dam, intakes, pumping station, consolidation, sea-dike, and drainage facilities had been constructed till 1990s, and the irrigation system has been restructured for its efficient management and adapted to globalization and climate change since 2000s. The infrastructure requires the priority of investment against other alternatives and it needs to accumulate information on natural resource, strategy and policy for irrigation development. The form of irrigation and the way it is managed have changed over the years. I personally classified the irrigation development into the modernity (1960s～1980s) via transition (1990s) and the post-modernity (2000s～).

3.1. The modernity era

The policy of “Economic growth is not possible without food security” was set up and executed. Korea experienced irrigation policy could be realized through matching up the timely target goals with the proper policy tools by decades. It is meaningful to formulate the policies of food security and industrialization to explain the characteristics of the Korean experience. For example, the policies can be classified into the category of law & system, food security, SOC infra, manufacturing industry, services, and safety & welfare etc. by decades. It is essential to secure finance and execute balanced budget for the economic success. The passion of the people
and great leadership are essential for a good fortune of the nation as shown in Figure 1. It is nowadays evaluated that economic growth was so successful, but human rights were suppressed in the society and democracy was retarded in the politics.

**In the 1950s: Experienced starvation and poverty after war**

Most of the farming infrastructure including irrigation system was destroyed during the Korean War. Because of poor domestic finance, 60% of the budget was from foreign aid. The time spirit of the decade might be called “Starving” - GDP/capita was only US$ 80. Korea was in imminent danger of high population growth and low agricultural productivity. It started from the reform of the ownership of farmland and the repair of irrigation facilities with the help of foreign aid. Act on high seawater land reclamation was legislated.

**In the 1960s: Drastic budget for the food security**

Economic growth was motivated by the military government in 1961 with powerful leadership. The time spirit of the decade might be called “Awakening” - GDP/capita was US$160. Even with the poor national finance, government paid great efforts to end extreme poverty and thus set up the first priority of national policy to be food security in the first 5 years economic plan under the slogan “Without success in agriculture, no success in economy” Law of farmland improvement was legislated in 1961 and backed up the related policies. The irrigation development started with small-scaled public irrigation facilities such as dam-reservoir, pumping station, intake weir, and tube well. Farmland consolidation for farm machinery started. Korea has reached the status of an advanced country not only by food security but also high-tech industry/conglomerates such as Samsung, Hyundai, LG and Pohang steel Co. The strategy should be set up with the connectivity of the policy. There was the Economic Plan Board & Youth vocational center in 1961, 1st National economic plan & Compulsory education, Tidal land reclamation & Family planning, Oil refinery, Fertilizer factory & Medical center, 5-year plan of food &10-year reforestation plan, and Incheon steel Co. & Industrial complex, in 1966, Hydropower stations &Green belt system, Seoul-Busan Express highway & Pohang Harbor, Free export zone & 5 years of farm machinery, SaeMaulUndong & Multi-purposed dam etc. The farming population was 15million which comprised 60% of total population and 40% of GDP was from the agricultural sector. The amount of export reached US$0.1billion in 1964 mostly by textile products.

**In the 1970s: SaeMaulUndong (SMU), a role model for developing countries**

SMU which means new village movement was a turning point of the Korean economy. It was a kind of mental revolution to break peoples’ pessimism and eradicate the poverty under the
slogan “Yes, we can” The basic philosophy of SMU was diligence, self-help, and cooperation. Law of promotion for rural modernization was legislated in 1970.

The time spirit of the decade might be called “Export-oriented industry” GDP/capita was US$2,000. It was “Take-off stage” by Rostow. Foreign loan projects to invest in large-scale irrigation systems were executed and repayment was done by other sectors.

The high yield varieties, chemicals, timely irrigation, and farm machines led to the self-sufficiency of staple food in the mid-1970s. Lots of farmers migrated to urban areas and became skillful workers after vocational training. Korea has few natural resources but plenty of human resources. Therefore, the government set up an economic plan of the export-oriented industry with the barter trade system. As a result, the more national budget has been concentrated to SOC and heavy industries such as express roads, tidal land reclamation, shipbuilding& motor industry, nuclear power, machine & chemistry, multipurpose dam, and overseas construction services etc. The amount of exports reached US$1billion in 1970.

In the 1980s: Interconnected food security with exported-oriented industry

During this period Korea grew to a highly industrialized country. The time spirit of decade might be called “Industrialized” GDP/capita was US$4,600. Farm mechanization with land consolidation had accelerated huge rural exodus to urban factories. The population of farmers was 10.8million and occupied 30% of total population. 14% of GDP was from the agricultural sector. After achieving food and social security, more investment to the heavy and chemical industry has been carried out. Rural community was getting vacant and new community plan was needed. Paradoxically, the shrinkage of the agricultural sector has promoted the manufacturing industry as a benefit in turn. It is a basic principle that agricultural economy has low competitive business compared to manufacturing and service industry. The amount of export reached US$10billion mostly by the products of steel, ships, cars, televisions, refrigerators and air conditioners in 1977. The budget of agriculture was US$0.66billionand occupied 6% of the total national budget of US$11billion in 1980.

In the 1990s: Globalization and restructured irrigation scheme to adapt to WTO

Korea became a member of OECD and joined WTO. Politics became more democratic after the civil revolution in 1987. The time spirit of the decade might be called “globalization” GDP/capita was US$10,800. It might be called “Transition period” from modernity to post-modernity in terms of irrigation policy. WTO is a favorable system to the Korean economy, but it is unfavorable to agriculture and farmers, because of low competitiveness of agricultural products in the global market. There are violent demonstrations against WTO, because it is not an eternal virtue and there exists still a possibility to be destroyed. We are afraid the agricultural infrastructure is collapsing and rural community is totally vacant. Agricultural policy has shifted
toward an open market system. Restructuring irrigation schemes such as large plot and
to automation had been executed to adapt to WTO. In other words, farmers are the victims of WTO
system and so innovative policy is needed because food security is still the foundation of the
national economy, various subsidies such as a free fee for irrigation water and a direct payment
for eco-friendly farming are provided under the national consent and farmers’ income-support
system. Otherwise we cannot sustain the rural community itself and its traditional cultures. Law
of rural maintenance and improvement was legislated in 1994.

Table 1. Direction of national economy and irrigation policy

<table>
<thead>
<tr>
<th>Decade</th>
<th>Korean economy</th>
<th>National economic policy (Irrigation project)</th>
<th>GDP</th>
<th>Spirits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>Korean war</td>
<td>Farmland reform, Social chaos and reconstruct new network, (140,000ha irrigated out of 1mln, Repair facilities by aids)</td>
<td>80 (US$/C)</td>
<td>Starving</td>
</tr>
<tr>
<td>1960s</td>
<td>Military government, Law and System</td>
<td>5yrs plan for economic development, Long term national plans, (60% farmers, 40% GDP, Drive small irrigation project) Transportation (Railroad, Highway, Harbor), Power, Textile–Steel–Oil–Water complex (Tidal land reclamation, Consolidation for farm machinery)</td>
<td>150</td>
<td>Awaken &amp; Forward</td>
</tr>
<tr>
<td>1980s</td>
<td>Export drive &amp; Electro technique</td>
<td>Export Steel, Ship, Car, Television, Fridge, Air conditioner (30% farmers 14% GDP, Total subside rule for irrigation facility, Rural community plan, Water fee 300kg/ha)</td>
<td>4,600</td>
<td>Democritization</td>
</tr>
<tr>
<td>1990s</td>
<td>Civilized democracy, Trade globalization</td>
<td>Semi-conductor, adapt to UR and WTO, (Law of rural maintenance and improvement, Restructuring irrigation and rural scheme, Water fee 50kg/ha)</td>
<td>10,800</td>
<td>Globalization</td>
</tr>
<tr>
<td>2000s</td>
<td>Progressive Government, Leading ICT</td>
<td>FTA, Smart phone, (Less concern on food &amp; rural space more on eco &amp; urban space, 860,000 irrigated out of 1mln ha, Subsides: Free water fee &amp; direct payment)</td>
<td>15,000</td>
<td>Eco &amp; Welfare</td>
</tr>
<tr>
<td>2010s</td>
<td>DAC in OECD Advanced country</td>
<td>United Korea (5.8% farmers 2.2% GDP, Promoting ODA project in rural development, Inter–Korea cooperation)</td>
<td>25,000</td>
<td>ODA &amp; 1 Korea</td>
</tr>
</tbody>
</table>
Most of the irrigation and rural development project in the modernity had been planned by the central government and executed uniformly and enforcedly by so-called “Top-down” system. In a case, sub-surface drainage improvement had been carried out without understanding the purpose of the project and farmers’ consent.

The budget of agriculture was US$4billion and occupied 10% of the total national budget of US$40billion in 1990. A total amount of US$22.4billion had been invested in irrigation and rural development during 1961 to 1998. 84% of total investment was for irrigation land and water development, 9% was for the improvement of rural living standards and 7% was for off-farm income project. The annual budget of infrastructure for rural land and water was 1.8% of the total national budget on average during 1961~1990. It was quite bigger than 0.6 or 1% in 2013.

It is meaningful to classify such policies into several categories in an inductive reasoning to explain the Korean experience through Kim’s image puzzle as shown in Figure 1. That is to say, it is normally very difficult to solve the cube puzzle but if you unfold the cube and find the underlying rule, then it’s getting much easier. It is similar to economic image puzzle.

Figure 1. K–Image puzzles to formulate the policies into categories.


3.2. The post-modernity

In the post-modernity, although the investment for food production has declined, the government has recognized the necessity to improve the effective management of irrigation facilities. The concept of irrigation and rural development has been widened to the improvement of rural living standards through the provision of the modern village, off-farm employment, social safety, and welfare services. Although infrastructure for agricultural production has been greatly improved, farmers feel relative poverty and rural communities are being exhausted. New innovative policies are needed for farmer's richness and rural amenities. There are disaster prevention, information techniques, agro-eco-environment system and improvement of public welfare facilities. The budget for irrigation and rural development project should be fairly allocated to improve the crop productivity and the livelihood of rural community depending on the level of the economic transition. The budget of agriculture was 6.2 billion and occupied 12% of the total national budget of US$52 billion in 1994. The budget ratio between the rural land and water and total national budget was 1.6%.

In the 2000s: Sustainable development and “Bottom-up” policy

The financial structure has been reformed for well-balanced budget and the harmonious policy between development and conservation has been driven. The time spirit of the decade might be called “Eco & Welfare” GDP/capita was US$15,000. The concept of sustainable development recommended by UNESCO has been reflected into the budget allocation.

The irrigation policy in the post-modernity has been diversely planned and the rank of priority for the projects has been determined autonomously by the residents and farmers, so-called “Bottom-up” system. Even in the highly modernized society, rural society should conserve its unique identity and invaluable amenity.

Meanwhile, the multiple functions of rice paddy farming have emerged. Rice paddy water supports multiple functions that provide for fish cultivation, flood control, groundwater recharge and cultural heritage, as well as promote the conservation of ecosystems. Paddy-systems serve as artificial wetlands which have good potential for preserving both human cultures and natural ecosystems in a sustainable manner. Rice paddy systems provide important ecosystems service at the river basin.

The irrigation and rural development projects have been focused on the new rural village with green tourism, drinking water and sewage system and rural industrial-complex to enhance the quality of rural life. And green tourism is highlighted as a favorable alternative to enhance the off-farm income. For example, new rural village project has been originally designed to improve
the 1,000 rural villages during 2003–2012. The average project cost per village was US$ 7 million for 3 years. In case of Alps village, 37 farm households make 10 times bigger income through green tourism of ice festival in winter and gourd festival in summer.

Upgrading flood design criteria to reduce flood risk and reinforcing dam to prevent natural disaster have been recently focused on to adapt to climate change. The design criterion of Probable Maximum Flood (PMF) for dam crest and spillway is approved and practically applied to 35 irrigation dams. The design criteria for the drainage pumping facilities are also being strengthened to cope with heavy storms.

Act on special measures for the promotion of farmers’ life and rural community was legislated in 2004. The amount of exports reached US$500 billion in 2010. The budget of agriculture was US$8.5 billion and occupied 8.5% of the total national budget of US$100 billion in 2001. The budget ratio of the rural land and water over total national budget rapidly decreased from 3% in 1997 to 1.5% in 2002.

**In the 2010s: ODA and One Korea**

The time spirit of the decade might be called “ODA & One Korea” GDP/capita was US$24,000. Even though 60% farming population dropped down to 6% (3 million farmers), it is possible to cultivate safely the paddy rice with elderly and women laborers due to the machinery farming. 2% of GDP is coming from the agricultural sector.

The target of irrigation and rural development has been recently extended not only to the improvement of living standards, modernized village, off-farm employment, but also to the cultural and educational system and medical service in the rural regions. “Without innovation in agriculture, no advanced Korea”

96 irrigation dams have been heightened with the total cost of US$2.7 billion by means of four major river restoration projects. For example, the heightened Seoam dam has multiple functions not only to increase agricultural production but also to conserve the rural environment in line with the comprehensive rural development projects.

The united Korea is a national target and a prerequisite to being a leading advanced country. The first step to cooperate with North Korea is to provide chemical fertilizer and seeds, and the second is to construct fertilizer and pesticide factories, and the third is to support the projects for the integrated rural development. Korea has recently proposed a joint study on watershed management and farmland restoration.
The budget of agriculture was US$18 billion and occupied 5.4% of the national budget of US$342 billion in 2012. The budget ratio of the irrigation and rural development over the national budget was 0.6% or 1%.

The innovative policy of irrigation and rural development has transformed its ideology from the modernity to the post-modernity. It has been shifted from development to conservation, from quantity to quality, from hardware to software, from growth to distribution, from one dimension of productivity to multi-dimension of natural resources, from homo farmland to hetero space, from Participatory irrigation management to Public irrigation management, and from top-down to bottom-up etc.

The annual budget for irrigation and rural development was 0.6 or 1% of the total national budget in 2013. It was quite lower than 1.8% during 1961～1998.

Table 2. The transformation of ideology from the modernity to the post-modernity.

<table>
<thead>
<tr>
<th>Modernity 1961～1990</th>
<th>Post-modernity 2001～</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development</strong></td>
<td><strong>Goal</strong></td>
</tr>
<tr>
<td>of high production, Farm income, Agricultural product competitiveness</td>
<td>Conservation of high quality and High valued local resources Global competitiveness</td>
</tr>
<tr>
<td><strong>1-D</strong>: Productivity (machinery, fertilizer), Corporative, Improving farmland, Hardware &amp; growth</td>
<td><strong>Core network</strong></td>
</tr>
<tr>
<td></td>
<td>M-D: Diversify source for tourism, ICT, Organic farming, Software &amp; welfare</td>
</tr>
<tr>
<td><strong>Cultivating homo space, Participatory</strong> Irrigation Manage, Subside for natural conservation</td>
<td><strong>Land &amp; water manage</strong></td>
</tr>
<tr>
<td></td>
<td>Hetero space by urban pressure, Public Irrigation Management, Bonus for conservation</td>
</tr>
<tr>
<td><strong>Top-down</strong> from central to local government, agricultural stakeholders</td>
<td><strong>Governance</strong></td>
</tr>
<tr>
<td></td>
<td>Bottom-up from local agricultural stakeholders to the central government</td>
</tr>
<tr>
<td>Economic growth under military government: developed</td>
<td>Modified OECD data</td>
</tr>
<tr>
<td></td>
<td>Democratic growth under civil government: advanced</td>
</tr>
</tbody>
</table>
4. Applying Korean Experience to the Developing Countries

Korea experienced the target goal of GDP/Capita US$24,000 in 2010 from US$80 in the 1950s. This can be attained only when the proper policy to solve the issue is organically interconnected with the timely law and system to assist the policy. It is essential to secure finance and execute balanced budget for the economic success. Surely the passionate national character and great leadership are the good fortunes of the nation.

SMU has been instructed to developing countries as a role model and its programs and projects are being undertaken in several developing countries.

Korea is the only country to have transformed her position from a recipient to a donor in terms of ODA. We are now reciprocating the favor we once received in the 1950s and 60s. So, since the 2000s, the government has given developing countries ODA funds for rural development through the KOICA. More than 20 irrigated agriculture projects are ongoing with a grant of 99.3 million in 2013 as shown in Table 3. It is important to understand the situation of the receiving countries and form a reciprocal and future-oriented partnership before seeking the selfish economic benefit of the donor country. Korean aid experience has been often criticized for its conditionality during the aid processes.

Table 3. On–going irrigated agriculture KOICA projects in 2013(from www.koica.go.kr)

<table>
<thead>
<tr>
<th>Country</th>
<th>Project name</th>
<th>Amount</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Improvement of productivity</strong></td>
<td></td>
<td></td>
<td>Period</td>
</tr>
<tr>
<td>Philippines</td>
<td>GIS system for integrated water resources development</td>
<td>3.5</td>
<td>2013~14</td>
</tr>
<tr>
<td>Mongolia</td>
<td>Agricultural productivity</td>
<td>1.6</td>
<td>2013~14</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Farm machinery and capacity building in high land</td>
<td>5.0</td>
<td>2013~16</td>
</tr>
<tr>
<td>El Salvador</td>
<td>Irrigation development project for rice productivity</td>
<td>3.2</td>
<td>2013~15</td>
</tr>
<tr>
<td><strong>Comprehensive agricultural project</strong></td>
<td></td>
<td>43.0</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>Karimantan comprehensive agricultural project</td>
<td>2.5</td>
<td>2010~13</td>
</tr>
<tr>
<td>Philippines</td>
<td>Qurino regional comprehensive agricultural project</td>
<td>5.0</td>
<td>2013~15</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>Parwan PRT comprehensive agricultural project</td>
<td>4.9</td>
<td>2010~13</td>
</tr>
<tr>
<td>Country</td>
<td>Project name</td>
<td>Amount</td>
<td>mil. US$</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>Ghana</td>
<td>Dawena comprehensive agricultural project</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>DR Congo</td>
<td>Chuenge comprehensive agricultural project</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comprehensive Agricultural Project</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Rwanda</td>
<td>Yarguru regional comprehensive agricultural project</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>Morogoro regional comprehensive agricultural project</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
<td>Mitigation poverty project</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>Improving farm income (WFP)</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Building Infrastructure</strong></td>
<td><strong>43.0</strong></td>
<td></td>
</tr>
<tr>
<td>Pakistan</td>
<td>Capacity building for agriculture &amp; livestock, Gunjo Univ.</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Myanmar</td>
<td>Land consolidation for machinery</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Capacity building Agricultural irrigation project in Dodota</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>Sudan</td>
<td>Agricultural technique training center</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>Groundwater development for irrigation in Monteverde</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dam and canal construction project in Chukisaki</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>Laos</td>
<td>On-farm income of 5 village in Vientiane</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lingsan road construction in Vientiane</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is instructive to play K-image puzzle to seek the way to reach a developed status in a deductive way. First, figure out what are the issues you are facing such as food shortage, bare mountain, poor finance, dense population, labor shortage and what are the appropriate tools (policy) to solve them for example, irrigation project, greenbelt system, forestation, foreign loan, family planning and vocational training and so on.
In this manner, you find the best way out of many alternatives and finally reach a developed status, less than a generation, with the help of global partners just as Korea has done. If the target goal of GDP/C is assumed to be US$ 10,000 in the 2040s in a developing country, then it can be attained only when the proper policies are systematically interconnected with the timely law and system as shown in Figure 2.

![Figure 2](image.png)

Lessons from the Korean experience

In the Round Table meeting, we’d like to share the experiences, strategies, policies and law systems for irrigation and rural development. Economic growth could be achieved not only by food security but also manufacturing and service industry. The success and limitation of Korean experiences could be shared with developing countries for the better development. The following lessons might be a way for a developing country to solve food security and reach an advanced status;

a) **National plan for food security:** In the 1960s, a policy of “Economic growth is not possible without food security” was set up. It gave us a lesson even if the contribution of agriculture to the national economy is relatively low, but without food security, national economy cannot be achieved.
b) **SaeMaulUndong (SMU) as a role model:** In the 1970s, SMU was a motive and turning point of Korean economic growth. It was a kind of mental revolution to break peoples’ pessimism and activate rural community. Foreign loan projects to invest in large-scale irrigation were executed and the self-sufficiency of staple food was achieved.

c) **Interconnect food security with high-tech industry:** In the 1980s, “Export-oriented industrialization” was achieved under the food security and stable society. Even if natural resources were very poor, export-oriented industrialization could be done by human resources with the skillful techniques.

d) **Globalization and adaptation to WTO system:** In the 1990s, Korea became a member of OECD and joined WTO. Restructuring irrigation schemes such as large plot and automation were executed to adapt to WTO. Law of rural maintenance and improvement was legislated in 1994.

e) **Sustainable development and “Bottom-up” policy:** In the 2000s, the concept of sustainable development recommended by UNESCO was reflected into the budget allocation. The rank of irrigation project priority was determined autonomously by the residents and farmers as “Bottom-up” system. Meanwhile, the multiple functions of rice paddy farming have been highlighted.

f) **International cooperation through irrigation project:** In the 2010s, Korea pays back the ODA funds once we received from advanced countries in the 1950s and has a responsibility as a member of DAC in OECD. A united Korea is a national target and a prerequisite to being a leading advanced country. Korea has recently proposed a joint study on watershed management and farmland restoration to North Korea.

**References**


• Kim, Tai Cheol, 2007, How to save irrigation water while conserving the eco-system and amenity? The proceedings of INWEPF workshop, Keynote speech, 9-29.

• KOICA, 2013, Final report of capacity building on irrigation and rural development in Dodota district Oromia state, Ethiopia.


• Moyo Dambisa, 2009, Dead aid, ALMA Publishing Co., Ltd.

• Ota, Shinsuke, 2008, Change of agricultural and rural infrastructure in Japan, - Focusing on background and practices of recent policies - the proceedings of Int’l Symposium for the 100th Anniversary of Irrigation Association. 133-151

1. Introduction: New Challenges and Questions for Irrigation in Asia

Natural resources and environmental services in Asia are under extreme pressure because of increasing economic development, agricultural growth, industrial development, waste and demands for food, housing, water and energy. Climate change is augmenting these pressures through its impacts on the intensity and frequency of extreme events, changing rainfall, temperature patterns and sea level rise. At the same time, agriculture and irrigation are major contributors to the problem. There is a need to switch to more sustainable and equitable growth patterns based on efficient use of resources, conservation and restoration of ecosystem services (i.e. green development) and to increase the resilience of production systems.

In addition, agricultural and rural areas are characterized by high incidences of absolute and relative poverty. At present, many farmers do not believe that they can meet their aspirations for decent and dignified livelihoods for themselves and their children in the agricultural sector or in rural areas. While there is awareness of the need to structurally transform the region’s agricultural sector, many farming, and rural communities perceive that structural transformation has been imposed upon them and presents a threat to their dignity, autonomy and control of their destinies. They see this transition as resulting in loss of access to or control over natural resources; degradation of their environment and health linked to “modern” agricultural practices; and increased insecurity.

The region and its agricultural sector, therefore, face two momentous and complex transitions: a structural transformation linked to fast, if uneven, economic growth, which leaves agricultural incomes stagnant, and a transition to sustainable agriculture aimed at reversing the unsustainable use and degradation of the region’s limited base of natural resources and increasing its resilience. These transitions are rarely considered together. A key challenge for decision-makers, however, is how to adopt policies and strategies to successfully support and orient this double transition in a sustainable and equitable manner. In this regard, green development offers several important opportunities: an overall greening of agricultural production which may improve livelihoods; a shift away from a number of agricultural support policies that provide incentives to increase output towards policies that promote resource use-efficiency in the sector and assist in adapting

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to changing climatic conditions; new possibilities to meet the policy as well as market driven
demand for greener agricultural products and to support policies related to payment for
environmental services, as well as climate related financial mechanisms; and the chance for
agriculture to support the greening of other sectors (e.g. energy or water) or to create jobs in the
environmental and natural resources sectors.

The challenge for the green development agenda is the extent to which it can help bridge a
widening gap between urban affluence and rural poverty, while also encompassing “green”
measures necessary to enhance ecological well-being.

Irrigation development has for decennia, been a backbone of poverty reduction and rural
development in Asia. The future role of irrigation in the changing economic and ecological
landscapes will vary depending on the livelihood context in a given rural setting, but the main
point is that it must be responsive to the dual transitional dilemma Asia faces today. How the
sector will manage these transitional challenges is the central question. This paper will review
the challenges and issues related to these transitional challenges, the changing relationship
between irrigation and rural development in the region in the context of managing these
transitions in a sustainable and equitable manner and conclude on some considerations on the
relevance of Asian experience to other regions.

A review of past achievements

Irrigation contributions to food security, poverty reduction and economic development over the
last 40-50 years in Asia are evident. 80% of the irrigation systems in Asia were built during this
period. By 2005, cereal production had tripled, real grain prices had declined by 40% and the
production of fruit, vegetables and feed had exploded.

The multiplier effect of investment in agriculture and irrigation on rural development and
poverty alleviation is well documented. In particular, the impact of irrigation development on
poverty reduction has been demonstrated to the extent that it is now commonly accepted as being
very high (IEG World Bank, 2006; JBIC Institute, 2007). Irrigation development has alleviated
poverty either directly, by increases in agricultural production, income and labor availability
(Hussein, 2005; Lipton, 2007), or indirectly by second-generation effects (improved access to
education and health, development of services, etc.). Nevertheless, irrigation investments were
often a missed opportunity, and could have better poverty reduction outcome if more
strategically designed (Darghouth et al., 2006). Likewise, small-scale irrigation
development has been found to have positive impacts on rural livelihoods for both traditional
small-scale irrigation (Angood et al., 2003), shallow tubewells (Angood et al., 2003; Brabben,
2004; World Bank, 2004-2007b) and the development of atomistic irrigation in South Asia had a much larger impact on poverty reduction than any irrigation government program (Shah, 2008).

Very small investments such as bucket irrigation or treadle pumps or mini drip kits may not have a real direct economic justification but may have a very significant nutrition or household food security impact (DFID, 2003). In the proper context, they can be a stepping stone for investment into an irrigation system with a higher unit costs (such as from treadle pump to shallow tube-wells in Bangladesh (Shah, 2008) or into other businesses. Securing the income stream allows a break out of the poverty cycle. Increasing wealth can lead to greater educational opportunities for children, and the chance to move out of farming altogether ⁴. Major issues are related to inequity: inequity of service delivery or water allocation upstream/downstream in particular and more generally related to proximity to the source of supply for technical reasons (Renault, 2007; JBICI, 2006), inequity of access to the water for social, legal, economic or local power structure problems (Hussein, 2005; Shah, 2008). Equity of land distribution is obviously a major factor in the distribution of irrigation benefits (Hussain, 2005; Hussain, 2006) while gender equity aspects combine positive and negative elements.

At the policy level, poverty reduction or rural developments under different names have long dominated the rationale for irrigation development, with some justification and level of success. A major poverty reduction impact of the green revolution has been the reduction of the prices of basic commodities. For some time, economic development and poverty reduction have been going rather well hand-in-hand and irrigation-based agricultural development has supported overall development. With the closing of the basins and the rising demand from other sectors, things become more complicated. The demand from other economic sectors increases and they usually have higher water productivity. The agricultural share of GDP may be decreasing fast but in terms of employment the agricultural sector may still massively dominate, with widely divergent dynamics according to the regions: in South Asia, rural populations are still increasing and are expected to peak in 2030 while for Southeast Asia and East Asia, the demographic transition is occurring very fast and will continue (Shmidhuber et al., 2009). Worse, the present income disparity between rural and urban areas and agricultural productivity, wages and earnings are predicted to increase in all sub-regions in Asia. One rural area’s water-based poverty reduction may affect other poor users downstream.

Two main periods in public irrigation evolution can be distinguished, a first post-colonial and cold war period where resources were abundant, dominated by engineering and agronomy, aiming at food security, with supply-driven system management, fixed crops, essentially cereals, ⁴ It is often a deliberate exit strategy, which underpins efforts to extract value from aquifers without concern for their sustainability.
and the current period since the 90s, aiming at improving livelihoods and incomes, with a freed and diversified cropping system, concerned with increased scarcity of resources, farmer-oriented management, a multi-disciplinary approach, with a switch from surface to conjunctive use and pressurized systems, and substantially increased cropping intensity. This does reflect a deliberate shift in public policies and the way irrigation and drainage systems were looked at, but this evolution has frequently happened in spite of or against public irrigation agencies. The region is changing fast. Wealthier city dwellers have new dietary demands requiring shifts in agriculture. Growing a range of crops requires a different irrigation regime than that needed to supply water to large areas planted with one or two cereals. Farmers have taken advantage of improved access to markets to diversify their activities and produce higher-value niche crops.

The large-scale, centrally managed irrigation schemes, but also the traditional farmer-managed irrigation systems, were not designed to be demand-driven or provide the reliable, flexible and equitable year-round water service that modern farming methods require. Beset with problems of poor design and maintenance, salinity and waterlogging, many schemes are in decline. Efforts to rehabilitate them have at best, mixed results. With poor service provision and lack of effective management, farmers have taken irrigation into their own hands, pumping water from aquifers, rivers and drains, investing in on-farm storage ponds to augment their supply and help them control their water supplies. Privately sourced groundwater now represents the bulk of irrigation in large parts of South, East and Southeast Asia. Unregulated development of this “atomistic irrigation” has boosted economic efficiency and productivity gains, but has resulted in excessive pressure on the resources. Efforts to reform irrigation schemes by transferring management to farmers have had poor results in terms of improving irrigated agricultural productivity, services to farmers, and the financial resource base for operation, maintenance. These reforms certainly suffered from implementation issues, but many doubt the capacity of irrigation institutions to reform.

As water scarcity is a key issue, pressure on agriculture water use to become more ‘efficient’ is increasing, but water conservation policies, strategies and investments are often founded on a misunderstanding. Productivity and efficiency gains do not mean that more production will be possible with less water. Increasing efficiency means that consumption is increased as the service more precisely and uniformly matches water needs. Irrigation losses and inefficiency appear high but most of these losses return to the basin as return flow or aquifer recharge, and can be used downstream or serve environmental or other functions. Irrigation and drainage systems provide water delivery and drainage services to farms and multiple uses, services and functions: fish farming, domestic and industrial water supply, navigation, groundwater recharge, flood
mitigation, biodiversity, micro-climate etc. Reducing water diversions or applications may end up saving no water, increasing water depletion, or merely reallocating water.

2. Changing rural livelihoods

Asian rural livelihoods have been changing rapidly as a result of economic growth, structural transformation of national economies, poverty reduction programmes and policy reforms. Rural economies are being integrated into national and wider economic spheres. Millions of poor people have escaped poverty through new opportunities offered by the changing economic environment. As a percentage of GDP, the economic contribution of agriculture is shrinking, and agriculture is commercializing and diversifying, driven by urbanization and commoditization. The share of the non-farm economic sector’s contribution to the rural economy is steadily rising. A vibrant rural dynamic is emerging in Asia with new hopes and opportunities, but also with risks and challenges. It should follow that a new approach to irrigation is needed that complements ongoing livelihood transformations and supports dynamic rural change processes, while ensuring sustainable ecological and economic development pathways.

The changing context: poverty, water and agriculture

The relation between water and poverty is getting more complex, and indirect. A recent study (Khanal et al., forthcoming) shows that there is no difference in poverty level between irrigated and non-irrigated zones. Rather, poverty is more concentrated in rice-based systems. This demonstrates that there are other factors beyond water that determines poverty as well as the linkage of water with poverty. These complexities need to be understood within the context of the transformations Asia is undergoing currently.

In recent times, rural livelihoods have been shaped by three interrelated transformations: structural, agricultural and dietary, driven by both global forces and local context. As explained by Timmer (2010), the process involves a successful structural transformation in which agriculture, through higher productivity, provides food, labor and even savings to the processes of urbanization and industrialization. A dynamic agricultural sector raises labor productivity in the rural economy, pulls up wages and gradually eliminates the worst dimensions of absolute poverty.

The net result of the structural transformation is that agriculture has been gradually integrating with other parts of the economy and its share in overall GDP has been sharply declining. At consumers level, the consumption of the grains has been decreasing whereas that of high-value food items like milk, meat, fruits and vegetables are rapidly rising due to urbanization and commoditization. Likewise, industrial crops for palm oil and biofuels
production are expanding exponentially. Commercialization and diversification of agricultural as well as growth in other sectors of the economy have led to rapid increases in non-farm activities in the rural economy.

These changes do not mean that the role of agricultural water management will decline; but it does mean that agriculture and agricultural water must be seen within the wider economic context, not through the sectoral lens. Because of the ripple effect of one sector to another and strong synergistic linkages between the two, the rural non-farm sector is now referred to by some as ‘neo-agriculture’ (Timmer, 2010), rather than an activity independent of agriculture. The rural non-farm sector has thus become an integral part of the agricultural transformation process and is a major contributor to rural development as well as poverty alleviation. Achieving harmonious growth of both the farm and non-farm sectors will remain an important pathway for rural poverty alleviation efforts in Asia.

**Water security challenges**

The water sector itself is confronted with several ecological challenges. A higher economic water security has been achieved so far at the cost of environment, as clearly seen from the Figure 2. This figure demands increased attention for improving environmental water security as well as resilience to water-related disasters, to maintain both economic growth as well as to provide rural livelihood support.
Agriculture still accounts for about 80 percent of freshwater withdrawal, but a large part of Asia is already in water-stressed condition and growing water scarcity is a major concern. While the current trend shows that agriculture water demand will slow down and much of increased water demand will arise from the industrial and domestic sector, managing agricultural water will still be of prime importance because of its large share, and a direct link to rural livelihood. In areas where water scarcity in absolute terms is not an issue, developing new schemes confronts with various social, environmental and economic limitations.

Climate change presents another serious challenge to poverty reduction and development efforts. It is superimposed on existing vulnerabilities and exacerbates current challenges in the rural production system, especially in the management of land and water resources. Its impacts are more severely felt by the rural poor because of their high degree of vulnerability and low coping capacity. The rural poor may be affected by climate change in several ways, but changes in agriculture are the primary means by which the impacts of climate change are transmitted to the rural poor, because of its dependence on climatic conditions and direct and indirect dependence of the rural poor on farming. The climate change-agriculture-poverty nexus is therefore critical to identify strategies to combat rural poverty in the coming decades. In addition, the increased risks of climate-related hazards like floods, drought and cyclones will have a profound impact on infrastructure and natural resources.
3. Implications for Irrigation and Rural Development

General implications

The trends and transformation in water and agriculture discussed in the previous sections will bear heavily on future approaches to water management and its linkage to poverty reduction and rural development. Some of the key implications for future are discussed in the following paragraphs.

First, agricultural changes tend to be reactive in nature. This means that agriculture needs to adjust, reform and modify in line with changes in other spheres of the economy. The era of agriculture-led poverty alleviation of the past is gradually transforming to more diversified forms of livelihood strategies. Agriculture still plays crucial roles, but should be seen in the wider context of economic development and has to find new balances between producing food, managing natural resources, promoting growth and providing a livelihood base for the rural population. Future water interventions should accordingly respond and adjust to these changes and redefine its space in the broader context of urbanization, industrialization and environmental concerns.

Second, potential water interventions in Asia will largely be ‘management-driven’ rather than development-driven both in surface and groundwater schemes. Asia has already developed a large portion of its water resources and many of the livelihood systems are based on irrigated
agriculture. Achieving sustainable management of water resources and increased the productivity of existing systems remains a key priority, not the development of new schemes. Though large parts of Asia are not water scarce and physical potential for new development exists in many cases, these options confront environmental, political and economic limitations.

Third, Asia must pay greater attention to building resilience against water vulnerabilities and the impacts of climate change. The poor condition of the water environment, continuing water disasters and the increasing threat of water scarcity and environmental degradation justify this. Economic water security in Asia has largely been achieved at the cost of the environment, and future economic water security will be threatened unless more attention is paid to managing the water environment.

Fourth, as rural livelihoods transform with changing economic and agricultural conditions, the future will need more demand-based flexible water control systems and multiple-use water services. This means the supply-oriented irrigation systems developed in the past to boost cereal crop production must be modernized to increase water productivity. Expansion of small-scale surface schemes and individually controlled atomistic irrigation will continue where water resources allow and where it is economically attractive.

Finally, while the dynamics of agriculture and water management and their linkages to rural livelihoods continue to change, poverty and rural livelihood issues have also gradually moved out of the agrarian domain as more diversified livelihood patterns emerge. Diversification has emerged both as a coping and a thriving mechanism (Start and Johnson, 2004) – thriving where it is driven by a growing and more flexible economy and ‘coping’ where diversification is an enforced response to failing agriculture, recession and retrenchment. In both ways, rural diversification will be a key determining factor in future poverty reduction programmes. However, the issue is not to search for alternatives to agricultural innovation, expansion and change, but to look at how best to integrate agriculture into the wider economy as a way of stimulating production and consumption linkages and promoting rural change. A vibrant neo-agriculture should be the priority for future rural poverty reduction, rather than looking at agriculture and irrigation in isolation.

Irrigating staple crops: practical implications

While crop diversification to supply developing local, national and export markets have provided and will continue to provide farmers with significant opportunities that will be enhanced by a more discerning and greener demand from consumers, it must be remembered that the bulk of agricultural production (and allocation of land and water resources) will continue to focus on the mass production of staples, such as rice and cereals, even though the share will
continue to decrease in quantity and value. For the farmers growing these staple crops, the “farm income problem” is the acute, and for them, land consolidation/rental and mechanization will have to play a role in boosting farmer productivity and farm income (Christiaensen, 2013). Farm sizes are already consolidating in some cases where economies of scale can be achieved (e.g. the core rice districts of the Mekong Delta), but they are fragmenting where traditional land tenure or land management techniques cannot be scaled, such as in Thailand or India (Dawe, 2010). In China, it has been calculated that a household growing only rice (with no other income sources) would need to increase its farm size by a factor of six now (and a factor of sixteen over the next five years) to match the typical income growth that rural households achieved from 2003–2008. Clearly this is not possible in such a short time span (Christiaensen, 2013).

Already, a number of countries in the region have adopted policies that deliberately aim at land consolidation in order to ensure that farming generates decent incomes and opportunities for employment:

- In the People’s Republic of Viet Nam, the policy objective of multiplying farmers’ incomes by 2.5 by 2020 translates into land consolidation and intensification for rice producers in areas with comparative advantage, and diversification out of rice and with a focus on quality and value addition in other areas.

- China has recently adopted a range of policies to facilitate the emergence of large, mechanized and specialized “family farms.”

- A key strategy in Malaysia to reconcile the objectives of its National Economic Transformation Plan to become a developed economy by 2020 and to continue to have a high level of self-sufficiency in rice is to create “estatization” and deliberate exit strategies for rice farmers in modernized federal rice granaries.

- On the other hand, Thailand’s “smart farmer” policy aims to develop a corps of farmers who are proud to be farmers and have the knowledge and skills to make complex decisions linked to market opportunities and to adopting sustainable practices. Nevertheless, the policy’s ambition (and criteria for “smart farmers”) is limited to farmers earning the official minimum wage. Although this would represent progress for many, it would be surprising if farmers were satisfied with the minimum wage as a reward for their skills, efforts and smartness (which obviously are not required in other sectors).

For these and other countries then, a key feature of the irrigation transitions is that it will need to be compatible with a process of expansion of farm sizes, especially for the production of staples, facilitated initially by land consolidation. Given the questionable prospects for green development to secure substantial increases in the welfare of most farming households, it would
seem that the adoption of sustainable intensification practices alone will not be able to underpin meaningful poverty reduction in rural areas. For most farmers, who will continue to be engaged in the production of staples, the adoption of sustainable and intensified agricultural practices would be socially and economically acceptable only if it is compatible with a substantial increase in the size of farm operations. Rural households would maintain small farms to produce staples in order to provide a social safety net, but it is unlikely that they would adopt the knowledge-intensive skills and invest the necessary time and capital to boost the agricultural productivity of only small land holdings. However, government regulations often hinder the sale/rental of land that would be required to increase farm size. Reform of land tenure laws is therefore an important, but apolitically delicate issue.

**The need for institutional innovation**

The changing nature of farming and rural livelihoods suggests that institutional models for irrigation management need revisiting and that innovation in this area is likely to be needed to support irrigation transitions. At the moment, key sources of institutional innovation are, on the informal water economy side, India and, on the formal water economy side, China. The range of spontaneous or autonomous institutions formed by farmers in India is staggering while spontaneous institutional innovations supporting water harvesting or groundwater recharge movements have had a massive effect (Shah, 2008). The private sector has also been very dynamic in the development of atomistic irrigation in the whole of South Asia. New forms of social management of groundwater have also been successfully tested in Andhra Pradesh and are being replicated in other states (Facon, 2010). While many of these models are dependent on local circumstances, this is an area where developers in that sub-region can look for inspiration. Local water markets have a substantial potential to travel and could be a model for countries planning to develop shallow tube well or pumped irrigation. China is also a source of successful innovation for formal institutions. China’s reforms of irrigation are based around creating profitable water businesses for the long-term financial sustainability of the project. The country has been largely successful with its bounded service provider model, which aims to create water-saving incentives for water managers.

Elsewhere in the region, but also in formal South Asia, the dominant model for institutional innovation has been the standard PIM/IMT model inspired by the Philippines. Its general failure has usually inspired a call for more reform. Efforts to research existing traditional forms of organization have been primarily geared towards their conservation rather than to assess their robustness or adaptability to change or the onslaught of pumped irrigation, seen as a threat by advocates of social capital (not by farmers). Malaysia, confronted with the rapid greying of a narrow farming population, is exploring the concept of “estatization” of water users associations.
on existing large rice granaries. Farmers retain ownership of land while most farming operations are done by professionals or are contracted out. The future will probably see similar evolutions (extended to the delivery of irrigation services) elsewhere.

The potential role of non-farm sectors to support a more sustainable irrigation: adopting a broader outlook

The emergence of farmers applying more sustainable intensification practices in irrigated systems, in a way that provides enhanced the socio-economic status and achieves production objectives for staples of national food security policies within the available natural resources base, will likely be facilitated by rural populations having opportunities for employment outside agricultural production. This in turn requires that other sectors would need to have the capacity to absorb labor from the agricultural sector and that members of farming households would need the skills to enter productive employment in other sectors. East and Southeast Asia have followed, to a large extent, a Japanese model of investing in the education and skills of rural laborers so that they can find employment in other sectors. In these sub-regions, this will be further facilitated by demographics as population growth is expected to peak during the 2040s, and even earlier in China. The situation is rather different in South Asia, where population growth is expected to peak much later, during the 2080s, and where there have been jobless growth patterns and a lack of public investment in education. As a result, the only feasible path, at present, for most farming households to employ their excess labor resources throughout the year lies in increasing agricultural intensity through the depletion of available water resources. Structural transformation, combining higher agricultural productivity and a dynamic non-agricultural economy and providing sustainable pathways out of poverty takes place in a context where degrees of freedom for agricultural policies are limited by policies of other sectors, crucially energy and water. Exit from agriculture has indeed been part of standard patterns of development in the region and elsewhere (FAO, 2013).

The key challenge to more sustainable and intensified irrigated agriculture there will therefore lie in mediating the transition in a manner that ensures a balance between the exit rate from agriculture and the absorptive capacity of the rest of economy, in order to avoid large-scale disruptions in livelihoods. This will require very significant public investment in policies and incentives that: (1) facilitate the transition towards sustainable agricultural practices (2) assist farmers and farmers’ organizations in developing the necessary skills, knowledge and other resources to adopt more sustainable and productive agriculture practices; and (3) support deliberate exit strategies that will involve skill development and labour absorption in manufacturing and services. Strengthened social protection systems could also contribute to aiding farmers to overcome uncertainties and provide predictable basic income which may
facilitate the adoption of sustainable intensification technologies and/or support exit strategies (FAO, 2013).

More broadly, it has been suggested that the development discourse would benefit from shifting beyond the rural-urban dichotomy to focus more on how best to urbanize and develop the rural non-farm economy and secondary towns. Evidence suggests that rural diversification and secondary town development lead to more inclusive growth patterns than metropolitization (Christiaensen, 2013) because more poor people find their way to the rural nonfarm economy in secondary towns where job opportunities are mostly non-skilled or low-skilled. These opportunities are also often more accessible (e.g. through commuting or by switching occupations locally) than those in distant cities. The World Bank’s 2009 World Development Report “Reshaping Economic Geography” (World Bank, 2009) has also called for the spatially blind provision of social services and infrastructure so that migration is only motivated by economic opportunities and not by the search for better amenities.

National and local contexts are very diverse however. The adoption of territorial approaches to sustainable natural resources management provide promising avenues for governments and local stakeholders to elaborate adapted, more comprehensive and multi sectoral strategies that address the combined challenges of rural prosperity and sustainability of ecosystems, including through the adoption of more sustainable irrigated agricultural practices, and through strengthening rural-urban linkages, where local water allocation among productive sectors, water supply and ecosystems can be framed to optimize economic, social and environmental benefits.

Managing transitions and modernization

The purpose of reconfiguring existing large-scale irrigation systems is to adopt irrigation design and operation concepts to changing objectives. These changing objectives relate to changing irrigation service needs of farmers and the needs of other water users, while fulfilling river basin objectives and improving economic and financial outcomes. This is the essence of the modernization of irrigation management which does not address only hardware changes needed to support operation strategies to support new management and service objectives, but also changes in management and institutional setup to promote service-oriented management on a sustainable basis (Facon and Mukherji, 2010). Obviously, a key factor in devising irrigation modernization strategies will be: what will the farmers look like and what their service requirements will be? Clarity on the anticipated or desired future size and nature of the future irrigation operational units and its evolution over time is required for the development of irrigation modernization strategies and many important details of design and operation.
Large-scale irrigation systems are, with very few exceptions, de facto or officially, providers of service to multiple uses (domestic use, hydropower, groundwater recharge, environment etc.). Understanding, optimizing and translating these uses into management objectives and operational strategies should be considered. The explicit management of these uses and recognition of farmers’ efforts can help to locate the most practical and economic options for improving service delivery and open up new opportunities to improve the financial viability of the systems by expanding the customer base in particular towards users who can afford to pay higher water service costs. An important principle of modernization of management is the unbundling of management into levels that provide irrigation delivery services to the next lower level. This simple idea clarifies the performance expected from each level of management, and the analysis of costs associated with each level’s operation. The type of operator for each level can vary from government to private to farmer-owned and managed. The Jiamakou Irrigation District in Shanxi Province illustrates a business model based on an unbundling of management into business units which trade water, information and money as a basis for on-demand irrigation ordering and delivery based on a pure service-oriented model (Facon, 2010). A practical consideration is where to locate the interface of final delivery from the canal system to an intermediate or farm reservoir. The type and scale of final irrigation distribution systems that farmers have organized to invest in or private operators have developed will provide a useful indication. This unbundling can support the development of clear strategies for the financing of management, operation and maintenance and upgrading, with clear interfaces for service and financial transactions. Farmers below the final delivery point may opt for various solutions for final delivery and locate investments in service improvement there while the upper levels focus on more stable bulk water supply may provide conditions for a more dynamic evolution of the systems (Facon and Mukherji, 2010).

The first step in this direction may be to push the need for flexibility and capability for adjustment as downstream as possible. This allows longer (life) time horizons for investments in the large bulk water systems and a minimum need for physical adjustment in the evolving service systems. In Indonesia, for example, the separation of bulk water supply and irrigation distribution and delivery is being discussed. This would mean that WUAs can enter into bulk water delivery service contracts with the private or public bulk water manager. These WUAs then can develop the necessary facilities to enable collective or individual flexibility enhancing measures (e.g. through local or on-farm storage or by developing access to groundwater). Bringing service delivery in line with water allocation, cost recovery or water charging policies is also an important consideration for modernization. The vast majority of irrigation systems are simply not capable of delivering water on a volumetric basis at any level of delivery in the system. Bringing water control and service delivery to a level where a service specification can
be confidently specified, contracted, delivered and evaluated will frequently require significant changes in operation strategies (Facon, 2010).

A participatory design of institutions and distribution systems based on present and future service requirements can be a valuable input into the institutional development, lower level investment, and irrigation management operators’ management plans. Uncertainty related to how transitions will unfold (in relation to farming unit size for example) has implications on financing and future investment at the final distribution level. However, in terms of modernization approaches, integrating strategic planning at lower levels with the farmers and their organizations on the future of the system in modernization processes will be a great progress over a lot of present thinking where farmer inputs are only about “priority” repairs or improvements without a plan.

4. Conclusion

Economic forces of change and emerging environmental contexts, including the impacts of climate change at both global and local levels, will shape and reshape rural livelihood strategies in the future. Asia is in transition, and the landscape of human activities is getting more complex. The dynamics of rural change will determine the pattern of agricultural growth, livelihood strategies and poverty contexts and the most appropriate type and nature of irrigation. The dynamics of this transition need to be understood and capitalized on to design successful water management programs that support poverty reduction, agricultural growth and environmental management in an integrated manner. The pace of the transitions is such that present decisions must anticipate that these transitions will occur within time spans that are similar to the deployment and duration of reform and investment. The problem of aligning the future trajectories of the irrigation systems in an increasingly variable climate and market to economic trajectories, river basin trajectories and producers/households’ trajectories will require a renewal of approaches and strategies. However, many irrigation agencies have not adapted to this new environment and these new challenges. There is a widening gap between official irrigation discourse and on-the-ground reality.

Economic development and a changed global context will change the nature of national food security strategies. Although it is likely that the production of staples will remain a key tenet, countries in the region need to develop comprehensive risk management strategies for national food security under water constraints that address/combine risks/options related to production variability, risks/options related to procurement and price fluctuations from the international markets, options related to storage of grain/other food items, water, fiscal/financial assets, risks/options related to social risks (social safety nets for vulnerable populations). This will
provide a clarification of the future mission of the irrigation sector. Beyond the national level, regional or sub-regional food security strategies may also influence the strategic role or need of irrigation at the national level (e.g. regional strategic stocks for grains, and enhanced trade). Regional and sub-regional economic integration processes both provide opportunities and constraints to the development of national risk management strategies. A multi sectoral approach to policy, strategy and investment decisions related to agricultural water management and water and food security have now become necessary and decision making has to be taken in the broader context of economic, food and water security. Decisions on key policy options and critical details will require clarity on major socio-economic orientations and societal preferences related to the structural transformation of the agricultural sector within the overall transformation of the national economies and the transition to green development patterns. In order to achieve a coherent, effective and feasible set of policies, strategies and interventions, explicitly addressing the following policy dilemmas, trade-offs and difficulties will be critical:

- Managing transitions: supporting resilience or a combination of improvements and exit strategies
- Managing the informality of the water economies
- Economic water productivity versus equity and other strategic goals
- Resource use efficiency versus resilience and redundancy
- Possibly diverging national, river basin and local objectives
- Political feasibility: “ideal” versus second-best options and
- Realistic financial arrangements for water operators vs. incentives for performance.

In the introduction, this paper promised that it would conclude on some considerations on the relevance of Asian experience to other regions. A first observation is that as Asia represents about seventy percent of the world’s irrigation, Asia’s trends and the future of irrigation in this region are a phenomenon of global impact. The drivers of change (with the exception of water scarcity which will vary across regions and will be more dominating in the Middle East and Northern Africa) and the agricultural restructuring process analyzed in the paper are global and are affecting all regions. In developed countries, of course, the process has matured over a period of over 150 years and the Asian transitions and transformation are taking place at an accelerated pace. Two key features of Asia irrigation is that the sector is mature and has reached a development plateau and, as far as public irrigation is concerned, has resisted change for a long time and now must change substantially, and quickly, losing control at the top in terms of policy priority and at the bottom in terms of transformations of rural livelihoods and evolution of...
farming. To a large extent, Asian Governments have maintained favorable terms of trade for agriculture, buffering the social impact of agricultural restructuring but maintaining the smallholder dominance of irrigated agriculture (its second key feature) and eroding relative incomes in agriculture. It now needs to adapt fast.

It is a fair assumption that the pace of change and the increasingly complex dimensions of rural development and national food security apply broadly across all regions to developing countries where smallholder farming dominates. The main conclusions and recommendations of this paper therefore seem to apply broadly beyond Asia. Countries with a significant irrigation sector developed by public agencies face the same questions and need to respond accordingly. Responses, as in Asia, will be determined by local conditions, broader development policies, societal preferences and natural resources assets. They need to plan ahead for a rapid transformation of agriculture within the lifetime of existing assets and within the duration of medium and longer term sectoral planning. Small-scale irrigation and atomistic irrigation likewise will face similar tensions and their development will need to be regulated for sustainability.

Countries with a nascent irrigation sector and that have ambitious irrigation development plans are starting in rather different conditions than Asia after the Second World War. First of all, water sector reform and the spreading of Integrated Water Resources Management should ensure that irrigation agencies do not acquire dominance over water resources and therefore avoid the river basin closure processes that result in wicked social and environmental situations. In other words, development of irrigation should be capped from the onset. Secondly, it is not likely that positive terms of trades and extensive financial support will be able to be sustained over time, even if it is needed, and provided, at the beginning. Decisions on investment and financing need to consider a socio-economic context that is highly dynamic and complex, a diverse and changing typology of farmers, irrigation systems and options, differing local circumstances, a diversity of investors, and needs to be more firmly anchored in major socio-economic development objectives and broader policies. This is very different from previous approaches linked to the progressive development of an “irrigation potential” based on a rigid model. FAO has developed a sectoral planning and management tool that fulfills these requirements, called a generic investment framework (Riddell et al., 2008). An essential component of this planning management tool is a solid monitoring and evaluation system. The tool links sectoral targets to overall socio-economic development targets. As the share of different types of farmers of the sector changes over the short, medium and long-term, so do the emphasis in terms of capital assets and the strategic importance in terms of actions to improve the enabling environment. And so do the implications in terms of indicative levels of public and private cost allocation for
capital investment and recurring costs between government capital (all sources, including river basin organizations), water users (beneficiaries) and the private sector. The development and management of these generic investment frameworks can be of great help in thinking about questions such as the strategic importance of investment in different types of irrigation systems (atomistic, small scale, large-scale) over time, developing realistic evolution scenarios for different types of irrigation systems over time in response to changes in the structure of the sector and future policy instruments and regulation of the sector, preparing for realistic financial planning over time, and identifying and pipelining adequate measures to improve the enabling environment and institutions that will reflect the objectives and nature of the different actors.

• References


• Khanal, P. R., Santini, G., Merrey, D. J., forthcoming. Water and the rural poor - interventions for improving livelihoods in Asia. FAO-RAP, 2014


• Schmidhuber, J., Bruinsma, J. and Boedeker, G., 2009. Capital Requirements for Agriculture In Developing Countries To 2050. Presented at the Expert Meeting on How to Feed the World in 2050. Food and Agriculture Organization, Rome


1. Introduction

The history of Thai rural development has been explicitly cited since the 1960s when the first National Economic and Social Development Plan was announced by the National Economic Development Board, Office of the Prime Minister. The milestone of each plan will be summarized in Table 1.

Table 1. Milestone of the National Economic and Social Development Plan

<table>
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<tr>
<th>Plan</th>
<th>Milestone</th>
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<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Plan (1961~1966)</td>
<td>- Investment in basic infrastructure systems, including huge irrigation project, road, electricity and etc.</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Plan (1967~1971)</td>
<td>- Decentralization of social services to regional and local areas in order to improve the living standard of rural people.</td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Plan (1972~1976)</td>
<td>- Reduce income inequality and wealth gap between urban and rural people - Reduce interregional economic disparity - Agricultural land reform</td>
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<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Plan (1977~1981)</td>
<td>- Promote income distribution - Creation of new regional economic area (i.e. Chiang Mai, Songkla)</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Plan (1982~1986)</td>
<td>- Improvement of agricultural productivity and diversification - Poverty alleviation plan by shifting from extensive to intensive agriculture - Speed up the distribution of land ownership (land reform and land title provisions)</td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt; Plan (1987~1991)</td>
<td>- Improvement of the efficiency of development - Establishment of appropriate land ownership types - Job creation, aiming to rural poor</td>
</tr>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt; Plan (1992~1996)</td>
<td>- Balanced development, concerning national economic growth, living conditions and regional growth)</td>
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<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; Plan (1997~2001)</td>
<td>- People-centric development - Development of regional economy</td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt; Plan (2001~2006)</td>
<td>- Philosophy of Sufficiency Economy - Poverty alleviation plan - Welfare</td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt; Plan (2007~2011)</td>
<td>- Participatory approach - Agricultural area preservation - Environmental conservation - Sustainable development</td>
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From the First Thai National Development Plan to the Tenth, the development paradigm has evolved in the context of both global and domestic changes. A significant shift in the country’s development planning has taken place since the 8th Plan (1997-2001), a shift from a growth-oriented approach to the new model of holistic “people-centered development.” In order to ensure more balanced development, priority was given to broad-based participation that would actively engage civil society, the private sector and academia in formulating the national development plan. However, economic mismanagement, which led to the 1997 Asian Crisis, prompted the adoption of the Philosophy of Sufficiency Economy as the guiding principle in the 9th Plan (2002-2006), while its practical applications became evident during the 10th Plan (2006-2011). In order to achieve sustainable development with a people-centered approach, it is necessary to enhance the country’s self-resilience by strengthening its economic and social capital and improving risk management in order to effectively handle internal and external uncertainties. This will lead the country towards sustainable development.

For the past 30 years, the total population of the country has increased from 46 million (1979) to 65 million (2012). However, the number of rural people has gradually decreased from 34 million (1979) to 30 million (2012). This could be the side effects of urbanization and economic growth. Results of past development prevail in a decrease of total fertility rate, increase in the number of aging people, increase in rural-to-urban migration and increase in income inequality between regions. The National Economic and Social Development Board (NESDB, 2012b) concluded that Thailand will encounter several critical challenges which are:

- Globalization
- Regional integration (i.e. AEC)
- Chindia hub
- Ageing world
- Climate change
- Security of food and energy
- Technology advancement

The Rural poor particularly the youths, elders and women are highly vulnerable to natural disasters and hazards. It is, thus the role of the government to address appropriate policies and public schemes so that rural poor can have greater choices and security in livelihood. As a
government agency responsible for water resource allocation mainly for agriculture, the Royal Irrigation Department refers to the process of comprehensive agricultural development in order to achieve:

- Sustainable growth in agricultural sector
- Improvement in income and living conditions for the rural poor
- Economic development through strengthening agricultural productivity, currently, the RID main role is not only the provision of sufficient water for all sectors, but also water management for natural disaster mitigation. An example of Mae Yom Operation and Maintenance Project will be illustrated in this paper to highlight some aspects of a water-based rural development project to deal with natural draught.

2. Mae Yom Operation and Maintenance Project

The catchment area of Yom River Basin is 5,500 km$^2$ covering 10 provinces or 4.6% of the country area. Yom River, 459 miles long, serves as the main river of the basin. The Yom River Basin accommodates 1,939,975 people, of which 683,347 people belong to an agricultural sector. The Gross Provincial Product (GPP) of an agricultural sector of the Yom River Basin achieves US$985.66 million (RID, 2013). A part of the Yom River, 175 miles long, flows through Phrae Province and supplies surface water of 778.8 million cm$^3$ annually. So far, Phrae Province, where the Yom River Basin is located, has not had a reservoir to serve as a water supply.

In 1947, the Royal Irrigation Department (RID) constructed a concrete weir, 350 m long, in the Yom River and the Mae Yom Operation and Maintenance Office was established to manage water from the weir. The weir supplies water for the irrigation area of 88,538 acres in a rainy season and 6,917 acres in a dry season. The water supply covers 6 districts and 158 villages. During a rainy season (May - November), the average maximum flow of the Yom River is 1,042 m$^3$/sec or daily runoff of 90 million m$^3$ while the average maximum flow in a dry season (November - April) is 3 m$^3$/sec or daily runoff of 0.3 million m$^3$. Water in the Yom River Basin had wildly fluctuated between flash flood in a rainy season and drought in a dry season. Therefore, local people were affected by the non-secure water supply which led to repeated damage and poverty.

Before implementing the initiative, the water could supply only 6,917 acres in a dry season (Figure 1). However, the needs of the dry-season farming had escalated to 36,364 acres, which caused the following difficulties:
Figure 1. Water supply and water demand in dry season

- Water shortages for the second crop season
- Farmers freely broke an irrigation structure in order to let water flow into one’s own plot
- Water fights emerged among water users, starting from head-end water users through tail-end water users
- The relationships between farmers and public irrigation staff were tense due to frequent farmers’ protests
- There were no integrated drought relief measures from government officials. Farmers then helped themselves by blocking a water body to raise water level into their own plots
- Income from farming was not enough to raise a family, thus provoking the rural poor
- Farming was often damaged by drought
- There was a seasonal migration of farmers to gain income in a dry season. The family relationship was unhealthy because family members lived apart, thus leading to social problems

3. The initiative pattern

The initiative was introduced in 2005. It was intentionally integrated knowledge from different field practices. The past lessons learned, mistakes, suggestions and local wisdom were modified with farmers’ involvement in setting an agreement on water taking, water management, and monitoring. The database on meteorology, hydrology, agriculture and water delivery was applied with GIS to study factors that affected the dry season farming. Further, the integrated functions of relevant government sectors i.e. the three-coherent task mechanisms, promoted the optimal drought prevention and mitigation.
The three-coherent task mechanisms were the collaboration between government offices and all stakeholders in the irrigation areas of the Mae Yom Operation and Maintenance Office. The mechanisms were driven by the provincial Disaster Relief Committee. Also, information from the initiative was brought to the Committee to designate roles and responsibilities of relevant parties (Figure 2).

The initiative encouraged participation from every stakeholder including related public agencies. Two principal strategies, that is, knowledge management and data dissemination and three-coherent task mechanisms, were applied to implement the initiative. The Mae Yom Operation and Maintenance Office acknowledged the importance of research and development and knowledge management. The Office has conducted several researches in accordance with GIS and drought prevention. Meaningful participation among relevant parties was based on comprehensive and updated information in order to make a right decision. The Mae Yom Operation and Maintenance Office, acting as a core public agency regarding irrigated water, disseminated the comprehensive water information, geographical database, and agreed on rules on water-taking via the following techniques. An engineering staff of the Office broadcast a radio program once a week at the National Broadcasting of Thailand / Phrae Province. Local radio stations and village loudspeakers were also effective to distribute the information to the main target group like farmers. Posters and board exhibition were conventional to provide information. Farmers meetings served as active forums to exchange problems and concerns between relevant parties.

4. The benefits of the initiative

- The initiative led to ease water conflicts in Thai society
- The increase in farmers’ income, which then became an incentive to maintain agricultural careers of Farmers as well as conserving the irrigation areas of the country
• The initiative facilitated more dry-season agricultural areas, thus enhancing food and energy security of the nation
• The dry-season agricultural products contributed to the national agricultural export, which served as one of the main components of the GDP

**References**


1. Introduction

The most important use of agricultural water is surely for food production. Food productivity depends on successful irrigation by distributed paddy cultivation particularly in the Asian region, which has a very high-water demand. It is safe to say that the development of agricultural water use itself is nearly equivalent to the development of rural areas when the volume of food production dominates the population.

But agricultural water does not only produce food; it also creates multifaceted and publicly beneficial intangible advantages such as conservation of biodiversity, the formation of scenic landscapes and replenishing of groundwater.

In order to comprehensively and appropriately operate and maintain infrastructures for agricultural water, a kind of specially purposed rural community is indispensable. Rural communities were in practice in Japan for a long time as Water Users’ Associations. Though it is not likely they had been aware of the multi-functionality, the Water Users’ Associations achieved effective water use through developing their own rules on water distribution etc., to be subsequently transformed into modernistic organizations.

One of the key factors of the transformation was the development of legal systems explained in Chapter 2-3. The “Land Improvement Act”, which was enacted during the mid-twentieth century, positioned its first principle in farmers’ voluntary water management known as Participatory Irrigation Management (PIM). It worked very well when Japan needed a rapid and urgent food production increase. In addition to the PIM, the Act strongly boosted new farmland reclamation and rural development nationwide.

Chapter 3-2 introduces a unique legal framework, “The payment for activities to enhance multi-functionality”, with a view to maintain terminal irrigation infrastructures. While the Water Users’ Associations, namely, Land Improvement Districts, played social roles in strengthening rural communities’ bonds and in fostering rural cultures, prosperous social customs have been conserved by proper maintenance of irrigation infrastructures. However,
Japanese rural societies have been weakened due to high economic growth and industrialization and this has consequently brought about difficulties in infrastructure maintenance. This is the background of the introduction of the new payment system. The unique payment system does not target the main and large irrigation structures because the national government, prefectures and municipalities can take measures such as subsidies and technical guidance through legally established Land Improvement Districts. The payment system aims to maintain terminal and small structures by involving non-farming local residents other than beneficiary farmers.

Chapter 4 introduces governmental actions to promote small-scale hydropower generation in Japan. It goes without saying that climate change is one of the largest external influences, thus these days, joint efforts between the agricultural sector and other sectors are internationally emphasized sloganizing the “Water-Food-Energy Nexus”. Under the current situation, small-scale hydropower generation is one of the effective uses of agricultural water. Once such system is installed properly, it becomes not only a reliable countermeasure against carbon dioxide emissions but also reduces operation and maintenance costs due to the selling of electric power. But installing a generator in/on irrigation infrastructure is not easy for farmers and Land Improvement Districts especially from technical and legal viewpoints, so governmental technical guidance, feasibility studies and developments or improvements of legal systems are key factors.

Chapter 5 analyzes common and different factors between Japan and other countries to find if it is possible to transfer successful experiences in Japan to other countries.

2. History in Japan

2.1. Rural development toward food production increase

From two thousand years ago when paddy cultivation reportedly began in Japan, irrigation skills to draw agricultural water from rivers evolved in accordance with the nationwide expansion of paddy fields.

Until the middle ages in Japan, roughly from the 13th to 16th century, the water sources of irrigation for paddy fields were rainfall, springs, small rivers and irrigation facilities that did not require large-scale construction work. From then on, irrigation technology advanced, enabling people to take irrigation water from larger rivers step by step. From the 17th to 18th century, development of new farmlands and construction of irrigation infrastructures were positively promoted resulting in high growth of farmland areas and population in Japan. The vast
amount of irrigation infrastructure in Japan, illustrated by irrigation canals of 400,000 km, dates back to historical development over a long period.

The way of managing the agricultural water infrastructure in Japan advanced in the direction of farmers’ self-management by organizing Water Users’ Associations to maintain social harmony after continual irrigation disputes among rural communities. A water management system like this is called Participatory Irrigation Management (PIM). Through the process of consensus formulation and discussion, strong bonds in communities and rural cultures were fostered. Later on, the Water Users’ Association became the base of modern water management organization called Land Improvement Districts (LID).

2.2. The beginning of modern national projects (Meiji era)

In the context of modernization and Westernization, the most drastic change in Japanese history was the political reform in the 18th century called the Meiji Restoration. The opening of Japan to the outside world after 300 years of isolation greatly impacted the bureaucracy, the judiciary, industry, culture and many other aspects of life. In parallel, the old class distinctions (samurai, farmers, artisans and tradesmen, in descending order of rank) were abolished.

Thus, numerous former samurai living privileged lives fell into poverty and had to find new livelihoods. Combined with the political intent of the day to encourage modernizing industry, the first modern national agriculture development project was implemented in 1879 to construct irrigation canals and so forth, namely Asaka-sosui, and the former samurai became the settlers.

The legal system was also modernized. Although the main objective of the Farmland Consolidation Act promulgated in 1899 was compulsory participation in the consolidation project, the construction of irrigation facilities was added in the amended Act’s main objectives.
in 1909. A national government subsidy system started in 1923 to positively promote prefectural projects.

Through further social changes and impacts for nearly three decades after that, it was time to establish a new law system.

2.3. Enactment of the Land Improvement Act

The Land Improvement Act came into effect in 1949 enabling farmers to establish legally powered Water Users’ Associations, called “Land Improvement Districts (LID)”, taking into consideration existing communities and cultural backgrounds. Thanks to the legal framework stipulated in the Act, further advanced rural development projects began to meet the extremely high demand for increasing food production of the day. The main characteristics of the Land Improvement Act, in other words, PIM in contemporary Japan, are described as follows:

a) Not the landowner but the cultivator shall participate in the Land Improvement Project as the beneficiary.

b) The prior conditions for starting the Land Improvement Project are farmers’ application and agreement.

c) Construction and management work can be implemented with more than a certain amount of agreement, usually two-thirds. The beneficiaries opposed to the project shall be involved in the project and shall shoulder the related costs regardless of their will.

These characteristics are rather unique compared to other countries. By (1) and (2), neither government(s) nor landowners can proceed with the project with top-down decision-making, and only the actual cultivators can commence with a bottom-up approach. Of course the beneficiary farmers are not proficient in civil engineering and legislation, therefore, once the project is approved, the government supports them establishing the plan and constructing facilities. National, prefectural and municipal governments also take part in bearing the cost of public works expenditures.

The characteristics in (3) explain an extremely strong compelling force. Although it depends on the category of the project, usually, the agreement of two-thirds or more of stakeholders forces their opponents to join the LID and impose a cost burden. In collecting the dues, directors of LIDs are given very strong executive power, which is equivalent to national tax collection. Nonetheless, it is likely to be difficult to implement and maintain the project if one in three
people are against it, so in reality, a Land Improvement Project is usually applied with a much higher rate of agreement than the regulation requires.

These approaches were effectively functional for a long time in developing rural areas. But due to the changes in social conditions in Japan, the need for additional frameworks arises.

3. Domestic Changes in Social Conditions and Countermeasures in Japan

3.1. Changes in domestic social conditions

Japan experienced high economic growth in the latter half of the 20th century. On the other hand, rapid urbanization has brought about unwelcomed changes in rural areas. For instance, the number of farmers keeps decreasing and the share of non-farmers in rural areas is increasing.

The influences on irrigation infrastructure by negative social changes should be analyzed dividing the facilities into main and terminal by their sizes.

The main facilities are operated and managed by LIDs. Social change weakens the financial situation of LIDs, increasing the burden on farmers. However, in such circumstances, the national government can take appropriate countermeasures such as:

a) Regular rehabilitation work utilizing a National Federation of Land Improvement Association fund

b) Technical training for operation and management by the National Federation of Land Improvement Association

c) Advice and instruction for enhancing the capacity of disaster prevention by municipal governments
Regarding the terminal facilities, they are not managed by LIDs but by rural communities, which means they depend only on farmers’ voluntary labor power.

Due to present day social changes, the maintenance work of terminal facilities has become too much for farmers, whose numbers are decreasing. Without appropriate maintenance of the terminal facilities, the multi-functionalities of agricultural water and farmlands cannot be fulfilled, such as national land conservation, groundwater retention, natural environment conservation and scenic landscapes. Since the effects attributed to the multi-functionalities benefit citizens nationwide, it is not fair that only farmers are imposed with the burden and the cost of sustaining multi-functionalities. From this viewpoint, the Ministry of Agriculture, Forestry and Fisheries launched “The Payment for Activities to Enhance Multi-functionalities” in 2007.

3.2. Payment for activities to enhance multi-functionality

As mentioned in Chapter 3-1, the number of farmers keeps decreasing in proportion to the high economic growth in Japan and non-farmers are already the majority of residents in 72% of rural villages. Against the weakened operation and management system in terminal irrigation facilities caused by the decrease of farmers, the Ministry of Agriculture, Forestry and Fisheries decided to focus on reinforcing the incentives for non-farmers to join operation and management tasks.

It is probably true that the non-farmers are not so interested in irrigation/drainage performances of canals near their houses because it is not directly related to their livelihoods. But
the canals can be considered as local common property with multi-functionality, such as conservation of biodiversity and formation of scenic landscapes. When developing the legal framework, therefore, it is important to give the entire community the incentive to join activities with the understanding that agricultural water is benefitting local society itself including non-farmers. Three principles of the system are illustrated as follows:

a) Self-motivation: participants must be voluntary in formulating their Activity Organization centering upon their village.

b) Self-decision: participants must decide the content of the activities by themselves to secure sustainable implementation.

c) Cooperation: Activity Organizations must cooperate with the national, prefectural and municipal governments.

The concrete flow of the activities is as follows:

a) Activity Organizations based on local communities, etc., are set up.

b) The Activity Organizations prepare their plans for the activities they want to perform in accordance with the guidelines and based on the results of discussions.

c) The Activity Organizations conclude agreements with municipalities.

d) The Activity Organizations receive payments and perform their activities in accordance with the plans.

e) The Activity Organizations keep records to submit reports to municipalities.

The original program began in 2007 and evolved into the current program in 2014. After the Act for Promoting Performance of Multiple Functions of Agriculture was enacted on April 1, 2015, the government operates the program based on the law. In 2015, the government allocated a considerably large budget for the program, the equivalent of approximately US$483 million. Furthermore, the actually granted amount to the Activity Organizations is more than double the national budget because the national government covers less than 50% of the total grant with the remainder incurred by municipalities. See table 1 for the unit prices of the grant.

The implementation of the activities is satisfactory. In 2015, 28,157 Activity Organizations participated in the program, covering 2.2 million hectares, which accounted for 52% of the total target farmland area of 4.2 million hectares in 2016.
Table 1. Example of the unit prices of the grant for each activity  
(For paddy fields in all prefectures except Hokkaido)

<table>
<thead>
<tr>
<th>Activities for farmland conservation such as canal cleaning, surface maintenance of farm roads and so forth</th>
<th>30,000JPY/hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities for enhancing quality of rural resources</td>
<td>24,000JPY/ hectare</td>
</tr>
<tr>
<td>Activities to extend lifespan of infrastructure</td>
<td>44,000JPY/ hectare</td>
</tr>
</tbody>
</table>

To confirm the effect of the program, a detailed survey by questionnaire was implemented by the national government. The respondents were 1,000 Activity Organizations randomly selected, taking into account the share of the target area, the categorical ratio of activities and activity durations. The parent population was 24,557 organizations excluding those engaged only in the activities to extend the lifespan of infrastructure.

According to the questionnaire, the activities are effective to enhance/maintain the local environment. For instance, 85% of the respondents answered that the activities have a considerable effect on creating scenic landscapes, removing weeds and preventing illegal dumping.
They also have a good effect on maintaining agricultural facilities including canals, farm roads and reservoirs, since 85% of the respondents also answered that the activities alleviate aging of these facilities.

In addition to visible effects, local residents get satisfaction through taking part in the activities. For instance, a villager, who had been working in urban areas from his youth until mandatory retirement, came back to his hometown and joined an activity organization. He said that he felt satisfied to be able to contribute to land conservation for the first time in his life. Better communication among locals was also counted in the effect that resulted in further rural development such as incorporation of agricultural firms.

4. Another Contribution of Agricultural Water as an Energy Source
4.1. Background
In the discussion about the contribution of agricultural water, the most influential global change, climate change which requires reduction of carbon dioxide emissions worldwide, should be emphasized because one of the best examples of the contribution is small-scale hydropower generation utilizing agricultural water. The advantage of the promotion of hydropower generation is to be able to meet two demands at the same time: reduction of carbon dioxide emissions and the reduction of operation and maintenance costs.

The history of hydropower generation dates back to around 1890, for example, the Sankyozawa power plant in Sendai city and the Keage power plant in Kyoto city, and hydropower generation was promoted nationwide after the promulgation of the Electricity Business Act in 1911. After 1952, the Act of Promoting Rural Power Station Construction promoted electrification in rural areas with no or insufficient electricity and 60 power plants are still in operation out of 300 that operated at the peak. In rural development projects after 1983, small-scale hydropower generation plants began to be installed utilizing irrigation facilities, and 69 power plants in the irrigation facilities were in use as of May 2016.

As stated above, Japan has developed hydropower generation for a long time. These days, renewable power generation gains special attention owing to the worldwide demand to limit carbon dioxide emissions and by the nuclear accident triggered by the Great East Japan Earthquake. In addition, OECD recommends a political framework that enables rural development taking into consideration renewable energy, while broadly dispersed power generation is also required in the event of regional disasters. In this context, the Japanese government promoted further small-scale hydropower generation by introducing some legal system improvements.

4.2. Governmental promotion of small-scale hydropower generation

The Japanese government has promoted small-scale hydropower generation with three approaches. The first is the Feed-in Tariff. Aiming at the focused expansion of renewable energy, the unit purchase price is decided with special consideration of the profit of the renewable power provider. An example shows the unit price is the equivalent of USD 0.34 per kWh, while the initial construction cost is the equivalent of USD 10 thousand per kWh and the maintenance cost is the equivalent of USD 750 per kWh. This price standard can be a high motivator for renewable energy expansion since it reaches the breakeven point in 7.5 years with 70% generation efficiency. The second is deregulation regarding related acts and procedures. As well as cutting or simplifying the procedures stipulated in the Electric Business Act and the River Act, the extent of the uses of generated power and of sales proceeds was expanded into operation and
management costs of the LID whereas it had been limited to direct use for operation cost of power plants and canals utilized for power generation. The third is the various supports by the Ministry of Agriculture, Forestry and Fisheries for studying, planning, designing and constructing small-scale hydropower generation. Concretely speaking, the feasibility study of small-scale hydropower, outline design and support service for making necessary documents of related Acts are illustrated. The current Long-Term Land Improvement Plan by the Ministry of Agriculture, Forestry and Fisheries (2011-2016) stipulates feasibility studies in 1,000 areas as its goal, and they are already completed. In the next Long-Term Plan (2017-2022), the proportion of renewable energy for all power consumption by irrigation facilities will be increased to more than 30% from approximately 18% at present.

Given as a case study, Shimanose dam in Wakayama Prefecture invested the equivalent of USD 1.4 million in a water turbine generator and related construction from 2010 to 2012. With an effective maximum height of 28.2 meters and maximum water use of 0.68 cubic meters per second, 780 thousand kWh of renewable energy was generated in 2013. It corresponds to the electricity consumption of 185 households and to carbon dioxide reduction of 429 tons. The 780 thousand kWh were sold for the equivalent of USD 260 thousand to offset the depleted operation and maintenance funds in the concerned LID and helped beneficiary farmers in need who were suffering from stagnant farm product prices.

5. Applicability to other Countries and Conclusion

Although the approaches of LID, the payment for activities to enhance multi-functionalities and promotion of small-scale hydropower generation worked effectively in Japan, their success
is debatable when applying the experiences to other countries, in particular, to Southeast Asian countries.

For the PIM approach, research shows that farmers’ groups in many countries do not adopt the PIM approach actively even though the effectiveness of PIM is adequately recognized and the establishment of the group is institutionalized. Therefore, the priority of promoting PIM should be high. Though the LID system can be a useful example in such case, there will be some hardships in applying the LID system because it is a legal framework and consideration is required according to cultural differences and so forth. But farmers’ participation in every stage of agricultural infrastructure development from proposal to maintenance is a natural and democratic approach.

As for the payment for activities to enhance multi-functionalities, the applicability greatly depends on the dynamics of the population in rural areas. Statistics show the rural population and the number of farmers in many Southeast Asian countries are increasing even though the rural growth rates are lower than the urban area or the whole country. Hence, the very problem Japan is going through regarding the capacity for operation and maintenance in terminal irrigation facilities may not be a problem that Asian countries currently confront. However, such problem is likely to occur in the future.

While Southeast Asian countries have recently enjoyed exponential economic growth and industrialization, the growth rate in the agriculture sector is relatively lower than GDP growth and the presence of agriculture in the state economy seems to be shrinking. Nevertheless, agricultural water must not be undervalued. Other than food production, agricultural water possesses various values without being economically quantified. When discussing the contributions of agricultural water, most countries may be making evaluations only with the food production quantity and quality of its output, though comprehensive and important indicators including multi-functionalities can be taken into consideration in addition to the economic approach of food production. For future social changes, which is probably a reduction of the number of farmers and an undervaluing of agriculture compared with other industrial sectors, the mentioned legal system with a wide viewpoint is a possible and reliable tool to operate and maintain agricultural water appropriately as before. Agricultural water also has a large potential to contribute to the energy sector and environmental conservation illustrated by the promotion of small-scale hydropower generation.

To perform all the useful aspects of agricultural water and to fairly evaluate the performance would be the most important points in considering the development of each nation.
• References

• Kanehiko Shindo, 2012, Examples of Restructuring of Participation-Type Water Management to Cope with the Changes in the Social Structure in Japan in Recent Years

• Forestry and Fisheries in Japan, 2016, Report of Independent Committee on the Grant System for Multiple Functions, Ministry of Agriculture

• Forestry and Fisheries in Japan, 2013, Irrigation and drainage, Report by Rural development Sectional Committee of Food, Agriculture and Rural Policy Council, Ministry of Agriculture

• G.M. Henegerada, Recent labor market trends in the food crop sector in Sri Lanka

• Norinchukin Research Institute Co., Ltd., 2014, Growth in Southeast Asia from the viewpoint of agriculture sector and related agricultural industry in each country

• Shozo Sakata, Institute of Developing Economies, 2012, Labor and employment in Vietnamese rural areas - Structural change in the labor market and statistics

• The Japanese Institute of Irrigation and Drainage, 2016, Report of supportive study for Japanese National Committee of Irrigation and Drainage

• The website of Agency for Natural Resources and Energy, Feed-in Tariff,

• Masao Matsumoto, Hiroyuki Shirakawa, Akihiro Onodera, 2013, Introduction of Small-Scale Hydropower in Agricultural and Rural Development Projects

• National Federation of Land Improvement Association, Collection of dues and compulsory process.
1. Introduction

1.1. General background

Indonesia is one of the largest archipelagic countries in the world, comprises of about 17,508 islands and isles, of which about 6,000 are inhabited. The archipelago stretches along the equatorial line between 6°8' North Latitude and 11°65' South Latitude and between 94°45' and 141°65' East Longitude, giving a total area of 5,193,150 km$^2$ of which 3,166,163 km$^2$ is sea territory. The country consists of five main islands, namely Sumatra (473,508 km$^2$), Java (132,187 km$^2$), Kalimantan (539,460 km$^2$), Sulawesi (189,216 km$^2$), and Papua (421,981 km$^2$). As equatorial areas, Indonesia has tropical monsoon-type of climate that gives dry season from April to September and the rainy season from October to March. The annual rainfall within the range of 1,800 to 3,200 mm giving the potential of water resources at about 3,221 billion m$^3$/year of which about 692 billion m$^3$/year is a steady flow. However, only 156 billion m$^3$/year or 22.5 percent being utilized, of which 127 billion m$^3$/year or around 81.5 percent is utilized for agricultural irrigation (Indonesian Agenda 21).

In terms of population, Indonesia is the fourth most populous country in the world. According to the national census of 2010, the population of Indonesia was 237 million and it was estimated to reach 255.4 million in 2015. Besides a huge number of population, almost 60 percent of the population lives in Java Island, this is only 7 percent of the total land area of the country. This condition gives stress not only in terms of food supply for the entire population but also population distribution, and in addition poverty especially in rural areas. The government of Indonesia is struggling to reach food security and poverty alleviation through the up and down economic conditions.
1.2. Food security

Given the fact that Indonesia is the fourth most populous country in the world, the government of Indonesia is striving to provide staple food for the entire population. Since rice is a dominant staple food in Indonesia, which requires enough water at a certain time of its growing stages. Irrigation facilities have played a major role in rice production. More than 80 percent of national rice production is supported by the irrigation system. In 2010, rice production in Indonesia was announced at about 66.47 million tons of un-husked dry field paddy or approximately equal to 37.37 million tons of rice. In terms of rice consumption, a total of 33.07 million tons of rice is needed, which actually provide 4.3 million surplus of rice production. It was reported also by 2013 surplus of rice production was 6.8 million tons.

Measuring food security, however is not just food production but also food accessibility and food utilization. Rice consumption is about 114.8 kg/cap/year which is considered higher than its standard consumption. However, policy to reduce rice consumption campaign at household level has shown a decline from 102.2 kg/cap/year in 2009 to become 90.2 kg/cap/year in 2012. Although statistically sufficient, but due to difficulty in distribution and rice stock safety purposes government of Indonesia still imports rice from various countries. Logistical Body State Corporation had imported rice about 680 thousand tons in 2010 and increased sharply up to 2.78 million tons in 2011, and then reduced to 844.16 thousand ton in 2014. These figures show that food security is still at the edge and requires strong policy support to achieve it. Besides food production, accessibility which depends on distribution and affordability are among factors that should be taken into consideration.
1.3. Poverty alleviation

As the fourth most populous country in the world, the government of Indonesia is struggling to alleviate the poverty of its population. From 252 million population figures in 2012, around 28 million still live under poverty line. Hence another 40 percent of the population remains vulnerable to decline since their income is just marginally above national poverty line set at $22.60 per person per month.

Another challenge to efforts in reducing poverty is the slower pace of job creation. Each year about 1.7 million youth enter the workforce. As a matter of fact, employment growth is now slower than population growth. While the poverty rate declined by 1% annually from 2007 to 2011, since 2012 poverty has declined by an average of only 0.3 percent per year. The current medium-term development plan, which is the third phase of the long-term plan, runs from 2015 to 2020, focusing, among others, on infrastructure development and social assistance programs related to education and health-care. Such shifts in public spending have been enabled by a reform of long-standing energy subsidies, allowing for more investments in programs that directly impact the poor and near-poor. Thus, a continued slump in demand for commodities, which was the fuel for Indonesia’s economic development in the past decade, has led to moderate GDP growth.

Agriculture development targets among others can support to alleviate poverty, especially in the rural area. Irrigation development and improvement of agricultural input can maintain farmers work in the agricultural sector and increase farm income.

2. Irrigation Development

Irrigation history in Indonesia has been significantly related with lowland paddies as the staple food of the people in ancient time. Unfortunately, there is no evidence when irrigation was initially practiced in Indonesia. But “modern” irrigation technique had not been developed until Colonial Era. The irrigation development, however, differs in terms of its policy and technology along the span of development. It can be noted several remarks of a major switch of its development namely Colonial Era before Second World War, Post Second World War Era or Old Order Era, New Order Era and Reformation Era.

2.1. Colonial era before Second World War

Irrigation development started during the early 19th Century. Due to the prolonged war in Europe it made financial crises worsen, the Colonial Government imposed compulsory
agricultural policy as called as “Cultuur Stelsel” or mandatory agricultural policy. The policy imposed farmers to cultivate 20 percent of agricultural land with commercial and cash crops such as sugar cane in lowlands area. To support the policy several irrigation systems had been developed mainly in Java Island, then later in Sumatra and Sulawesi islands. Farmers utilized remaining irrigation water for food crops. However, during that era, farmers were mostly poor and frequent incidents of hunger were recorded.

In terms of technical aspect, provisions of irrigation to support the policy were without any basic technical and agro-climatic data. Technical designs were based on subjective assumptions by means of trial and error. Several irrigation schemes failed to meet the objective previously been set up. The institution has been set up to deal with provision in providing public infrastructures including water resources and irrigation. By 1930 about 598,500 ha of irrigation systems had been developed. In addition, in 1937 first central water law had been enacted.

2.2. Post Second World War or old order era

At the beginning of The Old Order Era, due to severe economic and political uncertainties and availability of capable human resources no significant achievement was recorded. The government had set up irrigation development with special priority in the short-term objective, which was three-year development plan from 1951 to 1953. The Plan was never executed until the New Plan (Five Year Development Plan 1956-1960) had been launched. Political issues and struggling to unite the country made it even more difficult to develop as per the plan. During the period of 1945 and 1967, it showed nearly no growth in food production. In the year 1955 paddy production had been noted to be about 13 million tons from the cropping area of 5.52 million ha and increased to about 14 million tons in 1961 from the total area of 5.59 million ha. At that time Indonesia had severe lack of food stocks, and became the world largest importing country in the world. Several programs had been set up but did not meet the objectives in rising of food production. Irrigation development and rehabilitation were still in progress and therefore could not meet the immediate requirement. Agricultural extension programs through so-called “Five Efforts” (Panca Usaha) that includes (i) appropriate land preparation, (ii) better variety of seed, (iii) a balanced fertilizer (iv) appropriate pests and diseases control and (v) good irrigation system, was in the initial stage.

2.3. New Order era

New Order Era span from 1967 to 1998 started implementing a Five Yearly Development Plan. Massive new irrigation development, rehabilitation, and implementation of proper operation
maintenance, together with agricultural extension program and village cooperative unit took place. Bilateral and multilateral lending agency involved in providing development budget. By the end of Third Five Yearly Development Plan (1983) a total of about 800,000 ha of new irrigation had been developed, 1,680,000 ha irrigation system had been rehabilitated, 1,250,000 ha of the new swamp had been developed. The successful result of previous development was obvious where self-sufficiency in rice had been achieved in 1984. Although self-sufficiency in staple food had been achieved, due to population growth, that requires more food supply, also the development of industries and cities require land and water which therefore took agricultural land the achievement could not be sustainable. In 1987 government had to import rice again in order to safeguard the rice demand.

2.4. Reformation era

Following the 1997 economic crisis, New Order Government had declined and new government emerged. In 1998, Indonesia started to implement reformation policy in many aspects. Among others, decentralization and public participation are policies that had been applied. In the field of irrigation, rehabilitation, new development and proper operation and maintenance irrigation system are activities that still need attention. A total of 7.2 million ha irrigated land is divided into three governmental level, central, provincial and district authority. The existing irrigated area can only give a ratio between irrigated land and a total population of 1:31 or it can be said 1ha irrigated land should serve 31 people, which is quite small compared it to China 1:23 or India 1:16. The ratio gives a sign that rice production in Indonesia is not secure since it only relies on limited irrigation land area. The ratio in fact will become smaller, since the number of population is increasing, whereas irrigation land is decreasing due to land conversion.

3. Challenge in the Millennium Era

3.1. Population

The population of Indonesia was about 147 million in 1980 and increased rapidly to about 238 million in 2010. The approximate population growth was 1.49 per annum. The population of Indonesia in 2015 was about 255.4 million and will become 305 million in 2035. Indonesia’s population is ranked 4th in the world and if Indonesia’s population growth rate remains the same it will surpass the present population of the United State of America. In terms of food requirement, approximately a total of 42.17 million tons of rice has to be provided to feed the population in 2035. With the current trend of rice production it will give tremendous pressure to
fulfil required food to feed the entire population. In addition, a more urban type of population with urban sprawling in cities, require support for food from the existing agricultural land.

3.2. Agricultural land conversion

The trend of urbanization leads to a more land for housing, city services and industries needed. Agricultural land conversion cannot be avoided. It is predicted about 40,000 - 80,000 ha of agricultural land and most of them are irrigated sawah land have been converted to non-agricultural purposes annually. The trend is still continuing despite the fact that government has enacted law no 41/2009 concerning Sustainable Agricultural Land Protection. It is the challenges of authorities to protect agricultural land seriously. For an example from 2.8 million sawah land in Java only 49 percent has been protected by local government regulation on their spatial planning.

3.3. Watershed degradation

Rice cultivation rely on the availability of water and it requires 1,400 liters of water to produce 1 kg of rice or about 6,000-8,000 m³/rice crop/ha. The amount is huge compared to water requirement of other crops. Although average annual rainfall in Indonesia is high at a range of 1500-3000 mm/year due to monsoonal climate, 80 percent of rain come during rainy season for about 4-6 months only. The rest is considered dry season with less rain.

The river is the main source of water for irrigation. Currently most river water flow fluctuates daily and seasonally. Ratio maximum discharge and minimum discharge increase sharply. That is a sign of poor upper watershed of most rivers especially in Java Island. A number of the critical river basin also increased from 22 river-basins in 1994 to 108 river basin in 2009.

3.4. Climate Change

Climate change impacts in Indonesia has been reported in the IPCC4th assessment that there is an increase of rainfall in northern region and decline in the southern region. It has also been observed that there are changes in extreme events and severe climate anomalies including droughts. These will create severe flood risk with rising sea levels. Storage water capacity should be increased in order to provide enough water during dry season. Although, dam and other infrastructure’s safety should also be taken into consideration. Ability to predict weather condition in advance is necessary.
4. The Way Forward

4.1. Assessment

Bearing in mind that food security is one of government mission that has to be achieved, a reliable irrigation service is inevitable. Unfortunately, this is not the case. Irrigation infrastructure is in poor condition, water availability is scarce and often conflict with other purposes, and irrigation management is also far from sufficient.

According to recent studies found 6 challenges and identified issues within each challenges giving a total of 48 issues. The challenges include 1) ensuring irrigation management, 2) establishing role sharing in irrigation, 3) optimizing irrigation investments, 4) introducing efficient financing, 5) adopting institution and human resources arrangement and 6) adopting needed policy and regulation. The study provided in-depth evaluation and recommendation in overall internal irrigation key for success in managing irrigation system.

The recent report had also been published through World Bank sponsored a study on Irrigation Management Modernization. The study pointed out water security as a key issue then as a consequence irrigation services must be improved in a more efficient way through modernization irrigation management. With services oriented in mind then five pillars had been identified 1) water availability for water security; 2) functional irrigation infrastructure; 3) system management; 4) irrigation management institution; 5) human resources. Stressing on functional irrigation infrastructure cost-effective service delivery is its goal.

4.2. Irrigation management policy

In order to achieve food security and alleviate poverty, especially in the rural areas improvement of overall irrigation management should be carried out. The policy should cover improvement farming practices, economies of scale consideration and technical aspect should be established and applied.

a) Land consolidation

Land consolidation is meant to provide a larger plot in one place by reallocation of several pieces of land. In some cases farmers own land in small plots scattered and fragmented this makes ineffective farming system. With consolidation, the land will become larger plot, make easier to apply mechanization. However, since average land holding in Java is less than 0.3 ha, land consolidation in its self doesn’t increase economies of the scale of activity.

b) Land cooperation

The idea of land cooperation is to provide one large land that can be operated in the form of cooperation among farmers. Land titles from each farmer still exist, and farmers become
members of cooperation. Leasing is another method to get a wider land plot. Probably one secondary canal can become one management cooperation or commercial unit. Some farmers will get other jobs than being farmers or supporting agriculture chain activities. With this type of activities economic of scale can be reached.

c) Farm inputs

Timely and right amount of farm inputs is necessary to support large size of farm compared to the current size of the farm. With larger mechanization faster speed can be expected. Delaying farm input will make idle machine working hour that will affect directly the cost of machinery and operator.

d) Post-harvest improvement

Post-harvest includes threshing, drying and storage or milling the grain. This process will affect yield. Improvement of these activities can reduce losses that may be significant.

4.3. Sustainable irrigation agriculture management policy outlook

a) Intensified irrigated agriculture management

Establishment of five pillars in intensified Irrigated Agriculture Management these are: 1) Securing Water Availability; 2). Improvement of irrigation infrastructure; 3). Land consolidation block to fit with mechanization system through the cooperative unit; 4). Improvement of Operation and Maintenance management system including institutions, human resources and budgeting systems; 5). Farm management including farm input, farming practice and post-harvest management.

b) Intensified irrigated agriculture management

Establishment of another five pillars for extensive irrigated agriculture management includes: 1). Water security with the reservoir; 2). New irrigation infrastructure development; 3). Large irrigation plot suited to mechanization system; 4). Reliable Operation and Management Systems; 5). Commercial support from farm input, farming practice, and post-harvest.

It can be concluded that Irrigation management improvement by itself cannot actually solve from the point of view food self-sufficiency challenges. One obvious hindered is the small land holdings farm management system. Inefficiency and economics of scale of food production are among key factors. Enlargement of the land unit for food production is a plausible way out. Several methods can be identified, land consolidation, new irrigation plot of sawah in areal of about 30-50 ha small and medium enterprise system, and mechanization farming system. In addition, post-harvest improvement and empowerment of commercial farmer are also required.
1. Introduction

Increasing population and incomes are expected to call for 70 percent more food production globally to 2050. Renewed but smarter investment in modern agriculture is now seen as a vital component of global recovery to give more overall stability in food supply (FAO, 2011). In this context agricultural water use is one of the trending topics in water agenda in the last years. However, the international activity related to agricultural water or irrigation issues dates back a long time. The International Commission on Irrigation and Canals was set up with support from 11 countries as Founder Members (Brazil, Egypt, India, Indonesia, Italy, Netherlands, Serbia (former Yugoslavia), Sri Lanka, Switzerland, Thailand and Turkey) and at a meeting held at Simla (India) on the 24th June 1950 when a provisional constitution was adopted. The Constitution was finalized at the First International Executive Council meeting of the Commission, held in Delhi (India) in January, 1951 and the name of the Commission changed to International Commission on Irrigation and Drainage (ICID, 2016a). ICID forms a platform for the world irrigation community and interested development professionals to find solutions to problems plaguing the irrigated agriculture. Since 2011 ICID has provided a unique platform once every three years for multi-stakeholder in World Irrigation Forum (WIF) for sharing and learning by engaging in issues of interest at the global level (ICID, 2016b).

In Turkey, there is a growing awareness that water resources development must be sustainable. There are several public institutions and organizations working on the development of water resources. General Directorate of State Hydraulic Works (DSI) is a prime government institution responsible for planning and constructing facilities for utilization of water resources. Studies for the development of water resources in Turkey began in the 1930s. Initiated especially for the development of small-scale irrigation projects, the size and scope of these studies expanded in a relatively short period of time. After the late 1940s, activities in this respect gained a momentum and accelerated with the establishment of the related institutions on the development (Eroglu, 2007).

Nowadays major projects are planned to expand the irrigation system because agriculture is the greatest water consuming sector (with about 73%) and surveys had indicated that economically irrigable area is 8.5 million ha in Turkey. The most important project of the late 1980s and early...
1990s was the Southeastern Anatolia Project (with its Turkish acronym GAP). In order to achieve maximum benefit from water sources, DSI has shifted its policy from the classical open channel distribution network to more water saving systems particularly last years. Pipeline distribution network has been utilized extensively.

Turkey is a Mediterranean country where considerable improvement in the irrigation systems constructed and irrigation methods applied has taken place in the last years. This study evaluated the irrigation development process by making use of examples of local experiments in Turkey.

2. General Indicator

2.1. Location

Turkey (Türkiye) is located at the crossroads of Europe and Asia. So, Turkey forms a bridge between Europe and Asia, with about 97 percent of its land in Asia and the rest in Europe. The country is located between 26°~45° eastern longitudes and 36°~42° northern latitudes. Turkey occupies a total area of about 78 million ha, of which about 1.1 million is inland lakes.

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.

2.2. Land potential

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. Almost, one-third of the total area, 28 million ha, is classified as cultivable land. But when economic considerations are brought in, official estimated Turkey's irrigation potential is 8.5 million ha (Figure 1).

![Economically Irrigable Lands 8,5 Mha](image1)

![Agricultural Lands 28,05 Mha](image2)

![Total Surface Area of Turkey 77,95 Mha](image3)

Figure 1. Soil and Irrigable Land of Turkey
With Turkey's diverse geological, climatic, vegetation and topographical features, Turkey rooms in most of the large land groups found on the earth today. This richness also makes it possible to raise a diversity of crops, many of which are high in their quality.

2.3. Climate

Turkey's diverse regions have different climates because of irregular topography. While the coastal areas enjoy milder climates, the inland Anatolian plateau experiences extremes of hot summers and cold winters with limited rainfall (Sensoy et al., 2008).

The Black Sea region in the north receives rain throughout the year and has both mild summers and mild winters. The southern coastal Mediterranean region is regarded as subtropical, characterized by hot, dry summers and mild, rainy winters. The Aegean region (Western Anatolia) has mountains which run roughly east to west (i.e. perpendicular to the coast) and which are interspersed with grassy floodplains. This region also has a Mediterranean type of climate with hot, dry summers and mild winters. Central Anatolia is a vast high plateau with an average altitude of 1,132 meters above sea level and a semi-arid continental climate with hot and dry summers and cold winters.

The average annual temperature is 18-20 °C on the south coast, falling to 14-15 °C on the west coast, and fluctuates between 4 and 19 °C in the interior regions, depending on the distance from the sea and the altitude.

The average annual rainfall in Turkey is about 643 mm, with significant spatial and temporal fluctuations. Rainfall is scarce during the growing season in normal years in most parts of Turkey. Overall, the western and southern coastal regions receive 800-1,000 mm of rainfall per year. The northern coastal zone (the Black Sea region) receives the highest annual rainfall (1,260–2,500 mm). Central Anatolia receives the lowest rainfall (200-600 mm) which, combined with high temperatures and high evaporation rates, causes drought during the summer months. Evaporation and/or evapotranspiration rates are high particularly in the southeast region, which receives almost no rainfall during the summer, and can reach more than 2,000 mm/year. The southeast region records very low humidity levels, while the coastal regions have quite high levels, in line with precipitation rates (FAO, 2016)

2.4. Population

According to the results of the Address-based Population Registration System, the population of Turkey is 78.7 million in a total of 81 provinces. Annual population growth rate increased to 13.4 % in 2015 from 13.3 % in 2014. The proportion of the population living in towns and
villages was 7.9%. Turkish Statistical Institute (TUİK) has estimated Turkey’s population as 100 million for the year of 2030.

2.5. Water resources

As stated previously, geographically there is a large variation in annual precipitation, evaporation and surface run-off parameters in Turkey. Precipitation is not evenly distributed in time and space throughout the country. The available water per capita in Turkey is less than the World average. According to the projections related to the global climatic models, Turkey will be under the effects of dry and hot weather condition by 2030.

There are 25 hydrological basins in Turkey. The rivers often have irregular regimes. The 25 hydrological basins in Turkey have a total surface water run-off of 193 billion m$^3$/year. 31% of the potential is constituted by the Euphrates (Fırat) and the Tigris (Dicle) Rivers both of which have their sources in the eastern part of the country.

Considering the average surface water run-off which is 186 billion m$^3$/year with the surface runoff of 7 billion m$^3$/year coming from neighboring countries, the total surface run-off within the country reaches to the amount of 193 billion m$^3$/year. On the other hand, the average amount of ground-water leakage is 41 billion m$^3$/year. However, not all the renewable water resources can be utilized because of economic and technical reasons. Exploitable portions of surface run-off including inflow from bordering countries, and groundwater are 98 and 14 billion m$^3$/year, respectively. Thus, the total of economically exploitable water resources potential amounts to 112 billion m$^3$/year (DSI, 2009).

Annual renewable freshwater resource is the most significant indicator of the sufficiency of water resources in a country. While the freshwater resource per capita was 1652 m$^3$ in the year 2000, the value decreased to 1422 m$^3$ by the end of 2015 with a population of 78.5 million. The population is expected to be 100 million by the year 2030, thus the water resource per capita will then decrease to 1120 m$^3$/year by the year 2030. Therefore, Turkey will experience great water problems in future years (Gokalp and Cakmak, 2016).

3. The Improvement of Irrigation in Turkish Agriculture

3.1. Irrigation history

There is a strong relationship between water and civilizations. In fact, ancient civilizations have developed near water resources. Water-related documents and remains show that the oldest waterworks were realized in the Nile basin, in Mesopotamia formed by Euphrates and Tigris, in
Indus and Huang-Ho (Yellow River) basins, during the II and III. Millennia BC, primarily for control of rivers and for irrigation.

Anatolia-Asia Minor located at the crossroads of many antic civilizations has witnessed various water facilities during the last 4000 years. Central, western, southern and southeastern parts of Anatolia room in many water facilities built by Hittites (2000 BC), Urartu (1000 BC), rulers in the Hellenistic period, Romans, the Byzantine, Seljuk and the Ottoman. Some of these facilities are usable even in our day. Remains of other facilities are visible in many parts of Anatolia as examples of fine engineering skills. The most ancient remains of waterworks in Turkey date back to the II. Millenium BC, the Hittite period in Central Anatolia, like the Karakuyu dam, the spring water collection chamber in Bo_ázkale and some others. From the first half of the I. Millennium BC, the Urartu period in Eastern Anatolia, there existed various remains of dams and canals, some of them still in use like the 56 km long Amram canal, the dams at Kesis and Doni lakes (Ozis et al., 2005).

The first modern irrigation and drainage facility in Anatolia dates back to 1908-1914 (the Ottoman period) as “Çumra Irrigation and Drainage Project” (Cakmak et al., 2004). Starting from 1923, the Turkish Republic has spent huge effort in water resources development projects.

The State gave priority to the drainage of swampy areas as a part of combat against malaria, and introduced some small irrigation projects starting with the Republican era. Upon the establishment of the General Directorate of State Hydraulic Works in 1954 without the law. 6200, investments in such projects dam-reservoir construction, pumping, regulation and irrigation networks etc. were intensified (Kanber et al., 2005).

Turkey should develop its water resources, by making use of 4000 years of experience in order to provide food and light to its own citizens and to support neighboring countries.

### 3.2. Irrigation in the present

In 2015, 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 the development of only 48% of the available exploitable potential of 112 billion m$^3$.

In the current situation approximately 74 % of limited water resources of Turkey is allocated for agricultural purposes (Figure 2).
So, agriculture is by far the biggest user of fresh water in Turkey. Up to recent years, irrigation networks were designed as open systems and traditional irrigation methods are extensively used in Turkey's agriculture. But in recent years, closed irrigation systems have been planned, designed and applied. As it is known, pressurized irrigation is vital for rising of irrigation performance and using water efficiently (Fayrap and Güvel, 2015).

Current irrigation networks are composed of 39% classical canal (paved open canal), 43% canalatte and 18% piped systems (DSI, 2016a). The proportions of the classical canal, canal attend and piped systems irrigation networks under construction were 7%, 4% and 89%, respectively in 2015 (DSI, 2015). Use of piped networks instead of open canals in water conveyance and distribution will significantly prevent water losses and ultimately will provide significant water savings.

In addition to development investment, it is also important to apply modern and appropriate irrigation methods for improving irrigation performance and efficiency. Considering this fact, farmers have been encouraged to give top priority to water saving technologies. Using of drip irrigation system in this basin has provided an important contribution for water saving.

Extension activities by governmental and non-governmental organizations for raising public awareness about water scarcity and the need for saving water gained momentum in recent days. By the year of 2015, 70% of irrigation area was irrigated by surface irrigation, 17% by sprinkler and 13% was irrigated by drip irrigation methods (DSI, 2016b). As it is seen in Table 6, the proportion of irrigated area by surface irrigation methods has been decreased year by year.
Table 1. The proportion of applied irrigation methods by years (DSI, 2016b)

<table>
<thead>
<tr>
<th>Year</th>
<th>surface irrigation</th>
<th>sprinkler and drip irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>2012</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>2013</td>
<td>76</td>
<td>24</td>
</tr>
<tr>
<td>2014</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>2015</td>
<td>70</td>
<td>30</td>
</tr>
</tbody>
</table>

DSI and Ministry of Food, Agriculture and Livestock (MoFAL) encourage farmers to use sprinkler and drip irrigation methods. The drip (trickle) irrigation system has contributed to a marked increase of yield under open-field and greenhouse conditions in Turkey. Its use is increasing rapidly for vegetable and field crops. Greenhouse crops are also rapidly expanding in the Mediterranean region of Turkey.

The first crop, used for drip irrigation experiments, was strawberry in the Mediterranean region of Turkey. The first half of the 1970s was the time of adaptation of drip irrigation techniques in Turkey. Currently, farmers are using drip irrigation systems in particular in the Aegean and Mediterranean regions. Sprinkler irrigation systems are used Middle Anatolian in particular in the Konya closed basin, Southeastern Anatolian and Marmara and Mediterranean Regions (Tekiner and Kanber, 2002).

4. Selected Case From Turkey: GAP

GAP, Turkey’s largest integrated water resource project, is among the world’s most important regional development projects in terms of numeric size and influence. The general model in the GAP region must have an institutional and organizational framework that supports the development of water needs and water irrigation in the most effective manner. Important factors include raising the net benefit to the maximum value, continuity, feasibility and flexibility. The model should have early feasibility and the ability to become more active by adapting to changing conditions over time. It is important to determine potential models for managing irrigation works, dividing the entire irrigation system into fundamental operational components, and to determine probable administrative units for each of them.

The region of Southeastern Anatolia extends over wide plains in the basins of the lower Euphrates and the Tigris. The region is bordered by Syria to the south and Iraq to the southeast. Coined as "Fertile Crescent" or "Upper Mesopotamia", the region is also commonly referred to
as "cradle of civilizations." Throughout history, the region served as a bridge connecting Anatolia with Mesopotamia.

The Southeastern Anatolia Project (GAP) consists of energy, irrigation and domestic water supply projects located on around 78,000 km² area in the southeastern region of Turkey, which covers the lower Euphrates River from Keban dam to Syrian border, as well as the main branch of the Tigris River. The GAP was perceived as a programme to develop water and land resources in the region and planned as a package that comprised of 13 individual projects on irrigation and energy production on the Euphrates-Tigris basins. Altogether, these projects envisaged the construction of 22 dams, 19 hydraulic power plants (HPP) and irrigation networks for an area of approximately 1.8 million hectares. As of 2016, the realization of the irrigation projects (474,528 ha) has been 27% and the realization for the hydroelectric projects has been 60%.

The (GAP) is a multi-sector and integrated regional development effort approached in the context of sustainable development. Its basic objectives include the improvement of living standards and income levels of people so as to eliminate regional development disparities and contributing to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector. The project covers approximately 10% of Turkey’s area (7,800,000 ha), which comprises Gaziantep, Adıyaman, Şanlıurfa, Diyarbakır, Mardin, Siirt, Batman, Şırnak and Kilis cities in the basins of the Euphrates and Tigris and in Upper Mesopotamia (Figure 3). While the GAP region has a share of about 10% in both the total population and geographical area of Turkey, 20% of total irrigable land in Turkey is in this region and the region represents 28% of Turkey's total hydraulic potential mainly with the rivers Euphrates and Tigris.

Figure 3, Location of the GAP project area in Turkey.
The GAP area is located in a semi-arid climate zone. Therefore, the conversion from open-channel irrigation systems to enclosed, pressurized irrigation systems will yield significant benefits from many perspectives. Aside from evaporation, water losses in the irrigation structures, operational errors, the determination and pricing of the water used, measurement of the system’s efficiency, and the increase of irrigation productivity will result in a decrease in the amount of water going to drainage, and aid in the solution to problems related to this, and ultimately will achieve significant, positive contributions.

DSI has continued to its research about especially land consolidation, development of farming service, pond fishing and organic agriculture on dam basins with Food, Agriculture and Livestock Ministry and related organizations in a good relationship.

Limited water sources, using them for different purposes out of irrigation and continuously increased water demand for other purposes compel the conservation of water for the irrigation purpose. This condition has been observed at the irrigations in GAP. The requirement of long tunnels, conveyance canals and high altitude pumps to transmit water to irrigation area in GAP, makes water economy obligatory in irrigation. Since water will be important in the following years, the necessity of use of available water economically has been observed. Due to the soil and topographic conditions, sprinkler irrigation has been applied to Yaylak Project and Bozova Pumping Irrigation Project irrigated with water taken from Atatürk Reservoir by the means of Yaskca Tunnel. As the network system equipped with high-pressure pipes is operated according to the demand system, it was determined to design the main canal with downstream controlled according to this operation system. Water level and discharge control or canal regulation identified by electronic sensors in the main canal are provided by tainter gates controlled electronically just near the gates. As these executed researches are laboratory characteristic researches, obtained experiences will be used in the following other projects.

If irrigation systems and drainage requirements are considered as a whole based on optimization with an internally-integrated approach in terms of needs and feasible models, the benefits expected from the GAP will increase, and will have significant benefits not only for the regional and national economies, but also for the globalizing world economy.

GAP has become a well-known example of the transition from simple water development to efficient water management. It stands as an outstanding accomplishment in the field of water development and great engineering achievements in irrigation and hydro-power.
5. Conclusions and Proposals

In addition to population increase, rapid urbanization, industrialization, and irrigation systems in many regions of the world on different continents, the demand for water and water resources is rapidly increasing on a daily basis. However, the water resources available to meet these needs are limited. As a natural consequence, capacity-increasing studies on water resources and on irrigation systems, which account for the greatest water consumption, are being carried out based on the principle of optimum use. Irrigation rates vary depending on the country, geographic region and production design.

In order for agricultural irrigation to be successful, its yields and the expanse of the area in which irrigation is planned must be taken into consideration, and it must be understood that irrigation yields need to be high. When the matter is approached within this framework, there is general agreement among all relevant organizations that there is a need to determine the most appropriate operation, maintenance, and administration model for water irrigation in the region. For such a model to be successful, the investigation is necessary of such subjects as institutional and legal contents, social and cultural behaviors, the potential for environmental interaction, and financial and economic needs. It is also necessary that technical suitability is determined, as well as the ability to achieve continuity.

Turkey isn’t a water-rich country and agriculture is the most water consumptive sector as well (74%). Limited water sources, using them for different purposes out of irrigation and continuously increased water demand for other purposes compel the conservation of water for the irrigation purpose. Therefore water-saving technologies should be implemented and physical infrastructure problems should be solved and alternative water resources should be developed. Nowadays, pressurized piped systems have been used in irrigation networks to prevent water losses and to improve water use efficiencies.

General Directorate of State Hydraulic Works (DSI) is a prime government agency responsible for planning and constructing facilities for utilization of water resources. In order to achieve maximum benefit from water sources, DSI has shifted its policy from the classical open channel distribution network to more water saving systems particularly last years. Turkey has completed a large number of water resources development projects and several are in the construction or planning stages. Today the nation has the technological and management knowledge and experience necessary for the successful accomplishment of these projects.

DSI has continued to its research about especially land consolidation, development of farming service, pond fishing and organic agriculture on dam basins with Agriculture and Village Affairs Ministry and related organizations in a good relationship.
GAP has become a well-known example of the transition from simple water development to efficient water management. It stands as an outstanding accomplishment in the field of water development and great engineering achievements in irrigation and hydro-power. If irrigation systems and drainage requirements are considered as a whole based on optimization with an internally-integrated approach in terms of needs and feasible models, the benefits expected from the GAP will increase, and will have significant benefits not only for the regional and national economies, but also for the globalizing world economy.

Projects and construction based on water resources like the GAP, irrigation and drainage systems are long-term, high-cost, and for the most part publicly funded, and these need to be reflected in the water resource administration, with an approach in which all legal, administrative, social, technical, and economic activities related to water, from the basin to the farm are integrated.

References


• Sensoy S., Demircan M., Ulupınar U., Balta İ., 2008, Türkiyelklimi (in Turkish),


1. Introduction

In Taiwan, agricultural land extends approximately 917,000 hectares, 374,000 hectares of which is designated for management and allocation of agricultural water resources in support of the agricultural development by a group of farmers in early years who came together as a self-governing group, namely an irrigation association, for the purpose. The areas where the irrigation associations promote and manage irrigation systems are called the irrigated areas, the distribution of which is shown in Figure 1. On the other hand, Taiwan with its complicated and sharp topographic relief has many farmlands scattered around rural tablelands, slope lands or alluvial plains where the formulation of irrigation associations is unlikely. These areas are considered the “rural area” and estimated to be approximately 543,000 hectares.

In irrigated areas, with its flat topographic features, steady supply of water from rivers, large areas of cultivation and simple crop composition, the systematic allocation of irrigation water through open channels is more likely. In rural areas, the sharp topographic reliefs, the unsteady supply of water from streams, scattered areas of cultivation and great diversity of crops mean that the timing of the need for water supply is inconsistent. Therefore, the rural areas are faced with several challenges: 1) scarce water resources, 2) low efficiency in water use, 3) an aging population with a limited workforce, and, 4) the lack of funds to support management. For these reasons, the formulation of farmland irrigation associations to collectively manage the water resources and build the open-channel irrigation systems is difficult. The government takes measures to address these challenges in the development of agriculture in rural areas by promoting upland pipeline irrigation and subsidies for agricultural irrigation facilities, as further elaborated below.

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2. The Government’s Strategy of Improving the Irrigation Water Management in the Rural Areas

Given the sharp topographic relief, the concentration of rainfall during the summer season, a short period with surface run-off or even extreme weather conditions in Taiwan, the water resources for agriculture in rural areas can hardly be reserved and often lost. The water resource scarcity, low efficiency in water use, an aging population with a limited workforce and the lack of funds to support management, as described in the previous section, further exacerbates the challenges associated with the development of agriculture in rural areas. Therefore, the government puts in great effort to promote irrigation systems in the rural areas. The policies in support of the aim are explained below:

2.1. Private upland pipeline irrigation

As the farmlands in the rural areas are scattered across a large area with diverse crops of varying habits, flexibility in water use is of paramount importance to irrigation in the area. In consideration of such fact, the government introduced the pipeline irrigation technology to these places in 1983 and implemented so in gradual steps, and issued a letter order, the Guideline for
Promotion of Upland Pipeline Irrigation, in 2004. The Guideline authorizes the subsidies of farmers in utilizing the modern technologies in place of the traditional manual irrigation systems. The farmers may choose an applicable pipeline irrigation type according to the crops, farmland topography, farmland geology, farming habits, labor requirements and availability of the water resources. The advanced pipeline-based water allocation technology helps the farmers to maximize irrigation efficiency with the shortest amount of time and least amount of water. The subsidies support the field pipeline irrigation systems, power equipment, regulation and storage facility and control equipment, etc. As long as 49% of the cost may be covered by the government incentives, and therefore the evapotranspiration and the conveyance loss of agricultural water resources can be reduced by a large margin.

2.2. Guidance to the construction and operation of public facilities: expansion of the irrigated areas supported by irrigation associations

Although the upland irrigation systems may alleviate the problems faced by agriculture in rural areas, the government subsidies are made available only to the field irrigation facilities managed by private individuals. Maximization of efficiency in the use of water resources for collective agriculture development projects still has much to be desired. For this reason, Taiwan’s government is currently drafting a subsidy program for the field irrigation system in the rural areas. The irrigation associations are assigned the tasks of gathering the information about the needs associated with the agricultural development and of more urgent nature across the country, putting together the information and reporting to the competent authority accordingly. The competent authority, in turn, performs a benefit assessment based on the legality of the land ownership, contribution to the overall prospect of agricultural development, efficiency of the facilities, the justification of such allocation resources in the face of the public good. If the assessment determines that benefits will result from such project, then subsidies for the cost of construction and some part of the operation will be granted as the competent authority approves the expansion of the irrigated areas managed by the irrigation associations. The investment in the field irrigation infrastructure with cost-effectiveness and economies of scale are made in the hope to improve the supply of irrigation water in the rural areas.

3. Case Study

In recent years, the government promotes the building of more field irrigation infrastructures in rural areas than ever. In this study, a case analysis is performed. The subject of the analysis is the agricultural development in Dapingding District of Nantou County. According to a survey done by Nantou Irrigation Association, the advancement of agricultural technologies in the district is becoming more evident in the recent years as the need for irrigation water continues to rise.
However, the natural geological features in the district make a reservation of water resources difficult. Irrigation is mostly done by digging wells and pumping the groundwater. Furthermore, the lands are mostly privately owned as no funds are available for maintenance and management of such resources, making improvement in water use efficiency a challenging task in the district. Nantou Irrigation Association seeks to serve the farmers by changing the existing waterways managed by the irrigation associations; a public pipeline irrigation system (see Figure 2) for Dapingding district is planned for more effective management of the water resources and amelioration of the current water scarcity.

![Figure 2. Strategy for improving the irrigation water use in the rural areas – a case study of Dapingding District](image)

3.1. Natural features

Topography: Dapingding District, a tableland (see Figure 3), is situated north-west of Puli Township of Nantou County with an elevation of 500-750 meters above sea level. No rivers or streams of steady water supply flow through this district as the geological features of this district makes are servation of water supply difficult. Channeling the surface water through natural channels is therefore not an option. Trans basin diversion of water from the neighboring mountainous areas is also difficult due to the topographical challenges.

![Figure 3. Topographic Cross–Section of Dapingding District](image)
Soil: According to a soil survey of the district performed by Nantou Irrigation Association (see Table 1), the seat earth mostly consists of clay of more than one meter in thickness. The soil is not clearly stratified. The soil ranges from yellow-brown, olive, brown to red-brown in color, and has excellent drainage. Therefore, the soil properties shall be taken into consideration in managing irrigation water to avoid the loss by run-offs.

Table 1. Soil composition

<table>
<thead>
<tr>
<th>Location of the soil sample</th>
<th>Percentage Weight of Soil Composition</th>
<th>Soil Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand (%)</td>
<td>Silt (%)</td>
</tr>
<tr>
<td>Surface soil</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>20 cm under the surface</td>
<td>18</td>
<td>44</td>
</tr>
<tr>
<td>40 cm under the surface</td>
<td>27</td>
<td>42</td>
</tr>
<tr>
<td>60 cm under the surface</td>
<td>12</td>
<td>34</td>
</tr>
</tbody>
</table>

Rainfall: According to the rainfall statistics from 1999 to 2013, as analyzed and provided by Nantou Irrigation Association, the average monthly rainfall ranges from 40 to 424mm. The rainfall mostly concentrates in the months between May to August, taking up 68% of the annual rainfall. The wet season and dry season are clearly defined in the area.

3.2. Current agriculture practice

The area of the agricultural land in the district is approximately 348 hectares and evenly distributed. The main crops include passion fruit, papaya, vegetables (see Table 2) and other crops with higher economic values. However, with the completion of the National Highway No. 6 and the change in the consumer habits in the recent years, for the operation of agriculture-related businesses in the area, the trend towards a technology-intense and capital-intense sector based on refinement, infrastructurization and automation has become more evident. But given the water resource scarcity, the farmers often have to resort to purchase water from water trucks or dig deep wells (73% of the farmland) to meet the irrigation needs. Despite these measures, the needs for farm crops remain unfulfilled.
Table 2. Main Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area of Cultivation (hectare)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passionfruit</td>
<td>246</td>
<td>71</td>
</tr>
<tr>
<td>Papaya</td>
<td>68</td>
<td>19</td>
</tr>
<tr>
<td>Sponge gourd</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Other crops</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>348</td>
<td>100</td>
</tr>
</tbody>
</table>

3.3. Infrastructure construction

According to the infrastructure plan, water will be diverted from the west main line of the Nenggao Canal. The water sources that feed Nenggao Canal come from Jiuxian River of Huisun Forest Area and the water intake of Guandao River, being transported to Puli by way of gravity for irrigation. The planned public irrigation pipeline systems will utilize inverted siphon works and pipeline installations, in conjunction with several storage ponds and storage water towers, to supply water through facilities that allow sectional pressurization as well as branch lines connecting to the farmers’ field pipe irrigation facilities.

3.4. Budget requirement

According to the plan, the project requires a budget of NT$67,100,000. If amortized over 20 years, given an annual interest rate of 3.5% as well as an annual operation, maintenance and management cost of 5%, the total budget requirement for this project is $75,180,000. The annual cost is estimated to be $3,760,000.

3.5. Expected benefits

The benefits of the plan are divided into direct benefits and indirect benefits. The direct benefit of the plan arises from the addition of values to the crops with increased quality of production. The current value of these crops, based on the statistics released by the Council of Agriculture, is calculated to be approximately $316,700,000. Upon completion of the construction project, 2.5% of the annual value will be added to the current products. So, the direct benefit is estimated to be 7,910,000 (see Table 3). The indirect benefits include the protection of the crop properties, reduction of the impacts of a drought, stabilization of the local farmer population, the creation of
incentives for youth population to return home and reduction of the reliance on the pumping of groundwater. Amongst these, the benefit associated with the reduction of drought impacts is estimated to be 10% of the direct benefit according to the standards issued by the Council for Economic Planning and Development. So the combination of the direct and indirect benefits is estimated to be at least NT$8,700,000 each year with a benefit-cost ratio of 2.3, meaning the project is a cost-effective investment. The infrastructure project can effectively improve the irrigation water supply and promote the development of agriculture in the rural areas.

Table 3. The annual value of the crops in the district

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area of cultivation (hectare)</th>
<th>Production per unit area (kg/ hectare)</th>
<th>Crop value (NTD/kg)</th>
<th>Annual value (NT$10k)</th>
<th>Estimation of additional earnings</th>
<th>Value added (NT$10k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passion fruit</td>
<td>246</td>
<td>18,000</td>
<td>45</td>
<td>19,926</td>
<td></td>
<td>498</td>
</tr>
<tr>
<td>Papaya</td>
<td>68</td>
<td>50,000</td>
<td>30</td>
<td>10,200</td>
<td>2.5%</td>
<td>255</td>
</tr>
<tr>
<td>Sponge gourd</td>
<td>18</td>
<td>18,000</td>
<td>20</td>
<td>648</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Other crops</td>
<td>16</td>
<td>16,000</td>
<td>35</td>
<td>896</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>348</td>
<td>-</td>
<td>-</td>
<td>31,670</td>
<td></td>
<td>791</td>
</tr>
</tbody>
</table>

3.6. Subsequent operation

The district is planned to be incorporated into the irrigation area managed by Nantou Irrigation Association. The farmers will be required to pay the additional water pumping fee less the government subsidy to cover some basic cost. In practice, in planning for the farmland irrigation infrastructure in this rural district, Nantou Irrigation Association has formed a Dapingding Upland Irrigation Workstation to coordinate the allocation of the existing water resources within the scope of irrigation managed by Nantou Irrigation Association to the local farmers. Figure 4 specifies the division of duties and responsibilities associated with the maintenance of the field irrigation infrastructure. The water for irrigation will be supplied with the assistance of Nantou Irrigation Association. The water is diverted form Nenggao Canal and transported through the detention basins, main line, storage water towers, branch lines and water meters, all managed and operated by Nantou Irrigation Association. The meter readings represent the use of water by the farmers. So the farmers must be responsible for the management and maintenance of the water resource after it is transported beyond the water meter.
4. Conclusion

To better attend to the needs of agriculture in the rural areas, the government, in addition to the granting of subsidies to fund the private field upland pipeline irrigation facilities, also promotes the construction and operation of public facilities as a means of expanding the irrigated areas managed by irrigation associations in selected areas with greatest benefits had the program been implemented. As for the allocation of the budget, the government aims to promote upland pipeline irrigation systems to 2,000 hectares of agricultural land each year and to subsidize the field irrigation infrastructure up to NT$300 million per year with the objective of helping the construction of the irrigation facilities in the rural areas. Better farmlands may be incorporated into the area serviced by the irrigation associations, and subsidies are granted for the construction of their public infrastructure. For other areas, the government grants subsidies to private facilities in order to expedite the revitalization of agriculture in the rural areas, improve irrigation efficiency and facilitate the overall development of agriculture.

References


• Council of Agriculture, Executive Yuan. 2015. Farmland Irrigation Infrastructure Consolidation and the Improved Support for Decision-making Plan

• Council of Agriculture, Executive Yuan. 2015. Guideline for the Promotion of Upland Pipeline Irrigation.


• Council of Agriculture, Executive Yuan. 2016. The Upland Irrigation Area Program for Beiliao and Taiping Elementary School Districts in Puli.

• Council of Agriculture, Executive Yuan. 2016. Farmland Irrigation Infrastructure Guidance and the Subsidy of Irrigation Facilities outside of the Irrigation Area Review, Supervision and Auditing Plan.


• Nantou County Government. 2016. Bagua Mountain Chishui District P18 Pond Water Distribution System Installation Plan (First Construction Site).

• Nantou Irrigation Association. 2014. Puli Beiliao District Upland Irrigation Area Operation Plan.

• Taiwan Joint Irrigation Association. 2013. The Effective Use of Water Resources Managed by Irrigation Associations Improvement and the District Infrastructure Management System Betterment and Review Plan.


Chapter 2
Case Studies on Rural Development
Chapter II. Case Studies on Rural Development

Synthesis Report on Case Studies

The following “case study” papers on Contribution of Agricultural Water to the Rural Development in Asia were received for this technical paper. They are:

- "Examples of Restructuring of Participatory Irrigation Management to Cope with the Changes in the Social Structure in Japan" by Masao Miyazaki (Japan), presented at 2013 First WIF Meeting in Mardin, Turkey

- "The Impact of Agriculture Policy to Rural Water Management in Northern Taiwan" by Ray-Shyan Wu and Chia-Chi Ma (Taiwan), presented at 2013 PAWEES International Conference in Cheongju, Republic of Korea

- "Comprehensive Approach Towards Sustaining Agriculture Development in Myanmar" by Soe Myint Tun and Mu Mu Than (Myanmar) presented at 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea

- "The Process of Comprehensive Agricultural Development Project and Cases of Well-Developed Models on Rural Development" by Kamrul Ahsan (Bangladesh) presented at 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea

- "Achievements and Challenges in Irrigation Development: Experiences from Maharashtra State of India" by Suresh A. Kulkarni (India) presented at 2014 ICID Round Table Meeting Asia in Gwangju, Republic of Korea

- "Paddy Water Environment and Rural Development in Korea" by Kwang-Sik Yoon (Korea), presented at the Small Conference, organized by PAWEES and ASRWG, at 2016 PAWEES International Conference in Daejeon, Republic of Korea

- "Krasae Reservoir Project: Medium Scale Project for Rural Community in Eastern Region" by Arthon Suttigarn (Thailand), presented at 2016 2nd WIF Meeting in Chiang Mai, Thailand

- "Development of Benchmarking System for Irrigation Management in Vietnam" by Le Thi Hong Nhunghand Nguyen Tung Phong (Vietnam), presented at 2016 INWEPF WG2 Workshop in Ansan, Republic of Korea

- "Irrigation Management Transfer Program in National Irrigation Systems in the Philippines" by Bayani P. Ofrecio (Philippines), presented at 2016 INWEPF WG2 Workshop in Ansan, Republic of Korea
Each presenter from nine countries in Asia turned in a report on cases of agricultural water development and maintenance in their respective domain. The outcomes showed that the countries in Asia have been making a lot of efforts for rural development with agricultural water, and have achieved decent results. Each paper is summarized as follows.

Masao Miyazaki (Japan) presented examples of PIM restructuring in Japan. Japan has faced a great challenge that the number of farming households has decreased greatly in rural areas. To tackle this issue, the country developed a mechanism that enables different local public organizations to participate in irrigation management. This has brought various benefits, such as appropriate agricultural facilities management, vitalization of rural areas and improvement of rural environments.

Ray-Shyan Wu and Chia-Chi Ma (Taiwan) reported that agricultural GDP in Taiwan declined from 32% in 1951 to 2% in 2011, and the plantation areas of rice were drastically reduced from 790,000 ha in 1975 to 250,000 ha in 2011. In order to address such changes, the government of Taiwan implemented two systems for improving the efficiency of agricultural land water resources. First, a program titled “The program of water-resources distribution concerns the adjustments of rice-paddy and upland crop fields” was conducted from 1997. As a result, the use of agricultural water was reduced to 57% with saving 50 million tons of water at a model site TIA (Taoyuan Irrigation Association, 25,000 ha). The second program called “The medium-term plan of adjusting the cropping systems and rearranging the farmlands” implemented from 2011 achieved the expansion of cropping areas to 132% in 2013 on average from 2003 on the land of TIA. Also, the usage of agricultural water was decreased to 72%. Such outcomes have proved that those two systems were effective.

Myanmar is actively implementing a consolidation project for increasing the rate of agricultural mechanization and improving crop productivity. Soe Myint Tun and Mu Mu Tan (Myanmar) presented the case study for implementation of a comprehensive agricultural development project by land consolidation model farm in Nay Pyi Taw. The project is implemented for land improvement together with enhancing water management, applying GAP (Good Agriculture Practice), improving field access for machinery and transport, and capacity building for concerned stakeholders. As a result of previous three paddy cultivation seasons, cropping intensity has increased rather than 50% that can be seen as a tangible benefit. Moreover, the project stimulates intangible benefits such as motivation of farmers’ participation, improving socio-economic life of rural people, and remote area transportation.
Kamrul Ahsan (Bangladesh) presented a review of the process of potential comprehensive agricultural development project and cases of well-developed rural development models. Food production has been increased in folds over the decades and at the same time increasing use of chemicals in food production raises the major issue of health concern in almost all developing countries. Ecological farming is an alternative way of food production with higher growth using natural resources like soil, water and at the same time keeping the environment-friendly.

As well-developed rural development models, three models were suggested including SaeMaulUndong of South Korea, which is considered one of the most successful rural development models, Spark Programme of China and Model Farmer of Bangladesh.

Suresh A. Kulkarni (India) reported on agricultural water policy in Maharashtra State. Maharashtra is the second largest state in the country with 30 million ha of land and 115 million by population. The farming population is around 65 million with agricultural profits taking up 12% of the country’s GDP. While arable land is about 22 million ha in the state, irrigated land is only 20% (40% on average in India). There are 4,353 water user associations, which tells that agriculture is of great importance in Maharashtra. Accordingly, the state has been making efforts to improve awareness on and efficiency of irrigation by newly establishing laws of irrigation systems and management, and government systems. Also, it regularly provides educational and training programs for public servants and farmers.

Kwang-Sik Yoon (Korea) showcased an example of agricultural development model in Korea called “Yeong-san River Basin Comprehensive Development Project (YRBCADP),” which is a multi-functionality of agricultural water. Korea has implemented large-scale agricultural development projects for agricultural development since the 1960s, and YRBCADP is one of the major projects. The 1st stage of the project was initiated in 1972, and the 4th stage is still ongoing. The elements of the project include the establishment of agricultural dams at 4 sites and sea dikes at 3 sites, land consolidation, and agricultural water and drainage improvement, with a budget of around USD 3 billion.

Through this project, the land scale was expanded by 3.5 times, and crop output was increased from 3.97 ton/ha to 4.64 ton/ha. In addition, the local economy also benefited from the project, like for example increase in local tax collections twice as many as before and improved traffic conditions (35,000 cars per day).

Arthon Suttigarn (Thailand) introduced the pre-feasibility study of Klong Krasae reservoir project in Thailand. The storage capacity of the reservoir is 1,800 tons, and irrigation area is 3,162 acres. The number of beneficial households from the reservoir is 213 (14.81 acres per household), with the project cost of USD 12.2 million. The report analyzed that implementation of this project will increase the productivity of palm oil and rubber tree plantations and make
double cropping possible, leading to an increase in farmers’ net income by 49% from USD 9,185 to USD 13,690. From 2 times of public participation hearings, 98% of the village leaders agreed on this project, while only 49% of the residents living in the project areas agreed on this.

Le Thi Hong Nhung (Vietnam) introduces the development of a suitable Benchmarking system for irrigation management in Vietnam by reviewing the existing tools, proposing the main principles in using these tools, and finally the recommendation for better evaluation of the performance of the irrigation system. In this study the use of “MASSCOTE” as a tool, MASSCOTE is a method to evaluate the processes and operational efficiency as well as plans for irrigation system modernization. MASSCOTE was developed by FAO. As a result, this paper emphasized on the contribution of benchmarking development to the implementation of the program on improving the efficiency of the management and exploitation of existing irrigation scheme of the Vietnam government.

Bayani P. Ofrecio (Philippines) presents Irrigation Management Transfer (IMT) program in national irrigation systems in the Philippines. IMT is a National Irrigation Administration (NIA) program of gradually transferring the management Operation and Management (O & M) of National Irrigation Systems (NISs) to Irrigation Associations (IAs) depending on the size of the irrigation system and capacity of the IAs. The objectives of the IMT Program are the following: To organize and develop functional and self-reliant IAs capable and willing to operate and maintain the NISs; To develop and institutionalize a strong and dynamic partnership between the NIA and the IAs; To improve performance of the NISs and delivery of irrigation service; To give opportunities to farmers for better and more profitable agricultural production. Finally, IMT should not be misconstrued as a way of passing on the burden of O & M responsibilities from NIA to the farmers. Rather, it should be viewed as a way of giving the opportunity to the IAs to progress as dynamic groups, relying on their own resources and capabilities.
1. Mechanism of Japan’s Irrigation and Drainage System

In Japan, rice cultivation started about 2,800 years ago. Since then, paddy agriculture has spread to all areas of the country through the development of new paddy fields, and irrigation technologies to take agricultural water from rivers etc. were developed. As a result, an extremely refined irrigation and drainage system, with a total canal length of approximately 400000 km (which is about ten times as long as the circumference of the Earth), which is mainly composed of agricultural canals, has been developed in Japan. It sends water smoothly from water sources to paddy fields and drains water appropriately from paddy fields.

These agricultural canals, which include trunk canals, branch canals, and terminal canals, are often likened to the trunk and branches of a tree. Agricultural water taken at headworks constructed on rivers, is distributed to paddy fields through these canals.

Figure 1. Schematic diagram of Japan’s irrigation and drainage system

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The irrigation part of Japan’s irrigation and drainage system (see Figure 1) is divided into “dams and headworks,” “trunk canals” (which are central irrigation facilities), and “terminal canals” located near paddy fields. The drainage part of the irrigation and drainage system is divided into “terminal drainage canals” located near paddy fields, “trunk drainage canals” into which terminal drainage canals flow, and “central drainage facilities” such as drainage pump plants.” The central facilities are facilities that were constructed after the Second World War, and Land Improvement Districts started to assume the role of central facility management entities after the establishment of the Land Improvement Act in 1949. For example, back in 1900, Land Improvement Districts had not reached the level where they could construct central facilities in terms of both civil engineering technology and funds. It had been common for irrigation associations and local communities, which are current terminal irrigation facility management entities, to construct canals (singly or jointly) to take agricultural water from water sources such as rivers. It should be noted here that; Land Improvement Districts are managing not all of Japan’s irrigation and drainage system. That is, the management scheme is a layered one in which, in principle, Land Improvement Districts are responsible for managing central facilities and irrigation associations and local communities are responsible for managing terminal facilities.

2. History of the Management System

This section reviews the history of irrigation and drainage in Japan, and then outlines the formation of the management system’s structure.

In Japan, water use on a relatively small scale started around A.D. 600 using irrigation ponds and small rivers as water sources. Around the year 1300, water use using medium-sized rivers started in conjunction with land reclamation projects to develop paddy fields and water utilization projects initiated by feudal lords of the Sengoku era. Water use using large rivers started around 1600 as because of advances in technologies to reclaim land to develop paddy fields and irrigation technologies. After that, Japan’s population increased sharply in parallel with expansions of the total paddy field area. However, the utilization of large rivers back then did not involve the construction of central facilities such as those used nowadays, and used manually constructed timber-based diversion weirs and earth canals. Therefore, even though the water was taken from large rivers, the intake area per facility was smaller than that of the present day and water management was performed in a joint effort by multiple terminal management organizations.

The following subsections outline the history of water management organizations in Japan before and after the establishment of the Land Improvement Act in 1949.
2.1. Formation of water management organizations (before 1949)

In Japan, efficient water use made from time immemorial through the maintenance of agricultural irrigation facilities and water distribution management (water management) by water management organizations (organized by farmers) and other entities, with the facility maintenance and water management roles assumed mainly by farmers, who are the beneficiaries of water.

Control of nature and society has been extremely difficult up until now, because of harsh climatic changes that are characteristic of Monsoon Asia, destruction of diversion weirs by floods, and frequent irrigation rights disputes following droughts between upstream areas, downstream areas, right bank areas, and left bank areas.

The rules for taking water from rivers have been formed as a kind of social practice over many years partly because of numerous irrigation rights disputes including non-frequent but harsh ones in which people were killed. In the areas along each canal from the upstream to downstream ends, coordination has been made repeatedly between interested local communities, and an organization has been formed that can be called a common irrigation community. To maintain the common irrigation community, there are established water rules in the local communities comprising the common irrigation community and the residents of the local communities have been required to observe the rules.

Rural agricultural communities in Japan were formed through the bonding of families by blood and/or territorial ties around the core of agricultural operations and agricultural water use. Agricultural water has been maintained through collaborative efforts by the residents of local
communities, with the residents obtaining the right to participate in the common use of agricultural water by fulfilling the duty of providing labor for the collaborative efforts.

Through these tremendous efforts and labor provided by farmers, the system for agricultural water use has been formed and developed into its present form.

Local communities were formed from rural village communities to secure agricultural water. The rural village communities served as collaborative entities for the management of water, operation and maintenance of local resources. This includes: agricultural roads, irrigation pond, among others.

2.2. Water management system after the establishment of the land improvement act in 1949

To maintain a constant supply of agricultural water to farmland, it is important to appropriately operate and maintain the entire irrigation and drainage facility system from water intake facilities such as headworks to terminal canals around the farmland. In Japan, the central facilities constructed after the Second World War as mentioned above, are being managed by Land
Improvement Districts. They were established by farmers in pursuant to the Land Improvement Act. On the other hand, the terminal facilities are being managed by irrigation associations that are mainly composed of farmers and local communities. The latter, for which a management system has been formed based on the historical developments, has been responsible for the management of terminal facilities up to the present day since the establishment of the Land Improvement Act.

A feature of Japan’s water management system is the close and effective coordination and cooperation between the Land Improvement Districts. They are responsible for the management of the central facilities, and the irrigation associations and local communities, which are responsible for the management of the terminal facilities. This is because, the construction of central facilities as well as management rules is proposed by many organizations responsible for the management of the associated terminal facilities. Census is pursued, through exchanges to enhance mutual understanding.

Figure 5. Traditional management system for irrigation and drainage facilities

3. Weakening of the Management System Due to Changes in the Social Structure of Rural Villages

Japan’s farming population has constantly been on the decrease since the postwar period of rapid economic growth (Figure 6). In addition, urbanization of rural villages has been intensifying, with the proportions of non-farming households increasing and the proportions of farming households decreasing in rural villages. As a result, large changes have been brought
about in the social structure of rural villages, including the constant increases in the proportions of non-farming households in local communities (Figure 7). Such changes in the social structure of rural villages have started to cause changes in the agricultural water management system.

Central irrigation facilities are managed by Land Improvement Districts etc. through land improvement projects etc., but the management of terminal canals relies heavily on traditional irrigation associations and local communities. For this reason, the abovementioned changes in the social structure of rural villages have affected the management of terminal canals. Specifically, it has become difficult to perform adequately the management of the irrigation and drainage canals (removal of sediment that has accumulated on canal floors and weeding around canals), which used to be performed as a collaborative activity. If the numbers of farming households in rural villages continue to decrease, the management system may become weak, because it will lead to problems such as inadequate management of terminal canals, which will reduce the efficiency of water management.

4. Restructuring of the Management System

Changes in the social structure of rural villages weakened the Terminal Canal Management System. As the number of farming households decreased, the rate of participation in collaborative activities also reduced. This has led to the weakening of the operation and maintenance system for agricultural land and agricultural water.

Against this background of critical situations, the Ministry of Agriculture, Forestry and Fisheries initiated the restructuring of the Terminal Canal Management System. This restructuring was unique in the sense that, an incentive was provided for non-farming households as well as farming households to participate in the management of agricultural terminal canals.
The incentive was aimed at motivating all residents of the area to participate in the program. They had to recognize agricultural canal terminals, irrigation and drainage functions. They also needed to know the area of habitat for a diverse range of organisms, beautiful landscape and other functions. The main points are as follows:

a) A mechanism, which allowed participants to voluntarily setup activities, based organization around the community was created.

b) Various options were provided to be chosen by the participants (rather than pre-defining the activities to be performed by the activity organization).

c) A support scheme was established in which the national government, local governments, local public organizations, and local activity organizations collaborate with each other.

![Image](image.png)

Figure 8. Changes in the irrigation and drainage facility management system

### 4.1. Subsidy system for the operation and maintenance of farmland and water

The mechanism for “Subsidy System for the Operation and Maintenance of Farmland and Water” is as follows:

a) Activity organizations based on local communities etc. are set up.

b) The activity organizations prepare their plans for the activities in which they want to perform. This is in accordance with the guidelines and based on the results of discussions.

c) The activity organizations conclude agreements with municipalities.
d) The activity organizations receive subsidies and perform their activities in accordance with the plans.

e) Organize the records into reports, and submit the reports to the municipalities.

1) Activity organizations and the implementation scheme

A variety of entities including non-farming households and organizations have joined the activity organizations, and the these organizations have been performing their activities based on the results of discussions on the operation and maintenance of local resources.

“Local Conferences” that comprised of the local governments (of prefectures, cities, towns, and villages) are to be set up so that the operation and maintenance of farmland, agricultural water, etc., can be performed in an appropriate and effective manner based on coordination.
and cooperation between the national government, local governments, and local public organizations to allow activity organizations to receive subsidies and use them to perform their activities. The purpose of the Local Conferences is to provide direct support to activity organizations by serving as the interface between the national government and activity organizations.

2) Activities

The major activities to be carried out based on this system are basic resource maintenance activities such as the removal of sediment that has accumulated on the floors of agricultural irrigation and drainage canals and weeding around agricultural roads. The system is designed in a way that permits the enhancement of sophisticated farmlands and water maintenance activities.

This requires high-level technology such as guidance by an expert, preservation of the local environment, preservation of water quality, soil and biological diversity. The repair of joints of agricultural irrigation and drainage canals. The repair of cracked agricultural irrigation and drainage canals, repair of pavements on agricultural roads.

![Figure 11. Basic Activities Listed in Guidelines](image)

4.2. Activities of Restructured Management Organizations

1) Changes in the number of organizations and the total area of farmland covered

Currently, 19,677 activity organizations are performing their activities for 1.43 million ha of farmland throughout Japan in this system (FY 2011). This corresponds to 34% of the farmland selected (4.26 million ha) as the target farmland.
By land category, activities are being performed for 1,000,000 ha of paddy fields, 360,000 ha of upland fields and 70,000 ha of grassland, which means that about 70% of the activities are for paddy fields.

This system was started in FY 2007 with 17,122 organizations performing their activities for 1.16 million ha of farmland, and the number of organizations and the total area of farmland covered has increased steadily.

Table 1. Changes in the number of organizations and the total area of farmland covered

<table>
<thead>
<tr>
<th>Fiscal year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Organizations</td>
<td>17,122</td>
<td>18,973</td>
<td>19,514</td>
<td>19,658</td>
<td>19,677</td>
</tr>
<tr>
<td>Total Area of Farmland Covered (10,000 ha)</td>
<td>116</td>
<td>136</td>
<td>143</td>
<td>143</td>
<td>143</td>
</tr>
</tbody>
</table>

2) Compositions and sizes of activity organizations

Currently, about 1.52 million people (including people who are not farmers) and groups are engaged in activities of activity organizations as members (FY 2011). The participating groups are diverse and include neighborhood self-governing bodies, children’s associations, and women’s associations.

Activity organizations are formed within individual local communities, and the area of farmland specified in the agreement is in many cases between 20 ha and 50 ha.

Table 2. Numbers of activity organizations

<table>
<thead>
<tr>
<th>Individuals</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers (people)</td>
<td>Non-farmers (people)</td>
</tr>
<tr>
<td>1,141,000</td>
<td>249,000</td>
</tr>
</tbody>
</table>

Total: 1,520,000 people and groups

(Source) FY2011 Implementation Status Report

Figure 12. Proportions of the various types of participant groups in activity organizations
4.3. Effects and evaluations

1) Maintaining functions of farmland, agricultural facilities, etc.

The 1.43 million ha of farmland for which activities based on this system are being performed is being operated and maintained appropriately. In addition, 290,000 km of agricultural irrigation canals, 170,000 km of agricultural roads, and 30,000 irrigation ponds have been designated as target agricultural facilities, and their functions are being maintained.

2) Improving rural environments and vitalizing rural areas

In a questionnaire survey to activity organizations, about 90% of the responding activity organizations said that their activities were contributing to efforts to preserve and improve local environments. Environmental preservation activities often motivate residents who are not farmers to participate, and currently, diverse entities are engaged in such activities.

In addition, about 90% of the responding activity organizations said that their activities were contributing to efforts to vitalize rural areas, and the frequencies of meetings (community gatherings) and events for promoting rural areas are also increasing.
4.4. Examples of activities

Activities performed based on this subsidy are classified into 4 categories. The following subsections present examples of activities of each of the 4 categories.

1) Basic Activities Relating to Farmland, Canals, and Other Resources

![Canal cleaning](image1.png)

![Regular replenishment of gravel](image2.png)

Figure 18, Examples of basic activities

2) Activities to Preserve and Improve Rural Environments Including Biodiversity Preservation-and Landscape Development-related Activities
3) Repair and Renovation Activities to Prolong the Service Lives of Aging Agricultural Irrigation Canals, Agricultural Roads, and Other Facilities around Farmland

4) High-level Activities that Contribute to the Preservation of Local Environments, Including Activities to Preserve Water Quality, Soil, and Biodiversity
5. Conclusions

Participatory irrigation management in Japan has been classified into good practices by strong management organization and high technical level in the world. However, along with the change of members’ composition of the water management organization in the change of social structure, Japan’s experience suggests that there is a risk of losing the sustainability of the management organization in qualitative changes. At the same time it suggests that Japan’s experiences showed the prescription how to recover the sustainability of the management organization for these crises.

The role of participatory irrigation management is important to promote efficient water use in paddy agriculture worldwide. We believe Japan’s experience introduced here will be a reference for countries to launch a system of participatory irrigation management and give a big hint to the countries that are concerned about the sustainability of participatory irrigation management system in the changes of social structure. In particular, we are sure that "autonomy", "independence" and "cooperation" will be the key for success to organize participatory irrigation management system.

It is our sincere hope that Japan’s experience presented in this paper will serve as a source of reference for countries that wish to achieve efficient water use by newly-established systems for participatory irrigation management.
1. Introduction

During earlier periods, the social economy of Taiwan was predominantly based on agriculture. But with the economic development, industrial structure changing, the GDP of agricultural output was declined from 32% in 1951 to 2% in 2011. The plantation areas of rice, the main food crop of Taiwan, was reached a peak of $79 \times 10^4$ ha in 1975. Since then, the plantation areas declined with the changes in the industrial structure gradually reduced. The government adjusted the rice production and marketing structure in order to join the World Trade Organization. The Council of Agriculture started “The program of water-resources distribution, concerning the adjustments of rice-paddy and upland crop fields” in 1997. The plantation areas of rice declined from $36.4 \times 10^4$ ha in 1997 to $25.4 \times 10^4$ ha in 2011.

However, we compared the agricultural water use over the years, it wasn’t with a proportional decrease in irrigated area. In the meantime, domestic and industrial water demand is increasing year by year. The agricultural water was required to reduce because of new water sources development were difficult and higher costs in natural or social conditions.

The Council of Agriculture set the policy objectives for food self-sufficiency rate of 40% before 2020 in the "National Food Security Meeting" in 2011. For ensuring food security, they will adjust the domestic agriculture production structure, and improve the using efficiency of agricultural land and water resources. The medium-term project of adjusting the cropping system and rearranging the farmlands started in 2013. It coached the continuous fallow land landowners to rehabilitate for one crop-term or rent to others to crop industrial crops. It expected to improve the food self-sufficiency rate of 34.9% in 2016, and improve the total agricultural output value of 8.8 billion dollars, and also reduce the carbon dioxide emissions by 61,772 tons.

Because the agricultural policy will guild the willingness of production for farmers and using the situation for farms directly, it will have an impact on agricultural water management directly. “The program of water-resources distribution concerning the adjustments of rice-paddy and upland crop fields” and “The medium-term plan of adjusting the cropping system and

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rearranging the farmlands” are the greatest impacting agricultural policy on agricultural water management in recent years. In this paper, Taoyuan Irrigation Association for the study area, explored cultivated land area and water management changes under the guidance of the agricultural policy.

2. Research Area

The irrigation area of Taoyuan Irrigation Association (TIA) is located in north of Taiwan, which includes Taipei, Taoyuan, and Hsinchu counties. It can be divided into four irrigation areas, namely Taoyuan, Hukou, Tahsi and Hsinhai according to the physical features and irrigation system. The total irrigation area is 24,650 hectares. The irrigation water resource was Shihmen Reservoir, several rivers and effective rainfall. The climate in this region is sub-tropical climate with humid and hot weather. Therefore, crops grow all the year round. The annual average temperature is 21℃. The summer is long and a high temperature with an average of 27.6℃. The winter is short and lower temperature with an average of 15℃. The annual average rainfall is 2,000mm. There is an uneven distribution of rainfall in different seasons, that it has more rainfall in summer than in winter. The effective rainfall in the irrigation season makes up 15% of the total amount of water irrigated. The main crop occupying the 90% of farmland in the irrigation area is paddy rice, which can be grown twice a year. The remaining 10% of farmland in this area is planted with sweet potatoes, melons, vegetables, etc.

The irrigation area of TIA was divided into 329 irrigation groups. The irrigation water resources were reservoir supply of 56%, rivers supply of 29%, and effective rainfall of 15%. The TIA administered 284 ponds, the unique irrigation facilities in Taiwan, to regulate the irrigation water. The total water storage was $4.6 \times 10^7$ m$^3$. The TIA regulated irrigation water in the ponds cooperated with Shihmen Reservoir and rivers. Stored the irrigation water in the ponds first, and irrigated farms for the right time and right amount. It would improve the efficiency of rainfall, and irrigate stably.

Taoyuan Canal Taipei City Taoyuan County Shihmen Reservoir

Figure 1. Irrigation area aerial photograph of Taoyuan Irrigation Association
3. The Program of Water–Resources Distribution Concerning the Adjustments of Rice–Paddy and Upland Crop Fields

The Program was Taiwan’s response to the accession to the World Trade Organization, for adjusting the industrial structure of rice, cereals and deed sugar cane. It started in 1997. The plantation area of rice was declined from $36.4 \times 10^4$ ha to $30.7 \times 10^4$ ha in 2002. The plantation area of cereals was declined from $4.5 \times 10^4$ ha to $2.1 \times 10^4$ ha. The plantation area of deed sugar cane was declined from $2.2 \times 10^4$ ha to $1.2 \times 10^4$ ha.

Taiwan joined the World Trade Organization in 2002, and allowed to import some rice. Therefore, the area of fallow was increased year by year. The plantation area of rice was declined to $26 \times 10^4$ ha in 2012. But this program focused on rice area and yield adjustments without centralized fallow area, didn’t reduce the irrigation water in the meantime. The farmers cropped the rice in the dry 1st crop-term and rested in the wet 2nd crop-term for the higher production value of 1st crop-term rice, it reduced the efficiency of water resources.

In the Taoyuan area, the plantation area of rice was $3.97 \times 10^4$ ha in 1997, declined to $2.09 \times 10^4$ ha for joining the WTO in 2002. It declined further to $1.4 \times 10^4$ ha in 2007. Next few years remained at $1.2 \times 10^4$ to $1.4 \times 10^4$ ha.

Table 1. The Execution results of “The program of water–resources distribution concerning the adjustments of rice–paddy and upland crop fields”

| Maintain the domestic balance of rice supply and demand | The plantation areas of rice declined from $36.4 \times 10^4$ ha in 1997 to $26.9 \times 10^4$ ha in 2005, and $25.4 \times 10^5$ ha in 2011. The policy objectives of maintaining the domestic balance of rice supply and demand was achieved, |
| Stabilize the market prices | The annual average price per kilogram of Japonica Rice was $18.68$ for the previous 3 years by 2001, and increased to $22.12$ in 2009. It was reached the ideal state for adjusting the industrial structure of rice and stabilized the market prices effectively, |
| Ensure the income of farmers | The average farmer earning of 1st crop rice was $55,772$ for the previous five years by 2001, and increased to $60,407$ for the last five years. It was ensured the farmer’s income effectively, |
Reduce the domestic support for agriculture (AMS)

Reduced the AMS of the rice of public grain from 4.82 billion in 2001 to 2.77 billion in 2008. We compared the AMS in 2008 to the base year of 2001, the domestic AMS has dropped from 17.71 billion to 4 billion, a drop of 77%, reaching reduction goal.

Table 2. The Comparison of rice supply and demand of Taiwan for joining the WTO

<table>
<thead>
<tr>
<th>year</th>
<th>Area of Rice of Taiwan ($10^3$ ha)</th>
<th>Population of Taiwan ($10^3$)</th>
<th>Total Consumption of Taiwan ($10^3$ ton)</th>
<th>Total Supply of Taiwan ($10^3$ ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>importation</td>
<td>production</td>
</tr>
<tr>
<td>1991</td>
<td>429</td>
<td>20,286</td>
<td>1,519</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>332</td>
<td>22,278</td>
<td>1,269</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>307</td>
<td>22,396</td>
<td>1,273</td>
<td>144</td>
</tr>
<tr>
<td>2006</td>
<td>263</td>
<td>22,823</td>
<td>1,245</td>
<td>144</td>
</tr>
<tr>
<td>2009</td>
<td>255</td>
<td>23,042</td>
<td>1,243</td>
<td>144</td>
</tr>
<tr>
<td>2011</td>
<td>254</td>
<td>23,225</td>
<td>1,188</td>
<td>144</td>
</tr>
<tr>
<td>2012</td>
<td>260</td>
<td>23,316</td>
<td></td>
<td>144</td>
</tr>
</tbody>
</table>

Table 3. The plantation area and irrigation water of rice of TIA in 1995~2012

<table>
<thead>
<tr>
<th>year</th>
<th>1st crop-term</th>
<th>2nd crop-term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area of rice ($10^3$ ha)</td>
<td>Reservoir supply ($10^6$ m$^3$)</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>22.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>2005</td>
<td>9.2</td>
<td>129</td>
</tr>
</tbody>
</table>
Excluding the dry year, and to join the WTO in 2002 for the sector, the average rice area for 1st crop-term in 1995~2001 was 21.9×10^3 ha, the average reservoir supply was 185×10^6 m^3, meaning the average field irrigation depth was 848mm. The average rice area for 1st crop-term in 2002~2012 was 9.5×10^3 ha, the average reservoir supply was 139×10^6 m^3, meaning the average field irrigation depth was 1,455mm. After joining the WTO, the rice area had dropped to 43% of the original, and the reservoir supply and river supply were reduced to 75% and 73% in the meantime.

Comparing the field irrigation depth with the irrigation plan of TIA of 1,070mm, the field irrigation depth before joining the WTO was 848mm for the more rice area. To meet the demand for irrigation, the TIA need to perform more sophisticated rotation irrigation, as well as strict control of water distribution and improve the effective utilization of rainfall. After joining the WTO, the rice area had reduced significantly, and the field irrigation depth increased to 1,455mm, meaning the irrigation water was ample.

The TIA has the unique irrigation facilities of 284 ponds, and the total water storage was 4.6×10^7 m^3. It would coordinate with Shihmen Reservoir to store and regulate the irrigation water. In particular in the dry 1st crop-term, it could improve the efficiency of spring rainfall and delay or reduce the irrigation water supply for Shihmen Reservoir to save and store the water resources. Though the rice area had reduced significantly under the agriculture policy guiding, the decreasing ratio of the irrigation water was less than the rice area. But the abundant irrigation water would contribute to the environment during the wet season and lurk greater support capability for the livelihood and industrial water during the dry season.

For the examples of dry 1st crop-term in 2009 and 2011, the rainfall in Taoyuan area, was only 57% and 79% of the average of the last decade. The Water Resources Agency controlled the water allocation of Shihmen Reservoir from the beginning of the 1st crop-term. As the reservoir supply for irrigation was declined to 67% of the planning value, the TIA was required to support...
the Water Company for the livelihood and industrial water. The support amounts were \(22 \times 10^6\) m\(^3\) in 2009 and \(17 \times 10^6\) m\(^3\) in 2011. As the saving of irrigation water was \(54 \times 10^6\) m\(^3\) in 2009 and \(53 \times 10^6\) m\(^3\) in 2011, the real utilization of irrigation water was 53% in 2009 and 57% in 2011.

Table 4. Water Conservation of TIA in 2009 and 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Planned irrigation water demand ((10^6\ m^3))</th>
<th>Reservoir supply ((10^6\ m^3))</th>
<th>Support for Water Company ((10^6\ m^3))</th>
<th>Real irrigation water ((10^6\ m^3))</th>
<th>Real utilization of irrigation water</th>
<th>Water Saving ((10^6\ m^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>163</td>
<td>109</td>
<td>22</td>
<td>87</td>
<td>53%</td>
<td>54</td>
</tr>
<tr>
<td>2011</td>
<td>163</td>
<td>110</td>
<td>17</td>
<td>93</td>
<td>57%</td>
<td>53</td>
</tr>
</tbody>
</table>

4. The Medium–Term Project of Adjusting the Cropping System and Rearranging the Farmlands

The Council of Agriculture set the policy objectives for food self-sufficiency rate of 40% before 2020 in the "National Food Security Meeting" in 2011. For ensuring the food security, they will adjust the domestic agriculture production structure, and improve the using efficiency of agricultural land and water resources. The policy goals included mastering the international sources of food imports to strengthen the international agricultural investment and cooperation, building the food security classification management system, and mastering the food security stocks.

In order to reduce the international food supply risks caused by climate change, this agriculture policy would guide the farmers whose fields lying fallow for years to rehabilitate for one crop-term or rent to others to crop industrial crops. The recommended crops included the organic crops, regional specialties, import-substitution crops, and crops with export potential such as feed corn, soybeans, peas, lettuce, carrots, and short-term economic forest. It was expected to improve the domestic food self-sufficiency rate of 34.9% in 2016 and improve the total agricultural output value of 8.8 billion dollars, and also reduce the carbon dioxide emissions by 61,772 tons.

This project’s primary objectives are excellent farms lying fallow for all crop-terms by years. The recommended crops were drought-resistant crops whose irrigation demands less than the rice. We estimated the annual irrigation water demand for rehabilitation was \(6.46 \times 10^8\) m\(^3\). Comparing with the irrigation water supply last decade, the irrigation water demand will increase
to 16.8% in southern part of Taiwan as 6% in northern part of Taiwan. Although the irrigation water rights are able to support the current irrigation water supply plus the water demand for rehabilitation, the drought-support capability will decline relatively. There is a heavier burden for the management of water resources, in particular on the dry 1st crop-term.

The rehabilitated farm area was $12 \times 10^4$ ha in 2013 of the first year of the project. The increasing area of rice was $9.8 \times 10^4$ ha, the area of recommended crops just only $2.2 \times 10^4$ ha. Moreover, the main increased area was located in the area with higher risk of water shortage such as Taoyuan, Yunlin and Tainan. Therefore, the rice area for 1st crop-term was 12,275 ha in Taoyuan area, 132% for the last decade. We could classify the rice location according to the irrigation water source such as reservoir supply, rivers supply, and hybrid supply. The rice area and field irrigation depth of the TIA showed in Table 5.

Table 5. The Rice Area and Field Irrigation Depth of TIA in 2013 and the Last Decade

<table>
<thead>
<tr>
<th></th>
<th>Rice Area &amp; FID by Reservoir Supply</th>
<th>Rice Area &amp; FID by Reservoir &amp; River Supply</th>
<th>Rice Area &amp; FID by River Supply</th>
<th>Total Rice Area &amp; FID</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average 1st Crop-term in 2002~2012</strong></td>
<td>5,669 ha 1,371 mm</td>
<td>3,356 ha 982 mm</td>
<td>470 ha 5,847 mm</td>
<td>9,495 ha 1,455 mm</td>
</tr>
<tr>
<td><strong>1st Crop-term in 2013</strong></td>
<td>7,898 ha 893 mm</td>
<td>4,037 ha 795 mm</td>
<td>592 ha 4,957 mm</td>
<td>12,527 ha 1,054 mm</td>
</tr>
<tr>
<td><strong>Ratio</strong></td>
<td>130% 65%</td>
<td>120% 81%</td>
<td>126% 85%</td>
<td>132% 72%</td>
</tr>
</tbody>
</table>

*FID: field irrigation depth*

Due to the spring without rains, the rainfall within January to March on the watershed of Shihmen Reservoir was only 18% of the historical averages. The water elevation of the reservoir has been dropped from 244.6m as the full elevation on January 1st to 233m of March 12th. The effective storage of the reservoir has been dropped from 99% to 52%. The drought situation was more serious than the 2009 and 2011. Therefore, the Water Resources Agency controlled the water allocation of Shihmen Reservoir from March 1st, the reservoir supply for irrigation was declined to 75% of the planning value. Because of the significant increase in rice area, the TIA encountered several difficulties in irrigation water allocation. Fortunately, it rained as scheduled in early May, the reservoir supply satisfied the irrigation water as irrigation plan. The irrigation water supply for the whole 1st crop-term still satisfied 96% averages of last decade. While the field irrigation depth didn’t meet the planned depth due to the rice area increasing, the irrigation association will accomplish the irrigation plan with their experience of water management.
5. Discussion

In recent years in Taiwan, the greatest impact on agricultural water management in agricultural policy was “The program of water-resources distribution, concerning the adjustments of rice-paddy and upland crop fields” in 1997. This program was aimed at adjusting the structure of rice production and marketing in order to join the World Trade Organization. The plantation areas of rice were declined from $36.4 \times 10^4$ ha in 1997 to $26.9 \times 10^4$ ha in 2007. For the research area, excluding the dry year and joining the WTO in 2002 for the sector, the average rice area for 1st crop-term in 1995~2001 was $21.9 \times 10^3$ ha, the average reservoir supply was $185 \times 10^6$ m$^3$, meaning the average field irrigation depth was 848mm. The average rice area for 1st crop-term in 2002~2012 was $9.5 \times 10^3$ ha, the average reservoir supply was $139 \times 10^6$ m$^3$, meaning the average field irrigation depth was 1,455mm. After joining the WTO, the rice area had dropped to 43% of the original, and the reservoir supply and river supply were reduced to 75% and 73% in the meantime.

Though the rice area had reduced significantly under the agriculture policy guiding, the decreasing ratio of the irrigation water was less than the rice area. But the abundant irrigation water would contribute to the environment during the wet season and lurk greater support capability for the livelihood and industrial water during the dry season. For the examples of dry 1st crop-term in 2009 and 2011, the reservoir supply for irrigation was declined to 67% of the planning value, the TIA was required to support the Water Company for the livelihood and industrial water. The support amounts were $22 \times 10^6$ m$^3$ in 2009 and $17 \times 10^6$ m$^3$ in 2011. As the saving of irrigation water was $54 \times 10^6$ m$^3$ in 2009 and $53 \times 10^6$ m$^3$ in 2011, the real utilization of irrigation water was 53% in 2009 and 57% in 2011.

In order to reduce the international food supply risks caused by climate change and ensure the food security, the Council of Agriculture will adjust the domestic agriculture production structure, and improve the using efficiency of agricultural land and water resources. The medium-term project of adjusting the cropping system and rearranging the farmlands started in 2013. The rehabilitated farm area was $12 \times 10^4$ ha in 2013 of the first year of the project. The increasing area of rice was $9.8 \times 10^3$ ha, the area of recommended crops just only $2.2 \times 10^3$ ha. Moreover, the main increased area was located in the area with higher risk of water shortage such as Taoyuan, Yunlin and Tainan. The rice area for 1st crop-term was 12,275 ha in Taoyuan area, 132% for the last decade. Therefore, the field irrigation depth declined to 72%, in particular in the area of reservoir supply of 65%.
6. Conclusion

Targeting on the water-resources distribution concerning the adjustments of rice-paddy and upland crop fields following the accession to the WTO, the Water Resources Agency has been promoting related studies as well as projects, and has achieved preliminary results. However, for the comprehensive consolidation of the result, it is necessary to proceed with in-depth studies, in order for the successful distribution of agricultural water as an aid to the reliable public water-supply. Current implementation of the project as well as the fallow area was exercised by following the administrative system, that is, townships were responsible for execution under the supervision of county governments. However, when the goal on the saving of agricultural water is added, it is suggested to follow the local irrigation systems, that is, workstations or lateral would be responsible for the execution under the negotiation of irrigation associations. In other words, current regulations or procedures have to be reviewed and modified.

“The Medium-Term Project of Adjusting the Cropping System and Rearranging the Farmlands,” recommended the farmers to plant the less water-required crops such as organic crops, regional specialties, import-substitution crops, and crops with export potential for the original ideas and rehabilitated the fallows in the wet 2nd crop-term. But the actual rehabilitated fallows were rice paddy of 83%, and cropped in the dry 1st crop-term of 53%. The risk of water management for the dry season had increased. Due to the agricultural policy have considerable influence for farmer’s cultivation wishes, the agriculture agency should improve the management efficiency of farms and water resources in addition to consideration of the hydrological changes and crop yields adjusting.

References


• Tsai Tsan-Hsiung, “The Impact on Agricultural Water Demand Due to Partial Sabbath of Paddy Farming”, Department of Bioenvironmental Systems Engineering, NTU, 1996.


1. Country Profile

Myanmar, a South East Asian Country is situated in North Western part of Indochina Peninsula. Geographically it is located between 9° 32’ and 28° 31’ North Latitude, 92° 10’ and 101°10’ East Longitude. Generally, Myanmar topography is covered with the hilly and mountainous region, fertile river basin area, floodplains, coastal and delta area and low land area. While climatic conditions vary from extremely wet and humid to hot conditions depending on its topography. Due to such topographical and climatic condition, Myanmar is favorable for agriculture with the growing of diversification of crops and also seventy percent (70%) of the total population is residing in the rural area. So that, the agricultural sector in this country is not only of vital importance for food production but also a fundamental activity that dominates most people’s way of life. Therefore, any development in this sector has a significant impact on Myanmar society as a whole. In this context, the government is continuously striving to create opportunities so as to enhance agricultural development for ensuring the long-term benefit and improvement of socio-economic life of farmers, the majority of the population.

2. National Development Related Agriculture

Agriculture has always been the dominant sector in the Myanmar economy. It constitutes the core of the economy, represents 26% (2011 - 2012) of GDP, employs 61.2% of the working population and contributes over 16% of export earnings.

The present situation shows that, the country produces enough food to supply its people and exports the surplus by using abundance natural resources. The total land area is 67.7 million hectares, the cultivable land represents 26% of total area, 17.6 million hectares of which only about 11.92 million hectares is the net sown area.

Among them, for the expansion of new agricultural land, the remaining 0.32 million hectares of fallow land and 5.37 million hectares of cultural wasteland can be developed. Most of the

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agricultural land, which is about 8.02 million hectares, is currently cultivated by small-scale farmers and the average size of holding is 2.4 hectares. About 56% of the total sown area of 13.8 million hectares is small-scale farms which average size is less than 1.56 hectares.

And also, Myanmar is rich in water resources potential in which surface water is about 1082 km$^3$ of water volume per annum from a drainage area of about 738,230 km$^2$ while groundwater potential is about 495 km$^3$ in eight river basins in the country. As a part of water resources utilization in the agriculture sector, a number of 240 irrigation dams have been completed, further increasing the irrigable area of 1.15 million hectares (March, 2013).

Nowadays, the Government put forward continuous efforts to forge the pathways for supporting communities to transition from subsistence to commercial agriculture for the foundation of nation’s economy as well as improvement of socio-economic life of the rural population. Moreover, in order to achieve the first goal of Millennium Development Goals (MDGs) that is to reduce poverty level of 26% down to 16% by the year 2015, agricultural sector development plays a major role in reducing poverty.

In this circumstance, agricultural development plan lay down in line with national development plan by focusing on several approaches to promote agricultural productivity including, development of land resources of agricultural expansion, provision of adequate irrigation water for agricultural purposes, support for agricultural mechanization accelerated transfer of improved new technologies, development and utilization of high yielding quality seeds, provision of new farmland law, support for value chain technology, financial support, and encourage the investment in agricultural research.

3. Case Study of Comprehensive Agricultural Development

3.1. Project Background

The project focuses on creating a comprehensive agricultural development, through the implementation of a land development project in Nay Pyi Taw at the southern tip of the central dry zone. It introduces modernized farming in the area in accordance with improving the equity of irrigation water distribution, improving field access for machinery and transport, initiating the Good Agriculture Practice (GAP) in the area, enhancing a participatory approach to land development, the provision of a range of services and knowledge for smallholder farmers, and the building of institutional and technical implementation capacities at community, township and regional levels.
3.2. Project Area

The project area is located in Dekkhina Thiri and Leway Township, Nay Pyi Taw within the command area of two existing irrigation networks, namely Yan Aung Myin Dam and Ngaleik Dam. Agriculture practice in that area is rain fed rice cultivation as first crop and oilseed crops, industrial crops and vegetables are as second crops. Because this area is in a semi-arid region and due to climate change impacts on the area, most of the rainfed rice field areas depend on irrigation. The project area is about 1214 hectares and it involves seven village tracts with more than one thousand farmers household involves under project area.

3.3. Implementation Process

As a part of applying the modern technology, the government initiates the first operation to pilot a sustainable agricultural development model in Nay Pyi Taw through land development activities. The main objective of the project is to enhance the transformation of commercial agricultural productivity and improve on the socio-economic life of the rural population.

Land reclamation and consolidation includes land leveling to improve land and water use efficiency and crop productivity, rehabilitation and lining of main canals and distributaries, construction of tertiary irrigation canals required for improved on-farm water distribution and water saving, construction of drainage canals for improving of agricultural productivity and controlling the quality of soil, and construction of farm roads to provide easy access to the plots and use easily access farm to market for the reduction of post-harvest loss.

In the project area, farm plots sizes are particularly small, irregular in shape and average household landholding within the areas are around 2 hectares, so, that is limited access to productive assets.

Due to the project, irregular farm plot change into typical farm plot as 0.406 hectare (one acre) with a distance between farm roads of about 254 m, road width 3.6 m. In general, it is a good practice to initiate the land consolidation from the upper reaches of the water resource as the availability of irrigation water during the dry season for maximizing crop intensities in the areas.

Land development activities for the transformation from conventional agriculture to mechanized agriculture are being undertaken as follows:-

a) Construction of farm-land roads

b) Rehabilitation of main and tributary canals and Construction of drainages and tertiary canal for irrigation purpose

c) Transforming small plots into one-acre plots
d) Making it possible for farmers to afford and have access to Agricultural Machineries by facilitating the purchasing process of machinery through the introduction of installment payment procedures

The project is implemented by the of Ministry of Agriculture and Irrigation in synergy with line departments as Irrigation Department (ID), Agricultural Mechanization Department (AMD), Settlement and Land Records Department (SLRD), and General Administrative Department, Nay Pyi Taw Council. It should be noted that, not only Government Organizations support these projects, there is also support from the private sector farmers’ groups. Moreover, ID organizes Farmer Friends (FF) in order to assist both the government organization and farmers. The FF plays an intermediary role for sharing knowledge and disseminating information between the farmers and Government organizations. They also assist by sending Reports concerning farmers’ needs to the officials concerned. As a result of FF participation in Land Development works, there have been improved understanding and transparency among stakeholders. This understanding has also led to the smooth implementation of land development works.

3.5. Issues and constraints

This project was implemented in (2012-2013) fiscal year and its function started in last year monsoon paddy cultivation season. As such, land development work has little experience and it still needs to tackle some barriers for harmonizing national development plan and agriculture sector development.

In land development works, farmer participation in farm plot reallocation is essential and coordination of farmers themselves is also necessary for daily management and operation of the farm road, irrigation canal, and drainage canals. In order to take these responsibilities, farmers’ organization should be officially established for sustainable functioning. For that, farmer participation should be enhanced.

Due to the project, farmers can easily and effectively introduce agricultural machinery and control irrigation water, whereby the crop yields can considerably increase than ever before. However, basic investment cost is high such that, it is very necessary for farmers to have access to financial services including the government budget, international partners and local associations.

Moreover, it is noted that the following factors are also taking into consideration. They should expand microfinance and rural finance operations in rural areas and they should be made public for farmers. They should enhance the use of agricultural facilities, establish finished products facilities and create links with both local and International markets.
4. Lessons Learned

Before the commencement of land consolidation work, farm plot reallocation plan needs to be established and agreed by all concerned farmers. To prepare the plot reallocation plan, the concerned agency should provide information to the management committee about the acreages to be occupied by new farm road, irrigation canals and drainage canals to be constructed under this consolidation works. The loss of the land ranges from 5% to a maximum 10% in most cases based on the projects so far implemented.

Farmland consolidation requires mutual understanding and collaboration between the implementing organization and beneficiary farmers from the initial stage of planning. Furthermore, better circumstances among the stakeholders will enhance farming activities. A participatory approach is essential for implementation, such that stakeholders’ involvement will be encouraged in project planning and implementation.

Increased cropping intensity has expanded the use of machinery in agriculture from land preparation to harvesting. Required machinery are being produced and assembled locally or imported for distribution to the farmers.

At present, the initial cost of machinery is very high for farmers so that the government fully provides capital investment including the purchasing of machinery and implementation of farmland consolidation. After implementing the land consolidation, the government together with private companies provides rental services of farm machinery to be used easily in mechanized farms at the village level.

Private sector participation is encouraged by using the machinery and equipment for various activities in terms of materials, loans and technology in sustaining agricultural development.

Moreover, this project supports capacity building, especially for small-scale and poor farmers by providing services to facilitate the adoption of new technologies and practices.

5. Results and discussions

Farm mechanization has benefited the farmers in terms of time, labor and human energy savings. In addition, it has contributed to increased cropping intensity of the project area. As a result of monsoon paddy and summer paddy cultivation, cropping intensity has increased about 50% in the project area.

By increasing utilization of agricultural machinery along the production process, it has led to the reduction of losses and wastages from land preparation to harvesting. And also, farmers can
access post-harvest facilities such as a dryer, silo etc. so it helps to reduce post-harvest loss as well.

Farm road can be used to enable easy access to field lots from relevant farmers, villages and thus enhance socio-economic conditions of the remote area through improved transport means from fields to markets and village to village as well.

After the implementation of land consolidation, former ill-drained paddy fields become well-drained fields with a resultant change in improving water use efficiency, enhancing water saving and reuse of irrigation water is practiced in various forms for securing additional water. Due to the sufficient irrigation and drainage canals, on-farm level water management is appropriate for improving productivity and water usage can be reduced to 20%. Moreover, farmers can create an opportunity to increase their productivity by growing double and multiple crops. It will not only be a fast gain for farmers through the increase of crop production but also for the increase of per capita income and job opportunities.

6. Conclusion

For many years, the government incessantly puts efforts on agricultural sector development in line with vertical and horizontal approaches, including expansion of land area, promotion of irrigation water management, provision of financial and technologies despite its own limitation. However, it still needs to modify a concrete and comprehensive development plan which should be emphasized not only on improving technologies for land and water utilization practice but also on upgrading postharvest technology and to anticipate future market conditions as well as create access into those markets for small-scale and marginal farmers. Nevertheless, in order to cover land development in a country, it is necessary to create potentials for systematic expansion, replicating, adapting and sustaining successful investments through its investment tools, and funds from local and international partners.

References

• Myanmar Agriculture in Brief 2013

Abbreviations

• ID: Irrigation Department.
• AMD: Agricultural Mechanization Department
• FF: Farmers Friend
• SLRD: Settlement And Land Records Department
• GAP: Good Agricultural Practices
1. Introduction

1.1. Background

A majority of the world’s poorest people live in Asia. Of course, some Asian countries like Japan and South Korea are not poor as others like India, Bangladesh, Cambodia, etc. Causes of poverty in these countries are the pressure of excessive population growth on scarce resources; inadequate support for education, medicine, clean water and sanitation; poor land ownership pattern; and comparatively less foreign investment. Some of Asia countries have shown good progress on poverty reduction in recent years, like China and Malaysia (in China good progress was notably helped partly by control on population growth). Majority of the populations of developing countries are dependent on agricultural productions for their livelihoods. Asian farmers need to use more fertilizers, quality seed and developed intercultural practices but they are expensive and not available as expected for many of them to use in these countries.

Asian Development Bank (ADB)’s efforts and strategy to achieve food security in the region are outlined in the 2009 Operational Plan for Sustainable Food Security in Asia and the Pacific. The plan puts emphasis on the integration of agricultural productivity, market connectivity, and resilience against shocks and climate change impacts as the three pillars to achieve sustainable food security. ADB has committed $2 billion a year for 2010–2012 to the goal.

According to the FAO, global production will need to increase by 40% by 2030 to keep pace with global demand. Investment requirements for a more efficient and effective food supply will be huge, considering the decades of under-investment in the agricultural sector.

Irrigation becomes the most inseparable part of enhanced agriculture production particularly in rice. Asia faces an acute water shortage. By 2030, demand for water is anticipated to exceed supply by 40%. Since 80% of water is used for agricultural production, lack of water leads to

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lack of food. To grow more food with less water in the region, the productivity of water will need to be improved substantially, through more efficient and sustainable management of water.

**Agricultural mechanization** implies the use of various power sources and improved farm tools and equipment, with a view to reduce the drudgery of the human beings and draught animals, enhance the cropping intensity, precision and timelines of the efficiency of utilization of various crop inputs and reduce the losses at different stages of crop production. The end objective of farm mechanization is to enhance the overall productivity and production with the lowest cost of production. The contribution of agricultural mechanization has been well recognized in enhancing the production together with irrigation, biological and chemical inputs of high yielding seed varieties, fertilizers, pesticides and mechanical energy. Indian, Bangladesh and a few other countries Green Revolution is regarded as one of the greatest achievements of the 20th century. It has been adopted at a large scale benefiting small, medium and large size farms. Some of its aspects such as its impact on human labor employment in a labor-abundant economy have always evoked sharp responses from the policymakers. Several studies have been conducted on the impact of agricultural mechanization on production, productivity, cropping intensity, human labor, employment as well as income generation. Different researchers have concluded that farm mechanization enhances the production and productivity of different crops due to the timeliness of operations, better quality of operations and precision in the application of the inputs.

<table>
<thead>
<tr>
<th>Crop</th>
<th>1969</th>
<th>2009</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar Cane</td>
<td>538</td>
<td>1661</td>
<td>209%</td>
</tr>
<tr>
<td>Maize</td>
<td>270</td>
<td>819</td>
<td>203%</td>
</tr>
<tr>
<td>Wheat</td>
<td>309</td>
<td>686</td>
<td>122%</td>
</tr>
<tr>
<td>Rice, paddy</td>
<td>296</td>
<td>685</td>
<td>131%</td>
</tr>
<tr>
<td>Cow Milk</td>
<td>358</td>
<td>583</td>
<td>63%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>278</td>
<td>330</td>
<td>19%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>71</td>
<td>249</td>
<td>251%</td>
</tr>
<tr>
<td>Cassava</td>
<td>95</td>
<td>234</td>
<td>146%</td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>217</td>
<td>227</td>
<td>5%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>42</td>
<td>223</td>
<td>431%</td>
</tr>
</tbody>
</table>

Source: FAO
Irrigation is a vital component of agricultural production in many developing countries. From 1997-99, irrigated land provided two-fifths of crop production in developing countries, and accounted for about one-fifth of the cultivated area. The divergence in these statistics reflects the high crop yields and multiple cropping that is achieved through irrigation.

Agriculture is the largest user of water in all regions of the world except Europe and North America. In 2000, agriculture accounted for 70 percent of water withdrawals and 93 percent of water consumption worldwide. To grow daily food needs people and requires 3000 litres of water per person per day. Agriculture, particularly, rice cultivation, is vital to the well-being of the region. Asia produces and consumes around 90 percent of the world’s rice, according to FAO.

Increased demand for food in developing countries will be offset at a national level, to various extents, by increased agricultural production. A 61 percent increase in annual cereal production is expected to occur in the period 1997/99-2030. With the exceptions of sub-Saharan Africa and Latin America (where rainfed agriculture has greater significance), irrigated agriculture will provide much of this increase. In developing countries collectively, irrigated agriculture will provide 57 percent of the additional 256 million tons of cereals that will be produced in 2025 relative to 1995. Irrigation increases agricultural production through both the expansion of cultivable area beyond that possible under rainfed agriculture and higher crop yields.

Productivity in agriculture is the ultimate output of modern agronomy, plant breeding, agrochemicals such as pesticides and fertilizers, and technological improvements have sharply increased yields from cultivation, but at the same time have caused widespread ecological damage and negative human health effects. Selective breeding and modern practices in animal husbandry have similarly increased the output of meat, but have raised concerns about animal welfare and the health effects of the antibiotics, growth hormones, and other chemicals commonly used in industrial meat production. Genetically modified organisms are an increasing component of agriculture, although they are banned in several countries. Agricultural food production and water management are increasingly becoming global issues that are fostering debate on a number of fronts. Significant degradation of land and water resources, including the depletion of aquifers, has been observed in recent decades.

FAO urges Climate Change issue as an emerging and a major threat to food security and governments need to find “creative solution” and “alternative approaches” in order to deal with the challenge. Changes in air temperature and rainfall as well as more frequent floods and droughts will have long-term effects on the viability and productivity of world agro-ecosystems. In anticipation of these challenges, the agricultural system needs to adapt to changed conditions
and specific stresses. One way of doing this would be introducing crop varieties that can tolerate heat and water stress.

A major shift in agricultural method and their environmental impact is urgently required protecting productivity and food security in the future. Agricultural practices are often responsible for environmental degradation, such as non-sustainable food production, poor fuel use, natural resources depletion and habitat exploitation.

Comprehensive agricultural development refers to the capacity building of land resources for productivity; and strengthening agricultural ecological balance and support capacity of scientific and technological aspects of the farmers (Rao, 2013). Farmers in developing countries cannot address all these aspects of comprehensive agricultural development due to low or poor capacity in technical know-how, attitude and poor financial capacity.

Soil fertility and its sustainability for crop production mostly depend on the status of organic matter of the soil. Due to the intensive and continuous cultivation of the crop, soil organic matter is gradually depleting particularly in developing countries. The sources of organic matter are cow dung, compost, crop residue, farmyard manure, green manure etc. But most of these organic matters are not sufficiently available to satisfy the requirements in many cases. Adding organic matter by growing green manure crop alone is not possible because the poor farmers do not have sufficient land for growing the same by sacrificing their food crops (Bhuiya and Hossain, 1993). The existing cropping systems in a number of developing countries are rice based. The organic material like manure from straw or cow-dung is applied scantily in a paddy field.

Stresses on agricultural soil and water bodies are evident in a number of developing countries for intensive cultivation and excessive use of chemicals for agriculture production. Cultivation and application of green manure for rice have been studied at different institutes, but there are very little farmer’s fields in which green manure crop is cultivated or applied to rice crop.

Use of Fertilizer-Irrigation-Seed (FIS) technology has resulted in the break-through in cereal production in a number of countries in South East Asia in the late sixties and early seventies. But continuous crop cultivation especially cereal production puts stress on the agricultural soil as agricultural soil does not give enough scope to retain its organic matter content. As a result of higher Cropping Intensity (CI) improper cropping sequences and faulty management practices, depletion of soil fertility took place.

The modern rice crops are heavily fertilized to get high returns but not all fertilizers are used by crops. A typical crop response to the application of fertilizer indicates that the rate of
utilization of fertilizer falls in the heavily fertilized land. As a result, large quantities of nitrogen and mineral fertilizers are drained out to surface water. These also leach into groundwater or get absorbed into the soil in chemically unusable forms, particularly in soil having inadequate humus. The changed soil condition reduces fertilizer absorption by plant tissue. The excess nitrogen and phosphorus in water body deteriorate water quality and affect aquatic life. The residual fertilizers infiltrate into the soil with irrigation or rain-water and percolate a long way to join groundwater. Leaching of water from fertilized land is one of the major sources of nitrate pollution. A study of Bangladesh Water Development Board (1984) shows that 49 of the 136 wells had nitrates in excess of 0.5 mg/l. A total of 10 wells contained nitrate exceeding 20 mg/l.

Pests and disease controls are essential parts of modern agriculture to protect crops but these create the biggest impact on the environment. The danger of high concentrations of pesticides in soil arises from fertile soils that contain many living organisms. One pound of rich farm soil contains up to one trillion bacteria, 200 million fungi, 25 million algae and 25 million protozoa, as well as worms, insects and mites. They fix nitrogen for continued fertility of the soil, make minerals available to plants, retain moisture, aerate the soil and bring about the essential process of decay. Studies have shown that some chlorinated pesticides seriously inhibit nitrification by soil bacteria. Run-off after heavy rain on agriculture land may increase the concentrations of pesticides in river and water bodies. In river water at 45°F a concentration of 1.4 ppb of endrin will kill half the fish population. Most species of fish cannot survive insecticides in a concentration greater than about1-10 ppb (Bhuiya and Hossain, 1993).

Traditional biomass fuel is being continuously over-exploited in developing countries. The continuous diminishing of biomass fuel adversely affects the fertility of land as agricultural wastes are withdrawn for fuel and other uses (GoB, 1985). A study in Bangladesh shows that in part of the North-Western Region with droughty sandy ridge soil is poor in organic matter, symptoms of on-going desertification can be observed (Jansonius and Khan, 1994). So, conservation efforts are needed for certain resources due to their overexploitation. Ecological farming may be one of the most important options to cope with the situation.

1.2. Objective: The objectives of the present paper are to

a) review the performance of the comprehensive agricultural project; and
b) document a few well-developed models of rural development.
1.3. Importance of the Comprehensive Agriculture Production

Ecological farming is one of the well-accepted comprehensive agricultural production systems which emphasizes on the use of internal resources of the agricultural production system; advocating the use of more organic manures; and alleviating pollution of the environment by chemicals and fertilizer. Continuous and excessive use of fertilizer reduces the fertility of soil, in general. On the other hand, use of insecticide for crop cultivation destroys vast breeding areas of fishes and pollutes the groundwater resources. Ecological farming prescribes rational utilization of fertilizer and chemicals; and promotes the application of more organic matters. This type of control or more use of organic items in farming activities may bring an environmentally suited and economically viable farming system.

1.4. Methods Adopted to Prepare the Paper

This paper has been prepared by mostly reviewing secondary materials. Secondary materials mainly include the findings of a number of studies and reviewing of literature.

2. Results and Discussions

2.1. Ecological Farming

The traditional agricultural farming systems in Bangladesh include the elements like crop, livestock, fisheries, homestead and agroforestry. Livestock is an essential component of crop farming, supplying a part of draught power required for land cultivation, threshing and transport. In many parts of the world, livestock rearing serves as a critical counterpart to crop production and keeping farms ecologically balanced. In the recent past, the importance of agricultural farming system particularly crop-livestock interaction has been emphasized. Through farming system, locally available labor, feed and other resources are properly utilized and the system thus increases the production of cereal crops, vegetables, meat milk and eggs and also creates employment opportunity. Sustainable rice-livestock-fish farming provides economic, social and ecological benefit to the farmers (Hossain et al., 2000).

The most recent innovation in Chinese agriculture is a push into ecological farming. This rapid embrace of ecological farming simultaneously serves multiple purposes, including food safety, health benefits, export opportunities and by providing price premiums for the produce of rural communities. In the mid-1990s China became a net importer of grain, since its unsustainable practice of groundwater mining has effectively removed considerable land from productive agricultural use.
Ecological farming is a new production system which developed on the basis of the principles of ecology and economy of ecology. It is the combination of traditional agriculture, and practices and experiences of modern agriculture. Ecological farming is characterized by its comprehensiveness, productivity, stability, sustainability, diversity and organicalness (Zhengfang, 1996).

1) Components of Ecological Farming: This production system in ecological farming has six distinct characteristics. These are Comprehensiveness, Productivity, Stability, Sustainability, Diversity and Organicalness.

a) **Comprehensiveness:** Agricultural production systems which fulfill the combined production of agriculture, meeting up the requirements of society, available resources, existing environment and different productions methods. Comprehensive steps have to be taken for management and production in this farming.

b) **Productivity:** It means that it ensures more productivity of land, labor, energy and resources compared to the traditional production of agriculture. More production and more benefit and convenient environment are the core outputs of ecological farming.

c) **Stability:** Stability means “keeping productivity almost similar”. In this process the production takes place in cyclic manners through rationale infrastructures and comprehensive works which ultimately ensure comparatively more stability in the production system.

d) **Sustainability:** The capability of keeping the productivity similar in comparatively unfriendly environment mainly indicates the sustainability of the production systems. Different items in farms keep cycles in its production system which enables sustainability of
the production system. The factors concerned with sustainability in this production systems include i) deterioration & soil quality, ii) genetic diversity, iii) change of environment, iv) keep productivity in growth, v) pest management and vi) bring change of weak production system

ea) **Diversity:** Rational use of available natural resources in the production system. So, diversity and characteristics of agriculture vary from place to place in its production system. It also depends on the available natural resources in a particular area. So, the process of developing ecological farming varies widely from one place to another. Incorporation of more components in a particular ecological farm provides more diversified outputs. Ecological farming and its components in one area may not be similar to another area.

f) **Organicalness:** Maximum utilization of available resources in the farm has got priority in this production system and at the same time this production system discourages dependency of inputs from outside. So, pollution can be reduced by using organic dominant inputs and not using chemicals and pesticides.

2) **Process of Developing Ecological Farming**

The process of developing ecological farming varies from one place to another and dependent on available natural resources of a particular area. It also requires farmer’s skill and management ability to incorporate more components in the production cycle so, that more diversified outputs can be achieved from the same farm. Capacity building of both the service provider to the farmers and the farmers themselves are crucial inputs to adopt this unique agricultural production system. As outputs of different components of ecological farming are more compared to traditional agriculture so, this farming system can help in poverty reduction and improvement of livelihood of the poor farmers in developing countries.
Figure 2. Example of Recycling System of Guquan Ecological Farm, Nanjing, Jiangsu Province, China

Figure 3. Example of Cycling Technique Adopted by Farmers in Jiangsu Province, China
3) Difference between Ecological and Organic Farming

**Organic farming** is a form of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control. Depending on whose definition is used, organic farming uses fertilizers and pesticides (which include herbicides, insecticides and fungicides) if they are considered natural (such as bone meal from animals or pyrethrin from flowers), but it excludes or strictly limits the use of various methods (including synthetic petrochemical fertilizers and pesticides; plant growth regulators such as hormones; antibiotic use in livestock; genetically modified organisms; and human sewage sludge) for reasons including sustainability, openness, independence, health, and safety.

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ecological Farming in China</th>
<th>Organic Farming in the West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>Comprehensive agro production System with intensive management of principles of economics.</td>
<td>Agri. production System using no synthetic fertilizer and Chemicals.</td>
</tr>
<tr>
<td>Range</td>
<td>Agricultural forestry, Animal husbandry, Subsidiaries of fisheries.</td>
<td>Mainly crop plantation and animal husbandry.</td>
</tr>
<tr>
<td>Productivity</td>
<td>Higher Yield and profit</td>
<td>Yields lower than conventional Agriculture.</td>
</tr>
<tr>
<td>Techniques in use</td>
<td>Complicated and diversified</td>
<td>Relatively Simpler</td>
</tr>
<tr>
<td>Input of labor</td>
<td>More than organic farming</td>
<td>More than conventional agriculture</td>
</tr>
<tr>
<td>Organicalness</td>
<td>With organicalness</td>
<td>Pure organicalness</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Stability</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Organization of Management</td>
<td>Supported by Government at the very beginning</td>
<td>Gradually get the support from the government</td>
</tr>
</tbody>
</table>

4) Summary Findings of Studies on Ecological Farming in Bangladesh

Ecological farming played a key role in the huge growth of agricultural productions in China in the nineties. It is realized that this system of farming among others was one of the pioneering interventions for economic development of the country. Ecological farming is now used by the farmers of different countries like Egypt, Thailand, Bangladesh and etc. An inventory was taken
from a number of studies carried out in Bangladesh to assess the opinion of different stakes of agricultural production system about the importance and adoption of ecological farming. A few of the study findings are given below:

a) Twenty percent of the farmers in Comilla Sadarsub-district are aware of ecological farming. They feel that ecological farming is very important to keep soil fertility. They know that fertilizer deteriorates soil quality in terms of fertility and structure. The increasing trend of cropping intensity needs more nutrients to be supplied in agricultural land. As manures are scarce and fertilizers are readily available, so farmers use fertilizers for their crops.

b) The production capabilities of the fish decrease due to excessive use of fertilizer in agriculture field which drains into nearby water bodies. Besides, farmers feel that the main reasons for less production of fish is ascarcity of water in river, lakes and canals, etc. in the dry season.

c) Insecticides are widely used in different crops. Farmers directly buy insecticides from the market and use the same in their crops. Excessive insecticide is used in vegetables. Farmers do not adopt another method to control insects in the field. Farmers responded very little in adopting Integrating Pest Management (IPM).

- Farmers use a systemic insecticide in their vegetables which have long-lasting residual effects. They use 3-4 times more doses of insecticide than prescribed doses in their vegetable crops. Systemic insecticides have the residual effect of about one month after application. But farmers harvest their vegetables even in the same day after application of insecticides and carry those to the market. The residuals effects of these insecticides turn dangerous when harvested vegetables are kept in freezing temperature.

- Again farmers sometimes used insecticide for catching all the fish in their ponds. Fish caught by using insecticide has residual effects and can cause disease in the human body.

d) Increasing use of fertilizer weakens soil structures of agricultural land. Infiltration capacity of the soil is increasing and at the same time water holding capacity of the soil is decreasing. It is difficult to say whether excessive use of fertilizers causes this hazard for agricultural land or not. But it is known that if excessive fertilizer is used in clay soil, it loses structures of soils.

e) Well planned cropping pattern is instrumental in developing soil fertility. The diversity of rice dominated cropping pattern to non-rice dominated cropping pattern is necessary for the present situation. A number of farmers in the village adopt cropping pattern according to their own initiative. Besides, it is thought that if agricultural land is given rest for one season, the
strength of soil would increase. But increasing demand for agricultural output and high
dependency on agricultural lands prevent farmers not to give rest of their agricultural land.

f) Water is getting polluted from increasing use of insecticides. Some of the villagers think that
water of hand tube wells (HTs) is not safe and they boil water before drinking. Many of the
villagers think that increasing use of insecticides pollutes soil and groundwater.

g) Production of fish decreased significantly compared to that of the level of three decades ago
because of the use of insecticides in agricultural land. Farmers also said that, scarcity of water
was another major cause of decreasing fish production in the dry season.

h) The water holding capacity of soil has decreased. Besides, the water table of the area has
gone down. Hand tube wells of the villages have been becoming dry in the peak of the dry
season since last year.

i) There are some problems of drainage in the villages. Losses of crop due to drainage problem
occur during very high precipitation. The number of the culvert is inadequate compared to the
required number. Sometimes this standing water causes damage to the crops. Unplanned and
inadequate physical infrastructures like rural roads and culverts create problems in
agricultural productions.

j) Per unit area of production of crops remained almost similar in the last one and half decades
but the use of fertilizers increased up to seventy percent compared to the previous dose in the
same period. This is a quite unsustainable agricultural production system.

k) The attack of pests and diseases on agricultural crops increased manifolds compared to that
of three decades ago.

l) Farmers are aware of ecological farming. But high cropping intensity, less availability of
manures and compost, increasing the attack of pest and disease etc. limit them to adopt
ecological farming.

m) To motivate farmers about the adoption of ecological farming, training courses are needed to
be organized. Besides, a demonstration of ecological farming may help farmers to accept the
idea of ecological farming.

n) Sharecroppers prefer the use of fertilizer for crop production than that of cow dung because it
is voluminous and difficult to carry. Whereas farmers utilize cow dung when they cultivate
their own land. Also the lease arrangement limits the sharecropper in using cow dung on the
land as the benefit of using the same would be realized after sometime and would be derived
by the landowners.
o) The package FIS technology has brought a revolutionary change in the field of crop production. But excessive use of fertilizer for producing high yielding varieties of crops and for adopting high cropping intensity reduces soil fertility, in general.

p) Water gets polluted from the insecticide used in crops. But farmers feel that, the effect of insecticide can kill small fish only. They mentioned that Basud in 10G and 14G were harmful insecticides to the beneficiary soil insects and micro-organisms. Farmers in the villages do not use Basud in 10G and 14G. On the other hand, Dimacron - another insecticide has very less side effect and works as fertilizer too. Use of Dimacron is very common in Joypur (North) village (Ahsan et al., 1996).

2.2. Small Scale Surface Water Management for Local Development

Irrigation and drainage management through village-based organizations for enhancing crop and fish production and employment generation can be a model for local development in developing countries. Plain lands characterized by flood every year in the monsoon and scarcity of water in the winter and drainage congestions either in monsoon or round the year are suitable for applying this model. Macro-level interventions of constructing long flood control embankments and supporting structures although brought immediate benefit in some cases but become development disasters in a number of cases in the past. In addition, this type of development works could not bring local development or create an environment for local resource mobilization or ensuring local people’s participation in adopting development works for their own which is considered as the essential requirement for sustainable development.

1) Development of Project

The Small Scale Water Resources Development Project of Bangladesh was implemented during 1997-2002 in its first phase and 2002-2009 in its second phase with the objective to achieve a sustainable increase in agricultural production and income by small farmers in the project areas and which in turn has an impact on poverty reduction of the area through surface water management. All the development works have been implemented keeping the village-based organizations as the focal points. The project areas are located in western Bangladesh (where the standard of living was much lower than the eastern part). These achievements through the project can be categorized into three outputs: i) Beneficiary Participation and Water Management Association Development, ii) Development of Small-Scale Water Control Systems and iii) Institutional Support for Small-Scale Water Resources Development. The Second Small-Scale Water Resources Development Project which commenced in 2002 completed in 2009. This has developed 275 subprojects in 61 out of 64 districts of the country. Only three hill districts of Chittagong were not included in the project. The Project supported the development of Water
Management Cooperative Associations (WMCAs) that include landowners, land operators, women, fishermen and other vulnerable groups. The WMCAs have social and technical capital to undertake small-scale water resources (SSWRs) subprojects and improve the system of operations of water control structures.

2) Objectives

The main objective of this intervention was to develop socio-economic conditions of the villagers with the optimum use of available water resources through management development and ensuring people’s participation. The specific objectives of the project include: i) develop village-based water management society and ensuring participation of the villager in planning and development water management with due consideration of rural poor; ii) provide institutional support for Small-Scale Water Resources Development; and iii) develop small water control systems according to the need of local areas for developing the socio-economic condition of rural people.

3) Achievements in Brief

A total of 273 subprojects out of 280 had been completed in the first phase of the project and these are now operational. The completed subprojects were mainly a combination of Flood Control and Drainage (FCD) (58 percent), Drainage (DR) (17 percent), and Water Conservation(WC) 16 percent).

It has been evident from the evaluation that the project: i) could increase paddy (over 15,000 MTs per annum) & fish production (250 MTs per annum) and ii) efficient in farms of resources utilization & employment generation in the project area. Increased crop and fish production have generated tangible benefits for the village-based organizations such as poultry raising, kitchen gardening, livestock rearing & beef fattening, tree plantation and employment generation for the poor. Better household incomes enable poor households to take advantage of education & health and social services in their villages. In addition, the rural poor could build access to credit through the micro-credit programme of the organizations. Another important achievement of the project was to institutionalize the participation of beneficiaries in small-scale water development activities of the area. The linkages build up with Department of Agriculture Extension (DAE), Department of Fisheries (DoF), Department of Cooperative (DoC) etc. at the sub-district (Upazila) level helped these organizations to build their capacity in terms of getting training and other support and services on sustainable basis (Ahsan, 2012).
2.3. Well-Developed Model of Rural Development

1) Rural Development in SaemaulUndong

Green Revolution under SaemaulUndong in South Korea took place in two phases. The first phase (1970-75) focused on village modernization. In this phase materials were given to villages for self-improvement. SaemaulUndong Training Centres were setup to train and indoctrinate leadership. Integrated rural development ideology of Korea was used as a culture of cooperation at the local level to raise enthusiasm and mobilize contributions and participation among the villagers.

In the second phase (1972-78), the focus was concentrated on agricultural development. The green revolution took place in this phase in Korea. Effective agricultural extension service, the active role of rural cooperatives and mechanization in agriculture took place in this phase. Adoption of high yielding varieties of grains was termed as green revolution phase of SaemaulUndong. Farmers adopted mechanized farming to a great extent in this phase. The third phase of SaemaulUndong (1973-1977) dealt with the expansion of SaemaulUndong concept to non-agriculture and cities.

The SaemaulUndong had many laudable achievements (Table 3). Village modernization took place in most villages to materially improved living standards. The added focus on subsidized grain production tremendously increased rural incomes. Along with previously accomplished land reform, the programmes and project associated with the SaemaulUndong greatly reduced the most extreme forms of rural poverty, even though poverty remained widespread. Tiles replaced thatch roofs; village roads were widened and resurfaced; and stream embankments and irrigation facilities were substantially improved. Rural households had cooperative savings accounts to help finance purchases of durable goods and farm inputs like television sets as well as farm equipment and inputs (Douglas, 2013).

Table 3. Village Improvements through the SaemaulUndong, 1970

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Unit</th>
<th>Objective</th>
<th>Performance</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expanding Village Roads</td>
<td>Km</td>
<td>26,266</td>
<td>43,558</td>
<td>166%</td>
</tr>
<tr>
<td>Constructing New Agricultural Roads</td>
<td>Km</td>
<td>49,167</td>
<td>61,797</td>
<td>126%</td>
</tr>
<tr>
<td>Installing Small Bridge</td>
<td>Unit</td>
<td>76,749</td>
<td>79,516</td>
<td>104%</td>
</tr>
<tr>
<td>Constructing Village Centres</td>
<td>Unit</td>
<td>356,608</td>
<td>37,012</td>
<td>104%</td>
</tr>
<tr>
<td>Building Warehouses</td>
<td>Unit</td>
<td>34,665</td>
<td>22,143</td>
<td>64%</td>
</tr>
<tr>
<td>Housing Improvements</td>
<td>Unit</td>
<td>544,000</td>
<td>225,000</td>
<td>42%</td>
</tr>
<tr>
<td>Improving Village Layout</td>
<td>Village</td>
<td></td>
<td>2,747</td>
<td></td>
</tr>
<tr>
<td>Constructing Sewage System</td>
<td>Km</td>
<td>8,654</td>
<td>15,559</td>
<td>179%</td>
</tr>
<tr>
<td>Supplying Electricity</td>
<td>Households</td>
<td>2,834,000</td>
<td>2,777,500</td>
<td>98%</td>
</tr>
<tr>
<td>Operating Saemaul Factories</td>
<td>Unit</td>
<td>950</td>
<td>717</td>
<td>75%</td>
</tr>
</tbody>
</table>
The barley humps (rural famine before the barley harvest in the late spring) were dominated in most of the farms in Korea. About 80 percent of Korean farmhouses remained thatched, only 20 percent of them could enjoy electricity, half of them had no village entry roads for cars, and even power tillers were denied access in most village roads (Goh, 2010). Agricultural income per family was more compared to non-agriculture income until 1976 and contrarily huge lead was taken by non-agriculture income in 1979.

Table 4. Rural Households Income Changes in Korea, 1970–1979

<table>
<thead>
<tr>
<th>Year</th>
<th>Households Income</th>
<th>Agriculture Income</th>
<th>Non-agricultural Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount</td>
<td>Ratio (%)</td>
<td>Amount</td>
</tr>
<tr>
<td>1970</td>
<td>255,800</td>
<td>194,000</td>
<td>61,800</td>
</tr>
<tr>
<td>1973</td>
<td>480,700</td>
<td>390,300</td>
<td>90,400</td>
</tr>
<tr>
<td>1976</td>
<td>1,156,300</td>
<td>921,200</td>
<td>235,100</td>
</tr>
<tr>
<td>1979</td>
<td>1,531,300</td>
<td>1,531,000</td>
<td>696,200</td>
</tr>
</tbody>
</table>

Ho (1979) concludes that the economic impact of the SMU Factory program was quite modest. There were 361 Saemaul factories in 10 (ten) big cities South Korea in 1978. These grain millers were mainly concentrated around these big cities in Korea.

The SaemaulUndong is considered as one of the best models of rural development where agricultural development in the initial stages took the leading role. Agricultural development activities were successfully linked to agro-based industries which in fact turned Korean economy into the industrialized country through well plan and implementation under SaemaulUndong.

2) Chinese Spark Programme for Rural Development

At the end of the 1970s, the reform of economic institution first started in rural areas in China. The family output related contract responsibility system was established and has aroused the farmers’ enthusiasm for getting rich through hard work and brought about a significant change in the production relations in the rural areas. China is a large agricultural country with the population of 80% living in rural areas. Since the beginning of the 1980s, the township industries have developed rapidly and the rural economy has become unprecedentedly active. The specialization and commercialization of agricultural production have made the farmers more and more aware of the importance of science and technology, and hence the requirements for sciences have widely emerged in the rural areas. In March 1986, the Chinese government started the reform of scientific and technological institution in the whole country. Economic construction must rely on science and technology and scientific and technological
workers to be oriented toward the rural economy, extend research achievements of science and technology to rural areas and help develop the rural economy.

In May 1985, the Ministry of Science and Technology of China submitted to the State Council a suggestion to “implement a batch of scientific and technological projects of quick benefit so as to promote local economy”, in which the proverb “A single spark can start a prairie fire” was quoted, hence came the name of Spark Program, meaning that the spark of science and technology will extend over the vast rural areas of China. The Chinese government approved the implementation of this program in early 1986.

The Spark Program is the first program approved by the Chinese government to promote the development of rural economy by relying on science and technology and is an important component of plans for the national economic and scientific and technological development. The purpose of the program was to introduce advance, appropriate technologies into the rural areas and lead the farmers to rely on science and technology in rural areas, promote rural productivity, and expedite the sustainable, rapid and healthy development of agriculture and rural economy.

The Spark programme supports a large number of technical projects that use rural resources, need small amounts of investment, have quick benefits and advanced and appropriate in technology. The main components of this programme were

a) Establishing demonstrative science and technology guided enterprises in order to guide township enterprises to develop healthily and providing demonstration for the adjustment of rural industrial and product structures;

b) Developing a batch of complete sets of equipment appropriate for rural areas and township enterprises and organizing batch production;

c) Training rural technicians, managerial talents and farmer entrepreneurs; and

d) Developing high yield, high quality and highly effective agriculture and promoting the construction of rural socialized service systems.

The implementation of the Spark Program has attracted attention of many countries, in particular developing countries, foreign countries and international organization, such as UNDP, ESCAP, the World Bank and EEC, made contact with Chinese government on this program, and the loan from the World Bank in support of this program in 1991 has resulted in significant benefits. The experiences of the success of the Spark Program have been consulted by many countries, in particular learning their experiences of management of medium and small-sized enterprises and technical development and learning and importing advanced, appropriate technologies and equipment fit for rural development.
Along with massive entrepreneur development in rural areas Spark Programme ensured huge agricultural development through ecological farming. Diversified, sustainable environment-friendly ecological farming of China is widely accepted by the world community for its higher productivity in agricultural development (Spark Programme, n. d).

3) Model Farmer Extension of Rural Development

The Bangladesh Academy for Rural Development (BARD) developed a series of rural development programmes as a result of its continuous collaborative efforts with the rural population. The well-known “Comilla Model for Rural Development” was evolved by BARD in the late mid and late sixties and was successfully implemented throughout the country. This is in fact a combination of different models of rural development like Rural Works Programme (construction of rural physical infrastructures); Two Tier Cooperatives (Institutional infrastructures that develop and link primary cooperatives at the village level and federation at the sub-district level-provides supports and services to the primary cooperatives); Upazila Training and Development Centre (administrative infrastructure which ensures supports and services to the villagers from different offices at the sub-district level); and Upazila Irrigation Programme (grow more food through irrigation involving farmers organizations).

The primary efforts of developing village-based primary cooperatives were to organize village-based co-operatives which were then federated to an Upazila (sub-district) Central Cooperative Association (UCCA) for providing training, credit, service and supplies, etc. to the members of the primary societies. For effective organizational functions, the village cooperative societies were made to abide by certain conditions. Among those conditions the following two were related to agricultural activities: (i) to select a trustworthy man to be named as Manager from the group for attending the weekly training programmes held at the Upazila Training and Development Centre (UTDC) and (ii) to select an energetic and positive farmer from the village to be trained in agriculture to work as a Model Farmer (MF).

This concept of the model farmer was developed as a result of a series of studies conducted in the area. These studies indicated that the village level workers of agriculture extension department were the main sources of information. But their advice was not always followed by the farmers. Conversely, the farmers usually depended on other fellow farmers for advice. This gave birth to the idea of the local people to be trained as extension agents (i.e. Model Farmer). The MF was required to know more about agricultural aspects including crop production techniques, fish cultivation, poultry and dairy farming, use of manures and fertilizers, use of insecticides, etc. The regular weekly training held at the sub-district level enabled the model
farmers in adopting crop cultivation practices in their own farms. This involved close interaction between the government officials and the village farmers.

The officials (experts) of different departments, work at the sub-district level were brought to one campus at the sub-district level and they disseminate their technological know-how through training and demonstration to the managers and the MFs of village-based cooperative societies time to time. A demonstration farm was usually attached to the Upazila (sub-district) office. Thus the role of experts was transformed into the role of teachers. This training system increased interaction among the expert, village representatives and farmers, widening the horizon of an increased amount of information dissemination to the farmers and an increased amount of problem-solving efforts at the sub-district level.

The main responsibilities of the MF were to:

a) attend the regular training classes at a sub-district level for acquiring knowledge of modern farming;
b) practice whatever he learns in the training class, in his own farm for demonstration effects;
c) attend weekly meetings of the village society to create awareness about modern farming among other members; and
d) discuss the farming problems of the village society members in the training classes for an appropriate solution.

As the MFs are supposed to perform a variety of jobs on a voluntary basis, the success of the system depends on the type of representative chosen by the society members. The Sub-district Training Centre has simplified the Agriculture Extension Work. The Sub-district level Agricultural Officer finds here a platform to disseminate new ideas to rural people. The MFs disseminate the new technologies to their respective villages after attending the monthly meeting at the sub-district level (UTDC). The villagers easily accepted the new ideas and demonstrations done by MFs. It is believed that MF system of extension played a key role in the success of the green revolution in Bangladesh that took place in the late sixties and early seventies.

3. Conclusion

The natural resources of developing countries are threatened by both natural and anthropogenic mismanagement and over exploration. This resource base is under serious threat for unplanned use. Planning is therefore necessary for effective use of natural resources particularly land and water with due consideration to ecological parameters and effective use. Continuous and excessive use of chemicals in soils for the ever increasing demand of crops
reduces the fertility of the soil in general. On the other hand, use of insecticides for crop cultivation destroys vast breeding areas of fishes, pollute the environment and affect human health in many ways. Ecological farming may be one of the potential options to adopt in the agricultural production systems to address these growing problems in developing countries. This agricultural production system has developed on the basis of the principles of ecology and economy of agriculture. It prescribes rational utilization of fertilizers and chemicals and promotes the application of more organic matters. Mechanization including irrigation increased agricultural production in folds over the last few decades. Matching these huge achievements with environmental and ecological parameters and higher growth can significantly add a new dimension to an agricultural production system. Small-scale surface water management through village-based organizations can also be a project intervention to ensure comprehensive agricultural production like crop, fish, poultry and livestock and to create an environment for economic and social development in floodplain areas of developing countries like Bangladesh.

Application of appropriate technology among the mass people in developing countries is a big challenge. Experiences of well-developed rural development model particularly those which could bring positive changes in rural development can be used as inputs for evolving appropriate rural development model of developing countries. In SaemaulUndong emphasis given on agricultural development at the initial stage, developing agro-based industries for processing increased agricultural produces and then overall development strategy create a miracle success in South Korea which provided huge inputs for evolving appropriate model of rural development. Chinese Spark programme is a comprehensive development programme where both agricultural and non-agricultural development took place on the basis of optimum utilization of technology. This programme is globally accepted for its potentiality in the overall development of rural areas. Again MF model played a pioneering role in launching and organizing a green revolution in Bangladesh in the late sixties and early seventies. Involving the rural community in the process of technology transfer chain brought a new dimension of ownership of villagers in agricultural development through this model.

**References**


• Climate Change: FAO urges Changes to ensure food Security


• Economic valuation of water resources in agriculture

www.fao.org/docrep/007/y5582e/y5582e04.htm Cached


• Raising the agriculture alarm - Asia Weekly - China Daily Asia

www.chinadailyasia.com/asiaweekly/2014-05/16/content… Cached
... according to the United Nation’s Food and Agriculture Organization (FAO). Asia ... agricultural practices. ... Asia has seen increased productivity in ...


  Spark Program - China Development Gateway – Your Online ...
  chinagate.cn/english/1314.htm Cached

  China is a large agricultural country with the rural population occupying 80% of the national ... Goals, objectives and focal points of development of Spark Program.

ACHIEVEMENTS AND CHALLENGES IN IRRIGATION DEVELOPMENT: EXPERIENCES FROM MAHARASHTRA STATE OF INDIA

Suresh A. Kulkarni, India

1. Introduction

Maharashtra has 30.7 million ha geographical area and is the 2nd most populous (115 million) States of India (Figure 1). Presently, 58% population is rural while 42% is urban. As per estimates, by 2030 the State’s population is likely to be 142 million and the proportion of the urban population will exceed by 50%. Increasing food demand, rapid urbanization, rising living standards, expanding industrialization, and growing demand for energy are exacerbating a pressure on the limited freshwater resources of the State.

In Maharashtra, agriculture plays an important role in the State’s economy contributing about 12% to State’s GDP. About 12 million rural families living in 40,412 villages, directly and 65 million of population indirectly depends on agriculture for their livelihood.

Irrigated agriculture in particular acts as an ‘Engine of Growth’ for the rural economy and has been proven effective in poverty alleviation and increasing farmer’s income. The cultivable area of the State is 22.5 million ha while only about 20% area is presently irrigated which is quite low compared to India’s average of 40%. The successive Governments have given due importance to irrigation sector by making a substantial investment in water resources development. As almost 80% of the cultivable area is rainfed, providing moisture to grow atleast one crop is required for the majority of the rainfed farmers. The Government of Maharashtra has taken up an ambitious programme of watershed development with the objective of restoring and developing degraded lands, arresting the loss of the topsoil, recharging of groundwater and promoting water conservation.

2. Water Resources and Irrigation Development

The State has a semi-arid climate with annual average rainfall of 1360 mm ranging from 400 mm to 6000 mm. A major portion of the rainfall (88%) occurs between June to September. The average rainy days varies from 46 to 95 days across the State. The State has five main river...
basins and an annual average renewable availability of the surface water resources is estimated at 163.82 billion cubic meters (BCM). However, as per the decisions of the inter-state river tribunals, only 125.94 billion cubic meters (BCM) have been allocated to Maharashtra. Of the allocated water resources, about 67 BCM can be reasonably harvested and stored (GOM, 1999). The government has given high priority for construction of dams and today the State has the highest number of large dams (1845) which is 36% of India’s large dams.

Presently, a storage capacity of about 34 BCM has been created in the State. Besides the State sector, small water storages are also constructed through the local sector. There are a large number of percolation tanks, village tanks and underground bunds, Kolhapur Type (K.T.) weirs, and minor tanks. Farm Ponds are constructed by Agriculture Department in the farmer’s fieldstore runoff during the rainy season and use it during dry spells in Kharif (June-September) or Rabi (October–February) seasons as protective irrigation.

Those areas which cannot be irrigated by gravity, are irrigated by lifting/pumping water from rivers, reservoir backwater, and canals. Lift irrigation schemes (LIS) can be categorized as (1) State sector/ Government LIS, (2) Cooperative LIS, and (3) Private/ individual LIS. The groundwater resources of the State are estimated at 33 BCM, of which about 17 BCM is pumped annually for irrigation purpose through more than 2 million wells. Table 1 shows the number of irrigation structures in the State and local sectors using surface water and groundwater and the area irrigated in 2011-12.

Table 1. Irrigation potential created and actual irrigation from different sources*

<table>
<thead>
<tr>
<th>Category of irrigation scheme</th>
<th>Nos.</th>
<th>Potential created (million ha)</th>
<th>Actual irrigation (million ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) State Sector-Major, medium , and minor irrigation projects (including lift irrigation schemes, lifts on canals, reservoir water)</td>
<td>2,844</td>
<td>4,926</td>
<td>2,448</td>
</tr>
<tr>
<td>b) Local Sector- percolation tanks/ Village Tanks / underground bunds K.T.weirs/ Diversion weirs/ Minor tanks/ Small Lift irrigation schemes</td>
<td>62,229</td>
<td>1,503</td>
<td>0,531</td>
</tr>
<tr>
<td>c) Farm ponds</td>
<td>69,228</td>
<td>0,114</td>
<td>0,088</td>
</tr>
<tr>
<td>d) Cooperative lift irrigation schemes– surface water</td>
<td>10,131</td>
<td>n.a</td>
<td>0,606</td>
</tr>
<tr>
<td>e) Private lift irrigation schemes – surface water</td>
<td>n.a</td>
<td>n.a</td>
<td>0,874</td>
</tr>
<tr>
<td>f) Groundwater – Open wells/ bore wells (outside the command area of state sector projects)</td>
<td>16,16,00</td>
<td>0,172</td>
<td>0,172</td>
</tr>
<tr>
<td>Total (a + b + c + d + e + f)</td>
<td></td>
<td>6.72</td>
<td>4.72</td>
</tr>
</tbody>
</table>

150
During the last 10 years, depending upon rainfall amount, on an average about 70% of the created storage capacity has been actually realized in the state sector projects. Of the stored water, on an average about 61% was used for irrigation, 13% for drinking, 3% for industrial use, 5% for cultural releases and other uses, and about 18% of stored water is evaporated, annually. In the case of groundwater, about 85% is used for irrigation, 10% for industries, and 5% for domestic uses.

The state is categorized under 9 agro-climatic zones based on the soil type and rainfall amount. The Maharashtra Water & Irrigation Commission (GOM, 1999) has assessed the ultimate irrigation potential through surface water resources and 4.1 million ha through groundwater resources by adopting modern irrigation methods, watershed development and improve irrigation practices. Presently, of the 22.5 million ha cultivable land of the State, an irrigation potential of 6.72 million ha has been created through various surface water (state and local sector) schemes and groundwater, of which about 4.72 million ha is actually irrigated (see Table 1).

3. Participatory Irrigation Management

Although the concept of participatory irrigation management (PIM) was introduced in Maharashtra in the 1980s, there has been a mixed success with regards to their effective functioning. Presently, there are 4,353 water user associations (WUAs) covering about 1.724 million ha command area, of which 2365 were reported as functioning. Water Resources Department (WRD) supplies irrigation water to all WUAs on a volumetric basis, as per their entitlements/as per the water availability in the reservoir. The WUAs have the freedom to grow crops as per their choice and decide water charges to be paid by their members as per collective decision. In general, the WUAs found to be effective inequitable and efficient distribution of water and also in increasing the water productivity.

4. Micro and Sprinkler Irrigation

Maharashtra is a leading state in the cultivation of horticulture crops having 1.66 million ha under fruit crops, 0.48 million under vegetable crops, and 0.21 million ha under spices. As the fruit crops give better income, farmers are shifting from foodgrain crops to fruit crops. The
Government is also encouraging farmers through ‘National Horticulture Mission (NHM)’ to expand horticulture. The major fruits grown are Banana, Grapes, Mango, Orange, Papaya, Pomegranate, and Sweet orange. Fruits like mango and grapes are exported. The NHM has been scaled-up and implemented under “National Micro Irrigation Mission (NMIM)” commencing from 2010. Due to growing shortage of water, farmers have been adopting micro and sprinkler irrigation since 1986. Maharashtra is at the forefront in India to adopt micro and sprinkler irrigation systems with 1.177 million ha equipped with micro/ drip irrigation and 0.425 million ha under sprinkler irrigation. Figure 2 shows the percentage area coverage of different crops under micro-irrigation.

Subsidy assistance to the tune of 50% of the capital cost of the system is provided by the State and Central Governments to the farmers. The ultimate potential area which can be brought under micro and sprinkler irrigation in the State is estimated at 2.7 million ha which is about 10% of the potential area of the entire country.

5. Institutional Reforms and Policy Initiatives

Maharashtra State is also at the forefront of water sector reforms by establishing Maharashtra Water Resources Regulatory Authority (MWRRA) in 2005, enacting of Maharashtra Management of Irrigation System by Farmers (MMISF) Act in 2005, State Water Policy (SWP) in 2003, Benchmarking of Irrigation Projects since 2001-02, publication of Irrigation Status Reports, Volumetric pricing of irrigation water, formation of Irrigation Development Corporations and capacity building and training of the officers from Water Resources and Agricultural Departments and farmers at Water and Land Management Institute (WALMI). These reforms and initiatives have been found to be effective in increasing awareness and improving performance in the irrigation sector at large.

6. Challenges and Way Forward

Achieving water security for rural population is of paramount importance in countries like India where more than 60 percent population is dependant on agriculture for their livelihood.
Promoting rural development will bridge the ‘rural-urban’ divide and discourage migration to the urban area. Despite all the aforementioned strategies and measures, about 80% of the cultivable land is still dependent on vagaries of rainfall. On the one hand, there is an urgent need to create more storages through the construction of large and small dams, there is an equally pressing need for modernization of irrigation main system operation and on-farm management so as to use the available water efficiently and productively. Conventional irrigation methods used for field crops, especially sugarcane and rice are highly inefficient. Small and scattered landholdings hinder adoption of modern irrigation technology. There are 13.6 million operational holdings having average size as 1.44 ha in the State. About 78% holdings were below 2.0 ha. Poor infrastructure like roads, discourages the use of the modern farm machinery. In most peri-urban areas, untreated wastewater is used for irrigation posing a health risk to both farmers and consumers.

It would be useful for the developing countries to collaborate and learn from each other’s experiences in water resources development and agriculture water management for achieving water and food security. Maharashtra can offer its expertise, for example in (i) construction of large and small water storage structures, (ii) watershed management, (iii) adoption of micro and sprinkler irrigation technology, (iv) irrigation pumping technology, and (v) participatory irrigation management, etc. Similarly, the State looks forward to collaborating in the areas of advanced technology in reservoir operation, river basin management, on-farm water management, groundwater regulation and management, use of saline water and recycling of treated wastewater for irrigation, etc. It would therefore be beneficial to establish an International Center for Agricultural Water Management to train, guide and advice professionals from developing countries through capacity building in achieving water and food security in a sustainable manner.

**References**

1. Introduction

Sustainable management of water resources is a prerequisite for development and reducing poverty and hunger. Water is a key factor affecting agricultural production and reduction of rural poverty. The most important use of agricultural water could be food production, and the productivity depends on successful irrigation for paddy cultivation particularly in the monsoon region, which has a very high-water demand. The development of agricultural water use itself is nearly equivalent to the development of rural areas when the primary goal of society is feeding the population.

Agricultural water development can be achieved through constructing irrigation facility and increasing efficiency of irrigation water use. Therefore the infrastructures of irrigation such as a dam, intakes, pumping station, and consolidation, sea-dike, and drainage facilities had been constructed since 1990s, and the irrigation system has been restructured for its efficient management and adapted to globalization and climate change since the 2000s in Korea.

However, rural development include an increase of production, income, farming convenience enhancement, labor cost saving, rural economic diversification, population maintenance, living convenience improvement, industrial development, land creation, and lessening natural disasters. Chapter 2 introduces a comprehensive agricultural water development project and the effects of the project on rural development are addressed.

The rice paddy farming has been the backbone of the agriculture for a long time in Korea. Agricultural water management, construction and maintenance of irrigation facilities have been focused on rice paddy farming and water management has been conducted by water users in a rural area as a form of participatory irrigation management (PIM).
However, Korean rural societies have been weakened due to high economic growth and industrialization and this has consequently brought about difficulties in infrastructure maintenance. Therefore, PIM changed to the form of public irrigation management.

Agricultural water does not only produce food; it also creates multifaceted and publicly beneficial intangible advantages such as conservation of biodiversity, the formation of scenic landscapes and fostering social culture. Though it is not likely, country people had been aware of the multi-functionality. Chapter 3 addresses evaluation of the multi-functionality of irrigation and drainage systems in Korea.

Under the current climate change situation, water shortage in a rural area is expected and effective use of agricultural water is desirable as a reliable countermeasure against climate change. Chapter 4 covers results of a feasibility study of domestic water supply using agricultural reservoirs in a rural area in Korea.

2. Comprehensive Agricultural Water Resources Development and Rural Development

To analyze the effects of large-scale agricultural infrastructure investment on the rural development, Yeongsan river basin comprehensive development project (YRBCADP) was selected as the case project and evaluated the impacts of YRBCADP on agricultural and regional development individually. The analysis was conducted on the effects of YRBCADP on the agricultural and regional development in terms of increase of farmland area, agricultural productivity, population increase, regional income increase, transportation and accessibility improvement.

2.1. Overview of the YRBCADP

Yeongsan river basin comprehensive development project (YRBCADP) consists of 4 phases and Figure 1 shows geographical boundaries of each phase. Phase I was initiated in 1972 with a domestic fund of 81.2 billion won and foreign fund of 22.6 billion won (USD 48 million). By the YRBCADP, four large agricultural dams of 265 Mm$^3$ capacities were built and irrigation provision was made for 34,500 ha of farmland (YRFIA, 1987).

Phase II was implemented from 1978 to 1998 by constructing Yeongsan estuary dam (4.3 km), creating and arranging farmland and acquiring fresh water (254 Mm$^3$). In the initial stage, a fund for the YRBCADP was raised by the Korean government (42,200 million won, 47%) and IBRD
loan (47,700 million won (USD 99 million), 53%). However, in completion stage, total project cost amounted to 354,000 million won.

Phase III initiated in 1985, was composed of two tidal embankments (in Yeongam and Geumho lakes), farmland arrangement (reclaimed area of 12,500 ha and hinterland area of 8,500 ha), nine pumping stations, irrigation and drainage canals of 1,250 km. The project cost was 1,180 billion won (USD 915 million).

Phase IV is an on-going project. The estimated total cost of YRBCADP is 746 billion won (USD 578 million). It was initiated in 2001 and 31% of the estimated project cost has been invested until 2013. The core of the project components is to supply agricultural water from Yeongsan Lake to the farmland of 16,700 ha through the newly established Muan water pumping station. About 95% of the newly established irrigation canals, 476 km, are pipelined and water management automation systems are introduced.
2.2. Effects of YRBCADP on agricultural development

In terms of agricultural development, YRBCADP has contributed to the increase of farmland area, agricultural productivity, and farm income. The farmland of the project area was increased about 3.5 times, from 43,000 ha in 1970 to 150,000 ha in 2010, whereas it was increased about 2.9 times in the non-project areas. In addition, the average rice yield per area was 3.97 ton per ha in 1973 but it increased significantly to 4.64 ton per ha in 2010.

2.3. Effects of YRBCADP on regional development

1) Population increase

To figure out the effects of YRBCADP on regional development, population increase rates of three periods were analyzed; 1991-1996, 1996-2001, and 2001-2011. All those three periods show results that population growth rates of the project areas were higher than those of neighboring areas, non-project areas.

Figure 2 presents the comparison of annual population increase rates of the project and non-project areas. A trend can be found in Figure 2 that population increase rate of project areas is higher than that of non-project areas. Generally, population increase rate of an urban or suburban area tends to be higher than that of rural area. The results in Figure 2 reveal the fact that large-scale agricultural infrastructure development project, YRBCADP, affects positively on regional population increase.

![Figure 2. Annual Population Increase rates of Project and Non-project areas](image-url)
2) Regional income

The effect of regional income increase due to the project can be inferred by the amount of local tax collection presented in Figure 28. The Figure shows that the annual average increase rate of local tax collection in the period of 1991-1996 of project urban area, 46.8%, is nearly double of non-project area’s increase rate, 24.0%. In the period of 1996-2011, the annual average increase rate of local tax collection in project suburban area maintains its previous status, though the increase rate of non-project suburban shrank to half.

The result of comparison between both rural areas shows a similar trend. The project area, holds 18.2% increase rate of local tax collection whereas the non-project area, shows 10.1% of local tax collection rate. In the period of 1996-2011, increase rate of project rural area is higher than that of the non-project area; they are respectively 15.5% and 14.6%.

Figure 3 shows the trends that the regional incomes of project areas are higher than those of comparison group, non-project area. This reveals a fact that the agricultural infrastructure development project, YRBCADP, has positively affected regional income.

3) Transportation and accessibility

The tidal embankment has shortened the travel distance for about 35,000 vehicles per day and the sea gate of 8 rows has contributed to reducing transportation costs by transporting cargo and people by ships. Inland transportation improvement effect can be calculated by fuel price, car fuel economy, a number of vehicles passed per day. In addition, the effect includes the saving of depreciation cost, the increase of industrial competitiveness by shortening transportation
time, and the improvement of community people’s living convenience. It can be regarded that the project, YRBCADP, has contributed to the improvement of transportation and accessibility.

4) Interconnect food security with high-tech industry

In the 1980s, “Export-oriented industrialization” had been achieved under the food security and stable society. Even if natural resources were very poor, export-oriented industrialization could be done by human resources with the skillful techniques.

Large-scale agricultural development contributed to food security and lead to high-tech society by suppression of wage increase for urban laborers by lowering food prices, and saving on foreign exchange to supply food for the increasing urban population. Maintain high economic growth was also possible due to the high growth rate in the agricultural sector.

3. Evaluation of multi-functionality of irrigation and drainage systems in Korea

In Korea which belongs to the Asian Monsoon climate zone, the rice farming has been the backbone of the agriculture for a long time. Agricultural water management, construction and maintenance of irrigation facilities, which is essential to increase the productivity of the rice farming directly related to the national survival and prosperity were the duty of the country. Under this circumstance, cost sharing for agricultural water management or any social conflict about it did not exist.

Recently, the status of agriculture has been in sharp decline due to rapid industrialization and the countryside has changed to space of farming and non-farming population by the increase of rural society’s heterogeneity and urban sprawl. Therefore, the direct/indirect beneficiaries are becoming more and more varied according to these changes; the necessity for social discussion about the cost-sharing for maintenance and management of agricultural water and its related facilities is rising.

3.1. Social awareness of the multi-functionality of agricultural water

Agricultural water is a basic input for agricultural production activities and the farmer is the biggest beneficiary. But agricultural water and irrigation and drainage facilities can be considered as public goods by assimilating into the waterside ecosystem of rural space. Therefore, responsibility for its sustainability should be shared socially. Now, beyond the agricultural economic perspective that the area would be the agricultural production base, the
3.2. Cost share for O&M of irrigation facilities

In order to comprehensively and appropriately operate and maintain infrastructures for agricultural water, a rural community is indispensable. Rural communities were in practice in Korea for a long time as Water Users’ Associations. While the Water Users’ Associations played social roles in strengthening rural communities’ bonds and in fostering rural cultures, prosperous social customs have been conserved by proper maintenance of irrigation infrastructures. However, recently, participatory irrigation management (PIM) changed to the form of public irrigation management.

Korean farmers who have been serviced irrigation from facilities managed by local governments continue to pay maintenance costs, but other farmers who have been serviced irrigation from facilities managed by Korea Rural Community Corporation (KRC) run by government are exempted from water fee and maintenance cost. Due to these circumstances, OECD and other international organizations are regarding this government’s share of subsidies and requiring compliance of benefit principle. However, there have been no discussions to solve this problem between nation-municipalities-community-farmers.

3.3. Evaluation of multi-functionality of agricultural water and beneficiaries’ reasonable cost share

A study was conducted to identify multi-functionality of agricultural water, irrigation and drainage systems and assessment of beneficiaries’ reasonable cost sharing for irrigation and drainage facilities management in Korea based on analysis of benefit using AHP method with surveying expert opinions.

A total of 11 experts, whose expertise were water resources, irrigation drainage, rural planning, and agricultural economics participated in the survey of this study. Fourteen functions addressed in a previous study (KRC, 2006) were reviewed by experts group and important functions were selected. By conducting the second expert's group survey using pairwise comparison of multi-functions of irrigation and drainage system and AHP (Analytic Hierarchy Process) analysis method, relative importance weight on each function was elicited.

The beneficiaries of agricultural water were decided as people (nation), region (municipalities), local (village) residents, farmers, and other users. The share of benefit among beneficiaries was also determined by survey and AHP analysis.
The multi-functionality of irrigation and drainage systems was analyzed and result (total 1.000) is as follows; ‘Agricultural Water Supply’ is 0.466, ‘Multipurpose Water Supply’ 0.269, ‘Environmental Conservation' 0.136, ‘Social Culture Cultivation’ 0.070, ‘Emergency and Energy’ 0.059. So the function as agricultural water supply shows significantly higher weight value than the others.

The relative benefit of each function of agricultural water to the beneficiaries was calculated and summed up. Based on this calculation, the rational ratio of cost sharing for management of countryside water by beneficiaries is proposed as follows (100% in total); people (nation) 40, region (municipalities) 25, local (village) residents 15, farmers 10, and other users 10. The sharing ratio for farmers up to 10% of total cost matched with survey results from previous studies.

4. Feasibility study of domestic water supply using agricultural reservoirs in rural area

Currently, domestic water accessibility is high up to 98.5% nationally in Korea, but in rural areas it is less than 88.2% (MOE, 2013). Many researchers have predicted that droughts might occur more frequently in the future due to climate change (Kim et al., 2015; Park et al., 2015). Various measures are being taken into consideration as future water shortage measures such as the development of new dams, enhancement of existing dams, rainwater harvesting and reuse of sewage (Kim et al., 2015). Particularly in rural areas where insufficient water supply is expected, the supply of water from the agricultural reservoir is considered as one of the main measures.

4.1. Climate change and rural water welfare

A feasibility study was conducted to assess the likelihood of supplying domestic water supply by using agricultural reservoirs in rural areas of Korea. A total of 203 reservoirs were selected and evaluated as potential domestic water supply. Economic feasibility of some selected reservoirs and legal constraint were also examined.

4.2. Reservoir water balance analysis

Korean agricultural reservoirs were designed and managed to cope with 10 years frequency drought. Therefore, reservoir water balance analysis was conducted to estimate the amount of free volume that could be used as potential domestic water supply in a rural area even in 10 years frequency drought period while satisfying agricultural water supply.
Hydrological Operation Model for Water Resources System (HOMWRS) was used for possible water balance analysis of agricultural reservoirs in consideration of inflow from the watershed and the required amount of irrigation for paddy field and other downstream crop fields. The modified TANK model of Sugawara (1979) was mounted as inflow model of HOMWRS. The parameters of the model were estimated using locally established regression equation based on the ratio of the area of upstream watershed and land use pattern (forests, rice paddies, crop fields). The required amount of irrigation was estimated by considering the amount of effective rainfall, crop consumptive use (evapotranspiration and infiltration) and operation loss during growing season. Evapotranspiration amount was determined by Penman-Monteith equation.

4.3. Potential domestic water supply from agricultural reservoirs

More than one hundred reservoirs have enough water and the required water quality as potential domestic water supply. The analysis showed that more reservoirs satisfied economic feasibility when water was provided from reservoir outlet instead of delivering water to water treatment plant under current conditions. Economic analysis showed that adequate conditions for the economic feasibility of supplying domestic water in the rural area utilizing agricultural reservoirs were: population more than 2,000 and distance to delivery facilities was less than 4.5 km.

Including public interest functions such as community maintenance functions, balanced community development, improvement of the life quality of residents in the rural areas in the cost-benefit analysis is recommended to improve the economic feasibility.

Some measures to acquire the amount of domestic water for agricultural reservoir by water saving policies through incentives, changing cropping systems that require relatively small irrigation amount, and increasing irrigation efficiency could be sought for water welfare in the rural area of Korea.

5. Conclusion

A large-scale agricultural infrastructure development program such as YRBCADP conducted in Korea has positively affected not only the increase in agricultural productivity and introducing cash crops, but also the improvement of transportation conditions and regional income growth. The project has also contributed to community population in such a way that the number of residents has increased or the population decrease rate has been reduced. Thus, it can be concluded that the project has significantly contributed to creating a favorable living environment by strengthening agricultural and regional competitiveness and sustainability. The case study showed that Agricultural water resources development was the backbone of rural
development and modernization of the whole country. Industrialization and high-tech society couldn’t be achieved without successes of agricultural infrastructure first hand in Korea.

While Koreans have experienced exponential economic growth and industrialization, the growth rate in the agriculture sector is relatively lower than GDP growth and the presence of agriculture in the state economy seems to be shrinking. Nevertheless, agricultural water must not be undervalued. Other than food production, agricultural water possesses various values without being economically quantified. When discussing the contributions of agricultural water, most countries may be making evaluations only with the food production quantity and quality as its output, though comprehensive and important indicators including multi-functionalities can be taken into consideration in addition to the economic approach of food production.

The multi-functionality of irrigation and drainage systems was analyzed in Korea and those were ‘agricultural water supply, ‘multipurpose water supply, ‘environmental conservation, ‘social culture cultivation, and ‘alternative energy’. Relative benefit of each function of agricultural water to the beneficiaries was calculated, and the rational ratio of cost sharing for management of agricultural water (mostly paddy water) by beneficiaries is proposed as follows (100% in total); people (nation) 40, region (municipalities) 25, local (village) residents 15, farmers 10, and other users 10.

In rural areas where insufficient domestic water supply is expected due to future climate change, the supply of domestic water from the agricultural reservoir is considered as one of the main measures. Feasibility study of domestic water supply using agricultural reservoirs in a rural area was conducted in Korea and it was found that more than one hundred reservoirs have enough water and the required water quality for potential domestic water supply. This study showed that agricultural water has potential roles for rural water welfare against climate change.

References


1. Introduction

Thailand is an agricultural country where a population of more than 70% is engaged in farming. Government is the agency that provides water for agricultural sector. Water which is delivered to farmers is free of charge. The government has had a policy to increase irrigated areas every year. The water developments use lots of budget. Therefore, the government together with Royal Irrigation Department its implementing agency will consider the priority of the farmers by means of the necessity. An option for the necessity is from a rural community’s request. The requested document from them has been sent from the Regional Irrigation Office to Royal Irrigation Department in Samsen district, Bangkok. The water development process starts from survey study, Prefeasibility study, detailed design and construction, including the operation and maintenance when the projects finish the construction.

Bo Thong district, Chol Buri province is located in the eastern part of Thailand. It is about 28 kilometers from urban area. People in this area are farmers who grow fruits, rubber trees and rice. Nowadays, people use water from Klong Kasae as their water resource. Klong Kasae originates from mountains up to the headwater about 15 kilometers. In rainy season, there is lots of water in Klong Kasea but it has no water in dry season. The area has no reservoir to store water in rainy season for using in dry season when people need water for their plants. Therefore, a leader of the village in Bo Thong district issued a letter to Regional Irrigation Office to construct a dam in his area. The letter was forwarded to Central Royal Irrigation Office to study the feasibility of the project. The prefeasibility study had been finished in 2014.

2. Study Area

Krasae reservoir project is located between Moo 1 Kaohayod village and Moo 2 Kaocha-arng village, Pluangthong sub-district, Bo Thong district, Chol Buri province. The coordinates in WGS 84 of the proposed dam are 1, 459,741 Nand 781, 982 E or Latitude of 13° 11’ 28” North and Longitude of101°36’05” East from 1:50000 scale military map. The topography of headwork and inundation areas is in rolling valleys where a small channel of klong Krasae
originates. Beneficiary areas are at downstream of the dam. The topography are mountains and plains.

3. Methodology

As mentioned above, the paper focuses on Socio-economy and agriculture, including economic analysis and social impact assessment through public participation.

Figure 1. The Project Map of Klongkasae reservoir project, Bo Thong District, CholBuri

3.1. Study of Socio-economy and Agriculture

The study of socio-economy and agriculture was very important. The study is to understand the basics, and general economic, social and farm household or community in its present condition by focusing on the education of the population, economy, social structure and basic services, the opinions and views on the project, including the consideration of economic analysis and planning to project implementation. The data used in this study were secondary data from relevant agencies, including the interviews with community leaders and household on a sample of 20 households.
3.2. Economic and Financial Analysis

The project economic analysis is to evaluate whether the project is economically viable and support the contribution of the project to the rural community or not. The criteria for economic analysis are based on the project costs which were set at constant values in 2011 for cost and benefit, project’s period of 35 years, 8% discount rate per annum which is Thailand’s opportunity cost of capital, and conversion factors adopted from the World Bank’s study of Thailand case (Sadiq Ahmed; Shadow Prices for Economic Appraisal of Project: An Application to Thailand, World Bank Staff Working Paper, Number 609, Year 1983). The project economic indicators such as net present value (NPV), the benefit-cost ratio (B/C ratio) and economic internal rate of return (EIRR) were analyzed and used to show the economic analysis results.

Financial analysis was also examined. The analysis is on farmers’ income comparing between non implemented project and implemented the project by using Farm model as a tool.

3.3. Social Impact Assessment through Public Participation (SIA)

The project’s SIA was performed through public participation activities with the objectives to give all related parties the opportunities to share and suggest information, attitude and opinions about the proposed project. The project might be useful for the overall area but also adversely have an impact on some groups of people in the area. Therefore, project-affected people were encouraged to participate in every step of SIA process and were allowed to determine the project implementation guidelines to minimize the negative impacts and to suggest options and select the suitable option so that the project after implementation will indeed benefit communities and the society.

To conduct the SIA, the study was conducted in form of public participation as three meetings between RID’s officers and local people and stakeholders. The first meeting was arranged for leaders in the project’s area. RID’s officials informed them project’s proposal, project’s features, project’s benefit and impact, including listening to the leaders’ opinion and suggestion. The second and third meetings were arranged for local people and stakeholders to listen to their points of views, suggestion and options for the water development. The tools for these people participation were not only posters, leaflets, interviews but questionnaires as well. After finishing the process, the statistics were used to evaluate the results of the SIA study.

4. Result and Discussion

Klong Krasae reservoir project aims to provide water for croplands during the rainy season and dry season. The project will deliver water to the existing canals, which has a small irrigation
system along the canals to irrigate areas. This will ensure a sufficient amount of water to farmers consistently applied in the desired periods. As a result, the project can increase yield per acre, household income and stability to farmers’ life. The site survey shows that potential and availability of farmers are considered in good standing in terms of technology improvements, learning on development and cultivation and adaptation to the use of technology in various fields. In the future, when the project is implemented, farmers are likely to alter the crops and are ready to improve maintenance procedures up to date, as well as bringing new technologies to increase the confidence in the irrigation project managing both the quantity and duration of agricultural activities. This will contribute to increasing farmers' incomes by increasing yields and increasing cropland.

4.1. Economic analysis

An economic analysis of the project has put the benefits in comparison with the total cost over the lifetime of the project calculated by Discount Cash Flow Technique. The project's EIRR, NPV and B / C ratio is analyzed as follows.

\[
\text{EIRR} = 11.36\% \\
\text{Discount rate NPV (million baht) B / C ratio} \\
12\% \quad -14 \quad 0.95: 1 \\
10\% \quad 37 \quad 1.12: 1 \\
9\% \quad 73 \quad 1.22: 1
\]

The criteria for determining the appropriateness of the Office of National Economic and Social Development (NESDB) requires a suitable investment project which the rate of economic return of the project is in the range of 9-12, depending on the nature of the project. The analysis shows that the project is appropriate in the investment criteria. When taken into account with the needs of local people by then, this project should be considered to continue in the future because it gives a better quality of life for farmers to have water to the crop adequately and consistently. This improves productivity and revenue for farmers, including the stability of the occupation and a source of raw water for consumption and other byproducts.

4.2. Financial analysis

The farm model’s result is shown in Table 1. The project’s cultivable area per household is obtained by dividing the project’s beneficial area of 3,163 acres with 213 beneficial households to be 14.81 acres per household. The cropping pattern will be improved if the project is implemented due to water availability and consistency. It will be similar to the current situation.
but fruit trees will grow more than vegetation which are grown repeatedly in wet and dry season. Palm oils have been proposed to plant increasingly from 0.07 acre per household to 2.06 acre per household or increasing of 2,842% while the rubber tree increases of 27.6% and wollongong increases of 212%. Meanwhile, cucumber and lentils can be planted as the 2nd repeated crops in dry season if the project is implemented. The farm model shows the comparison of the financial analysis between future without project and future with the project. It shows that total net income per household increases from 9,185 US dollar to 13,690 US dollars per household or increase of 4,504 US dollars or 49%.

Table 1. Financial analysis with Farm Model

<table>
<thead>
<tr>
<th>Item</th>
<th>Cultivated area (acre)</th>
<th>Cultivated Net Income per acre (US dollar)</th>
<th>Total Cultivated Net Income (US dollar)</th>
<th>Future with project</th>
<th>Future with project</th>
<th>Future with project</th>
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<td>Cultivable area</td>
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<td>Wet season / year crops</td>
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<tr>
<td>1) 1st Cropping</td>
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<td>0.32</td>
<td>408.16</td>
<td>130.61</td>
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<td>- Palm oil</td>
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<td>139.15</td>
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<td>2.06</td>
<td>370.21</td>
<td>762.64</td>
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<td>- Rubber tree</td>
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<td>759.00</td>
<td>6,603</td>
<td>11.10</td>
<td>1,177.68</td>
<td>13,072.30</td>
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<td>- Mangosteen</td>
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<td>49</td>
<td>0.66</td>
<td>630.85</td>
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<td>- Woolongong</td>
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<td>10,678</td>
<td>14.80</td>
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<td>14,946.33</td>
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<tr>
<td>2) 2nd Cropping / intercropping</td>
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<tr>
<td>- Cucumber</td>
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<td>0.32</td>
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<td>89</td>
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<td>0.32</td>
<td>304.34</td>
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<td>0.16</td>
<td>407.75</td>
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</tr>
<tr>
<td>- Lentils</td>
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<td>-</td>
<td>-</td>
<td>0.32</td>
<td>304.34</td>
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<td>Net Income from livestocks</td>
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<tr>
<td>Total net income from farms</td>
<td>10,833.48</td>
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<td>add out-farm income</td>
<td>1,646.24</td>
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<td>minus cash expenditure in household</td>
<td>3,294.67</td>
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<td>Increased income per household</td>
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<td>Net income increased per acre</td>
<td>304.18</td>
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</tbody>
</table>

Remarks:

1/ assume that no income in this activity in future with project
2/ assume that out-farm income constant in future with project
3/ assume this expenditure increased at 4%
4/ Money exchange rate: 33 Baht = 1 US dollar
The project also increases the cropping intensity. At present, the cropping intensity is 103.2% in rainy season and 2.4% in the dry season; however, if the project is implemented, the cropping intensity will be improved to 106.25% and 12.5% in a rainy and dry season, respectively.

1) Analysis of labor

Labor is one of the most important inputs to project’s productivity; however, it is quite a problem with some farmers in the project’s area because most workers are likely to work in the industrial sector. As a result, workers in the agricultural sector are relatively small. Currently, farmers in the project’s area use their own labor in conjunction with hired labor in some activities. In the future with the project, workers are expected to increase in crop plants. The analysis of labor is expected to increase from 120,029 person-days per year to 154,938 person-days per year, representing an increase of 34,910 people. Farmers must invest time and effort more in making agriculture. This may require all household members’ labor to contribute to certain activities and times.

2) Crop yields

The average yield per acre of the crop is increased in the future with the project under the assumption that a thorough and adequate irrigation water throughout the year coping with use of various inputs and the introduction of new technical knowledge and new technologies. The information gathered from the papers of the agricultural district shows the average yield per acre of crops in the future with the project as follows:

- Rubber 110kg per acre.
- Palm oil 1,384kg per acre.
- Fruit 514kg per acre.
- Wollongong 474kg per acre.
- Cucumber 395kg per acre.
- Beans 356kg per acre.

4.3 Social Impact Assessment through public participation (SIA)

The first public participation was held on May 26, 2010. The first meeting invited local leaders associated with the project. The participants of 50 people consist of 34 men and 16 women. The meeting aimed to provide local leaders with the knowledge and understanding of the project and share their opinions by answering individual queries. The evaluation of the questionnaire shows
that the 97.83% of local leaders agreed with the construction of Klong krasae reservoir project, whereas 2.17% disagreed. The disagreed local leaders were not confident on how much compensation of land and properties were paid to the affected people. They needed the government to inform more of the cost of compensation and duration.

The second public participation was held on June 10, 2010. The second meeting invited local people and stakeholders who associate with the project’s area of 100 people consisting of 67 male and 33 female. The purpose of the meeting was to give them a deeper understanding of the project and to hear their comment and suggestion individually. After the meeting, 91 questionnaires were replied, consisting of 62 or 68.13% from male whereas 29 or 31.87% from female. It shows that there were 60.44% of attendance having acknowledged the project before, whereas 39.56% having not acknowledged earlier. 49.35% agreed with the construction of reservoirs, while 40.66% disagreed. From the questionnaire, it found that the people who did not agree with the construction of reservoirs are people who live in the inundation area of the project.

The summary of public participation in this medium scale water development project shows that from 137 questionnaires from 68.61% of male and 31.39% of female 71.53% have had known that there will be a study of reservoirs, whereas 28.43% have not known before these public participation. 72.27% agreed with the construction of reservoirs, while 27.74% disagreed.

There were considerable public comments and questions on various issues. To fulfill the public participatory activities, a study team had provided experts from Royal Irrigation Department to answer questions from the public until it is satisfactory. The comments or questions from the public can be summarized as follows:

a) If the construction is conducted now, how much and when compensation on land and properties should be and pay, respectively?
b) How can government compensate growing trees in the inundation areas of the reservoir and how the size of trees affects the compensation?
c) When the reservoir is completed, the road was flooded to create an alternative road or not.
5. Conclusion

The pre-feasibility study of Klong Krasae reservoir project has been finished. The project started from the request of the people in Bo thong district due to the chronic drought in the dry season for many years. The study team considered project planning as a medium reservoir which has normal storage of 18.12 million cubic meters from the annual run-off of 60.96 million cubic meters or a ratio of normal storage to annual run-off is about 1 to 3.36. The Zone type dam is selected due to the availability of construction materials in the area. The maximum height of the dam is 21 meters with the length of 441 meters. However, three saddles are needed to be constructed to close the reservoir for that storage requirement. The construction cost is about 12.2 million US dollars. This water development is domestic use, agriculture and ecological system, where 100 household and agricultural areas of 3, 163 acres will benefit. Although the project might not impact the environment and not the study of the Environmental Impact Assessment (EIA), The project will impact people of 20 households to evacuate from the inundation area. However, this impact will be compensated by the government as issued in the law.

The study of the project contributes largely to the people in the project’s area. It can relieve their concerns on the drought in the dry season. The economic analysis shows feasible to conduct this project. The financial analysis by Farm model shows the promise to the rural community with more incomes in future with the project, including the average yields per acre of crops increasing and cropping intensity increasing, as well. The labor requirement is also increased to the local people in the community of Bo thong district. However, the social assessment shows that there are some concerns from the stakeholders who own the land inside the projects area. Their concerns are mostly about the compensations and land replacement. These concerns have
been everywhere in Thailand where the water development such as reservoirs is performed. This might need more efforts from associated government officials to explain more to people and provide a fair compensation, including the suitable environmental impact mitigation plan, implementation and monitoring of the project’s area.

**References**

1. Background

1.1. Status of irrigation sector in Vietnam

Nowadays, there are many irrigation systems of all scales over the country, of which about 904 medium and small schemes with 200 hectares commanded area of each and about 110 schemes with over 2,000 hectares commanded area of each. The allocation of an irrigation system with over 2,000ha command area and irrigated agriculture area by regions were shown in figure 1.

Figure 1. Allocation of irrigation system with over 2,000 ha of command area and irrigated agriculture area by region in Vietnam

However, due to the inadequacy of its capacity compared with application requirement, lack of technical personnel, low investment rates, asynchronous, backward technology and management methods and unreasonable decentralization, the performance of water resources management in the irrigation systems is not high [9]. Baseline data of Irrigation Efficiency indicator of 8 irrigation systems [2][4] was shown in Figure 2 below.

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22 Deputy Director General, Vietnam Academy for Water Resources (VAWR); Tel. +84-4-3563-4071, Fax. +84-4-3853-6290, Email: phongicd@vawr.org.vn, phongicd@gmail.com
1.2. State policies on irrigation sector in Vietnam

In the context of Vietnamese, Government issued a national program on restructuring of the country's economy, including the National Program on Restructuring the Agriculture Sector was approved in Decision No. 899 / QD-TTg dated June 10, 2013 by the Prime Minister, MARD issued the National Program on Restructuring Irrigation Sector (PRIS) in Decision No. 794 / QD-BNN-TCTL dated 21st April 2014 with the goal of "Improving the efficiency of irrigation sector, restructuring the agricultural sector towards higher added value and sustainable development; meet the development of the economic - social sectors; improve disaster prevention and adaptation to climate change; contributing to the modernization of agricultural infrastructure, rural and new rural development".

PRIS [10] has given the tasks to be achieved including: (i) strengthening and developing infield irrigation, associated with building a new rural; (ii) strengthening the organizational management and exploiting irrigation works; (iii) developing an active irrigation agriculture towards modernization; (iv) developing infrastructure irrigation for intensive farming and aquaculture with main species in the Mekong Delta, the coastal regions in the Central Vietnam; (v) improving safety level in disaster prevention, storm, flood, lake dam safety. Proactive prevention, avoidance or adapted to minimize losses and protect the safety of citizens, ensure the stability and development of production in terms of climate change; (vi) improve the effectiveness of disaster risk management and dam safety by applying advanced technology and capacity forecasts, disaster warnings, preferably non-structural solutions; and (vii) improve the efficiency of management and exploitation of works of rural water supply in a sustainable way both in terms of infrastructure, management model and financing.

Besides, this national program also provides performance orientation, including: (i) improving the efficiency of management and exploitation of irrigation systems; (ii) developing irrigation for crops; (iii) developing irrigation infrastructure serving aquaculture; (iv)
improving the safety level for reservoirs; and (v) improving capacity of natural disaster prevention.

The main measures for the implementation of tasks in the project with the above direction including: (i) improving the quality of irrigation planning, strengthen the management comply with the content planning innovation such as the planning, review of national irrigation plan, plan and plan for prevention of natural disasters, dam safety; (ii) improving the institutional policies; (iii) adjusting the structure of public investment; (iv) innovation of science and technology activities; (v) strengthen the State management apparatus for irrigation; and (vi) training human resources, and strengthening international cooperation.

Currently, a number of solutions serving the effective implementation in the scheme restructuring of irrigation sector are also built to focus on many different aspects, may include: (i) "National program on improvement of the performance of existing irrigation and drainage systems" focused on solutions to improve management efficiency exploiting irrigation works [9]; (ii) "Training programs on improvement of knowledge, specialized skills on management and exploitation of irrigation schemes" focuses on aspects of capacity building in management and exploitation for all levels of management from clue to on-farm; and (iii) "Program on development of on-farm irrigation, focusing on building development, institution and technology at the on-farm level.

2. Introduction to Irrigation Modernization in Vietnam

2.1. The concept of irrigation modernization in Vietnam

The role of irrigation and drainage infrastructure and management in such structural transformations should be of interest given the level of public and private investment in the sub-sector. And while the magnitude of the challenge in meeting current and future demand for irrigated products has been acknowledged in economic accounts of regional development, evidence of ‘quality’ solutions is hard to come by. In many instances irrigation institutions have found it difficult to adopt service-oriented management principles and position the sub-sector in relation to changing demands, and changing capacities. This is despite the examples from water supply or energy utilities.

The lack of attention to hydraulic and institutional detail on the region’s large irrigation schemes threaten to foreclose opportunities for positive modernization at a time when the nature of the supply of inputs is likely to change as much as the demand for other multi-functional services from irrigation and drainage systems.
After 20 years of implementation of irrigation system improvement projects in the Asian region by FAO and the World Bank with different approaches and different views on Modernization of irrigation, the definition of modernization of irrigation was carried out and agreed by participants who work in the field of irrigation development in a workshop of FAO in Bangkok, Thailand in 1997 such as: “Modernization of an irrigation system is defined as the act of upgrading or improving the system capacity to enable it to respond appropriately to the water service demands of the current times, keeping in perspective future needs, or as a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes with the objective to improve resource utilization (labor, water, economics, environment) and water delivery service to farms. This involves institutional, organizational and technological changes and implies changes at all operational levels of irrigation schemes from water supply and conveyance to the farm level. The objective is to improve irrigation services (and minimize associated costs) to farmers, and improvement in canal operation will generally be a critical first step in the process”.

Regarding the situation of the role of irrigation sub-sector in the context on the restructuring of the agricultural sector, it should be possible to re-calibrate the irrigation sector to allow it to adapt to changing demands on irrigated agriculture. These include the progressive urbanization of the region and the deepening of food retail value chains. But the factors of supply are also changing dramatically as the economic transitions proceed. Changing labor availability and rising rural wage levels are prompting land consolidation and adoption of mechanization to maintain acceptable levels of land productivity. The change will be triggered by the overall productivity of farm operations of which water is just one input. However, by looking at the detail of water services, it may be apparent that many irrigation problems need to be addressed outside the realm of the irrigation and drainage sub-sector. To a degree this work has already started through the sub-sector (including the RAP and MASSCOTE tools). But while these are very useful tools to assess service levels and propose interventions to achieve or improve agreed levels of service, the application of these tools needs to be iterated with reference to the national and regional economic frames as they transition.

2.2. Trend of irrigation modernization in Vietnam

In recent years, the Official Development Assistance (ODA) funded projects in irrigation sector focus on improvement of the irrigation schemes toward modernization (FAO, Bangkok, 1997). A concept of service was applied in designing modernization of irrigation schemes rather than merely rehabilitation and improvement of infrastructure as before.

23 Modernizing Irrigation Management – the MASSCOTE Approach - FAO Irrigation and Drainage paper 63
The concept of irrigation management modernization through service-oriented management was initially developed by WB for improving the operational efficiency of 6 large irrigation schemes over the country including (i) Dau Tieng; (ii) Da Ban; (iii) PhuNinh; (iv) Ke Go; (v) Yen Lap; and (vi) Cau Son - Cam Son [3]. The results, as well as the lessons learned on irrigation modernization projects in VWRAP project were pre-condition for the implementation of other on-going ODA projects on irrigation development financed by the World Bank in Vietnam [2].

The sub-projects in VWRAP project also involved objectives of on-farm irrigation development with such activities as (i) irrigation management transfer and PIM; (ii) strengthening and development of water user’s organizations; and (iii) training for capacity building. These activities supported for effective on-farm water management in order to improve the performance of irrigation system. Figure 3 demonstrates increase of economic development and water productivity of the irrigation systems of Ke Go, Ha Tinh province and PhuNinh, Quang Nam province under VWRAP project [2], [12].

![Graph 1](image1.png)

**Sources**: VAWR, 2013

**Figure 3. Benefit from irrigation modernization in VWRAP project**

Achievement and lesson learned on Irrigation Modernization of VWRAP project became the foundation for implementation of other irrigation development projects in Vietnam funded by ODA fund of international donors such as Phuoc Hoa Water Resources Project, funded by ADB and AFD, or Vietnam Irrigated Agriculture Improvement Project (VIAIP/WB7), funded by WB.

With the modernization approach, the irrigation management needs to be changed from the traditional method to the new methods consistent with such approach. The knowledge and skills of management and operation of modern irrigation schemes providing service agreements for end users were developed and transmitted to the stakeholders in the irrigation management system. This is a precious inheritance to be able to update and develop these materials for
application to the irrigation schemes in our country to contribute to the improvement of operational efficiency.

2.3. Application of RAP/MASSCOTE in irrigation modernization in Vietnam

Nowadays, RAP and MASSCOTE method can assist preparing a strategic plan on Irrigation Modernization [6], which was recommended in the irrigation sector restructuring master plan as well as applied in some irrigation systems in Vietnam under ODA projects in order to support irrigation managers develop vision and plan of system improvement. Besides, non-structure measures supported for on-farm irrigation development (PIM program) are also integrated in the orientation of irrigation development for comprehensive irrigation sector restructuring.

MASSCOTE is an approach for assessing the process, the effectiveness of performance as well as developing modernization plan for the irrigation scheme. MASSCOTE is developed by FAO with the general content consisting of all aspects in irrigation management to make a standard framework aiming to improve the procedure of operation of the irrigation system on the basis of extensive experience with irrigation modernization programs in Asia between 1998 and 2006.

RAP/MASSCOTE, which included clear and specific guidance on assessment of water delivery services of irrigation systems, were proposed to be an appropriate tool in the “National Program on Restructuring the Irrigation Sector” as well as the “National Program on Improvement of the Performance of Existing Irrigation and Drainage Systems” that issued by the MARD. Until now, RAP/MASSCOTE was applied to build an irrigation modernization strategic plan for 15 irrigation systems in the Northern mountain [1] region and 8 irrigation systems in the Central region [4]. Some figures of irrigation system performance from RAP/MASSCOTE application in 8 irrigation systems in Central region was shown in Figure 4.

Sources: VAWR, 2015

Figure 4. Results of RAP/MASSCOTE application in Vietnam
2.4. Irrigation modernization framework

Base on the achievement of RAP/MASSCOTE apply, MARD has a plan to disseminate RAP/MASSCOTE for building irrigation modernization strategic plan by the development of an Irrigation Modernization Framework (IMF). The content of the irrigation modernization proposed framework will include (i) the process of implementation of irrigation modernization includes the activities required for the implementation of relevant aspects of the modernization of irrigation; and (ii) the role and responsibilities of the parties involved in the modernization of irrigation systems [11].

The development of the IMF approach based on,

(i) Service-Oriented Management; and (ii) Modernization of Irrigation. Therefore, the basic content of the modernization framework will be based on steps taken by irrigation system modernization to manage service oriented as shown in Figure 5 with a process comprising the steps of: (i) Assessment of irrigation system performance; (ii) Developing the strategic plan of irrigation system modernization; and (iii) Monitoring/ Evaluation & Adjustment. Besides, the contents of steps should also include the roles and responsibilities of stakeholders in the formulation and implementation of Modernization plans [13].

Figure 5. Process to build Irrigation Modernization Framework

In the IMF, the Monitoring and Evaluation of Irrigation Modernization process is important to revise, adjust the irrigation modernization strategic plan to adapt to the local social-economic development purposes. The Monitoring and Evaluation (M&E) should be carried out regularly during the implementation of the strategic plan on irrigation modernization with the aims: (i) Ensure the plan is implemented in accordance with the pre-defined roadmap; and (ii) Promptly amend goals as well as the problems to improve the strategic plan on irrigation modernization to fit the general context. During this period, the M&E system should be developed and used for the implementation of the strategic plan on irrigation modernization; or development and application
of Benchmarking system; or application of rapid assessment procedures RAP and MASSCOTE method to assess the performance of irrigation system after a period and consider the level of rehabilitation/improvement to meet requirements of service.

The detail IMF will be completed in 2017 as well as a Benchmarking system with about 26 irrigation systems in Red River Delta will be piloted with the IMF application [5].

3. Brief Introduction to Benchmarking for Irrigation Management

Benchmarking can be defined as [8]: “A systematic process for securing continual improvement through comparison with relevant and achievable internal or external norms and standards”.

The overall aim of benchmarking is to improve the performance of an organization as measured against its mission and objectives. Benchmarking implies comparison – either internally with previous performance and desired future targets, or externally against similar organizations, or organizations performing similar functions. Benchmarking is a management tool already in use in both the public and private sector organizations.

Irrigation and drainage are essential services to irrigated agriculture – providing and removing water to suit the crops’ needs. Thus, in the irrigation and drainage sector we are interested in improving the level of service provision to water users, thereby enabling them to maintain or increase levels of agricultural production. In approaching benchmarking for the irrigation and drainage sector there are three characteristics that need to be borne in mind (i) Irrigation and drainage service providers operate in a natural monopoly environment; (ii) Irrigation and drainage entails complex and interacting physical, social, economic, political, technical and environmental processes; and (iii) Performance of irrigation and drainage schemes is site-specific.

Benchmarking process for irrigation and drainage system as shown in figure 6 include 6 steps such as: (i) Identification and planning; (ii) Data collection; (iii) Data analysis; (iv) Integration; (v) Action; and (vi) Monitoring and Evaluation.

Sources: Hector Malano and Martin Burton, 2001

Figure 6. Benchmarking process
**In the world**

The Benchmarking system for irrigation management was initiated by the research institutes in the field of irrigation modernization such as World Bank, Food and Agriculture Organization of the United Nations (FAO), International Program for Technology and Research in Irrigation and Drainage (IPTRID), International Commission on Irrigation and Drainage (ICID), and International Water Management Institute (IWMI). These institutes have disseminated the concept of effectiveness evaluation of irrigation system by quantifying the operational indicators of irrigation management agencies. Benchmarking irrigation and drainage projects have been implemented in many countries. However, in each country, there is a difference in methodology and applied tools. Since, there is no international standard methodology and tools for evaluation, each country has to study and apply their own methods and tools that are suitable for the specific conditions of their country. Developing a common indicator set that widely applied is time-consuming and requires practical testing over time. Hence, the irrigation managers need to understand that the Benchmarking system for irrigation management is a process rather than an activity that can be implemented in a short time.

**In Vietnam**

In fact, the development of water resources management in general and irrigation management in particular in Vietnam is not sustainable despite the efforts of increasing investment and organizational restructure. To measure the irrigation system improvement, the operational monitoring and evaluation have been required in many documents. However, the M&E has not been implemented in a uniform and systematic way.

According to the Ordinance No. 32/2001/PL-UBTVQH10 dated 4/4/2001 of the Standing Committee of the National Assembly on the Exploitation and Protection of Irrigation works (hereafter called as the Ordinance No. 32/2001/PL-UBTVQH10), the Irrigation Management Companies were considered as the public service providers under the management of the Government. In particular, these companies have to periodically report on the irrigation management aspects including structure management, water resources, human resources, and finance in accordance with existing regulations. The legal document includes (i) Circular No. 11/2009/TT-BTC dated 21/01/2009 of the Ministry of Finance on the monitoring and reporting on the financial management; (ii) Circular No. 65/2009/TT-BNN dated 12/10/2009 and Circular No. 56/2010/TT-BNN dated 01/10/2010 of the MARD on the effectiveness evaluation and development planning of Irrigation Management Company; (iii) TCVN 8304: 2009 for irrigation works under the irrigation system by the Ministry of Science and Technology dated 31/12/2009,
etc. However, these policies are still lack of guidelines on M&E that leads to the difficulties in enforcement.

In this context, the information monitoring process has been conducted in several different ways, depending on the perception of irrigation managers but still following these above policies. Since 2002, the concept of irrigation modernization as well as the service-oriented management (SOM) approach [6] has been introduced in the irrigation sectors through the World Bank funded projects. In these projects, the tools such as RAP, MASSCOTE [6], etc. were firstly used for evaluating the efficiency of the irrigation system. This is also the foundation to develop a strategic plan for irrigation modernization. Through the implementation of RAP/MASSCOTE, the fact showed that the information is still insufficient for Irrigation Management Companies (IMCs) to comprehensively evaluate the quality and efficiency of irrigation system operation.

4. Status of Benchmarking System for Irrigation Management

4.1. Benchmarking system for irrigation management

Currently, with the service-oriented management approach on modernization, some studies developed the evaluation system for the operation of irrigation work (Benchmarking) in Vietnam, namely:

Benchmarking system of Vietnam Water Resources Assistance Project (VWRAP)

A consultancy service was conducted to develop a standard Benchmarking system for irrigation management under the Vietnam Water Resources Assistance Project (VWRAP/WB3). With this Benchmarking, the indicators were divided into 5 thematic groups, including:

a) Project management
b) Water management
c) Human resource management
d) Financial management
e) Environmental status.

To calculate the evaluation indicator as mentioned in the above group, a guidance system on baseline indicator collection. The baseline indicators were used to calculate the target indicator as well as collecting and calculating methods.
This system was piloted in 4 irrigation systems under VWRAP including (i) Yen Lap; (ii) Ke Go; (iii) PhuNinh; and (iv) Dau Tieng. The result of these pilot systems laid the foundation for the application of evaluation for the operation of irrigation systems in Vietnam.

**Benchmarking system issued by Directorate of Water Resources**

Based on the standard Benchmarking system developed under VWRAP, the Directorate of Water Resources of MARD screened and issued the operational evaluation indicator for irrigation. This Benchmarking aimed at supporting the management of Directorate of Water Resources. This indicator set was not divided into groups and included 28 evaluation indicators.

This set of indicators was piloted in 2014 to 110 major irrigation systems in Vietnam. With the lessons learned from the application, the new indicator set will be developed and promulgated for better use.

**4.2. Benchmarking’s tools for irrigation management**

**ABCDE+F framework [7]**

In the Asia – Pacific region, irrigation plays an important role in agricultural production and food security. Hence, important institutes such as WB, ADB, and FAO wanted to have a common picture on irrigation management modernization. Based on that, they can prepare a comprehensive technical assistant plan for irrigation sector in the region.

A simple framework with the acronym of ABCDE + F with the 4-step process is used to assess the overall status of irrigation services in 5 participated countries (China, Indonesia, Malaysia, Thailand and Vietnam) and establish baseline information for the region. This approach is designed to provide information about the current status and potential elements of irrigation sector to the policymakers. The general framework of this approach was presented in Table 1 which can be applied where appropriate.

- A short-term analysis is required to assess how to match with the current and the near future conditions and improve water supply service at national level;
- A long-term analysis is required to identify the modernization strategy based on new targets of improved or maintained operation in the future.

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24 34th ASEAN Summit of Ministers of Ministry of Agriculture and Forestry on 27 September 2012 in Vientiane
Table 1. Basic ABCDE+F framework

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>A: Accounting</th>
<th>B: Bargaining</th>
<th>C: Codification</th>
<th>D: Delegation</th>
<th>E: Engineering</th>
<th>F: Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>National water audit</td>
<td>National water council</td>
<td>National water law</td>
<td>Regulation policy</td>
<td>Interbasin transfer</td>
<td>Agricultural growth</td>
</tr>
<tr>
<td>Basin</td>
<td>Basin audit</td>
<td>Basin planning Board</td>
<td>Basin plan</td>
<td>River basin organization</td>
<td>Hydromet network</td>
<td></td>
</tr>
<tr>
<td>Service Interface Basin – Main Irrigation System</td>
<td>Water account</td>
<td>System representation on Board</td>
<td>Water use rights + bulk allocation and service standards</td>
<td>Bulk delivery payments</td>
<td>Flow management system</td>
<td></td>
</tr>
<tr>
<td>Main Irrigation System</td>
<td>Irrigation Committee</td>
<td>System operation plan</td>
<td>Irrigation system authority</td>
<td>Conveyance + drainage system</td>
<td>Annual review and plan setting</td>
<td></td>
</tr>
<tr>
<td>Service Interface Main Irrigation – Sub-Irrigation System</td>
<td>System scheduling account</td>
<td>Water use association federation (WUAF)</td>
<td>Scheduling agreement</td>
<td>Service contract and revenue flows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub Irrigation System</td>
<td>Secondary</td>
<td>Cropping schedule</td>
<td>WUAF</td>
<td>Flow control and storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service interface WUAF – WUA</td>
<td>Water User Association (WUA)</td>
<td>Service agreement + payment mechanism</td>
<td>Cross regulation operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WUA</td>
<td>Tertiary</td>
<td>WUA</td>
<td>Drainage</td>
<td>Performance review</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service interface WUA – Farmer</td>
<td>Water account</td>
<td>Service agreement</td>
<td>Turn out operation</td>
<td>Information flows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td></td>
<td>Water order</td>
<td>Delivery and payment</td>
<td>On-farm technology</td>
<td>Farmer income</td>
<td></td>
</tr>
</tbody>
</table>

Source: Jacob Burke et al., Bangkok, 2013

**MASSCOTE and Rapid Appraisal Procedure (RAP)**

MASSCOTE is a method to evaluate the processes and operational efficiency as well as plans for irrigation system modernization. MASSCOTE was developed by Food and Agriculture
Organization (FAO) by aggregating all aspects of irrigation management and put under a standardized framework. This approach aimed to improve the operational procedure of irrigation system based on the experience from irrigation modernization programs in Asia period 1980-2006.

MASSCOTE is used to develop a strategic plan on the modernization of irrigation system through a proprietary process with the following steps:
- Identify the characteristics of the system, the water resources and the factors affecting the management;
- Divide the management units;
- Identify service and operation strategy for each management unit; and
- Synthesize and strengthen the operational strategy for main systems;

MASSCOTE is an iterative process based on ten successive steps, but more than one round of implementation is required in order to determine a consistent plan. Several necessary steps need to be discussed before achieving a final agreement. Phase 1 of MASSCOTE focused on basic information and Phase 2 focused on the vision of the system and the options for improving the management of water services. The stepwise MASSCOTE process is presented in Figure 7.

Sources: Daniel Renault et al., 2007

Figure 7. Stepwise MASSCOTE process
**Rapid Appraisal Procedure (RAP)** is a process for collecting and analyzing the system data in the office as well as in the field. This is also a process to check input data such as water supply, water allocation points (ET, flow, etc.) RAP helps systematically monitoring the hardware and the process of water transmission and allocation within the system to other points (from the source to the field). Both external and internal indicators are developed to provide (i) baseline information to compare the system with and without the modernization, (ii) standardization to compare with other projects, and (iii) basis to propose specific recommendations for modernization and improvement of water allocation services. RAP has provided a list of practical indicators which contributed to the development of modernization plans through various steps of MASSCOTE.

The rapid appraisal for irrigation system can provide a precise and practical description of the system status, as well as procedures and works that affect the current system. This allowed to identify measures, main actions to quickly improve the water supply services – especially RAP is conducted by the local irrigation management agencies. RAP can easily provide valuable insights on the designs and operations of the irrigation systems. The relation between RAP and MASSCOTE and Irrigation Modernization was shown in Figure 8:

![Figure 8. RAP/MASSCOTE in Irrigation Modernization](image)

**Sources:** Daniel Renault et al., 2007

**4.3. Advantages and disadvantages of the existing Benchmarking system and its tools**

**ABCDE+F Framework**

This overall framework is used for evaluating the irrigation management. It can evaluate many aspects such as (i) roles of stakeholders from the central level to on-farm level on irrigation management; (ii) irrigation management elements: institutions, techniques, M&E, etc.; and (iii) relations among stakeholders. However, this framework only provides qualitative assessment;
and cannot evaluate the efficiency of system operations. Hence, this framework is suitable for overall qualitative assessment on irrigation of a region or a country.

**RAP/MASSCOTE**

Benchmarking system for irrigation management using tools such as Rapid Appraisal Procedure (RAP) and MASSCOTE provides information on the current status of the irrigation system and quality of infrastructure. However, the application of RAP/MASSCOTE requires experienced and qualified experts as well as budget. Besides the achievements, the development of a strategic plan on Irrigation Modernization by MASSCOTE has not had specific guidance on preparing detailed implementation plan of Irrigation Modernization strategy such as:

- Activities of improvement and modernization of infrastructure as well as management are still isolated within an internal irrigation system whilst they do not reveal interconnection between irrigation management levels.
- Although plans and strategies of irrigation modernization involve related concepts, they are still localized within the scope of the system and do not take in to account the context of Integrated Water Resources Management with river basin approach.
- Responsibilities and relationships between irrigation management levels (from the national level to farm level) in terms of the institution, technique, monitoring and evaluation, etc. are not addressed specifically and clearly in the strategic plan on Irrigation Modernization with MASSCOTE method.

An appropriate monitoring and evaluation system for Irrigation Modernization has not been developed and proposed.

**Benchmarking**

**Benchmarking of VWRAP**

This system was piloted in 4 irrigation systems under VWRAP including (i) Yen Lap; (ii) Ke Go; (iii) PhuNinh; and (iv) Dau Tieng. The pilot results showed both advantages and disadvantages, specifically:

**Regarding the data collection for the calculation of indicators:**

Each system requires 28 indicators which are divided into 6 groups. The total indicators of 4 piloted irrigation systems are 112. In order to collect the indicator data, it is important to assess the collection ability and reliability of data, know the advantages and disadvantages when using the data, understand the difficulties that system managers encounter with, identify clearly each
indicator and propose measures to improve the results. The quantity and quality of each indicator group are presented in Table 2 and 3:

**Table 2. Summary of collection data**

<table>
<thead>
<tr>
<th>No.</th>
<th>Group of indicators</th>
<th>Quantity</th>
<th>% collected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Needed</td>
<td>Collected</td>
</tr>
<tr>
<td>1</td>
<td>Area</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Water supply</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Structure</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Finance</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Human resources</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Environment</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>112</strong></td>
<td><strong>68</strong></td>
</tr>
</tbody>
</table>

**Regarding the evaluation indicators:**

Based on the collected data, the evaluation indicators are divided into different groups. Each system should have 29 distinguish indicators. The total indicators of 4 systems are 116. Data provided by IMCs will be synthesized and reorganized into data table for the analysis and comparison of indicators. The number of calculated, reliable, and not reliable indicators is summarized in Table 3:

**Table 3. Summary of calculated indicators**

<table>
<thead>
<tr>
<th>No.</th>
<th>Group of indicators</th>
<th>Quantity</th>
<th>% calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Needed</td>
<td>Collected</td>
</tr>
<tr>
<td>1</td>
<td>Structure management</td>
<td>24</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>Water management</td>
<td>44</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>Human resources management</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Financial management</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Environmental management</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>116</strong></td>
<td><strong>77</strong></td>
</tr>
</tbody>
</table>

The summary table showed that IMCs can provide 66% of required indicators. Of which, indicators related to water management is the most adequate (93%) while the environmental management has the lowest percentage (only 13%). The lack of information and data for on-farm...
and environmental management cause the impacts on the related indicators such as the human resources on farm, labor productivity on the farm, changes in conductivity and acidity. Specifically, about 7 indicators are not reliable as its data is from an untrusted source. As a sequence, the final results are abnormally different from the reality and other systems.

**Benchmarking issued by Water Resources Directorate**


The application of evaluation criteria on irrigation management was conducted in 63 provinces and cities. This approach was also applied in 03 inter-provincial irrigation systems managed by MARD. IMC collected the data, and then conducted the assessment based on the indicators issued by MARD. The final results indicated the low suitability level of the evaluation system as the understanding and implementation capacity of IMC is still low.

5. Development of a Suitable Benchmarking System for Irrigation Modernization in Vietnam

5.1. Principles

To evaluate the operation of irrigation work using existing evaluation tools such as RAP, the overall method of WB required a lot of time and money as these methods need a huge work of experienced experts. In order to evaluate the operation of irrigation system under the framework of Vietnam Irrigated Agriculture Improvement Project, the following fundamental principles should be taken into consideration as the followings;

1) **Principle 1:** Refer FAO guideline and experience in the world

   Guideline for Benchmarking performance in the irrigation and drainage sector [5] is an important reference source as it is widely adopted in the world and in Southeast Asia countries such as Thailand, Indonesia and Malaysia. These countries have similar natural, socio-economic conditions as Vietnam. In addition, a guideline for rapid appraisal procedure of FAO, efficiency evaluation of irrigation system of IWMI, and assessment guidelines of other countries, etc. are good sources for references.

2) **Principle 2:** Restructure the benchmarking system based on the irrigation management perspectives in Vietnam
The evaluation is based on the classification of indicators on water resources management in order to achieve the performance targets in terms of productivity (production), satisfactory (water supply), durability (irrigation structure), viability (economics) and sustainability (environment). This type of classification is not familiar and suitable to the irrigation management of Vietnam. In fact, there are 4 groups namely: structure, water resources, finance, and human resources management identified in Vietnam.

3) **Principle 3**: Optimize the available and collectible data

Ideally, the benchmarking performance for irrigation system should start from the improvement of monitoring activity. That means all the indicators should be determined before establishing a new system. In reality, a number of indicators are known as impossible to access or estimated precisely. In this case, replace them with other similar indicators can be a solution. For example, it is a challenge for IMC to estimate the asset value at on-farm level with acceptable accuracy number. It is also a big challenge for even experienced consultants. Therefore, the indicator of irrigation canal density can be used instead of on-farm canal value.

4) **Principle 4**: Review the mid-term and long-term strategy to prepare the implementation roadmap

At first, this principle seems to contradict the above three principles. The development of mid-term strategic plan process should consider this principle. However, this problem can be solved when applying RAP/MASSCOTE for irrigation systems.

5) **Principle 5**: Consider the needs of irrigation system managers

As analyzed above, each evaluation indicator set is used for the different purpose of managers (water managers, project managers, irrigation exploitation managers, etc.). For this reason, the development of evaluation indicators for the operation of irrigation work should refer the irrigation managers regarding the necessity, efficiency, and feasibility of the system.

5.2. Content of proposed evaluation indicators

During the application of RAP/MASSCOTE at the irrigation systems, IMC staff will receive guidance on the data collection, indicator calculation using RAP and structure assessment using MASSCOTE. We have discussed with trainees about the benchmarking system. As a result, a suitable Benchmarking system for irrigation management will be proposed to meet the requirements of IMCs.

The indicators were divided into 5 groups, specifically:
a) **Water management indicator group:** The water management was characterized in 2 areas: (i) the volume of water distributes to users and (ii) system capacity to meet the water use changes. Indicators of this group will provide information of water supply situation, water transmission capacity, water use efficiency of the whole system as well as on-farm.

b) **Irrigation structure indicator group:** These indicators reflect (i) the ease water transmission and distribution through irrigation infrastructure quality assessment; (ii) the irrigation service capacity in comparison with the client needs; (iii) operation and service providing capacity; and (iv) water resources management capacity of the system. The infrastructure of the irrigation system will be evaluated at system level (managed by IMC) and on-farm level (managed by WUA).

c) **Indicator group on finance, employee, and water user association:** The financial indicators help answer a series of questions related to water management’s finance and assess the water management sustainability including (i) ratio between operating cost and revenue; (ii) ratio between maintenance cost and revenue, etc. These indicators related to employee provide evaluation information on the human resources of the system; to see whether the system has sufficient employee for operation or not. And finally, indicators related to water user association provide evaluation information on the efficiency and sustainability of the system operations namely distributing water to farm surface.

d) **Economics indicator group:** These indicators reflect the serving objectives of the irrigation system to the sector (agriculture and non-agriculture sector). These indicators help to observe whether the system is developing or not. In other words, to see what extent the water management brings to the economy.

e) **Environmental indicator group:** This indicator group is used to measure the amount of organic matter that affects the irrigated water resources in the system. The change in the chemical properties of water at the intake and outtake reflect the system’s capacity to deal with the problems of environmental destruction.

The indicators can be calculated under the absolute value (million m$^3$, the number of employees, etc.) in order to monitor the irrigation process during the modernization process; or calculated under the relative value (m$^3$/ha, ha/employee.) in order to compare the performance efficiency among irrigation systems. Details indicators are presented in Annex 1.

Except for the indicators in Group 5 - Environmental management that dependent on the monitoring needs of each system, the remaining indicators closely serve irrigation management activities and have high feasibility in the calculation process. These indicators are monitored on yearly basis and will be the basis to propose initial recommendations on the modernization of irrigation management.
Simple software, e.g. Microsoft Excel, should be developed to enter collected or calculated raw data to a worksheet. Based on the calculated results, the indicators will be listed in another worksheet. In addition, a diagram system will be developed to easily observe the changes.

6. Conclusions and Recommendations

6.1. Conclusions

By reviewing the development process of Benchmarking for Vietnamese irrigation systems, we achieved the following results:

a) *Generally analyse the evaluation system:* Indicate the necessity of the efficiency evaluation indicators of irrigation system in the world and in Vietnam during the modernization process of irrigation system

b) *Analyse the advantages and disadvantages of evaluation systems:* Inherit the successes and failures from evaluation method for the irrigation system. Based on that, develop a suitable evaluation system for Vietnam.

c) *Propose suitable Benchmarking system for irrigation management:* Meet IMC’s requirements in operating irrigation system towards services and high feasibility in application

d) *Propose a standard process for the development of integrated assessment:* Propose specific steps to group individual indicators into a standard set. Analyse the implementation capacity and detect difficulties during the implementation process. The results will be used to develop the general benchmarking performance for irrigation systems.

6.2. Recommendations

Through the process of developing Benchmarking system and discussion with technical experts of irrigation systems, the identification of evaluation indicator for the operation of irrigation work is technically feasible. Each evaluation indicator contains its own meaning and can provide useful information related to the operation and management of irrigation services. The overall assessment will be summarized and analyzed by managers or consultants.

To better the evaluation system, we would like to recommend the overall scoring system in order to support the state management and improve the operations of the irrigation system. From the total value of all of the indicators, we can identify the final value for a specific month to generally evaluate the irrigation system’s effectiveness. For example, if the average score of a
certain irrigation system is 4.0/10, the operation of this system is below average; and vice versa if the score of the system reached 6.0/10, the operation of this system is at an average level.

In principle, the above recommendation can be turned into action by assigning weights to each indicator based on the importance level of the indicators to the evaluation results. Then use the weighted average method to determine the overall value of the indicator group. Continue to assign weights to the indicator group and calculate an average weighted for the overall value of the indicator groups that identified in the previous step to thereby calculating the overall value for the entire indicator group. This approach has been applied to quantify indicators during the rapid appraisal procedure (RAP). The calculation process is described in Figure 9:

\[ GI: \text{aggregate value of a group of indicators} \]

Figure 9. Process for the identification of common indicators

We also found that the above process will encounter two problems:

a) The indicator has different dimensions; in order to get the same dimensions or reduce their dimensions is not an easy work.
b) The weight value (even in the case that the indicators have the same dimensions) of the indicator or the indicator group needs the contribution of experienced experts and scientists in this field.

Therefore, we propose a further detailed study to address the above issues and develop a general scoring system of evaluation indicators in scientific and accurate manners.

### References


Annex 1: Proposed Benchmarking system

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of indicator</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1: Water management indicator group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.1</td>
<td>Total water supply to users</td>
<td>Total water supply to users at the crossing point between the company and water users</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.3</td>
<td>Total water supply through the headwork</td>
<td>Total water supply through the headwork</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.5</td>
<td>Total annual water supply</td>
<td>Total annual water supply for irrigated area through the headwork and precipitation</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.7</td>
<td>Water demand of crop</td>
<td>Water demand of all crops in year (ET)</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.9</td>
<td>Actual water demand of crop</td>
<td>Actual water demand of crop (ET–effective rainfall)</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.11</td>
<td>Total water supply for especially demand of crop</td>
<td>Total water supply for especially demands of crop (salinity wash-away, earthwork ⋅⋅⋅)</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1.13</td>
<td>Total water supply for non-agriculture services</td>
<td>Total water supply for non-agriculture services such as: domestic use, aquaculture farming, industry, husbandry, environment, etc.</td>
<td>Mil. m³</td>
</tr>
<tr>
<td>I1.14</td>
<td>Area of irrigated area</td>
<td>Total cultivated area in the system</td>
<td>Ha</td>
</tr>
<tr>
<td>I1.15</td>
<td>Total irrigated area</td>
<td>Total cultivated area of different crops</td>
<td>Ha</td>
</tr>
<tr>
<td>I1.16</td>
<td>Annual irrigated water volume for one unit of irrigated area</td>
<td>Total annual water supply on irrigated area</td>
<td>m³/ha</td>
</tr>
<tr>
<td>I1.17</td>
<td>Annual irrigated water volume for one unit of irrigated area</td>
<td>Total annual water supply on irrigated area</td>
<td>m³/ha</td>
</tr>
<tr>
<td>I1.18</td>
<td>Irrigation efficiency of the whole irrigated area</td>
<td>(Actual water demand of crop/Total water supply to the system)</td>
<td>%</td>
</tr>
<tr>
<td>I1.19</td>
<td>Irrigation efficiency at field surface</td>
<td>(Actual water demand of crop/Total water supply to users)</td>
<td>%</td>
</tr>
<tr>
<td><strong>Group 2: Structure management indicator group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2.1</td>
<td>Total length of the main canal</td>
<td>Total length of the main canal(s)</td>
<td>km</td>
</tr>
<tr>
<td>I2.2</td>
<td>Total length of reinforced main canal</td>
<td>Total length of reinforced main canal(s)</td>
<td>km</td>
</tr>
<tr>
<td>I2.3</td>
<td>Percentage of reinforced main canal</td>
<td>Percentage of reinforced main canal</td>
<td>%</td>
</tr>
<tr>
<td>Code</td>
<td>Name of indicator</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>I2.4</td>
<td>Total length of distribution canals</td>
<td>Total length of secondary and tertiary canals managed by IMC</td>
<td>km</td>
</tr>
<tr>
<td>I2.5</td>
<td>Density of distribution canals</td>
<td>Total length of secondary and tertiary canals system managed by IMC compared to irrigated area</td>
<td>km/ha</td>
</tr>
<tr>
<td>I2.6</td>
<td>Total length of reinforced distribution canals</td>
<td>Total length of reinforced secondary and tertiary canal system managed by IMC</td>
<td>km</td>
</tr>
<tr>
<td>I2.7</td>
<td>Ratio of reinforced water distribution canals</td>
<td>Ratio of reinforced secondary and tertiary managed by the company</td>
<td>%</td>
</tr>
<tr>
<td>I2.8</td>
<td>Total length of on–farm canal</td>
<td>Total length of on–farm canal managed by WUA</td>
<td>km</td>
</tr>
<tr>
<td>I2.9</td>
<td>Density of on–farm canal</td>
<td>Total length of on–farm canal managed by WUA compared to irrigated area</td>
<td>km/ha</td>
</tr>
<tr>
<td>I2.10</td>
<td>Total length of reinforced on–farm canal</td>
<td>Total length of reinforced on–farm canal managed by WUA</td>
<td>km</td>
</tr>
<tr>
<td>I2.11</td>
<td>Ratio of reinforced on–farm canal</td>
<td>Ratio of reinforced on–farm canal managed by WUA</td>
<td>%</td>
</tr>
<tr>
<td>I2.12</td>
<td>Total regulating stations on the main canal</td>
<td>Number of regulating structures on the main canal</td>
<td>Station</td>
</tr>
<tr>
<td>I2.13</td>
<td>Density of regulating stations on the main canal</td>
<td>Ratio between regulating stations and total length of the main canal</td>
<td>Station/km</td>
</tr>
<tr>
<td>I2.14</td>
<td>Total regulating stations on distributing canal</td>
<td>Number of regulating structures on secondary and tertiary canal managed by the company</td>
<td>Station</td>
</tr>
<tr>
<td>I2.15</td>
<td>Density of regulating stations on distributing canal</td>
<td>Ratio between of regulating structures on secondary and tertiary canal managed by the company compared to the total length of canal</td>
<td>Station/km</td>
</tr>
<tr>
<td>I2.16</td>
<td>Total water intake in canal system</td>
<td>Total water intake in canal system managed by the company</td>
<td>Station</td>
</tr>
<tr>
<td>I2.17</td>
<td>Number of water intakes managed by one staff of the company</td>
<td>Ratio between water intake in canal system managed by the company compared to number of operation staff of the company</td>
<td>Sluice/pers</td>
</tr>
<tr>
<td>I2.18</td>
<td>Number of water measurement stations on the main canal</td>
<td>Number of water measurement stations on the main canal</td>
<td>Station</td>
</tr>
<tr>
<td>I2.19</td>
<td>Density of water measurement stations on the main canal</td>
<td>Ratio water measurement stations on the main canal compared to total number of important work on the main canal (regulating, intake of secondary canal, siphon, aqueduct, etc.)</td>
<td>%</td>
</tr>
<tr>
<td>I2.20</td>
<td>Number of water measurement stations on distributing canal</td>
<td>Number of water measurement stations on secondary and tertiary canal managed by the company</td>
<td>Station</td>
</tr>
<tr>
<td>Code</td>
<td>Name of indicator</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>I2.21</td>
<td>Density of water measurement stations on distributing canal</td>
<td>Ratio between water measurement stations on secondary and tertiary canal managed compared to total number of important work on the main canal (regulating, intake of secondary canal, siphon, aqueduct, etc.)</td>
<td>%</td>
</tr>
</tbody>
</table>

**Group 3 Financial and employee indicator group**

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of indicator</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I3.1</td>
<td>Total revenue of the company</td>
<td>Total revenue of the company from water distribution service (including non-agricultural needs)</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.2</td>
<td>Total expense of the company</td>
<td>Total expense for the performing water distribution service (including non-agricultural production activities)</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.3</td>
<td>Ratio between expense/revenue</td>
<td>Ratio between expense for water distribution services and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3.4</td>
<td>Operation expense</td>
<td>Total salary and bonus of employee for the performing water distribution service</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.5</td>
<td>Ratio between operation expense and revenue</td>
<td>Ratio between salary and bonus of employee for the performing water distribution service and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3.6</td>
<td>Maintenance expense</td>
<td>Total expense for annual regular maintenance of the system work</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.7</td>
<td>Ratio between maintenance expense and revenue</td>
<td>Ratio between annual maintenance expense of the system and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3.8</td>
<td>Structure restoration expense</td>
<td>Total expense to restore damaged structures</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.9</td>
<td>Ratio between restoration expense and revenue</td>
<td>Ratio between annual restoration expense of the system and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3.10</td>
<td>Improvement and modernization expense</td>
<td>Total expense for modernization and reinforcement</td>
<td>Mil. VND</td>
</tr>
<tr>
<td>I3.11</td>
<td>Ratio between modernization expense and revenue</td>
<td>Ratio between annual modernization expense of the system and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3.12</td>
<td>Total employees of the company</td>
<td>Total employees of the company for the performing water distribution service</td>
<td>person</td>
</tr>
<tr>
<td>I3.13</td>
<td>Area managed by the company employees</td>
<td>Area managed by one company employee</td>
<td>ha</td>
</tr>
<tr>
<td>I3.14</td>
<td>Number of employees directly operate the system</td>
<td>Number of employees directly operate the system</td>
<td>person</td>
</tr>
<tr>
<td>I3.15</td>
<td>Area managed by operation staff</td>
<td>Area managed by an operation staff of the company</td>
<td>ha</td>
</tr>
<tr>
<td>Code</td>
<td>Name of indicator</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>I3_16</td>
<td>Number of employees of WUA performing the water distribution tasks</td>
<td>Total IMC staff of WUA in the system</td>
<td>person</td>
</tr>
<tr>
<td>I3_17</td>
<td>Area managed by employees of WUA</td>
<td>Area that managed by one operation staff of WUA</td>
<td>ha</td>
</tr>
<tr>
<td>I3_18</td>
<td>Area managed by an employee in the whole system</td>
<td>Area that managed by an operation staff (of the company and WUA)</td>
<td>ha</td>
</tr>
<tr>
<td>I3_19</td>
<td>Revenue of WUA</td>
<td>Total revenue of WUA from water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>I3_20</td>
<td>Total revenue of WUA</td>
<td>Total revenue of WUA from water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>I3_21</td>
<td>Total expense of WUA</td>
<td>Total expense for the performing water distribution service of WUA</td>
<td>VND</td>
</tr>
<tr>
<td>I3_22</td>
<td>Ratio between expense/revenue of WUA</td>
<td>Ratio between expense for water distribution services and revenue from water distribution service of WUA</td>
<td>%</td>
</tr>
<tr>
<td>I3_23</td>
<td>Operation expense of WUA</td>
<td>Total salary and bonus for employees of WUA for the performing water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>I3_24</td>
<td>Ratio between operation expense and revenue of WUA</td>
<td>Ratio between salary and bonus for employees of WUA performing water distribution service and revenue from water distribution service</td>
<td>%</td>
</tr>
<tr>
<td>I3_25</td>
<td>Maintenance expense of WUA</td>
<td>Total expense of annual regular maintenance of WUA</td>
<td>VND</td>
</tr>
<tr>
<td>I3_26</td>
<td>Ratio between maintenance expense and revenue of WUA</td>
<td>Ratio between annual maintenance expense for the system and revenue from water distribution service of WUA</td>
<td>%</td>
</tr>
<tr>
<td>I3_27</td>
<td>Structure restoration expense of WUA</td>
<td>Total expense to restore damaged structures of WUA</td>
<td>VND</td>
</tr>
<tr>
<td>I3_28</td>
<td>Ratio between restoration expense and revenue of WUA</td>
<td>Ratio between annual restoration expense for system damages and revenue from water distribution service of WUA</td>
<td>%</td>
</tr>
<tr>
<td>I3_29</td>
<td>Improvement and modernization expense of WUA</td>
<td>Total expense for modernization and reinforcement of irrigated structures of WUA</td>
<td>VND</td>
</tr>
<tr>
<td>I3_30</td>
<td>Ratio between modernization expense and revenue of WUA</td>
<td>Ratio between annual modernization expense of the system and revenue from water distribution service of WUA</td>
<td>%</td>
</tr>
<tr>
<td>I3_31</td>
<td>Annual average income of employee</td>
<td>Annual average income of employee for the performing water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>I3_32</td>
<td>Average income of operation staff of the company</td>
<td>Average income of operation staff of the company for the performing water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>I3_33</td>
<td>Annual average income of employees of WUA</td>
<td>Annual average income of employees of WUA for the performing water distribution service</td>
<td>VND</td>
</tr>
<tr>
<td>Code</td>
<td>Name of indicator</td>
<td>Description</td>
<td>Unit</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>I3.34</td>
<td>Revenue from water</td>
<td>Revenue from water distribution for 1 m³ water to the crossing point between company and WUA</td>
<td>VND/m³</td>
</tr>
<tr>
<td>I3.35</td>
<td>Expense for management and operation of water distribution</td>
<td>Operation expense to take 1 m³ water to the crossing point between company and WUA</td>
<td>VND/m³</td>
</tr>
</tbody>
</table>

**Group 4**  
**Agriculture production and economics indicator group**

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of indicator</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I4.1</td>
<td>The total annual production value</td>
<td>Agricultural production value of annual crops</td>
<td>MIL VND</td>
</tr>
<tr>
<td>I4.2</td>
<td>Cultivated product value/ irrigated area unit</td>
<td>Agricultural production value of annual crops for 1 ha agricultural production area</td>
<td>VND/ha</td>
</tr>
<tr>
<td>I4.3</td>
<td>Cultivated product value/ irrigated area unit</td>
<td>Agricultural production value of annual crops for 1 ha irrigated area (including several crops)</td>
<td>VND/ha</td>
</tr>
<tr>
<td>I4.4</td>
<td>Economic value of water</td>
<td>Agricultural production value of annual crops for 1 m³ irrigated water from the head work</td>
<td>VND/m³</td>
</tr>
<tr>
<td>I4.5</td>
<td>Economic value of water demand of crop</td>
<td>Agricultural production value of annual crops for 1 m³ water demand of crop</td>
<td>VND/m³</td>
</tr>
</tbody>
</table>

**Group 5**  
**Environmental performance**

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of indicator</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I5.1</td>
<td>Average salinity of irrigated water</td>
<td></td>
<td>dS/m</td>
</tr>
<tr>
<td>I5.2</td>
<td>Average salinity of drained water</td>
<td></td>
<td>dS/m</td>
</tr>
<tr>
<td>I5.3</td>
<td>Average $\text{BOD}_5$ in irrigated water</td>
<td></td>
<td>mg/l</td>
</tr>
<tr>
<td>I5.4</td>
<td>Average $\text{BOD}_5$ in drained water</td>
<td></td>
<td>mg/l</td>
</tr>
<tr>
<td>I5.5</td>
<td>Average COD in irrigated water</td>
<td></td>
<td>mg/l</td>
</tr>
<tr>
<td>I5.6</td>
<td>Average COD in drained water</td>
<td></td>
<td>mg/l</td>
</tr>
</tbody>
</table>
1. The Philippines

The Philippines (officially the Republic of the Philippines) is a sovereign island-nation in Southeast Asia situated in the western Pacific Ocean. It consists of 7,107 islands that are categorized broadly under three (3) main geographical divisions from north to south: Luzon, Visayas, and Mindanao. Bounded by the West Philippine Sea (South China Sea) on the west, the Philippine Sea on the east and the Celebes Sea on the southwest, the Philippines shares maritime borders with Taiwan to the north, Vietnam to the west, Palau to the east and Malaysia and Indonesia to the south.

The country has a unitary presidential constitutional republic form of government. With an area of 300,000 square kilometers (30 million ha), it has a total population of 103 million as of 2016. Its capital city is Manila (pop. 1.78 million) and the most populous city is Quezon City (pop. 2.70 million), both part of Metro Manila (pop. 12 million).

Agriculture employs 30.4% of the Filipino workforce as of 2014, according to the World Bank. The Philippines is the 8th largest rice producer in the world, accounting for 2.8% of global rice production but was also the world's largest rice importer in 2010.

It is a founding member of the United Nations (UN), World Trade Organization (WTO), Association of Southeast Asian Nations (ASEAN), the Asia-Pacific Economic Cooperation (APEC) forum, and the East Asia Summit. It also hosts the headquarters of the Asian Development Bank (ADB).

The country is now considered a newly industrialized nation, which has an economy transitioning from one based on agriculture to one based more on services and manufacturing. As of 2017, GDP by purchasing power parity was estimated to be at $873.966 billion. Primary exports include semiconductors and electronic products, transport equipment, garments, copper products, petroleum products, coconut oil, and fruits.
2. The National Irrigation Administration

The National Irrigation Administration (NIA) was established as a government-owned and controlled corporation (GOCC) by virtue of Republic Act 3601 (1963) as amended by Presidential Decrees 552 (1974) and 1702 (1976). It is the main agency in the Philippines mandated to harness and develop all available and possible water resources in the country primarily for irrigation purposes.

Additionally, NIA is authorized to construct multi-purpose water resources projects designed mainly for irrigation, and secondarily for hydroelectricity power development and other uses such as flood control, drainage, land reclamation, domestic water supply, roads and highways construction and reforestation, among others, provided that the plans, designs and the construction therefore, shall be undertaken in coordination with the other concerned agencies.
As a GOCC, NIA has to generate its own revenues to finance its operations. Thus, it is bestowed by the government with the power to charge and collect irrigation service fees or administration charges from all beneficiaries of national irrigation systems (NIS) constructed by or under its administration to support their continuous operation. It is likewise empowered to recover funds or portions thereof expended for the construction and/or rehabilitation of communal irrigation systems (CIS) and pump irrigation systems.

Among NIA’s authority is to transfer or delegate the partial or full management and O&M of NIS to duly organized irrigators’ associations (IAs) subject to terms and conditions approved by the agency’s governing Board of Directors. The authority to transfer O&M to IAs in NIS is being implemented by the Agency through the Irrigation Management Transfer (IMT) program which is the subject matter of this paper presentation.

3. NIA Organizational Structure

NIA at present is under the Office of the President of the Philippines through the Office of the Cabinet Secretary (CABSEC). Previously, the Agency was attached to the Department of Public Works and Highways and Department of Agriculture. NIA’s powers and functions are exercised by a Board of Directors composed of seven (7) members namely: the CABSEC who sits as Chairman, the NIA Administrator as Vice Chairman, a Corporate Board Secretary, and the following as members – the Secretary of the Department of Public Works and Highways, the Director General of the National Economic and Development Authority, the President of the National Power Corporation, and the President of the National Confederation of Irrigators Association representing the private sector.

The day-to-day operation and management of the Agency is vested in the NIA Administrator assisted by a Senior Deputy Administrator, a Deputy Administrator for Engineering Operations, and a Deputy Administrator for Administrative and Finance. The Administrator and the Deputies are officially based at the NIA Central Office located at Epifanio de los Santos Avenue, Diliman District, Quezon City, Metro Manila.

For field operations and project implementation, Regional Irrigation Offices (RIO), Integrated Irrigation Systems Offices (IISO), Project Management Offices (PMO) and Irrigation Management Offices (IMO) are established throughout the country.

As of December 2015, NIA’s total manpower complement from Central and Field offices (RIO, IISO, PMO and IMO) reached 6,265 personnel.
Figure 2. NIA Organizational Structure

Figure 3. NIA Personnel Complement from 2010 to 2015
4. Status of Irrigation Development

Out of the Philippines’ 30 million ha land area, about 10.39 million ha or 35% is classified as agricultural lands. Based on 3% field slope, the potential irrigable area is about 3.02 million ha or 29% of the area identified as agricultural lands. As of December 2015, the total area developed with irrigation facilities is 1.73 ha or 56.57% of the identified potential irrigable area. Shown in Table 1 is the status of irrigation development as of December 2015.

5. Classification of Irrigation Systems

In terms of ownership and management, irrigation systems in the Philippines are generally classified into four (4) categories namely:

a) **National Irrigation Systems (NISs)** are schemes with a service area of 1,000 ha or more. These types of irrigation systems are constructed and owned by the government through NIA but O&M is jointly managed with IAs.

b) **Communal Irrigation Systems (CISs)** are systems with less than 1,000 ha service area. These schemes are jointly constructed by NIA and the IA, but after project completion, O&M and ownership of the systems are completely handed over to IAs.

c) **Private Irrigation Systems (PISs)** are owned by private individuals or groups, developed with or without government assistance and unless the owners seek NIA assistance, these types of irrigation systems are managed independently by the owners.

d) **Other Government Agencies-assisted Systems (OGA)** are those that are constructed or assisted by other government offices aside from NIA but just like the other 3 schemes are turned over to farmers for O&M and management.

The total firmed-up service area of all 4 types of irrigation systems is about 1.71 million ha or about 56.57% of the 3.02 million ha total irrigable area in the whole country. Table 2 presents the area served by each type of irrigation system by region and major island group.
Table 1. Status of Irrigation Development as of December 2015, NIA, Philippines

<table>
<thead>
<tr>
<th>Region</th>
<th>Potential Irrigable Area, ha</th>
<th>Firmed-up Developed Area, ha</th>
<th>% Irrigation Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAR 1/ 1</td>
<td>97,310</td>
<td>89,727</td>
<td>92.21</td>
</tr>
<tr>
<td>1</td>
<td>262,744</td>
<td>169,660</td>
<td>64.57</td>
</tr>
<tr>
<td>2</td>
<td>456,898</td>
<td>275,987</td>
<td>60.40</td>
</tr>
<tr>
<td>3</td>
<td>480,783</td>
<td>291,830</td>
<td>60.70</td>
</tr>
<tr>
<td>4a</td>
<td>85,929</td>
<td>47,889</td>
<td>55.73</td>
</tr>
<tr>
<td>4b</td>
<td>138,719</td>
<td>69,387</td>
<td>50.02</td>
</tr>
<tr>
<td>5</td>
<td>239,440</td>
<td>132,846</td>
<td>55.48</td>
</tr>
<tr>
<td>LUZON</td>
<td>1,761,823</td>
<td>1,077,326</td>
<td>61.15</td>
</tr>
<tr>
<td>6</td>
<td>189,934</td>
<td>115,858</td>
<td>61.00</td>
</tr>
<tr>
<td>7</td>
<td>46,159</td>
<td>42,771</td>
<td>92.66</td>
</tr>
<tr>
<td>8</td>
<td>84,081</td>
<td>68,861</td>
<td>81.90</td>
</tr>
<tr>
<td>VISAYAS</td>
<td>320,174</td>
<td>227,490</td>
<td>71.05</td>
</tr>
<tr>
<td>9</td>
<td>74,952</td>
<td>45,270</td>
<td>60.40</td>
</tr>
<tr>
<td>10</td>
<td>113,631</td>
<td>60,953</td>
<td>53.64</td>
</tr>
<tr>
<td>11</td>
<td>147,313</td>
<td>64,241</td>
<td>43.61</td>
</tr>
<tr>
<td>12</td>
<td>286,263</td>
<td>116,199</td>
<td>40.59</td>
</tr>
<tr>
<td>13</td>
<td>159,249</td>
<td>71,018</td>
<td>44.60</td>
</tr>
<tr>
<td>ARMM 2/</td>
<td>156,205</td>
<td>45,567</td>
<td>29.17</td>
</tr>
<tr>
<td>MINDANAO</td>
<td>937,613</td>
<td>403,247</td>
<td>43.01</td>
</tr>
<tr>
<td>PHILIPPINES</td>
<td>3,019,609</td>
<td>1,708,063</td>
<td>56.57</td>
</tr>
</tbody>
</table>

1/- Cordillera Administrative Region
2/- Autonomous Region for Muslim Mindanao
Source: Corporate Planning Department, NIA
Table 2. Service Area by Type of Irrigation Systems as of June 2016, NIA, Philippines

<table>
<thead>
<tr>
<th>Region</th>
<th>Firmed-up Service Area, ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NIS</td>
</tr>
<tr>
<td>CAR</td>
<td>13,996</td>
</tr>
<tr>
<td>1</td>
<td>46,684</td>
</tr>
<tr>
<td>2</td>
<td>149,282</td>
</tr>
<tr>
<td>3</td>
<td>194,369</td>
</tr>
<tr>
<td>4a</td>
<td>20,552</td>
</tr>
<tr>
<td>4b</td>
<td>18,938</td>
</tr>
<tr>
<td>5</td>
<td>23,189</td>
</tr>
<tr>
<td>LUZON</td>
<td>467,010</td>
</tr>
<tr>
<td>6</td>
<td>47,090</td>
</tr>
<tr>
<td>7</td>
<td>11,538</td>
</tr>
<tr>
<td>8</td>
<td>21,348</td>
</tr>
<tr>
<td>VISAYAS</td>
<td>79,976</td>
</tr>
<tr>
<td>9</td>
<td>16,361</td>
</tr>
<tr>
<td>10</td>
<td>25,827</td>
</tr>
<tr>
<td>11</td>
<td>35,466</td>
</tr>
<tr>
<td>12</td>
<td>66,377</td>
</tr>
<tr>
<td>13</td>
<td>33,510</td>
</tr>
<tr>
<td>ARMM</td>
<td>25,643</td>
</tr>
<tr>
<td>MINDANAO</td>
<td>203,184</td>
</tr>
<tr>
<td>PHILIPPINES</td>
<td>750,169</td>
</tr>
<tr>
<td>% Distribution</td>
<td>44%</td>
</tr>
</tbody>
</table>

Source: Corporate Planning Department, NIA
6. Inventory of National Irrigation Systems

As of June 2016 inventory, there are 231 NIS located in the 16 Regional Irrigation Offices (RIOs) and two (2) Integrated Irrigation System Offices (IISO) throughout the country with an aggregate firmed-up service area of 750,169 ha. There are 2,903 IAs organized in these NIS with a total membership of 580,616 farmers.

Table 3 presents the inventory of NIS, the number of IAs organized as well the number of farmer-beneficiaries as of June 2016 by Region/IISO.

7. Operation and Maintenance of National Irrigation Systems

NIA operates and maintains the NIS jointly with IAs. Activities for O&M include, among others, operation of storage and diversion dams, running of pumps, operation of gates, turnouts and drainage ditches, preparation and implementation of cropping and irrigation schedules, water delivery and distribution, maintenance of the physical facilities including service and access roads, and repairs of minor damages caused by floods and typhoons. Capacity building of both NIA staff and IA officers and members is also part of the NIS O&M.

After the construction of a national irrigation project (NIP), the completed project is commissioned as an NIS and placed under the direct management of IMO of a concerned RIO. Services such as water delivery and distribution to farms, repair and maintenance of irrigation facilities are provided by NIA.

For the services rendered, NIA charges farmers and other water users an Irrigation Service Fee (ISF) the rate of which is dependent on the type of irrigation system, cropping season and type of crops planted. Regardless of the type of crop, ISF is denominated in cavans of dry unhusked paddy rice per hectare (1 cavan = 50 kilograms). Payment of ISF for rice crop is either in-kind form or its cash equivalent based on the prevailing government support price (GSP) for paddy rice at the time of payment. For crops other than rice, payment shall be the cash equivalent at the prevailing GSP at the time of payment. The rates are subject to further adjustment in the case of on-going and future NIPs and some projects utilizing groundwater where capital investments and O&M costs are higher. Table 4 presents the existing ISF rates collected from users of NIS.
Table 3. Inventory of National Irrigation Systems as of June 2016, NIA Philippines

<table>
<thead>
<tr>
<th>RIO/IISO</th>
<th>No. of NIS</th>
<th>Firmed-up Service Area, ha</th>
<th>No. IAs</th>
<th>No. of Farmer-Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAR</td>
<td>2</td>
<td>13,996</td>
<td>52</td>
<td>14,556</td>
</tr>
<tr>
<td>1</td>
<td>26</td>
<td>46,684</td>
<td>282</td>
<td>70,472</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>64,106</td>
<td>203</td>
<td>48,247</td>
</tr>
<tr>
<td>Region 2–MRIIS</td>
<td>4</td>
<td>85,176</td>
<td>357</td>
<td>63,937</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>74,729</td>
<td>340</td>
<td>54,540</td>
</tr>
<tr>
<td>Region 3–UPIIS</td>
<td>17</td>
<td>119,640</td>
<td>413</td>
<td>86,190</td>
</tr>
<tr>
<td>4A</td>
<td>39</td>
<td>20,552</td>
<td>95</td>
<td>14,965</td>
</tr>
<tr>
<td>4B</td>
<td>12</td>
<td>18,938</td>
<td>120</td>
<td>14,063</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>23,189</td>
<td>81</td>
<td>34,069</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>47,090</td>
<td>164</td>
<td>34,783</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>11,538</td>
<td>71</td>
<td>13,518</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>21,348</td>
<td>80</td>
<td>18,309</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>16,361</td>
<td>62</td>
<td>9,110</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>25,827</td>
<td>103</td>
<td>19,084</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
<td>35,466</td>
<td>130</td>
<td>20,542</td>
</tr>
<tr>
<td>12</td>
<td>17</td>
<td>82,425</td>
<td>223</td>
<td>47,203</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>27,709</td>
<td>127</td>
<td>17,028</td>
</tr>
<tr>
<td>ARMM</td>
<td>4</td>
<td>25,643</td>
<td>140</td>
<td>29,744</td>
</tr>
<tr>
<td>Total</td>
<td>231</td>
<td>750,169</td>
<td>2,903</td>
<td>580,616</td>
</tr>
</tbody>
</table>

Source: Operations Department, NIA
Table 4. Irrigation Service Fee Rates in NIS, cavan/ha, Philippines

<table>
<thead>
<tr>
<th>SCHEME/CROP</th>
<th>WET SEASON</th>
<th>DRY SEASON</th>
<th>THIRD CROP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diversion Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Other Crops</td>
<td></td>
<td>60% of the rate for rice</td>
<td></td>
</tr>
<tr>
<td>Annual Crops</td>
<td>Cash equivalent of 7.5 cavans of palay per hectare annually</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishponds</td>
<td>Cash equivalent of 5.0 cavans of palay per hectare season</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reservoir/Storage Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>2.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Other Crops</td>
<td></td>
<td>60% of the rate for rice</td>
<td></td>
</tr>
<tr>
<td>Annual Crops</td>
<td>Cash equivalent of 7.5 cavans of palay per hectare season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishponds</td>
<td>Cash equivalent of 6.0 cavans of palay per hectare season</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pump Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>2.0 – 10.00</td>
<td>2.75 – 12.00</td>
<td></td>
</tr>
<tr>
<td>Other Crops</td>
<td></td>
<td>60% of the rate for rice</td>
<td></td>
</tr>
<tr>
<td>Annual Crops</td>
<td>Cash equivalent of 7.5 cavans of palay per hectare season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishponds</td>
<td>Cash equivalent of 15.0 cavans of palay per hectare season</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 cavan = 50 kg of dry unhusked paddy rice

In comparison, CIS is constructed with government funding assistance taken up as a loan without interest of the IA and to be repaid or amortized annually in a period not exceeding 50 years. During the construction period, the concerned IA provides a counterpart contribution (about 10% to the project cost) and is treated as an equity that is deductible from the project cost to be amortized. The equity may be in the form of labor, materials and/or cash contribution. A special CIS development program being offered by NIA called “30% equity” allows the IA to contribute only 30% of the project cost and subsequently, the 70% is rendered free – meaning the IA is longer obliged to pay annual amortization.
After completing the amortization payment or after complying with the 30% equity, a certificate of ownership of the CIS is awarded to the IA giving full proprietorship to the association. However, while O&M and ownership were transferred to the IAs, the NIA continues to provide technical assistance and conduct of necessary capacity building activities and training in order to sustain IA functionality.

8. Organization and Development of Farmers into IAs

To pursue the mandate of turning over the management and O&M of NIS, farmer-beneficiaries are first organized, trained and developed into water users associations locally known as Irrigators Associations or IAs (or in some cases Irrigation Service Cooperatives).

An IA is a group of farmers in an irrigation system organized according to water source - usually a lateral canal. One critical step in organizing the IA is to form a cluster of all the farmer-beneficiaries being served by a common turnout into Turnout Service Area Group (TSAG) - the basic organizational unit of the IA. We say TSAG formation is critical because the TSAGs are the building blocks or foundation of an IA. A weak foundation could lead to an unstable organization.

A turnout is a structure located at the entrance of a main farm ditch or canal which regulates the entry of water into the Turnout Service Area (TSA) - the extent of the area that can be irrigated by a turnout (Figure 4).

Figure 4, ORGANIZATION OF FARMERS INTO TURNOUT SERVICE AREA GROUP(TSAG)
The TSAGs in each lateral or sub-lateral canal elect their own set of officers, are finally consolidated and formed into one (1) IA. The IA then elects their own set of officers normally from among the TSAG leaders (Figure 5.)

![Organization of TSAG into Irrigators Association (IA)](image)

**Figure 5. ORGANIZATION OF TSAG INTO IRRIGATORS ASSOCIATION (IA)**

During the organization and development stages, various capacity building and training activities are being provided to the IAs in preparation for their eventual takeover of O&M responsibilities. Among the training courses for the IAs are: (1) Basic Leadership Development Course, (2) Financial Management Training, (3) System Management Training and Workshop, (4) Value Formation Seminar and, (5) Livelihood and Entrepreneurship Seminars. Below is a brief description of each training course:

a) **Basic Leadership Development Course** - the IA officers are taught practical skills in managing and leading their association’s activities and affairs. On the other hand members become aware of their own responsibilities and to put these into practice.

b) **Financial Management Training** - concepts and actual practice in financial planning, budget preparation, and simplified bookkeeping and financial reporting are the main subjects being taught to the officers and selected members.
c) **System Management Training and Workshop** - the IA officers and members gain skills and knowledge in the overall management of the irrigation system including preparation of cropping schedules, repair and maintenance of irrigation facilities and effective and efficient water delivery and distribution.

d) **Value Formation Seminar** - the IA participants enhance their positive values as members of the IA, the community and as good citizens who love the country and care for its welfare and well-being.

e) **Livelihood and Entrepreneurship Seminars** – knowledge and skills in other crafts and industry as a source of livelihood and entrepreneurial skills in managing small businesses to augment the income of the individual farmers and their IAs.

Over the years the IAs perform their expected obligations and functions. During this process, new needs will arise and these emerging necessities will be the focus of any capacity building programs to be designed and implemented. The timing of each training course is dependent on the stage of development of the IA. Likewise, a regular assessment of the IAs’ performance is conducted to specifically pinpoint weak area(s) of IA operation needing improvement and those areas that have to be sustained.

After an IA is organized, it is registered with the Securities and Exchange Commission as a non-stock, non-profit and non-sectarian organization. The registration of an IA gives it juridical personality to enter into contractual or legal arrangements not only with NIA but with other agencies and institutions as well. A dedicated NIA staff called Institutional Development Officer is deployed in the service area of the NIS to spearhead the IA organization and development process.

Two (2) typical organizational structure of IAs are shown in Figures 6 and 7. Figure 6 shows an ordinary IA with purely O&M activities while Figure 7 illustrates an IA with both O&M and agri-business ventures.

### 9. The IMT Program

IMT is NIA’s program of gradually transferring the management of the O&M of an NIS to IAs depending on the size of the irrigation system and capacity of the IA. The IA could be an individual primary IA, Council of IAs or Federation of IAs. Transferring the management of NIS to IAs is part of NIA’s mandate as previously mentioned. The IMT policy and implementation guidelines are embodied in various Memorandum Circulars issued by NIA.
Before the implementation of IMT, NIA started the Participatory Irrigation Management (PIM) program in NISs in the early 1980s. It was a follow through after the successful formulation, testing and nationwide adoption of IA organization and participatory development in CIS in the mid-1970s. The present IMT undertaking actually evolved from the early PIM experiences.

Figure 6. Organizational structure of IA with purely O&M activities

Figure 7. Organizational structure of IA with O&M and agri-business activities

Transferring management of NISs to IAs could be viewed in two (2) perspectives:
1. **From NIA’s perspective:**

   a) IMT is a mandate from the agency’s charter and other relevant Philippine laws;

   b) There is a need to improve NIS O&M performance in terms of:

      • equitable water delivery and distribution;
      • narrow the gap between irrigated and service area; and
      • increase ISF collection efficiency; and

   c) Improvement of NIS performance needs the joint effort of NIA and the IA/farmers.

2. **From IA’s point of view:**

   d) Opportunity to develop their capacity for organizational and system management;

   e) Better chance for improvement of NIS performance as the IA directly manages O&M;

   f) Opportunity to build-up IA capital; and

   g) Prospect for higher agricultural production and income for IA members.

10. **Objectives of the IMT Program**

    The objectives of the IMT Program are the following:

    a) To organize and develop functional and self-reliant IAs capable and willing to operate and maintain the NISs, wholly or partially;

    b) To develop and institutionalize a strong and dynamic partnership between the NIA and the IAs for the delivery of efficient irrigation service to farmers;

    c) To improve the performance of the NISs and delivery of irrigation service, in terms of equitable water distribution, and timely and reliable water deliveries. Indicators of improved performance are:

       (i) More equitable water distribution,

       (ii) Better timely and reliable water deliveries,

       (iii) Higher cropping intensity, and

       (iv) Higher ISF collection efficiency.

    d) To give opportunities to farmers for better and more profitable agricultural production. Farmers are expected to benefit from better irrigation service in terms of higher yields and farm incomes.
e) To attain a sustainable operational and financial viability of the NISs and consequently the IAs and the NIA as a whole. Improved NIS performance triggers the following:

(i) better agricultural production and profitability,
(ii) the willingness of farmers to pay ISF,
(iii) higher ISF collection efficiency and
(iv) more funds for O&M of NIS, therefore, better maintenance and sustainable operation of NIS, and sustainable inflow of funds or income to IAs and the NIA to support the O&M of NIS.

11. IMT Transfer Strategy

The strategy for the management transfer of NIS is being pursued according to four (4) distinct contractual arrangements called “models”.

**Model 1** – The NIA still manages an entire NIS but transfers to the IA specific O&M activities such as: a) Maintenance of canal facilities and structures; b) Operation activities such as discharge monitoring and preparation of list of irrigated and planted area, and c) Distribution of ISF bills and campaign for its payment.

Depending on the capacity and willingness of the IA, actual ISF collection can be added as a responsibility especially in NISs that have a limited staff. For taking over maintenance responsibilities, the IA and NIA will negotiate for the former’s compensation considering the standard labor capacity for canal clearing and existing wage rates in the locality. For assisting in the collection of ISF current account, NIA and IA agree on a base collection level and the IA gets a share of the collected amount only after the agreed level is satisfied.

In the collection of ISF back accounts, the IA gets a share of 25% for accounts that were accumulated before the signing of the IMT contract and 5% of the collected amount for back accounts incurred after the signing of the contract. Figure 8 shows the NIA and IA respective area of responsibility under Model 1.
**Model 2** – The NIA manages the main system, from the headworks to the main canal up to the headgates of lateral canals and transfers to the IA the O&M and management of the laterals, sub-laterals, and terminal facilities including ISF collection in the area covered by the IA.

IA incentive or share in ISF collection in this model is based on the total fee collectible in the covered area. For gravity systems, the Break-even O&M cost of the IA area is first determined and then the respective NIA and IA shares are negotiated based on the concept of “fair sharing of responsibilities and benefits”.

In the case of pump systems, the cost of running the pumps is first deducted from the total ISF collection, after which the share of each party in the excess amount shall be negotiated, again considering the concept used in gravity systems.

For collecting back accounts incurred before contract signing, sharing is similar to Model 1, i.e. IA: 25% and NIA: 75%. However, all back accounts incurred after the signing of the Model 2 contract are already considered as the responsibility of the IA.
Model 3 – The NIA manages the headworks and portion of the main canal up to the junction of the first lateral canal and transfers to the IA the management of the rest of the system downstream of the specified junction.

Determination of the NIA share and IA incentive under this model follows the same procedure in Model 2. Figure 10 shows the NIA and IA respective area of responsibility under Model 3.
**Model 4** – The NIA completely transfers to the IA the management of the entire system including the headworks and stops all its activities on the management of the system except monitoring, evaluation, a collection of seasonal or annual payments from the IA and periodic technical assistance as may be requested by the IA.

The IA will be responsible for collection, safekeeping and management of ISF. It will pay NIA an Irrigation System Rental Fee (ISRF) equivalent to the money value of 1.50 cavans of dry paddy (computed at the government support price of palay at the time of billing) per hectare per year based on the firmed-up service area of the system. The ISRF will cover the cost of technical assistance and cost of using the irrigation facilities and structures.

In cases of major damages due to “force majeure” and/or major repair and rehabilitation beyond the financial capacity of the IA, the NIA will be responsible for doing the detailed engineering and implementation of the repair works with IA participation and will finance 70% of the cost. The IA will finance 30% of the cost and assist the NIA in the planning and implementation. Figure 11 shows the NIA and IA respective area of responsibility under Model 4.

![Figure 11. NIA and IA Responsibility under IMT Model 4](image)

**Other Transfer Options** – The NIA shall also accommodate, on a case-to-case basis, other emerging possibilities on IMT. Such options may include: (a) Tripartite agreement among NIA, IA and Local Government Units (LGU); (b) Long-term lease contract; or (c) Management by
competent third parties. These options are, however, subject to the approval of the NIA Administrator or the Board of Directors.

12. Contract Negotiation

Before any IMT contract between NIA and IA is effected, the latter must first pass the IMT Contract Eligibility Criteria – a set of indicators showing an IA’s readiness to assume O&M responsibilities. The ensuing negotiation takes place as soon as an IA is found to be eligible. The negotiation considers the willingness and capability of the IA to undertake O&M responsibilities. The major points for discussion during the contract negotiation are the: a) NIA and IA responsibilities in the IMT Contract; and b) compensation, payment schedule and payment criteria. The IMT Contract negotiation must be carried out in an open and transparent manner.

The development of the capability of the IA to perform IMT Contract responsibilities is the function of NIA. The capability development interventions that will be provided by the NIA to the IA must be based on an objective training needs evaluation and consistent with the list of responsibilities under the IMT contract targeted to be negotiated.

13. Status of Implementation

It must be re-emphasized that before the existing IMT policy guidelines (MCs 47 s. 2008 and 27 s. 2011) took effect, transferring of an irrigation system’s O&M responsibilities to IAs were already in effect as of late 1970’s. The present IMT program to delegate or transfer management responsibilities had actually evolved, from what was then known as Stage, Type and Joint System Management contracts and other local arrangements between NIA and the IAs (in some cases with involvement of LGUs), into what is now popularly known as IMT. But while those early modes of management handover were covered by official circulars, their actual implementation varied from one NIA Region to another, more so from one NIS to another. Incentives and compensation to IAs were not uniform, sometimes even the nature of obligation and responsibilities were assorted and deemed not fair enough as claimed by some IAs. Said situation, more often than not, resulted in confusion not only with the farmer-clientele but even within the Agency as well.

Responding to the clamor for a “unified” regulation, the Agency issued MC 47, series of 2008 containing NIA’s IMT Policy and Implementing Guidelines. But still even with this issuance, some questions were still raised by field offices and these persisted especially on the aspect of IA compensation and ISF collection incentives. Finally, MC 27, series of 2011 was circularized as the Second Edition of the NIA IMT Policy and Implementing Guidelines in reaction to those
issues and concerns brought up both by the IAs and by field implementers. The latest guidelines have significantly fast-tracked the IMT program implementation.

As of June 2016, there are already 2,660 or 96% out of 2,777 organized IAs in NIS that had entered into IMT contracts. Of the total number of IAs with contracts, 1,196 or 45% are in Model 1 while 1,298 or 49% have Model 2 contracts. Only 86 IAs (3%) and 80 IAs (3%) have Model 3 and Model 4 contract arrangements, respectively. Breakdown of IMT contract by Model is presented in Table 6.

14. Improvement in ISF Collection

The massive implementation of the IMT program was done by NIA in 2011 after the issuance of the new implementing guidelines. A year after, in 2012, there were noted improvements in ISF collection as shown in Table 5.

Table 5. Five-Year ISF Collection Data in National Irrigation Systems NIA, Philippines

<table>
<thead>
<tr>
<th>Year</th>
<th>ISF Collection, in Pesos</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1,254,147,901</td>
<td>–</td>
</tr>
<tr>
<td>2012</td>
<td>1,350,464,477</td>
<td>7.67</td>
</tr>
<tr>
<td>2013</td>
<td>1,554,562,581</td>
<td>15.11</td>
</tr>
<tr>
<td>2014</td>
<td>1,804,437,639</td>
<td>16.07</td>
</tr>
<tr>
<td>2015</td>
<td>1,879,013,801</td>
<td>4.13</td>
</tr>
</tbody>
</table>

15. Accelerating Program Implementation

The original target of NIA is to roll out its rationalization or organizational streamlining plan side-by-side with IMT implementation. According to the plan, as the redundant staff is retired, irrigation areas are to be handed over at the same time to IAs for their management. This proposition, however, did not completely materialize. While phasing out of positions was started in 2008 and completed in 2012, the progress of IMT program implementation happened at an almost snail pace. In fact, data indicated that by the end of 2010, only 494 out 2,770 organized IAs or just 17% had entered into IMT while 1,736 personnel out of 2,508 affected positions or 69% had already availed of the rationalization program.
Table 6. Status of IMT Program Implementation, NIA, Philippines

As of June 2016

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Total</th>
<th>With IMT Contract</th>
<th>By Transfer Model (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>No. of IAs</td>
<td>2,777</td>
<td>2,660</td>
<td>96</td>
</tr>
<tr>
<td>No. of Farmers</td>
<td>564,053</td>
<td>547,085</td>
<td>97</td>
</tr>
<tr>
<td>Area Covered (ha)</td>
<td>677,360</td>
<td>653,035</td>
<td>96</td>
</tr>
<tr>
<td>Length of canal covered (km)</td>
<td>14,088</td>
<td>13,665</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: Institutional Development Division, NI

The slow stride in IMT implementation was mainly attributed to the seeming reluctance of some IAs to accept O&M responsibility unless irrigation facilities are rehabilitated or restored to operable conditions. Others argued that IMT is not being not fully supported because there are some unclear provisions in the policy guidelines notably: (1) vagueness of the concept “fair sharing of burdens and benefits” as basis of negotiation, (2) items to be considered in the computation of break-even point as basis for ISF collection sharing, (3) IAs’ lack of start-up capital or seed fund if and when they assume management; and (4) extent of IA share in the collection of backs accounts.

Notwithstanding these initial hindrances, however, it is noteworthy that IMT contract signing “peaked up” in the last 4 years (2012-15) and the trend is continuing. As reflected in Table 2, 96% of all IAs had already entered into IMT contracting as of June 30, 2016. The target is to attain 100% by the end of 2017. More importantly, NIA wants to see the IAs graduate from the simple canal maintenance (Model 1) to the more developmental Model 2 if Models 3 & 4 may be restrictive to some. It is a challenge that requires the commitment of all stakeholders for the program to succeed.

16. The IMT Road Map

The IMT Road Map is basically a comprehensive plan committed being pursued by NIA field implementers in consultation with their IA counterparts in order to accelerate IMT implementation in their respective areas. It is a course of direction, sort of a catch-up plan (as rationalization plan is now fully implemented) to be undertaken by every office to expedite the
progress of IAs’ acceptance of O&M management from its present stage to the final IMT Model contract. This final IMT Model contract must be determined as realistic and sustainable by the Agency in consultation with IAs/IA Federations and other stakeholders. Correspondingly, the roadmap should include any programmed physical improvement (rehabilitation/ restoration or both) of irrigation system facilities as well as capacity-building programs for the IAs and the retained NIA staff. Table 7 presents the overall IMT Road Map based on the consolidated reports prepared by all RIO and IISOs.

17. Program Challenges

As stressed in the foregoing sections of this paper, the aim is to attain 100% IMT compliance by the end of CY 2017 - meaning all IAs in NIS programmed for management transfer would have entered into any O & M contracting arrangement. The biggest challenge, however, is to increase the level of IA participation in NIS management – from Model 1 which is mainly maintenance work to at least Model 2 which will include water distribution, minor repairs and ISF collection. In fact, one of the major commitments of NIA to the Governance Commission for Government-Owned or Controlled Corporations (GCG) – the agency that oversees the operations of all GOCCs - is accelerating the IMT program and raising the degree of IAs participation and making it sustainable.

Table 7. Overall IMT Road Map, NIA, Philippines

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Baseline 2013</th>
<th>Progress to Final IMT Contract (No. of IAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2014</td>
</tr>
<tr>
<td>Model 1</td>
<td>1,174</td>
<td>1,243</td>
</tr>
<tr>
<td>Model 2</td>
<td>1,031</td>
<td>1,211</td>
</tr>
<tr>
<td>Model 3</td>
<td>77</td>
<td>80</td>
</tr>
<tr>
<td>Model 4</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Other Contract</td>
<td>120</td>
<td>61</td>
</tr>
<tr>
<td>No Contract</td>
<td>248</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>2,660</td>
<td>2,665</td>
</tr>
</tbody>
</table>

Source: Institutional Development Division, NIA

Since the IMT program was introduced, the following remain as challenges:

a) Repair of defective and/or dysfunctional irrigation facilities and structures as a pre-condition of IAs to enter into IMT contracting – Most IAs are hesitant to accept the responsibility of taking over the management of the irrigation system unless the facilities that are defective or dysfunctional are restored first. Because of budget constraints,
however, NIA can only program the rehabilitation or major repairs based on available funds. Somehow, this farmers’ cautious attitude has delayed IMT implementation.

b) Some IAs’ are dissatisfied with their existing contracts due to their complete repair of facilities as agreed during the NIA-IA negotiation stage. In some cases, IAs accepted IMT responsibilities even if there are still facilities and structures needing repair or rehabilitation with the expectation that these physical interventions will come in a short while. But for some reasons, the repairs came late as stated above and the IAs were left to fend for themselves using their own resources if only to have irrigation water delivered to their farms by defective or dilapidated facilities.

c) Inadequate IA start-up capital or seed fund for initial operation of service area transferred to them. The lack of or inadequate fund for O&M poses a big challenge and problem for an IA to enter into IMT contract or to upgrade the existing one. The IAs is aware that payment of their incentive or remuneration will only be realized after satisfactorily performing their obligations as stated in their contracts. If they accept the contract, they will have to use their own meager resources first until their incentives from NIA arrive. Because of this predicament, the IAs is hesitant to sign the IMT contract.

d) IA share in ISF collection may not be adequate to cover the O&M expenses of the service area transferred to them. The actual amount of incentive for the IAs especially in Models 2 and 3 is the actual amount of ISF collected. In the usual sharing arrangement, the share of NIA must be satisfied first before the IA gets its own. For example, if the agreed sharing scheme is 70:30 where 70 is the share of NIA and 30 is for the IA, the IA should collect more than 70% of the ISF collectible before it can partake in the amount they themselves collected.

e) Pronouncement by the new Government that ISF will be abolished soon. The early pronouncement by some sectors that ISF will be soon free has greatly affected the program. The IAs with lower model contracts are discouraged from upgrading to higher models aware that their incentives are dependent based on ISF collection while new IAs lose their desire to enter into IMT contract.

18. Concluding Statement

The transfer of responsibility and authority for irrigation management from the government to non-governmental entities like IAs is a worldwide reality and the Philippines or NIA for that matter is not an exception. In fact, as mentioned earlier, it is a mandate and therefore
forthcoming and inevitable. IMT should not be misconstrued as a way of passing on the burden of O & M responsibilities from NIA to the farmers. Rather, it should be viewed as a way of giving the opportunity to the IAs to progress as dynamic groups, relying on their own resources and capabilities. It is NIA’s moral obligation and commitment to expedite IMT and see to it that the IAs realize that aspiration. After all, NIA and IAs are partners in irrigation development and management and this relationship has been proven to be strong as ever over time.

**References**

- Ofrecio, Bayani, “Participatory Development and Management: A Cornerstone of Philippine Irrigation Program”, Tsukuba Asian Seminar on Agricultural Education, University of Tsukuba, Ibaraki Prefecture, Japan, November 2005
- NIA Annual Reports, 2011-2015
- Official reports of the System Management Division, Institutional Development Division, Operations Department and Corporate Planning Group, NIA
- Wikipedia, Free Encyclopedia, 2017