Food Security by Optimal Use of Water

Synthesis of Theme 2.2 of the 6th World Water Forum

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INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID)

Food Security by Optimal Use of Water

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Marseille, France, March 2012

Coordinators:

Food and Agriculture Organisation of the United Nations (FAO), Rome, Italy

ICID•CIID

International Commission on Irrigation and Drainage (ICID), New Delhi, India

January 2014

International Commission on Irrigation and Drainage (ICID), established in 1950 is the leading scientific, technical and not-for-profit Non-Governmental Organization (NGO). ICID, through its network of professionals spread across more than a hundred countries, has facilitated sharing of experiences and transfer of water management technology for over half-a-century. ICID supports capacity development, stimulates research and innovation and strives to promote policies and programs to enhance sustainable development of irrigated agriculture through a comprehensive water management framework. The mission of ICID is to stimulate and promote the development and application of the arts, sciences and techniques of engineering, agriculture, economics, ecological and social sciences in managing water and land resources for irrigation, drainage, flood management, for achieving sustainable agriculture water management.

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Prepared by:

Pasquale Steduto	Food and Agricultural Organisation of the United Nations (FAO)
Bart Schultz	International Commission on Irrigation and Drainage (ICID)
Domitille Vallee	Food and Agricultural Organisation of the United Nations (FAO)
Suresh Kulkarni	International Commission on Irrigation and Drainage (ICID)
Macarena Johns	Consultant in land and water development

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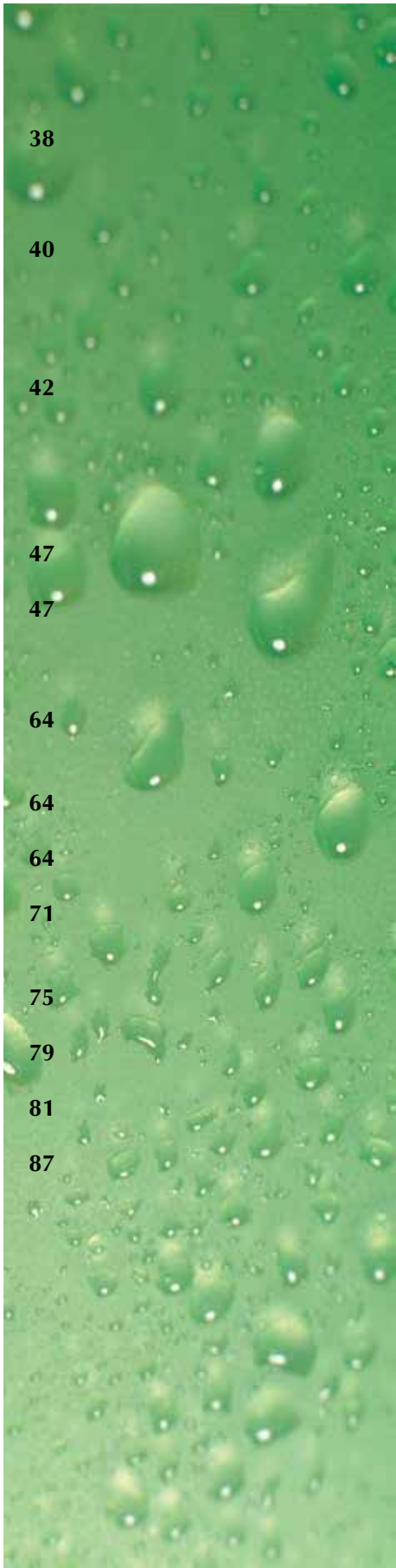

Preface

The 6th World Water Forum (WWF6) held in Marseille, France in March 2012, concentrated on 'solutions' and addressed 12 thematic priorities intended to cover issues of financing, governance, and knowledge related to water management. Under each theme, a series of targets translated the identified issues into concrete and achievable objectives and workable solutions proposed during the preparatory process and at the Forum.

ICID jointly with FAO was involved in the preparations of the Thematic Priority 2.2 on 'Contribute to Food Security by Optimal Use of Water' with Dr Pasquale Steduto from FAO as the Coordinator of the Core Group and Prof Bart Schultz, President Honoraire, ICID as Co-coordinator. Under this thematic priority nine targets were identified and debated in various sessions including the opening session, a multi-stakeholder panel, and a synthesis session during the Forum to move from "targets" to "solutions".

ICID had earlier constituted a Task Force on WWF6 under the chairmanship of Pres. Hon. Prof. Bart Schultz, which together with FAO had engaged a growing number of experts during the preparation process through online surveys and sessions at high level international conferences. Efforts were made to engage experts both online before the Forum and face to face during the Forum to ensure that interested people have an opportunity to influence action plans and recommendations on water and food security on the water agenda.

The Core Group and Target Groups reviewed existing and potential needs, as well as existing and potential solutions to reach targets. The observations and results were presented in three sessions by the Core Group and nine sessions by the Target Groups during the Forum. The results of the preparatory work and the presentations and discussions during the sessions have been brought out in the Core Group Synthesis Report electronically published at http://www.icid.org/wwf6/coregroup_report_2.2.pdf. The complete report is also provided in

the CD provided in the jacket in the inside back page. The present publication is based on this Synthesis Report.

The full report has been circulated to all the National Committees of ICID for taking further necessary action. It is hoped that report will contribute to food security by way of optimal use of water and help in carrying forward the outcomes to the future international forums.

This report has been possible due to the untiring efforts of Dr Pasquale Steduto and Ms Domitille Vallee of (FAO), Prof Bart Schultz and Dr Suresh Kulkarni of ICID and Ms Macarena Johns. It would not have been possible to reach at these important conclusions without the active participation of the experts during the preparations – literature review, debates, dialogues and sessions - as well as the contribution of participants at the various sessions during WWF6.

(Avinash C Tyagi)
Secretary General

January 2014

Summary

The Worlds' population is expected to grow from 7 billion in 2012 to 9 billion by 2050. This growth is especially expected in the urban areas of the emerging and least developed countries, while no growth is expected anymore in the developed countries. In addition the standard of living in the emerging countries (almost 75% of the Worlds' population) is rapidly rising, among others resulting in changes in diet, with more animal products.

The World population growth combined with the expected rise of living standards, growing demands for animal feed and energy from crops (bio-fuels) require a substantial increase of cereal production to ensure sustainable food security. Various organizations estimate that a 70 - 100% increase in cereal production is required over the next 25 - 30 years. There is also a common understanding that 80 - 90% of this increase will have to come from existing cultivated land and only 10 - 20% from land reclamation. However, due to urbanisation, desertification, salinization, etc. the cultivated area is in fact decreasing.

At present 55% of the food comes from areas with a form of water management and 45% from the areas without any (only rainfed) water management system. At the cultivated area of about 1,500 million hectares (ha) most of the cultivation takes place under rainfed conditions without any water management system (1,100 million ha). About 300 million ha is provided with an irrigation system (among which 60 million ha with drainage as well) and an additional 130 million ha is provided with a drainage system only.

Achieving the required increase in food production seems to be possible, provided that improvements are made along the full chain of options from supply to demand, i.e., from producer to consumer. Overall, global food production meets the current demand (consumption and losses). The Global Food Stock is relatively stable, although its ratio to the increasing consumption has decreased over the past years from 30 to 20% of the annual utilisation. This increases the sensitivity in case of decreases in production. However, it is estimated that 30 to 50% of the food produced is in fact wasted by post harvest losses and food waste.

The contributors to the Theme Contribute to Food Security by Optimal Use of Water identified nine Targets that address the relevant aspects. Sustainable intensification of the cultivated areas without a water management system may improve the livelihood of smallholder farmers, and their food security, but will only marginally contribute to the required increase in food production (5 – 10%). In order to also improve income, the intensification would have to be complemented with efforts to diversify production by adding high-value cash crops to increase incomes - during the dry season - so that smallholder farmers can also purchase inputs for better seeds and inputs for rainfed cereal crops.

As far as water management is concerned the real contribution to the required increase in food production would have to come in particular from improvement and extension of agricultural water management - from storage to management - in the production areas most vulnerable to climate variability, the modernisation, upgrading or complementing of existing irrigation and drainage systems. Special attention is needed to sustainable management of the water sources for agriculture and food. It is proposed to investigate closely the governance of groundwater, the safe use of non-conventional waters, as well as the options for increasing water storage - of all sizes - to make agriculture and the large population of smallholder farmers more resilient to climate change impacts.

Today's agriculture sector faces a complex series of challenges: i) to produce more food of better quality while using less water per unit of output; ii) to provide sustainability of diets and to reduce malnutrition; iii) to provide rural people with resources and opportunities to live a healthy and productive life; iv) to apply clean technologies that ensure environmental sustainability; v) to cope with possible impacts of climate change; and vi) to contribute in a productive way to the local and national economy, from producer to consumer. This last point relates to post-harvest losses and food waste issues, and to the need to consider the efficiency of the food supply chain from producer to consumer, in order to reduce unnecessary waste. Water for food needs to consider the overall context in which water management for agriculture takes place.

The nine Targets proposed to the global water agenda on water and food security were formulated as follows:

(i) By 2020, rainfed land productivity (yield per unit area) will sustainably increase by 25% in Africa and by 15% in Asia - as compared to the 2005 - 2007 baseline. Water productivity (yield per unit of water) of rainfed agriculture will sustainably increase for grains by 20% in Africa and in Asia by 15% compared to the 2005 - 2007 baseline;

(ii) By 2020, sustainably increase by 15% - as compared to the 2005 - 2007 baseline - water productivity per unit land and per year (yield per m3, per ha and per year) of irrigated agriculture (for specific crop categories);

(iii) Increase sustainable productivity and lower costs of water management (yield per ha, per m3 of water and per unit production cost) in such a way that by 2025 there is food security at affordable prices for all;

(iv) By 2015, increase by 25% - as compared to the 2005 - 2007 baseline - the safe use of non-conventional waters, either treated wastewater or saline water, in agriculture and aquaculture, together with an increase in the number of countries recognizing the WHO-FAO-UNEP Guidelines for wastewater use in agriculture and aquaculture where insufficiently treated wastewater is used;

(v) Increasing the capacity of water storage in support of irrigated agriculture in an environmentally sufficient and socially sound management;

(vi) By 2015, develop and adopt at least two macro-regional visions optimizing water use for food security and by 2020 develop 200 sub-regional sustainable agriculture plans;

(vii) By 2015, develop national strategic action programmes for key 'hotspot' aquifers exploited by intensive agricultural use (% aquifer depletion, % pollution), including a local definition of maximum admissible drawdown (MAD) and a local definition of maximum admissible pollution levels (MAP) for agricultural uses;

(viii) By 2015, define water-related components of a strategy that will improve the food supply chain efficiency by 50% and promote sustainable diets, including steps for its implementation by 2025;

(ix) Support the smallholder farmers in order to better manage agricultural water, produce more goods and services and reduce by 2020 the proportion of smallholder farmers without access to water training and water credit by 50%.

In the regional process, which was developed in parallel to the thematic process, some of the Targets have been dealt with in a more specific way at the regional level. This concerns the regions Asia and the Pacific, the Americas and the Mediterranean Region.

The Core Group and Target Groups have reviewed and focused on existing and potential needs, as well as existing and potential Solutions to reach the Targets. The Solutions proposed are based on present sustainable practises and promising new approaches. The observations and results were presented in three sessions by the Core Group and nine sessions by the Target Groups during the 6th World Water Forum, March 2012, Marseille, France.

Theme 2.2. Contribute to Food Security by Optimal Use of Water was introduced in an opening session, and the range of perspectives was explored in a Multi-stakeholder Panel. An action plan for the water community to contribute to food security was summarized in the Synthesis Session building on each individual Target Group sessions outputs.

The results of the preparatory work and the presentations and discussions during the sessions were presented in a Core Group Synthesis Report on which this publication is based.

We sincerely hope that in this way we may Contribute to Food Security by Optimal Use of Water in such a way that water management will enable sufficient global food production under the rapidly increasing need and will not be a constraint anymore for sufficient global food production to eradicate undernourishment.

1. Introduction

This publication presents the main results of literature reviews, dialogs, debates, discussions and of the sessions during the 6th World Water Forum (WWF6) of Theme 2.2 on Contribute to Food Security by Optimal Use of Water. Based on the fundamentals of Food Security, the publication evaluates the line of reasoning that was developed in a Background Note and on the Summaries and Session Proposal Report of the Core Group and the nine Target Groups of Theme 2.2. The process that was followed is depicted in Figure 1, which resembles the steps formulated by the International Forum Committee.

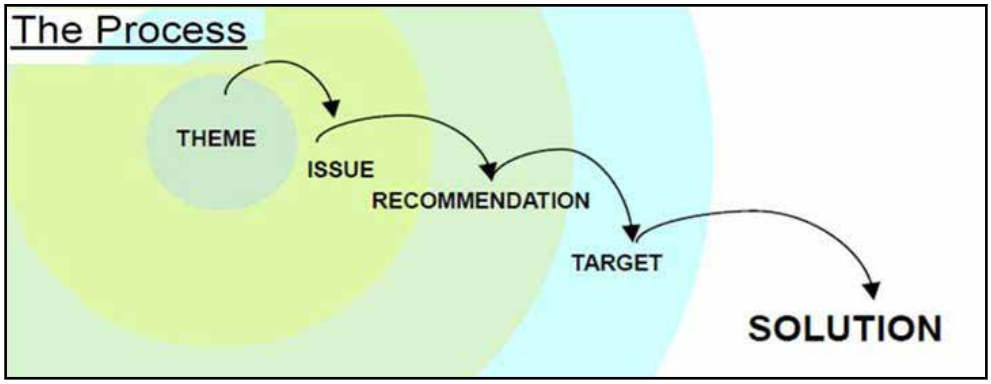

Figure 1. Schematic representation of the process involved in the development of 'Solutions' for the 6th World Water Forum

This publication is intended to show the main results of the analysis and related discussions along a logical pathway from water-related dimensions (issues), relevant to the thematic priorities, to further elaborations on the Targets, Recommendations and Solutions. The Targets, Recommendations and Solutions addressing these issues were presented in the Sessions during the Forum and are summarised in this publication. It shows the proposals for measures/interventions/conditions, actions and milestones that could be seen as Solutions to contribute to the achievement of the Targets. Major actors that could play important roles in the implementation of the Targets and Solutions were identified as well.

When entering the complexity of the theme of Contribute to Food Security by Optimal Use of Water, though, the apparently straightforward process depicted in Figure 1 required further specification. However, before entering into this it was considered

worthwhile to refer to the 5th World Water Forum (WWF5) where two topics were devoted to Water and Food, being Topic 2.3: Water and food for ending poverty and hunger and Topic 2.4: Optimizing multiple uses of water systems e.g. water supply and irrigation. A review of the Synthesis Report of WWF5 showed that a significant part of the recommendations had indeed been followed up, but that still significant efforts in the field of water management would be required to achieve the required increase in food production. The preparation Forum preparation process for Theme 2.2 therefore elaborated on the conclusions and recommendations of these two Topics, the developments since then, the preparations for and the presentations and discussions during WWF6 and the expectations for the short and medium term future.

There is a regionalization of the optimal use of water for food security problems, i.e. the spatial differentiation of the food and water problems and of the underlying causes. This clearly indicates that regional variations will have to be taken into account. In addition, it is important to consider that certain core issues are contentious and often reflect competing interests, competing analysis of data and different perceptions of relative urgency. This concerns potential competitions/conflicts between rural and urban sectors, between agriculture (the largest consumer of water) and various other sectors, between food production and consumption (food waste) and competing priorities related to the urgency of feeding a rapidly expanding urban population and the importance of addressing the possible impacts of climate change. It also relates to contention over other issues, e.g. to the underlying economic models, especially with respect to smallholder market versus commercial interests. This suggests that the prevailing conflicts and contradictions would have to be highlighted, or that fundamental questions would have to be formulated as first steps. Because of this

contention and competition it needed to demonstrate that stakeholders were engaged broadly and participated widely to promote that the fundamental questions addressed were representative and fairly articulated.

It is widely agreed that many issues related to the optimal use of water for food security are interconnected. The inter-linkages between these issues and other themes such as cultural asset, energy, trade, ecosystem, food quality/safety and diets, flows, fisheries, aquaculture, etc. have to be taken into account. In relation to this it can be mentioned that the Global Water Partnership (GWP) has stated that the water crisis is two folds: the results of implementing the wrong development paradigm, and a crisis of governance.

Technical and organizational solutions need to be in line with prevailing and realistically achievable governance capacities. Therefore, it will not be sufficient to build consensus with respect to specific Targets to be pursued (e.g. increased water productivity)[1]. The pathways guiding us towards these Targets need to be scrutinized. In this context, special consideration needs to be given to issues of governance.

This publication summarises a very broad and consultative process with many stakeholders involved. The dialog/debate will continue until the milestones as formulated by the Target and Solutions Groups will have been reached in such a way that water management will enable sufficient global food production under the rapidly increasing need and will not be a constraint for sufficient global food production to eradicate undernourishment.

We hope that this publication can create a useful reference for improvement of the insight in the issues at stake and can contribute to food security by optimal use of water.

1 Water productivity is defined as the ratio of net benefits from crop, forestry, fishery, livestock and mixed agricultural systems to the amount of water used to produce those benefits. More specifically, physical water productivity is defined as the ratio of agricultural output to the amount of water consumed.

2. Background and Rationale of the Priorities for Action and Cross-cutting Subjects

This chapter presents the background and rationale of Theme 2.2 and its Targets and Solutions.

2.1 Setting the stage: the experience, potential and challenges of agricultural water management's contribution to food security

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Poverty encompasses different dimensions of deprivation that relate to human capabilities and is thus closely intertwined with food security.

In the framework of increasing demand, changing consumption patterns, developments in markets, urbanisation and climate change, food security and agricultural livelihoods have regained importance in planning at National and lower levels. In the last fifty years, agricultural water management has helped to meet the rapidly rising demand for food, and has contributed to the growth of farm profitability and poverty reduction as well as to regional development and environmental protection. The fundamental challenge is how to meet the ever-rising demand for food in a context of the above mentioned processes while at the same time increasing farmer incomes, reducing poverty, and protecting the environment, all with a legacy of mixed results from irrigation development and from an increasingly constrained water resource base.

Food security and poverty

The concept of food security includes nutrition security. This widely accepted definition considers four dimensions of food security:

1. availability of sufficient quantities of food of appropriate qualities, supplied through domestic production or imports (including food aid). Food availability addresses the supply side of food security and is determined by the level of food production, food stock levels and net trade;
2. accessibility of appropriate foods for a nutritious diet is strongly determined by the level of available resources to acquire those foods. Concerns about insufficient food access have resulted in a greater policy focus on incomes and expenditure in achieving food security. Accessibility brings food security closer to poverty reduction;

3. food security is also about meeting nutritional requirements. Though it was traditionally perceived as consuming sufficient protein and energy (food quantity), the importance of micro-nutrients for a balanced and nutritious diet (food quality) is now well appreciated. The converse of this is malnutrition, which is the condition that results from taking an unbalanced diet in which certain nutrients are lacking, in excess (too high an intake), or in the wrong proportions;
4. stability dimension of food security is about maintaining all above conditions at all time and reducing the risk of adverse effects of a shock (e.g. an economic crisis or climatic extreme event) or cyclical events (seasonal food insecurity).

Poverty encompasses different dimensions of deprivation that relate to human capabilities including consumption and food security, health, education, rights, voice, security, dignity and decent work

Food insecurity appears whenever one of the above mentioned conditions is not met. Disruptions in supply will reduce availability and stability. Economic hardship will adversely affect accessibility and utilization. There can be different degrees of food insecurity. Food insecurity can last for a certain duration and be either chronic (long-term: as result of chronic climatic severity, extended periods of poverty, lack of assets and inadequate access to productive or financial resources), transitional (short-term: relatively unpredictable, typically the result of climatic events such as droughts and/

or floods), or cyclical (generally seasonal: due to lack of adequate governance and planning). Additionally, food insecurity can be more or less severe, and range from acute (where the population faces a significant threat of loss of life, which can require emergency interventions and is usually qualified as humanitarian emergency) to famine (the most extreme situation, with substantial loss of life and qualified as a humanitarian catastrophe).

Poverty is closely intertwined with food insecurity. In periods of economic hardship, exacerbated by poor governance, lack of capacity or adverse effects of climatic variability, food availability will decrease and access will be increasingly difficult. This will in turn generate more hardship through loss of income, loss of life and loss of resources that will instead have to be dedicated to the struggle to find alternative sources of food. The food price increases of 2008 have for example resulted in an estimated net increase of 44 million people in poverty. This added to the 1.2 billion people already living below the extreme poverty line of US$ 1.25 per day. Higher prices of food lead to higher levels of undernourishment.

In the framework of increasing demand, changing consumption patterns, developments in markets, urbanisation and climate change, food security and agricultural livelihoods have regained importance in planning at National and lower levels

The vicious circle of food insecurity and poverty can be broken by aiming to attain food security as the foundation on which poverty can be reduced or even eradicated. Food security will free up resources, restore health and confidence and increase incomes either directly (farmers) or indirectly (increased productivity and economic growth). To achieve this is already a challenge under normal circumstances.

Since the 1960s, yields of irrigated cereals have doubled (rice, maize) or increased threefold (wheat) as demand has more than doubled during that period yield increases have contributed two-thirds of the matching production increase (except in Sub-Saharan Africa). However, there is a significant gap in productivity of crops, livestock and aquaculture among the Continents of the World. This can be illustrated with the example of maize productivity (Figures 2, 3 and 4). Maize yields can vary from 2 tons/ha in Africa to 4 tons/ha in Asia or South America, to almost 10 tons/ha in North America.

There are several reasons why such productivity gaps exist. In addition to variations in soil fertility, land and water availability, smallholder farmers often don't have sufficient economic means or incentives to adopt yield enhancing seeds or cropping techniques, they may lack access to information, extension services, technical skills and sometimes available technologies have not been adapted to local conditions. Poor infrastructure,

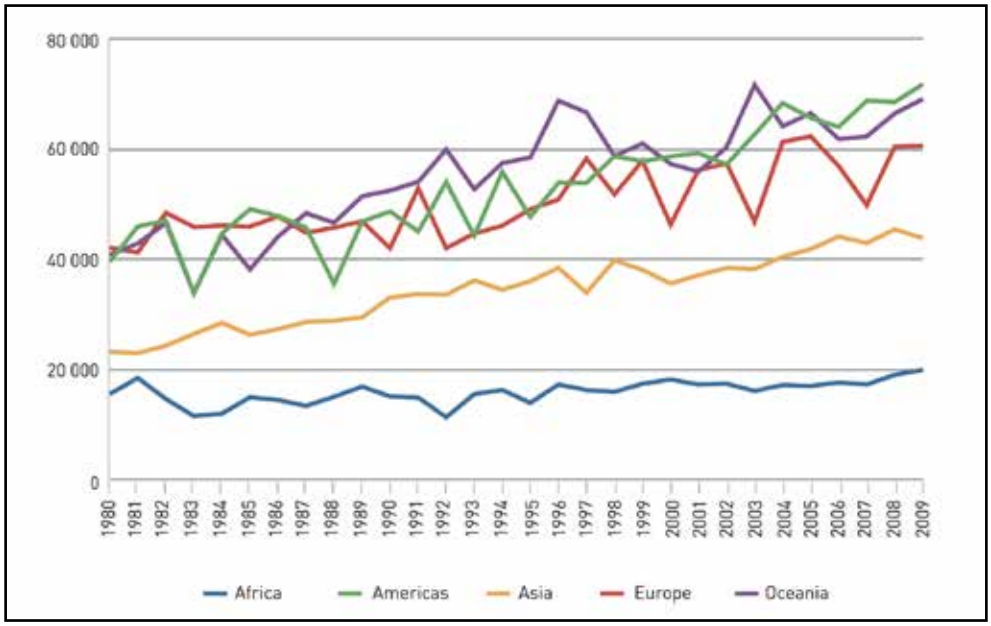

Figure 2. Progress in maize yields in the different Continents in tons/ha over the period 1980 - 2009 (data Food and Agriculture Organization of the United Nations (FAO))

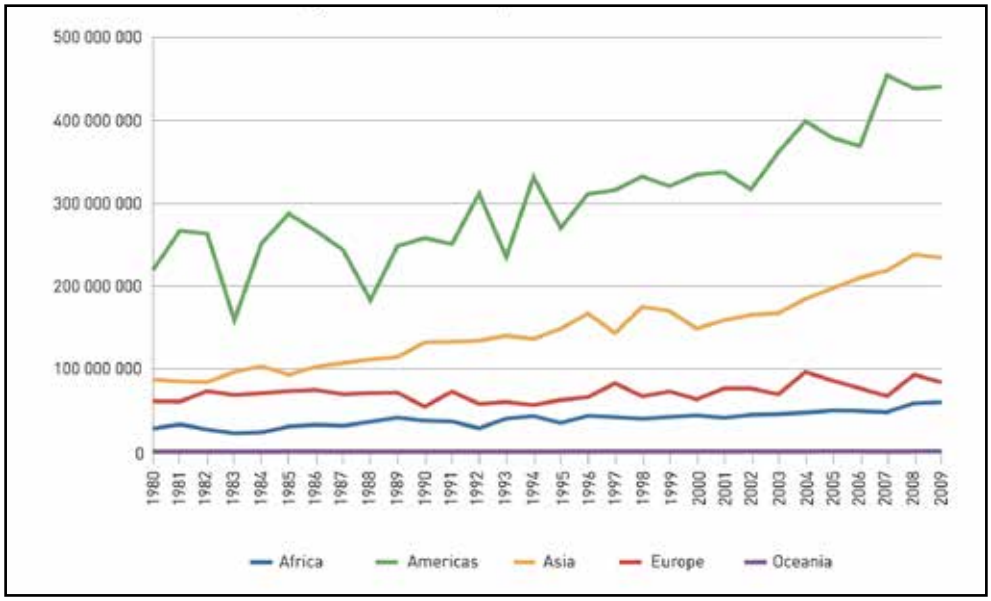

Figure 3. Progress in production of maize in the different Continents in million tons/year over the period 1980 - 2009 (data FAO)

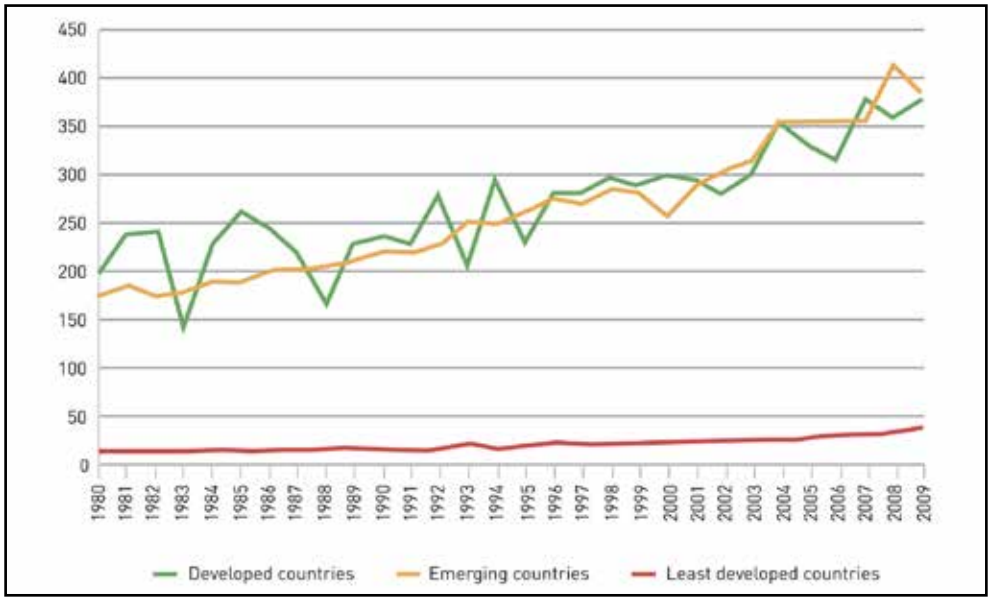

Figure 4. Progress in production of maize in the three different types of countries[2] in million tons/year over the period 1980 - 2009 (data FAO)

weak institutions and discouraging farm policies can also create obstacles to adoption of improved technologies at farm level.

Several conditions are necessary to ensure food security. Better protection and management of water resources used in irrigated and rainfed agriculture, as well as in post-production segments of the food chain are important. In the rapidly urbanizing World there is a need for societies to raise awareness of rural challenges and to give farmers and those involved in the food industry the recognition and the means to ensure food security, to innovate and to reconcile agricultural progress and sustainable management of natural resources, particularly water.

2.2 Feeding 9 billion people in 2050 without additional water

There are several trends that intensify and complicate the way forward. The Worlds' population is expected to grow from 7 billion at present to 9 billion by 2050 (Figure 5). This growth is especially expected in the urban areas of the emerging and least developed countries, while no growth is expected anymore in the developed countries. In addition the standard of living in the emerging countries (almost 75% of the Worlds' population) is rapidly rising, among others resulting in changes in diet, with more animal products.

2 Developed countries. Most of the countries in Western and Central Europe, North America and some countries in Central and South America, the larger countries in Oceania and some countries in Asia.
Emerging countries. Most of the Eastern European countries (including Russia), most countries in Central and South America, most countries in Asia (including China, India and Indonesia), and several countries in Africa.
Least developed countries. Most countries in Africa, several countries in Asia, 1 country in Central America and most of the smaller countries in Oceania.

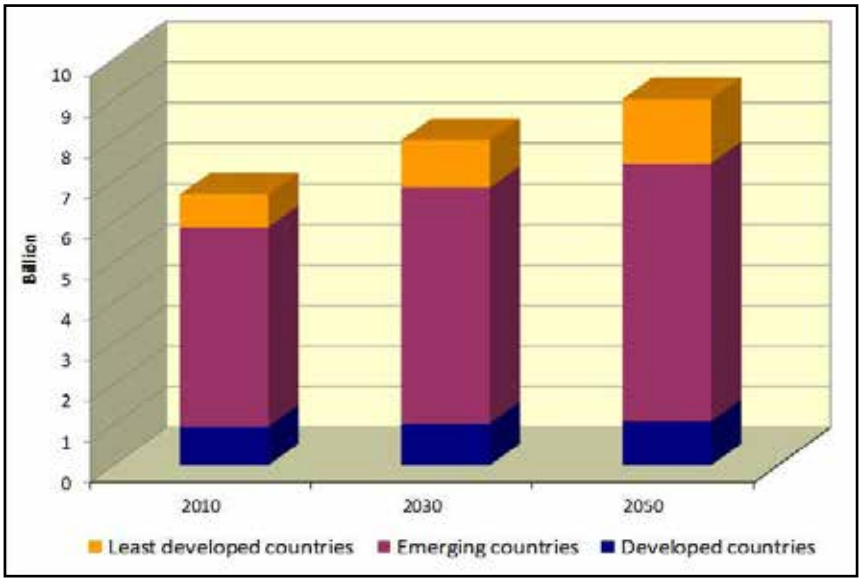

Figure 5. Population and population growth in the least developed, emerging and developed countries (data UNDP Population Reference Bureau)

A third development is the improvement in life expectancy from 46 in the 1950s to 65 around 2005. Due to this future global food demand is expected to increase by some 70%, and will approximately double for emerging and least developed countries. As a result, output of cereals in emerging and least developed countries will have to rise by more than 60% by 2030 and irrigated cereal yields in these countries need to increase from the present 3.2 - 3.5 tons/ha to 4.5 - 5.0 tons/ha, with rice yields going up by 25%, and wheat yields by 30%, a considerable challenge given that these yields will have to be higher than the present cereal yields in the developed countries.

Moreover, the World is rapidly becoming more urbanized and wealthier (Figure 6). Due to this food preferences are changing, with, among others increases in demand for products like milk, meat, fish, fruits and vegetables, that all require more water to be produced.

Although present global food production is still sufficient to feed the Worlds' population, malnutrition affects large numbers of people and is even increasing. This last phenomenon is exacerbated by competition from increased demand for bio-fuel, where the supply chain consumes the same inputs - particularly land and water - in a significantly more intensive manner. This may have contributed to increased food price volatility. Indeed, the long downward trend in cereal prices made a turnaround in the period 2000 - 2002 and prices rapidly increased in the period 2007 - 2008 when a combination of relatively lower strategic reserves, poor harvests, droughts and a sudden rush to plant bio-fuels in the United States and Europe reduced trade volumes. Rising food prices may exert financial pressure on net importers of food and on poor populations. Variability in prices is problematic when variations are large and unpredictable, as they pose food security risks for consumers and governments, while

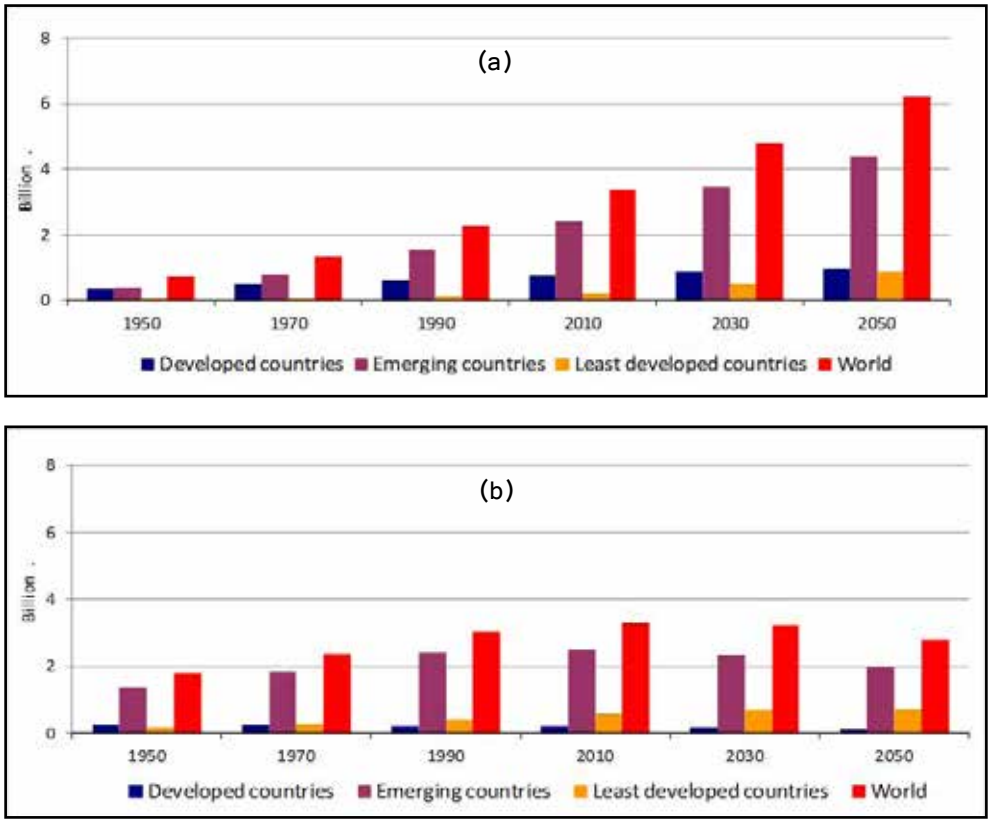

Figure 6. Development of urban (a) and rural (b) population in the three different types of countries and at the global scale (data United Nations, Department of Economic and Social Affairs, Population Division)

discouraging investment in agriculture due to increased financial risks for producers and traders.

2.2.1 Future food demand and production sources

In order to feed the larger, more urban and partially richer population, it is estimated that in the forthcoming 25 - 30 years food production (net of food used for bio-fuels) would have to increase by 70 - 110% at global level and at least double in the emerging and least developed countries[3]. The estimate of 70% for future food requirement assumes no changes in dietary or efficiency/waste adjustment of food demand. However, it needs to be acknowledged that depending on the diet composition, the water demand could vary, particularly for meat intensive diets. If the required increase is compared

3 Note: there is a certain range in the forecasts. It would be therefore worthwhile to analyze different forecasts and the considerations on which these forecasts are based.

with the speed of increase over the past period, it can be observed that the speed of increasing food production has to be significantly faster to cope with the expected need.

There is a common understanding that 80 - 90% of the necessary production increases would have to come from increases in yields and farming intensity at existing cultivated land.

Increased yields will, however, not be enough to feed the expected population of 9 billion. The extra land to be put under crops (and therefore to be taken from pasturage and forest) has been estimated at 120 million hectares (12%) by FAO for emerging and least developed countries (Sub-Saharan Africa and Latin America), which may appear to be a modest figure in comparison with the total for all land under crops worldwide (1.5 billion hectares) and the land areas that can be potentially used for crops. Nevertheless, this number is debated, as is that for the gains in yield that are possible and it does not take into account losses from erosion and urban expansion, which will need to be offset, nor the expansion that will be required to meet new non-food demand.

It will therefore be of importance to analyse which part of this increase can be achieved by: i) improvements or expansion of rainfed agriculture with, or without a drainage system; ii) modernisation of irrigated agriculture, either without, or with a drainage system for wet periods, or groundwater table and/or salinity control; iii) livestock improvement; iv) better management of capture fisheries; v) improved water use in aquaculture and feed formulation; vi) improvements in multiple uses of water for food production, e.g. integrated farming systems and non-extractive water uses, e.g. cage culture in lakes. This increase in food production will have to be achieved at affordable costs and affordable prices, especially for the urban poor. In light of this it is of interest that most increase in arable land in the past has been for irrigated agriculture (Figure 7). Further, an opportunity to increase productivity without additional water lies in increasing the efficiency of the food supply chains, especially in reduction of food losses and waste. Food losses and waste are currently estimated at 30% as an average for all food commodities, and therefore there is a potential for significant reduction and subsequent increased output of food.

With respect to these developments it will also be of importance to indicate to what extent government support and institutional reforms will be needed to achieve the required increase, especially in the emerging and least developed countries.

2.2.2 Contribution of agricultural water management and its challenges

In the last fifty years, agricultural water management has helped to meet the rapidly rising demand for food and has contributed to the growth of farm profitability and poverty reduction as well as to regional development and environmental protection.

The Green Revolution has provided the springboard for many emerging countries to transform from agrarian to industrializing economies. The Green Revolution technology of high inputs of nitrogen fertilizer, applied to responsive short-strawed, short-season varieties of rice and wheat, often required irrigation to realize its potential.

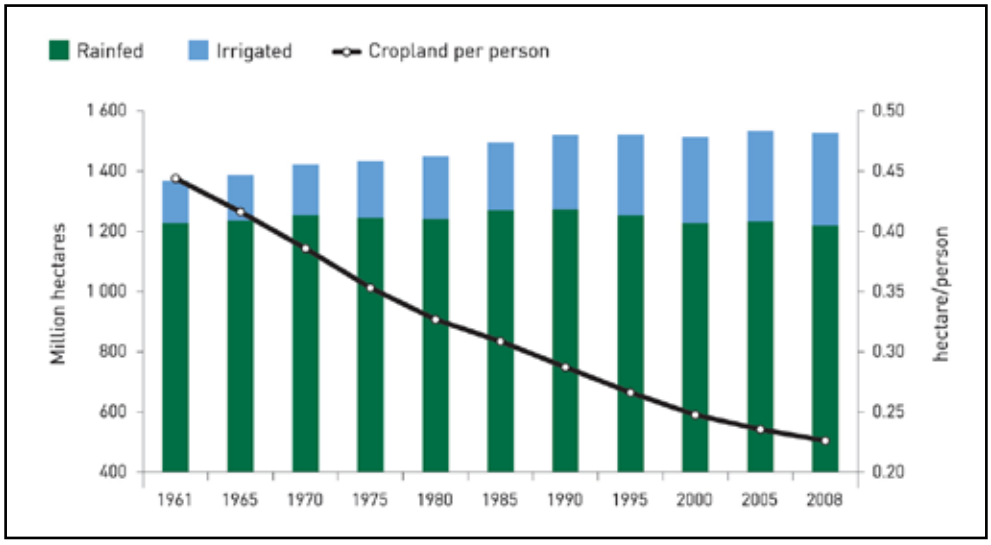

Figure 7. Evolution of cropland surface area between 1961 and 2008 (data FAO).

When growing food crops, the timing and reliability of water supply is critical. Water management in irrigation achieves stability of crop production by maintaining soil conditions close to optimum for crop growth. Irrigation allows the cultivation of crops when rainfall is erratic or insufficient, insures high-value, high-risk horticulture from failure and has played a major role in achieving national and regional food security, particularly in Asia, as well as in improving individual livelihoods.

The irrigated area of the World increased significantly during the early and middle parts of the twentieth century, driven by rapid population growth and the resulting demand for food. Production and average yields of irrigated crops in these countries have responded to this demand by increasing two- to fourfold. Irrigated agriculture now provides approximately 40% of the Worlds' food, including most of its horticultural output, from an estimated 20% of agricultural land, or about 300 million ha worldwide.

As water and land managers farmers are also stewards of the environment and they provide many environmental services and amenities to society. Irrigation and its infrastructure help mitigate the impacts of drought and floods, stabilize river flows and reduce erosion and silt loads. This has contributed to shaping the rural area and to social and cultural values.

2.2.3 Drivers of change in food supply and consumption

Global prices, availability of energy, policy response to recent financial and food price problems, increasing demand for bio-fuel feedstocks, and especially in case of rainfed agriculture possible impacts of climate change are among the major uncertainties the World faces in preparing responses to current and future challenges.

Agricultural production is sensitive to a range of influencing factors. Among these factors are developments in the sector, introduction of innovations in practice, market fluctuations, production conditions, flooding and in case of rainfed agriculture inter-annual variability of climate, especially the occurrence of drought and environmental degradation. Given the wide range in the projections of changes in climate and a possible increase in climate variability, increases in the frequency, severity, or duration of extreme climatic events and environmental shifts may have significant impacts on the production of rainfed food crops. Paradoxically, this may favour increased productivity of floodplain fisheries. Thus, human beings and the agricultural practices and strategies they utilize would have to be, as they have been for millennia, adapted to changes in climate and natural habitats while seeking to maintain biodiversity and securing fruitful environments for succeeding generations. Related to these influential factors a special item that so far has not received the attention that it deserves is the need for sufficient animal feed, especially in arid and semi-arid regions. More attention needs to be paid to this aspect, while it is generally an important aspect in the livelihood of smallholder farmers.

Solutions are expected to lie with public sector investments in infrastructure and institutions, and sound policies to stimulate adoption of technologies that reduce costs and improve productivity - higher output per hectare or shift to double cropping, or high value crops - thus increasing agricultural incomes. In light of this participatory irrigation system management (PIM) may contribute to improved water management

and productivity, particularly in small-scale irrigation systems. Increased stakeholder involvement in the operation and maintenance of major irrigation systems will be of major importance for more successful outcomes. In addition, there may be opportunities in the form of soil water management systems, storage, drainage, etc. that could be used to enhance food production from aquaculture for fisheries.

Changes in crop management techniques can also help closing productivity gaps. Plant and animal breeding may play an important role in closing yield gaps by adapting varieties to local conditions and by making them more resilient to biotic (e.g. insects, diseases, viruses) and abiotic stresses (e.g. droughts, waterlogging, depleted soils, flooding). Agricultural strategies, such as the development of bio-fuels in some areas may be a threat to water and food security. It is therefore appropriate to match economic and territorial issues at relevant geographical scales.

Given the currently recognized challenges to achieve food security it is important to develop sustainable strategies to improve the resilience of agriculture and it's supporting ecosystems to meet the Worlds' needs. Especially in case of rainfed agriculture climate change may have a significant impact on agricultural production. A goal would have to be to develop strategies to improve the resilience of agriculture and rural livelihoods. In Africa, Asia and Latin America, for instance, yields of rainfed agriculture could decline by between 20 and 40% if no effective adaptation measures are taken. Even if climate change is expected to increase productivity of rainfed agriculture, or aquaculture in certain areas (thanks to an extended growing season), it is generally agreed among the research community that climate variability and the frequency of extreme weather events will increase even in the near future in all regions. More productive and resilient agriculture requires higher effectiveness with respect to food security goals and increased efficiency, substantial increases in irrigated agriculture, as well as in the use of natural resources and inputs for production.

Energy. As countries further develop, the need to reduce the burden of increasing energy demand on the environment and lessen climate change effects through increased energy diversification and energy efficiency is becoming a global challenge. Within the energy context, agriculture plays a double role: on the one hand, agriculture will have to supply additional food and most of this increase will have to result from productivity increase, therefore more energy will be required; on the other hand, agriculture can also be a potential supplier of energy through bio-energy sources, which may

suppress the amount of agricultural yield used for food. Fossil fuels will no longer be the only source for energy to increase productivity but energy sources have to be considerably diversified so as to allow for further agriculture intensification. This is because, as fossil fuel sources decrease, prices increase; which in turn drives input prices up, consequently this increases agriculture production costs and bears a risk on food security. It is important to ensure that bio-fuels are produced in a sustainable manner and that the issue of indirect land use change and the possible threat to global food security will be effectively addressed.

Trade. Over a recent period of ten years (1999 - 2008) the developed countries have on average exported about 7.6% of their cereal production. The emerging countries were net cereal importers, but only at a marginal level (2.6%) compared to their own production. The least developed countries have imported on average 4.4% of their own production, or received it as food aid (Figure 8). With respect to the cereal production there is also quite a difference in the production in kg/person per year between the least developed countries in Asia (about 275 kg/person/year) and in Africa (about 105 kg/person/year) (Figure 9). Up to about 2007 the importing least developed countries have benefited from the higher supplies and lower prices of agricultural products on world markets, which were to a certain extent the result of subsidies for production and trade in the developed countries. As this support is being reduced, prices are expected to increase, leading to higher food import bills for the least developed countries dependent of food imports. It is therefore important that food importing countries will become more resilient to price increases at the world market (Figure 10). The rapid increase in prices of cereals in 2007 reduced the purchasing power of the poor and vulnerable, placing them at risk of hunger and malnutrition. These food prices undermined gains in poverty reduction and have pushed large numbers of people back below the poverty line. Those most vulnerable to food price changes need to be protected from nutritional deprivation, reduction in their real purchasing power, and asset shedding. Failure to protect the poor from income reduction could undermine recent gains in poverty reduction and political and macro-economic stability.

Several countries are highly dependent on food imports because they are resource constrained (e.g., some countries in the Near East and North Africa). Other countries have food import dependence for quite different reasons (e.g., countries in Sub-Saharan

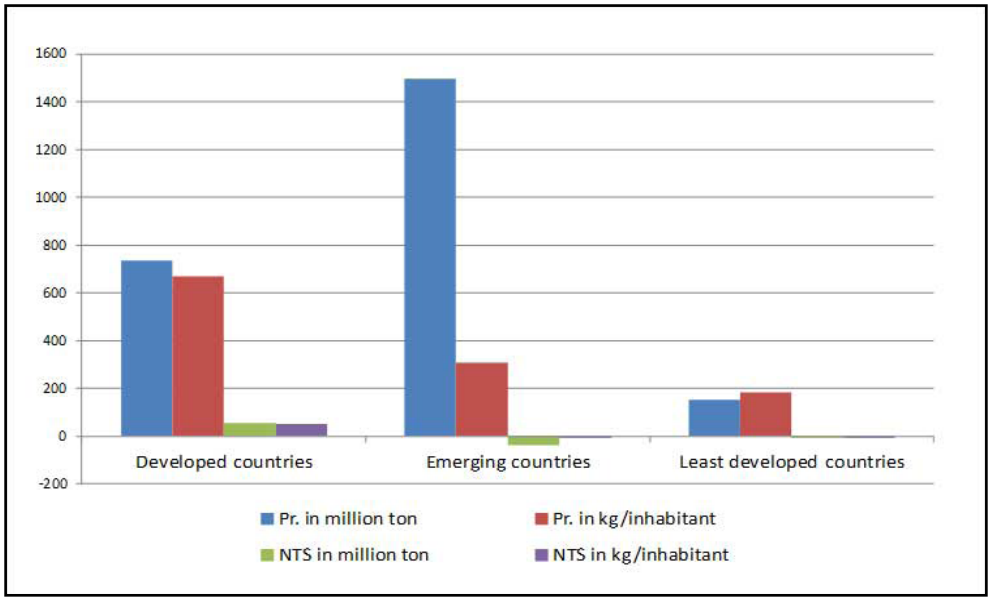

Figure 8. Some characteristic average data with respect to cereal production. Pr. = production, NTS = net trade surplus (+) export, (-) import (data FAO)

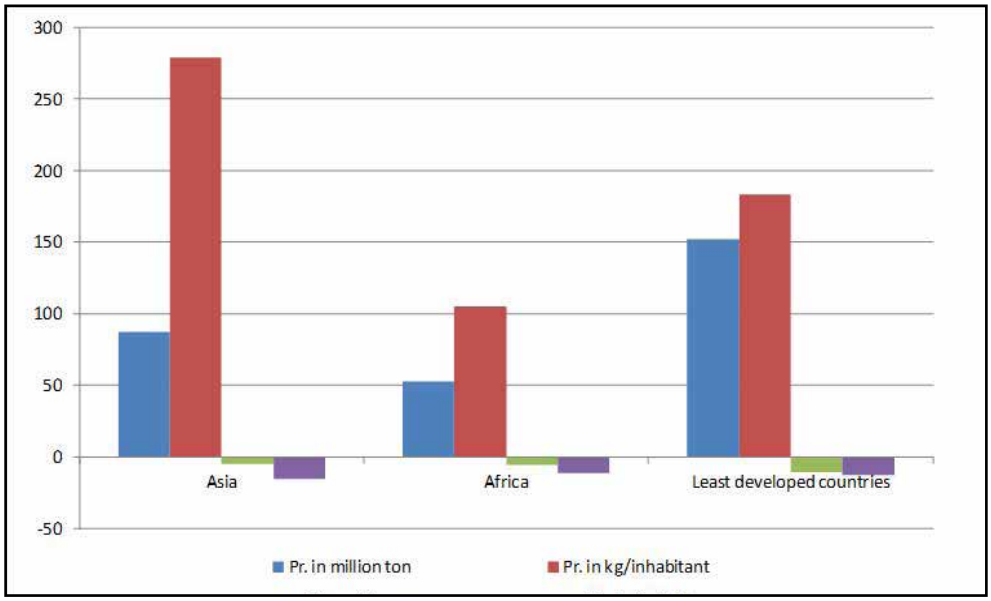

Figure 9. Some characteristic average data with respect to cereal production in the least developed countries of Africa and Asia. Pr. = production, NTS = net trade surplus (+) export, (-) import (data FAO)

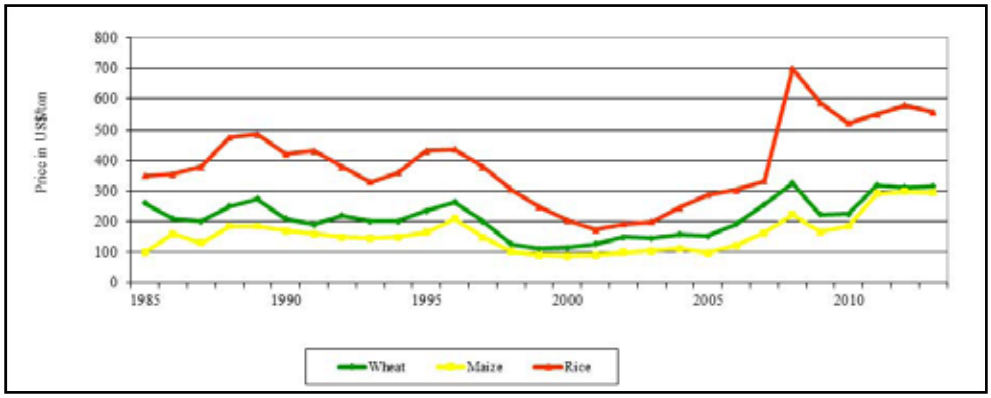

Figure 10. World market prices for wheat, maize and rice (data International Monetary Fund (IMF))

Africa). For many, their agriculture sector and water management measures, despite relative abundance of natural resources, are underdeveloped and therefore they are unable to satisfy the domestic demand for food. Many countries will continue to depend on international trade to ensure their food security (Figure 11 and Table 1). Unilateral decisions by countries to restrict exports may aggravate the situation and can result in increased speculation. Several factors point to the risk of growing price volatility. Least developed food deficit countries need to reduce their vulnerability to international market shocks.

Steps to prevent future food shortages include establishing effective social safety nets, measures to tackle price volatility including appropriate use of food reserves, significant investments in modernisation of irrigation and drainage systems (including both technology and management techniques aiming at fair sharing between users), as well as in the installation of new systems, anticipation of possible impacts of climate change, especially with respect to rainfed agriculture, productivity-enhancing and fair sharing governance mechanisms for smallholder farmers and new institutional arrangements.

2.2.4 Implication of uncertainties on production systems

The fundamental challenge is how to meet the ever-rising demand for food in a context of volatile markets and climatic uncertainty while at the same time increasing farmer incomes, reducing poverty, and protecting the environment, all with a legacy of mixed results from irrigation development and from an increasingly constrained water resource base.

The demographic and increased income push to food demand is expected to continue and it is expected that irrigated agriculture will have to provide close to 60% of the extra food needed over the next 25 years. However, remaining opportunities to develop new resources for agricultural water management are fewer and more expensive than those in the past.

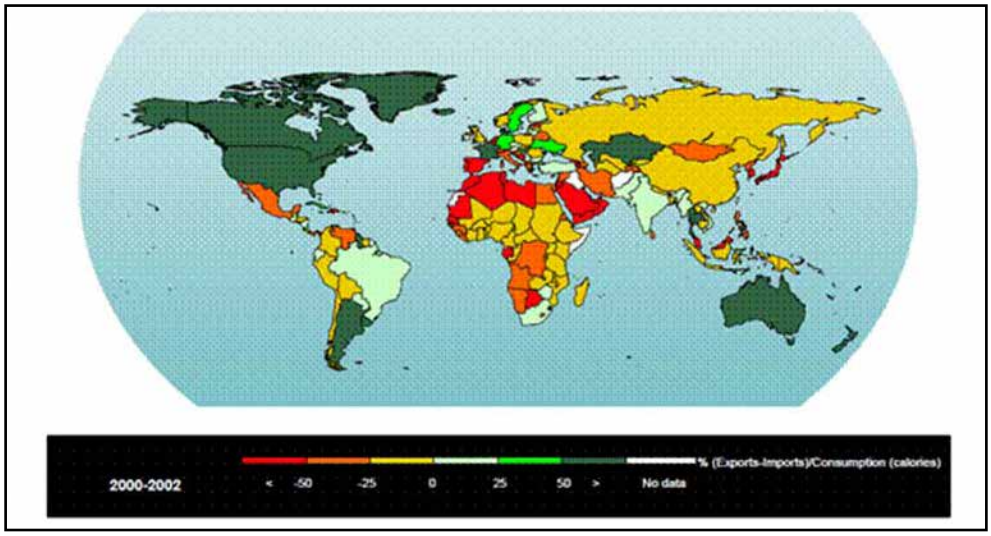

Figure 11. Average net trade in food in 2000-2002. The volume of food exported (green) or imported (yellow-red) is expressed as a percentage of total consumption in each country and represents, for the food importing countries their relative dependence on external sources of food (FAOSTAT online).

Table 1. Average cereals production, import and export during the years 2006-2008 (million tons) (data FAO and UNDP Population Reference Bureau)

Source / region	Production (million tons)	Imports (million tons)	Export (million tons)	Net import (million tons)	Export/ production (%)	Population (million) (2010)
Asia	953	130	45	83	4.7	4,030
Africa	137	59	6	54	4.1	965
Americas	600	28	152	-94	58.9	911
Europe	430	24	53	-29	12.2	731
Oceania (Australia)	27	1	11	-14	54.2	35
World	2,150	270	270	-0.1	12.6	6,670
Developed countries	943	70	192	-122	20.3	956
Emerging countries	1,067	130	74	104	6.9	4,920
Least developed countries	133	23	5	18	3.4	798

Donor funding for irrigation development peaked in the 1970s, but reduced to a marginal contribution by the 1990s in the aftermath of disappointment with the performance of large-scale irrigation schemes, corruption, low feasibility associated with construction, and rising awareness of the impacts of large-scale water diversion on eco-systems. The low productivity of many schemes in the emerging and least developed countries has prompted a change in policy of donors in the sector, away from new infrastructure and towards programs that would have to improve the performance of existing schemes through institutional reform (for example introduction of public private partnerships (PPP) or improvement of water rights frameworks), improved management (water accounting for example) and the deployment of readily available technologies (including incentives for the adoption of on-farm technologies such as pressurized/drip irrigation, or best practices such as adjustment of cropping patterns, better soil moisture conservation practices, supplementary irrigation, zero/minimum tillage, deep-rooted crops, mulching, etc.).

Especially in emerging countries the role of Government is changing, responsibility is being decentralized, farmers are playing a greater role in decisions and investments, and more and more, markets are driving growth. The sustainability of future schemes through shared cost-recovery for which the sustainability cost may be expected from the farmers is essential though it is also important to provide guidance on proper risk-sharing. Small and medium-scale irrigation and drainage schemes need to be targeted to improve their profitability.

With respect to the modernisation of schemes in the emerging and least developed countries it is of importance that most of the schemes were originally developed by the Central Governments. These governments can/will generally not continue to take full responsibility for operation and maintenance of the schemes. Due to this transfer of responsibilities and/or even of ownership of the schemes to the stakeholders is an on-going process. This will imply a much larger role of the stakeholders and private sector, especially in large-scale farming, and in the emerging countries in the smallholder schemes as well. Among others this will require more attention for extension and government subsidies to the stakeholders and private sector to make the modernisation processes and schemes successful. In parallel to such processes there will also be an important role for innovation. This implies that available research results would have to be better implemented in practice and that research projects and programmes would have to be linked to improved applications in practice.

Rainfed areas where most poor people live have been largely bypassed by public investment in irrigation and drainage. In addition to more intensified and diversified irrigation and to some expansion of the irrigated area especially in Sub-Saharan Africa, a major effort is needed to enhance water management in rainfed agriculture, though this is less straightforward than in the case of irrigated agriculture.

2.2.5 Implications of increasing food supply on water and ecosystems

Water availability for agriculture is increasingly constrained. Irrigated agriculture accounts for about 70% (2,850 km^3 per year) of the freshwater withdrawals in the

World, and up to 85% in emerging and least developed countries. In addition rainfed agriculture uses 6,400 km^3 per year. In the 20th century global water use has been growing at more than twice the rate of population increase. It is expected that the amount of water withdrawn by irrigated agriculture will need to increase by 11% by 2050 to match the demand for biomass production[4]. Agricultural water use is perceived as the main factor behind the increasing global water scarcity with its rapid growth based on the availability of large quantities of low-cost water. This rising demand for agricultural water faces increased demand from domestic and industrial uses and increased pressure to release water for higher value uses. This will be a considerable challenge in water-constrained areas. Many areas are already enduring competition for water and rising costs. An increasing number of regions are reaching the limit at which reliable water services can be delivered (Figure 12). The situation will be exacerbated as demands of fast growing urban areas place increased pressure on the quality and quantity of local water and land resources.

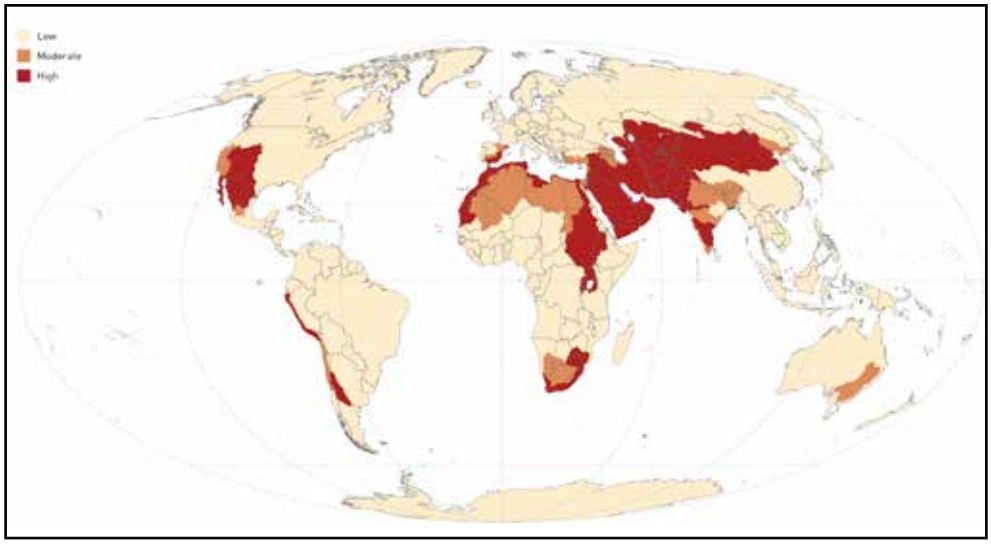

Figure 12. Global distribution of water scarcity by major river systems (data FAO).

For years groundwater provided an alternative resource and helped maintain the pace of, mostly private, irrigation expansion, stimulated by cheap pumps and subsidized energy. However, in many basins groundwater is being mined. In addition environmental stress is growing as many agricultural production systems approach the limits of water and

4 From Climate change, water and food security (FAO, 2011) based on The resource outlook to 2050: By how much do land, water and crop yields need to increase by 2050? (Bruinsma, 2009). Projected trends in demand for food and agricultural production are based on the United Nations (UN) Statistics Division medium population projection, the World Bank income growth projections and FAO's estimates of future agricultural productivity. The calculation of water demand assumes that all minimum demands for potable water and daily kilocalorie intake have to be met. Demand for water (streamflow or groundwater) reflects irrigation needs, whereas water use in rainfed agriculture is considered only in terms of evapotranspiration of water from the available rainfall.

land resources (Figure 13) and farmers are facing increasing difficulty in fulfilling their role in preserving the environment.

In quite some emerging and least developed countries drainage is neglected despite its potential contribution to soil fertility management, which could enable irrigated areas to reach a higher combined soil and water productivity potential. Unpredictability of climate change and resulting changes in the hydrological cycle, which may modify rainfall patterns and lead to increased temperature, may impact agriculture and reduce crop productivity. Water availability may be reduced in areas where irrigation is needed or has comparative advantage. Stability of supply might be endangered by an increase in frequency and intensity of extreme weather events.

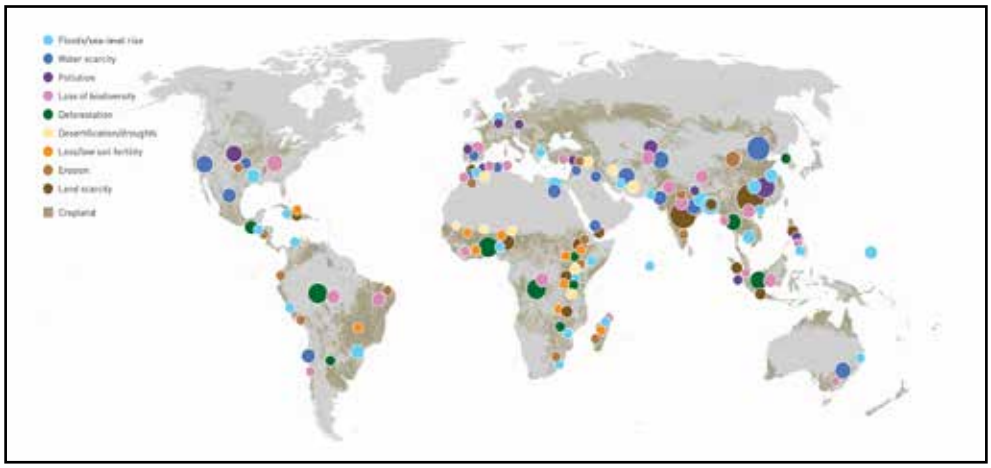

Figure 13. Schematic overview of risks associated with main agricultural production systems (data FAO)

With respect to these items a challenge will be how to lessen the pressure on agricultural water by bringing in low quality water and reuse of wastewater in agriculture and aquaculture. In addition, more and more ecosystem functions are now being given water allocations rather than being treated as residual users. Agriculture in its relationship with water can also deliver environmental services. In relation to further food production a proportional allocation of water would have to be associated. Increasing input use efficiencies in agricultural production will be essential as natural resources are getting scarcer, and prices of non-renewable resources like fossil fuels, nitrogen, and phosphorus are expected to increase over the next decades.

Ecosystems and biodiversity, which are generally recognized as essential resources for agriculture intensification and smart food production, are threatened by urbanization, deforestation, pollution, diversion of flow from rivers and river basins and the conversion of wetlands. Aquaculture and inland capture fisheries are important ecosystem services of inland water ecosystems and depend on functioning ecosystems for productivity. As a result of agricultural modernization, changes in diets and population density,

humankind increasingly depends on a reduced amount of agricultural biological diversity for its food supplies. The gene pool in plant and animal genetic resources and in natural ecosystems which breeders need as options for future selection is diminishing rapidly. A dozen species of terrestrial animals provide 90% of the animal protein consumed globally and just four crop species provide half of plant-based calories in the human diet. There is still abundant species diversity in fisheries, but this is also under threat; a wide variety of fish provides 20% of total animal (including fish) protein.

2.2.6 A way forward

Agricultural water management has played and will play a central role in reducing the risk of food insecurity and sowing the seeds of future growth in emerging and least developed countries. However, the past decade has witnessed reduced momentum in that respect, as the limits of the model of expansionary irrigation have been met, exacerbating the need to identify and implement new instruments in the contribution of water towards food security.

To some extent solutions to facilitate expansion of efficient irrigation through improved infrastructure and increased water productivity are known and available. The dissemination of new irrigation models based on the combination of seasonal management options (legal and institutional framework, capacity, participation of the private sector, etc.) and available technologies, as well as progress on low-tech issues such as aquifer management, drainage and supplementary irrigation, would help meet the ever-rising demand for food from an increasingly constrained water resource base.

With reflections of the above developments and constrains in mind the following recommendations, Targets and Solutions have been developed as a multi-faceted approach that would support decision-makers to act in the various potential ways like: the improvement of irrigated and rainfed agriculture productivity, the development of alternatives such as wastewater reuse or improved drainage, the improvement of storage capacity, the implementation of pilot activities in critical areas and the reduction of waste of food.

2.3 Priorities, Targets and Solutions[5]

In preparation of the Theme Contribute to food security by optimal use of water an inventory was made of recommendations from the main political processes on food security. In addition Thematic surveys have been conducted to obtain the broadest possible input into the process. The consultation process for these surveys engaged nearly 1000 people through online surveys or during various events from November 2010 up to WWF6. The results of these surveys have been published on the website of the World Water Council (WWC). The obtained information of the surveys has been used in formulating the priorities as presented underneath.

5 The text in this section is to a certain extent based on recommendations of the High-Level Expert Forum on 'How to feed the world in 2050' (October 2009).

One of the main objectives adopted by the World Food Summit on Food Security in Rome 2009 was to reduce by half the number of hungry people by 2015, meaning to reduce to 420 million people at latest by 2015. To achieve this objective requires integrated actions at the National levels and coordination at the international level with involvement of the main stakeholders along the food chain from producer to consumer, including the food processing industries: importers and exporters, suppliers of inputs, equipments and services and the actors responsible for food quality and safety. In light of this the World Economic Forum (WEF) has stated that agricultural players worldwide would have to engage in and coordinate their efforts in order to establish a new vision on agriculture where food security, environmental sustainability and economic opportunity can be combined to increase the production by 20% by 2020, while decreasing emissions by 20% and reducing the prevalence of rural poverty by 20% every decade (Figure 14).

The way forward implies sustainable intensification, and therefore improved water governance, more and more effective water management systems, better adapted to climate variability and local circumstances, prevention or reduction of over-exploitation of water systems, pollution, desertification/erosion of river basins, transfer of land and water due to urbanisation, flooding and salinization. Some of the recommendations are presented underneath.

Figure 14. Food security, environmental sustainability and economic opportunity (World Economic Forum (WEF))

2.3.1 Sustainable intensification of food production with water management to reduce the productivity gap

Sustainable intensification of food production with water management to reduce the productivity gap implies to increase land and water productivity in agricultural systems, including aquaculture and forestry. In most countries with agriculture-based economies, where the rural population is more than 40% of the total population and agriculture has a predominant economical, social and ecological role, increasing productivity to achieve food security is clearly a priority.

Improving the productivity of smallholder farmers in poor rural and peri-urban communities and in production based agriculture across the global economic spectrum may be the best and most sustainable way for reducing hunger by increasing access to quantity and variety of nutrition and improving the quality of locally available food. Investing in smallholder farms also provides another important pillar in efforts to sustain economic growth. If food demand is to be met in future, increased outputs will have to come from intensified and more efficient use of limited stocks of land, water and genetic resources across the spectrum of farming practices.

Production targets to guide action

Three production Targets give guidance to the actions:

(a) **Target I.** By 2020, rainfed land productivity (yield per unit area) will sustainably increase by 25% in Africa and by 15% in Asia - as compared to 2005 - 2007 baseline. Water productivity (yield per unit of water) of rainfed agriculture will sustainably increase for grains by 20% in Africa and in Asia by 15% compared to 2005-2007 baseline;

(b) **Target II.** By 2020, sustainably increase by 15% - as compared to 2005 - 2007 baseline - water productivity per unit land and per year (yield per m3, per ha and per year) of irrigated agriculture (for specific crop categories);

(c) **Target III.** Increase sustainable productivity and lower costs of water management (yield per ha, per m3 of water and per unit production cost) in such a way that by 2025 there is food security at affordable prices for all.

Reaching the Targets

Innovation. The technological options available to producers need to be as broad as possible, ranging from new plant varieties and animal breeds better adapted to changing conditions; to farming systems with improved water- and labour-saving technologies; reduction of losses and waste, and natural resource management. New, or tailored technologies will be needed to address the problem of increasing water scarcity, and also to reduce food losses throughout the food supply chains. Increased use of sustainable aquaculture as an efficient source of animal protein production will also help. Apart from soil erosion, loss of fertility and reduced biodiversity that in certain cases is associated with farming, a problem with meeting the food security agenda using current techniques is the risk of degradation of the environment that may in

certain cases also act as a catalyst to human-induced climate change. Addressing these challenges will require pushing the technology frontier outwards, while attempting to avoid potentially disastrous stress on marginal areas that in the past provided significant ecological and environmental buffers. This could be achieved by developing and disseminating innovative technologies, farming and management techniques but also by making existing technologies accessible to smallholder farmers in emerging and least developed countries. These farmers are one of the solutions to maintain food security. In order to ensure a wide uptake of modern technologies it is indispensable that technological progress does not bypass resource-poor smallholder farmers who may be risk-averse and thus may not adopt new technologies unless they can be at relatively low cost and low risk to their livelihoods and household food security. Conservation agriculture can improve crop yields, farm profitability and soil productivity and make agriculture more sustainable, while providing greater resilience against drought and other stresses. Yields are less variable from year to year, while labour and fuel costs are lower. However, conservation agriculture is knowledge intensive, location specific and will require investments in research on suitable varieties, management practices, appropriate machinery, etc.

Plant and animal breeding techniques. Breeding techniques, particularly modern biotechnology, have aroused public debates in the last decade. Technically speaking, modern biotechnology has the potential to speed up development of improved breeds and varieties, which may increase yields and/or decrease losses. Precision agriculture, with controlled inputs and integrated plant nutrient management systems provides new tools for further improving efficiency. Fertilizer consumption is expected to rise, especially in emerging countries and to a certain extent in the least developed countries. Nitrogen represents 90% of fertilizer consumption. Fossil energy accounts for 70 - 80% of the cost of manufacturing nitrogen fertilizer. Because major efficiency gains in manufacturing nitrogen have already been made, it is likely that fertilizer prices will in future rise in line with energy prices. Increasing on-farm use of nitrogen and supply of biologically fixed nitrogen are good options for efficiently using fertilizers. Integrated pest management aims to minimize the amount of pesticides applied by farmers by using other control methods more effectively. Countries like: Bangladesh, India, Jordan, Mali, Niger and Viet Nam have introduced integrated pest management and have experienced increased production accompanied by lower financial, environmental and human health costs.

Agricultural, including aquaculture, research. In emerging and least developed countries, agricultural research is

the most productive long-term investment in support of the agricultural sector, followed by investments in education, infrastructure and input credits, which are the most productive investments in the short-term. Investments in research have rates of return of 30 to 75% and long-term benefits. In order to achieve the yield and productivity gains that are needed to feed the World in 2050 greater priority has to be given to agricultural research, development and extension services.

2.3.2 Investments in water infrastructure combined with demand management for agriculture

Addressing the yield challenge requires to improve water access and therefore increase of water storages where needed, diversification of water sources - using non conventional sources - as well as expanding or modernisation of irrigated areas and wider use of management practices that will improve the efficiency of water use, e.g. water harvesting techniques and conservation of soil moisture (Figure 15).

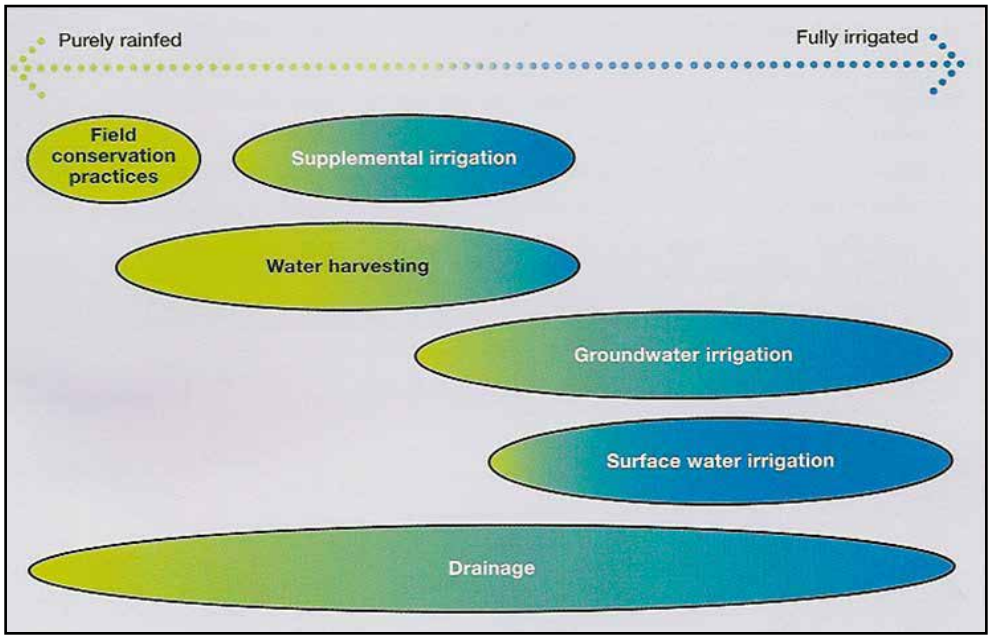

Figure 15. Diverse options for agricultural water management (International Water Management Institute (IWMI), 2007)

In severe water scarce regions, the efforts would have to focus on getting more crop per drop. This is a critical area where agricultural water management must interact with water resources management, food supply chain and land use planning. Though this is difficult to achieve as there is often a disconnection between economic pressures on one side (farmers look to maximize income, infrastructure managers look for profitability, governments strive for growth and food security) and environmental pressures on the other (constraints on water resources as a result of competition with other uses,

including environmental flows), these views could be reconciled with well designed investments that would be outlined in growth strategies.

Supporting Targets to guide action

The supporting Targets that give guidance to the actions are:

(d) **Target IV.** By 2015, increase by 25% - as compared to 2005-2007 baseline - the safe use of non-conventional waters, either treated wastewater or saline water, in agriculture and aquaculture, together with an increase in the number of countries recognizing the WHO-FAO-UNEP Guidelines for wastewater use in agriculture and aquaculture where insufficiently treated wastewater is used;

(e) **Target V.** Increasing capacity of water storage in support of irrigated agriculture in an environmentally sufficient and socially sound management.

Reaching the Targets

For reaching the Targets in essence demand-side measures, such as pricing signals or non price factors, need to be combined to supply-side measures, such as aquifer recharge enhancement, rainwater harvesting, conjunctive use of surface water and groundwater (as a flexible, autonomous and privately financed adaptation to poor service and/or restricted water availability), or reuse of drainage or treated wastewater (with proper attention to overall trade-offs including human health risks, pollution, etc.) to promote the sustainable use of water resources. Water resources and sources management also implies better planning and storage management.

Improved water management allowing for multiple uses of freshwater can improve food production whilst allowing other users access to water. Rice paddies and irrigation schemes can be managed to allow sufficient water for harvesting fish and other aquatic animal diversity. Hydropower development may have negative impacts on fisheries. These impacts can be reduced by timing water outflows and by use of fish passage facilities. Reservoirs are generally being engineered to allow for municipal, industrial and fishery uses of the water.

2.3.3 Promote a sustainable and adaptive way to intensify agriculture production and invest in agricultural water targeting smallholder farmers. Particular efforts need to be made in least developed country most vulnerable to changes

Global changes like: financial conditions, energy, soaring food prices, trade distortion and speculations, possible impacts of climate change, etc. make the least developed countries most vulnerable and exposed to high risk of food insecurity, particularly for the poorest populations and countries with a high dependence on imports of food. For food supply to be sustainable, action needs to be taken to arrest the degradation and, may be, eventual destruction of the natural resource base. This requires investments to manage the resource base, improve technical production efficiency (yields, productivity) and develop practices that foster sustainable and intensified food production.

Most of the investment, both in agriculture and related sectors, will have to come from private sources, primarily farmers themselves purchasing implements and machinery, improving soil fertility, etc. Farmers will invest in agriculture only if their investments are profitable and relatively low-risk. Investments in local markets and strengthening them are of importance, especially in the least developed countries. A close look at trade structures, which can disrupt national and local markets, is needed.

Planning Targets to guide action

The planning Targets that give guidance to the actions are:

(f) **Target VI.** By 2015: develop and adopt at least two macro-regional visions optimizing water use for food security; and by 2020 develop 200 sub-regional sustainable agriculture plans;

(g) **Target VII.** By 2015, develop national strategic action programmes for key 'hotspot' aquifers exploited by intensive agricultural use (% aquifer depletion, % pollution), including a local definition of maximum admissible drawdown (MAD) and a local definition of maximum admissible pollution levels (MAP) for agricultural uses.

Some Solutions

Encourage private sector investments. Private sector investment needs to be encouraged at all stages in the food supply chain - as input to the farm, in seed and fertilizer production and distribution, and after harvesting in processing, marketing and distribution. Countries need to create a favourable investment climate and address issues such as lending policies to agriculture, risks and limitations on the ability of microfinance systems to bring about a step-change in production and productivity. A strong and innovative rural financial system that allows the rural poor to have access to capital and their own savings, as well as insurance schemes, are clearly important in this context.

Create linkages across sectors and support at multiple scale. Smallholder farming needs to be integrated with the non-farm sector, both at the input side and at the output side of the farm, and be more able to adapt. Actions to lower barriers to the development of farm/non-farm linkages may include addressing deficiencies in infrastructure (as they limit investment opportunities), improving agricultural technology and promoting farmer organizations (as organized farmers tend to be more proactive in forging linkages with e.g. agribusinesses). A major problem in designing policies and programs geared towards non-farm rural activities, is that those activities may be neither under the mandate of the Ministry of Agriculture nor under that of the private sector. This constraint needs to be resolved before meaningful policies can be developed towards the rural non-farm sector. With respect to this there is a need for a revitalization of knowledge sharing mechanisms in agriculture.

Dissemination. Agricultural extension programs are meant to ensure that information on new technologies, plant varieties and cultivation practices reaches farmers. Spreading knowledge, skills and technology, as well as sharing best practices and successful know-how between South to South smallholder farmers are major challenges. In many countries, extension services have been cut in line with the reforms of public institutions.

Facilitation. Private entrepreneurs and non governmental organisations (NGO) may play a facilitating role in developing linkages between agro-industry and farmers. This role may include organizing farmers or assisting NGOs or private enterprises to take on responsibilities as providing credit, assisting with inputs, providing information on

technology and ensuring that contract requirements are met. In this way, the public sector, NGOs and private entrepreneurs may help directly to create beneficial linkages between agro-industry and farmers, and indirectly by creating other linkages between the farm and non-farm sectors.

Integrate environmental constraints. Maintenance of inland water ecosystems will allow intensification without compromising ability of the ecosystem to provide resources and a safety net in case other food production sectors fail or falter.

Get effective and regulated markets as food security for an increasing number of countries will depend on international trade and access to a stable supply of imports. There is a consensus that openness to international trade is a fundamental component of an overall mix of policies, which can foster economic growth and reduce poverty and food insecurity. International trade is of importance for the emerging countries and to a certain extent for the least developed countries, particularly for the smaller ones, for which the limited size of their domestic markets may constitute a constraint to efficient use of their domestic production potential. However, increased openness to international trade is not without costs, often in terms of unemployment, the decline of productive sectors in agriculture, increased concentration and agglomeration of the food system which leaves out smallholder farmers. Another factor that needs attention is the increased instability in commodity markets as reflected by more volatile prices.

2.3.4 Reconcile agriculture development with urban development and optimize synergies between agricultural and non-agricultural activities to optimize water use for food security

Food security issues vary substantially between rural and urban contexts and need to be addressed differently. Today's World population is evenly distributed between urban and rural people. However, the trend is clearly towards progressive urbanization of the Worlds' population (Figure 6). Urbanization will be most pronounced in the emerging and least developed countries of Asia and to a certain extent of sub-Saharan Africa. The food security balance is skewed in favour of urban people: between 70 to 75% of the poor and hungry live in rural areas in the emerging and least developed countries. They include smallholder farmers, landless labourers, traditional pastoralists, artisanal fishermen, and marginalized and vulnerable groups like refugees, indigenous people and female-headed households. Their income levels may be too low to purchase the necessary food at prevailing prices in the market. They may not have access to land for their own cultivation, or may lack the necessary assets or access to credit to help cope with difficult times. Also they may find themselves outside any public assistance or programme that provides them with in-kind or cash transfers to supplement their food acquisition capacity. Agriculture is therefore at the heart of livelihood strategies that often include a combination of activities, e.g. hunting and fishing. In countries with the highest incidence of undernourishment, agricultural employment is paramount. Moreover, worsening standards of living in rural areas drive people to cities - especially youth and young adults - thereby exacerbating urban poverty while the reverse does not often happen. Hence, agricultural growth needs to play a central role in strategies to reduce hunger and poverty.

With respect to farming it may be expected that the on-going urbanisation in the emerging and to a certain extent in the least developed countries will have its impact as well. In the developed world farming has gone in the past century through a significant up-scaling. For example in the Netherlands a farmer could have a living from 5 ha at the beginning of the 20th century and from 50 ha by the end. Similar processes can be observed in several emerging countries and to a certain extent already as well in some least developed countries. In several others despite rapid urbanisation the agricultural population is not decreasing and may even continue to increase. In these countries smallholder agriculture will therefore retain an important place. The overall consequence will be that farmers will have to produce for significantly more urban people. This will require an increase in farm sizes, or a transfer to higher value crops. Especially in the least developed countries it also implies that infrastructures have to be strengthened in order to secure the flow of food to the necessary places. Such trends will have to play an important role in measures with respect to food security at affordable prices for all.

Supporting Targets to guide action

The supporting Targets that give guidance to the actions are:

(g) **Target VIII.** By 2015, define water-related components of a strategy that will improve food supply chain efficiency by 50% and promote sustainable diets, including steps for its implementation by 2025;

(h) **Target IX.** Support the smallholder farmers in order to better manage agricultural water, produce more goods and services and reduce by 50% by 2020 the proportion of smallholder farmers without access to water training and water credit.

Moving towards the Targets

Supporting rural growth. The contribution of agriculture, including aquaculture and fisheries, to hunger and poverty reduction goes beyond its role as a source of food production and therefore increased food availability, lower food prices at local level and the stability of food supplies. A role is as well that of a driving force for overall development of the rural space, employment and incomes for the rural poor. Rural incomes impact access and stability of access by increasing the purchasing power of the poor and in many instances also by playing the role of a buffer against external shocks. Rural growth is also an outcome and a determinant of the access to the non-food inputs of nutrition security: education, care and access to services. All tend to improve with rural growth, but are also push factors behind it.

Increases in agricultural productivity are essential in this context. An increase in agricultural productivity raises farm incomes. The extra income from agricultural growth can create demand for goods and services, thus contributing to the virtuous cycle in which agricultural and rural off-farm income grow and sustain each other's growth. Therefore, increases in agricultural productivity create a series of effects in the rural areas through the growth of rural off-farm activities, i.e., synergy between agriculture and the rest of the rural space. Factors such as technology, access to resources and

markets are some of the factors that determine the incentives and the capacities of the rural poor to participate in and benefit from overall rural growth. These factors can also increase sustainable growth possibilities and empower next generations.

Support urban and peri-urban agriculture water access. Urban agriculture including aquaculture, both commercial and subsistence, can be a source of income and employment. It may have a role in addressing food security in urban areas, while it produces about 15% of the food consumed in urban areas. Also the increased reliance of urban consumers on purchased food renders food fortification and supplementation programs generally more effective in urban areas. Despite the existence of urban agriculture in many cities, though, urban people rely much more on purchased food to meet their nutritional needs, and hence a steady food supply at prices that they can afford is what matters most for their food security. Efficient food-producing and food-marketing systems are the first pillar of urban food security, as they have implications for both the price and the safety of food. Fast urbanization requires that more and more food be supplied to the cities, and this may put weak food distribution infrastructures under stress. Capture fisheries are often in non-urban or peri-urban areas and marketing and distribution, as well as maintenance of freshwater ecosystems will be needed.

Policymaking for urban food security has the advantage, when compared to rural, of:

1. having to reach a population that is much more spatially concentrated;
2. being able to rely on a network of public services (education, health) that is usually more developed and far-reaching than the rural one;

3. being able to rely on more developed civil society, producers, manufacturers and to a certain extent NGO networks that can bridge the gap between public and private sector actions.

Improve the efficiency of the food supply chain from producer to consumer; and reduce unnecessary demand (excessive consumption and waste/losses): The sub-sectors of the agri-food economy, at the input and output side of farming, and agri-businesses play an important role in ensuring that safe and nutritious food is made cheaply available as widely as possible. The changes in the food distribution chain and their implications for nutrition, food safety, food prices, dietary changes and farmers' profits are attracting increasing attention across the emerging and least developed countries. Food policy needs to deal with these domains. Innovative approaches are required bringing together public administration and the private sector.

It is not enough to ensure that future yields are high in some high-potential countries that can export surpluses to deficit countries. Rather, improvement of productivity and resilience of production systems is of importance in countries with limited import capacity and, within countries, in those areas where productivity growth in agriculture is important for raising rural incomes, improving access to food for the poor and enabling local agriculture, including fisheries and forestry, to compete with low-price food imports.

Actions to achieve Target VIII will require coordinated efforts from many actors. At the local level, it will be essential to invest in post-harvest technologies and associated institutional arrangements. Better market contacts presume involvement of food industry and agents that are dealing with distribution to/from wholesale, retail and food outlets. Finally, consumer organizations, in cooperation with food industries have a great responsibility to promote sustainable diets and reduction in the waste of food.

A move towards sustainable diets will have multiple benefits for public health and environmental sustainability, with synergies felt across a number of sectors. The development of guidelines on sustainable diets would have to counsel the need to reduce the intake of highly processed energy-dense foods with high water demand.

3. Target Action Plans, Solutions and Commitments

3.1 Synthesis on Target and Solutions Groups' key progresses in tackling the Priorities for Action and Cross-cutting Subjects main issues

As said within the Theme 2.2 nine Target and Solution Groups were established. In preparation of WWF6 all the groups had prepared a summary on their topic. In addition the Target and Solution Groups prepared a Target Action Plan with milestones and responsibilities. In six of the nine Action Plans activities as a follow-up to WWF6 were formulated. These Targets and the formulated milestones by the respective Groups as far as they would have to be implemented as a follow-up to WWF6 will be presented in Chapter 5. For the detailed Target Action Plans reference is made to the Target Session Proposals of the different Target and Solutions Groups that were placed of the website of the World Water Council. In underneath text the key issues of the Target and Solutions Groups are summarised.

Target I.	**By 2020, rainfed land productivity (yield per unit area) will sustainably increase by 25% in Africa and by 15% in Asia - as compared to 2005 - 2007 baseline. Water productivity (yield per unit of water) of rainfed agriculture will sustainably increase for grains by 20% in Africa and in Asia by 15% compared to 2005-2007 baseline**

According to the Comprehensive assessment on water management in agriculture (IWMI, 2007), improving rainfed farming could double or quadruple yield. One main reason why yield gaps exist is that farmers do not have sufficient economic incentives to adopt yield enhancing seeds, fertilizers, other inputs or cropping techniques. Other reasons include lack of access to information, extension services and technical skills.

Poor infrastructure, weak institutions and discouraging farm policies can also create huge obstacles to adoption of improved technologies at farm level. Solutions lie with public sector investments in infrastructure and institutions, and with sound policies to stimulate adoption of technologies that reduce costs as well as improving productivity. Changes in crop management techniques can also help closing yield gaps. Plant breeding plays an important role in closing yield gaps by adapting varieties to local conditions and by making them more resilient to biotic and abiotic stresses.

To meet the requirements of this Target, productivity of rainfed farming systems will have to be increased. Measures to improve land and water productivity in rainfed systems may include:

(a) increasing of rainwater availability to crops when most needed through rainwater harvesting and soil and water conservation practices;
(b) reallocation of available surface and groundwater to be used conjunctively with rainwater during drought spells in supplementary irrigation practices;
(c) minimizing of evaporation losses by improved water and crop management including conservation agriculture and mulching;
(d) adaptation and use of improved crop varieties that are tolerant to drought and responsive to improved management;
(e) investments in fertilizer application in areas of deficiency and poor access;
(f) development of financial frameworks to provide incentives for the adoption of best practices and new technology;
(g) promotion of safe and productive use of low quality water in appropriate agricultural applications.

Increased land and water productivity in rainfed systems will imply improved technologies and practices but also the need for capacity building, financing, marketing systems and adequate policies and institutional changes. The main stakeholders in the improvement of rainfed systems will include farmers, land owners, extension services in agriculture and rural development, local governments, regional/state governments and federal governments. Costs will necessarily increase for the farmers, but will be offset by increased yields, and thus greater total revenues.

Individual countries will have to assess their needs and develop strategies that are economically and technologically feasible given the constraints of the locality. Also consideration needs to be given to the current and future social, cultural and environmental issues surrounding land and water use in the locality. Individual countries will need to develop measurement tools to assess the progress towards the Target. Once these tools have been developed, they can be used to determine the appropriate percentage increase as compared to the 2005 – 2007 baseline.

Target II. **By 2020, sustainably increase by 15% as compared to 2005 - 2007 baseline water productivity per unit land and per year (yield per m^3, per ha and per year) of irrigated agriculture (for specific crop categories)**

The World is facing a progressive condition of scarcity of water and land resources that is threatening the ability of key agricultural systems to provide global food security. Freshwater resources are limited and the amount of arable land available for agriculture is decreasing. Demand for food is increasing from a fast growing, wealthier and increasingly urbanized population, and cities are exerting pressure to reallocate water from agriculture to urban needs.

Increased water productivity in agriculture is imperative to meeting global food needs and agricultural sustainability. However, the majority of large-scale irrigation systems are performing well below their potential. The World will not achieve food security without significant increases in the amount of irrigated land and in water use efficiency. Accordingly, to enhance the productivity of irrigated agriculture, coherent strategies and plans to optimize irrigation technology and management are needed.

To meet the requirements of this Target, global freshwater productivity will have to be increased. The efforts under this Target focus on the opportunities for improving physical water productivity, especially in areas of low productivity. Measures to improve physical water productivity may include:

(a) enhanced operation and maintenance of irrigation systems;

(b) on-farm water management to minimize non-productive consumption of water;

(c) use of improved crop varieties;

(d) use of improved cropping systems and agronomics, such as conservation tillage;

(e) design and construction of upgraded or new irrigation water delivery systems;

(f) employment of improved or advanced irrigation systems;

(g) development of financial frameworks to provide incentives for the adoption of best practices and new technology;

(h) use of low quality water in non-conventional (not for direct human consumption) applications such as forestry;

(i) aquifer characterization to determine quantity and quality of available groundwater;

(j) evaluation of surface water supplies to determine quantity and quality available for agriculture use.

Increased water productivity in irrigation through improved technologies and management practices is the path to the solution for improving water productivity in large-scale irrigation networks. The main stakeholders in the improvement of physical water productivity will include farmers, land owners, irrigation districts/agencies, local governments, regional/state governments and federal governments. Costs will necessarily increase for the farmers, but will be offset by increased yields, and thus greater total revenues.

Individual countries will have to assess their needs and develop strategies that are economically and technologically feasible given the constraints of the locality. Also consideration needs to be given to the social, cultural and environmental issues surrounding water use in the locality. Individual countries will need to develop measurement tools to assess the progress towards the Target. Once these tools have been developed, they can be used to determine the appropriate percentage increase as compared to the 2005 - 2007 baseline. Then, comparisons based on yield per m3, per ha and per year can be made for specific crop categories.

Target III. Increase sustainable productivity and lower costs of water management (yield per ha, per m^3 of water and per unit production cost) in such a way that by 2025 there is food security at affordable prices for all.

As stated before the World population growth combined with the expected rise of the standard of living, especially in the emerging countries, require a rapid increase in food production to ensure sustainable food security. The main concern is to increase sustainable productivity of food production. As an average, areas provided with an irrigation and/or drainage system are about four times more productive than areas without a water management system. Therefore, irrigation and drainage are essential to ensure food availability. If irrigation and/or drainage systems are not improved and/or extended, or worse, are not sustained due to competitive uses of land (urbanisation, industrial development) or other reasons, the required progress of productivity in rainfed agriculture without a drainage system will be very difficult to reach.

However, water management has a price. It needs political will and means to invest. Its sustainability relies on the fact that agriculture is able to pay for the sustainability cost (operation, maintenance, modernisation or upgrading of the assets, and eventually as far as can be determined environmental cost of withdrawn water). Hence, these costs need to be clearly identified and optimized.

The balance between costs for production, farm gate and consumer prices is obviously a key question to ensure both availability and food access for all at affordable prices. The full cost of food may be hard to be paid by all consumers. On the other hand farmers need to get a fair income for their food production, enabling them to recover their costs. Furthermore, too low prices may prevent farmers to stay in agriculture to produce food and may contribute to the propensity to move to other crops until insufficient production leads to crisis and higher food prices. The question is to set the appropriate share of costs between economic stakeholders and public solidarity.

Thus Target III has translated such issues and developments in a set of potential Solutions that are based on present sustainable practises and promising new approaches.

Target IV. **By 2015, increase by 25% – as compared to 2005-2007 baseline – the safe use of non-conventional waters, either treated wastewater or saline water, in agriculture and aquaculture, together with an increase in the number of countries recognizing the WHO-FAO-UNEP Guidelines for wastewater use in agriculture and aquaculture where insufficiently treated wastewater is used**

Non-conventional water (NCW) is defined as water from a source not conventionally used for agricultural production, primarily water that is of lower quality. The two major sources are:

(a) wastewater, following its use for domestic, municipal and industrial purposes;
(b) saline water from groundwater, drainage and surface sources.

Within these sources there is a spectrum of quality and quantity. The extremes of the quality spectrum for wastewater would be undiluted untreated sewage at the low end and quaternary treatment at the high end. For saline water the low quality end might be seawater and very brackish groundwater, while the high end could be freshwater and desalinated water.

The safe use of NCW requires that human health is not impacted and that short- and long-term environmental quality is maintained at an acceptable level. The economic feasibility of using NCW in agriculture depends on many factors, such as the cost of treatment for safety, pumping costs, distribution costs, and competition from alternative

uses such as landscaping and amenity. In some regions wastewater is already a common water source as safer water sources are not available. In other countries NCW is becoming the major source of water for agriculture as conventional sources of good quality water decline or are diverted for other uses. NCW can be used as it is or blended with other water to produce the desired quality and quantity. In the case of untreated but usually diluted wastewater, safety measures as outlined in the WHO-FAO-UNEP guidelines have to be adopted.

The Target of increasing the use of NCW primarily benefits peri-urban areas and countries where conventional renewable water resources are limited or demand already equals or exceeds supply.

Wastewater

Cities and towns generate a stream of water that has already been used, such as for domestic purposes. This stream of water represents a waste product which must be either disposed of safely or reused downstream as a resource. Apart from its value as water, it may also contain nutrients which benefit agricultural production. There can, however, be a mismatch between its rate of production and the demand by agriculture which varies with the irrigated area and the time of the year. Agricultural production close to cities is the most cost effective use. Use of this water requires consideration of: production, future availability, reuse safety/guidelines, present reuse status, governance/ policies/legislation/monitoring and compliance, storage facilities, and long-distance transportation networks and pumping requirements.

Saline water

Production of salt-tolerant crops can generate economic value from saline water where the environmental conditions are conducive. Excess water must be used to prevent salt accumulation in the vadose zone. For sustainability this excess should not cause environmental or resource degradation.

Whatever the source of NCW, it must be an element in a broader water management approach encompassing demand management and strategies for supply and conservation. The economics of using NCW relative to other sources, and the development of an implementation strategy, including capacity building, are vital because good management is essential for its safe use in agriculture.

Target V. Increasing capacity of water storage in support of irrigated agriculture in an environmentally sufficient and socially sound management

Secure access to water with reliable storage and irrigation has boosted economic growth in many developed economies of the Americas and Europe. The green revolution in Asia has enabled the transformation of agriculture-based economies to industrial and emerging market economies.

In many cases, these storages also are the ones serving multi-purposes like hydropower contributing to energy security, simultaneously. The level of creation of storages in many emerging and least developed countries in Africa as well as in Asia, however, cannot be considered to be adequate enough to withstand future challenges due to drought and thus ensure food security. Countries in sub-Saharan Africa store only about 4% of their annual renewable flows, compared with 70 - 90% in many developed countries. Yet water storage is essential to ensure reliable sources of water for irrigation, water supply and hydropower, and to provide a buffer for flood management. In Africa about 340 million people lack access to safe drinking water and almost 500 million lack access to improved sanitation facilities. It is thus understandable that the First African Water Week, convened in Tunis in March 2008, opened with a call for greater efforts to ensure water security nationally and regionally.

In arid and semi-arid parts of countries in Asia the high population pressure has also enhanced demands, and these are in some cases, in excess of supply resulting in a few basins getting closed. A few countries are contemplating long distance water transfer as in China and India to meet the exigencies of water shortage for multiple needs, while simultaneously addressing the enhancing efficiency and reducing demands.

Rapid pace of groundwater development has resulted in a number of problems. In many arid and hard rock areas, overdraft and associated water quality problems are increasing. The development of groundwater in some coastal areas has led to landward movement of the seawater fresh water interface resulting in contamination of fresh

water aquifers. In addition to problems caused due to human interference, natural factors like occurrence of high content of fluoride, arsenic and iron are also affecting the groundwater quality in several places. In many situations, the over exploitation of groundwater to an unsustainable level, as it obtains now, can be reversed with proper storage supplies for the systems developed with irrigation facilities, thereby weaning the farmers from resorting to unsustainable abstractions, which also seek energy and associated greenhouse gas effects.

Lack of storage also may cause economic losses due to flooding and drought. Polluted water has high costs for human health. In short, adequate investments in water management, infrastructure and services can yield a high economic return by avoiding such related costs.

Viewed from the angle of the likely impact of climate change, various in-country studies as in India, project the possible intensification of the hydrological cycle due to rise in temperature i.e., increase in rainfall but with increased variability in time and space leading to floods drought- flood like situations more frequently and more severely affecting the poor and vulnerable sections of the society at large.

A lot more is yet to be accomplished in securing enough storage to combat droughts and also manage floods in many river basins in emerging and least developed countries. These not only result in losses year after year due to damage but also human suffering and losses of life and cattle. The lack of adequate finances for investment had come in the way of creating adequate storages in many river basins, around the turn of the century with funding agencies opting out of dam construction due to various reasons and one such included the economic viability. The low agricultural prices, which prevailed till 2008, were the reason behind the lack of enthusiasm in funding agriculture as well as in storage dams for irrigation. However, the subsequent steep rise in food prices following the steep rise in oil prices led many governments to reverse their perceptions and the investment needs for dams and storages are back again as an agenda. This is a welcome trend as the World can no longer be silently watching more and more starvation, particularly in Africa and Asia. The need for storage, especially in certain emerging countries is obvious if we look into country-wise scenarios and an inter comparison as shown in Table 2.

For many countries with insufficient storage cushions, the case for creating storages would have to form part of their agenda. Given the projected rise in population in many of the emerging and least developed countries in Africa and Asia and the changing demographic patterns, including urbanization, the necessity to move up in the ladder of industrialization shall necessitate reservoirs and carry over storages to look beyond annual flows, if scope exists.

Table 2. Annual storage available in some relevant countries

A general scenario of per capita storage available based on dam backed storage (large and small)	Annual storage available per capita in m^3
Russia	6100
Australia	4730
Brazil	3150
United States	1960
Turkey	1740
Spain	1410
Mexico	1250
China	1110
South Africa	753
India	225

Target VI. **By 2015: develop and adopt at least two macro-regional visions optimizing water use for food security; and by 2020 develop 200 sub-regional (national, local, large area, etc.) sustainable agriculture plans**

One of the greatest global challenges is how to secure access to sufficient, safe and nutritious food to meet the Worlds' population dietary needs and food preferences for an active and healthy life (food security) while using the scarce water resources in an equitable and sustainable way (water security).

In support of sustainable agriculture, water and food security it would be necessary to prepare and implement sustainable agriculture plans at regional and sub-regional level. The macro-regional scale (e.g. West Africa, Europe/Euro-Mediterranean) is a relevant scale to conflict prevention and thus to develop, where appropriate, shared visions and ambitious policy frameworks for food security. The European Union is a historical example. Experience, however, shows that this was not often the case. The new challenges of regional and global food and water security, and climate change would thus have to lead to reinforce the importance of this scale for strategic reflection and action. Challenges are enormous in some regions of the World. Unprecedented challenges will need unprecedented innovative and proven solutions.

The regional scale (sub-national regions, large agricultural areas) could be seen as the right scale to mobilize major professional actors to build shared visions, strategies and action plans for sustainable agriculture development and sustainable food security. Such economic visions and strategies may lead for example to an appropriate choice of crops and practices.

The territorialisation of strategies and approaches could also be the way to reconcile the economic and social dynamics and the environmental challenges, to find the necessary trade-off between these three dimensions of sustainable development and to build synergies among them. It can help stakeholders to decide, in due time, on necessary changes and adjustments of economic and production practices to achieve equity and absorb shocks. It can help actors avoiding confrontation with difficult situations due to lack of anticipation. The territorialisation can also identify the assets of the territories from which agriculture could make profit, and it allows synergies development with other regional actors: industries, cities, tourism, etc., for win-win strategies.

Sustainable development strategies at such scales are also a condition to meet many objectives fixed by environmental policies. Some states and regions are beginning to engage in these new approaches. States and/or local governments with major agriculture players elaborate territorial diagnostics, scenarios and action plans.

Target VII. By 2015, develop national strategic action programmes for key 'hotspot' aquifers exploited by intensive agricultural use (% aquifer depletion, % pollution), including a local definition of maximum admissible drawdown (MAD) and local definition of maximum admissible pollution levels (MAP) for agricultural uses

Groundwater use in agriculture has accelerated with the advent of the motorized pump. Today, irrigated areas reliant upon groundwater are estimated to occupy almost 40% of the global area equipped for irrigation. This demand for groundwater has facilitated intensification of agricultural production both within existing surface irrigation areas and on land that would otherwise have no alternative supply. In either case the pressure on aquifer services is such that many important aquifer systems are stressed to the point of no-return - their capacity to sustain flows of acceptable quality groundwater and absorb agricultural chemicals is exhausted and agricultural production has to be abandoned. Taken with the anticipated impacts of climate change in long-term recharge patterns in

key agricultural production areas such as the Mediterranean Basin, the imperative to manage the demand for groundwater falls squarely on the shoulders of agriculture to both sustain important zones of precision agriculture and conserve strategic aquifers for critical potable water supplies.

The purpose of this action is to develop a set of strategic action plans at aquifer level to reverse or slow down trends in aquifer depletion and degradation where agricultural livelihoods are currently impacted but livelihood dependence is expected to continue. Aquifers that have been degraded beyond repair are not expected to be included - only those with some prospect of remediation. The results of recent national groundwater reviews undertaken by the World Bank, for instance, may provide a basis for identification.

Strategic action programmes for specific aquifers need not be elaborate, but they have to involve the right set of users and regulators at local level and this has to be agreed with national governments. Financing of the initiatives would need to be negotiated through technical cooperation agreements and co-financing.

Accordingly, the Action Plan for Target VII would be expected to comprise the following steps, divided into appropriate stages of formulation, detailed design and implementation:

1. **Stage I:** Identification and agreement on target aquifers

    (a) identification of key national institutions active in groundwater management for agriculture with declared interest in solving groundwater allocation and

protecting aquifers. Key national institutions could be Central Groundwater Board, India. Ministry of Water Resources China, United States Geological Survey (USGS);

(b) identification of key regional support institutions with a declared interest in groundwater management, like: Sahara and Sahel Observatory (OSS), Southern African Development Community (SADC), Organisation of African States (OAS) and the Economic and Social Commission for Asia and the Pacific (ESCAP);

(c) design and transmission of survey to identify priority hotspot aquifers and stakeholders at national level;

2 **Stage II:** detailed design of Strategic Action Plans (SAP) (including MAP and MAP indicators) and field programmes

(a) mobilization of finance through technical cooperation agreements;

(b) design of material to facilitate application of maximum admissible drawdown (MAD) and maximum admissible pollution levels (MAP) methodologies;

(c) design of strategic action plan and field programme in each country;

3 **Stage III:** Implementation of field programmes

(a) inception of field programme in priority aquifers;

(b) monitoring for field programme;

(c) reporting of results;

(d) synthesis of results.

Target VIII: By 2015, define water-related components of a strategy that will improve food supply chain efficiency by 50% and promote sustainable diets, including steps for its implementation by 2025.

Food and nutrition security and improved livelihoods of farmers, who depend on large volumes of water to produce the food, entails three efforts: i) to enhance water productivity; ii) to ensure that as much as feasible of the agricultural production is secured for farmers' own consumption and consumers, i.e. a more efficient food supply chain; iii) to stimulate the demand and intake of food with lower water demand in relation to its nutritional value.

Sustainable diets are diets with low environmental impacts, which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.

During the last few decades little attention has been devoted to what happens with the food that is produced, how much of it is lost and wasted in the supply chain and how

much is actually eaten or beneficially used in other ways. Figures are uncertain, but according to many observers between 30 and 50% of agricultural production are lost or wasted.

Post harvest losses and waste of food is commensurable with a waste of the water, as well as other natural resources that were used in production. Moreover, they imply lost opportunities for farmers. Generally, a low efficiency in the food supply chain incurs various costs and impedes healthy and sustainable diets per drop of water.

Socio-economic and political circumstances play an important role in production, access and how the available food is used. As a result of uneven income distribution and dependence upon political contexts, access to the food available is far from equitable. Overeating has become much more prevalent than undernourishment. Moreover, it is relevant to mention that about 35 - 40% of the grain produced is converted to feed.

With increasing water scarcity and with high rates of undernourishment, overeating and conversions, it makes sense to scrutinize how efficient and productive water is used not only in production but also the link to sustainable diets. High efficiency in production needs to be combined with high efficiency in the supply chain. Pre-and post-harvest losses need to be reduced through cost-effective efforts. Processing and marketing, especially outside local markets require increased attention. In addition, with increasing disposable income among large segments of Worlds' population, consumers' attitudes and behaviour is a strong driver in the use of water and other resources.

Socio-economic changes are most obviously demonstrated in conjunction with a massive urbanization. Growing distance between producers and consumers, physically and mentally means new demands on food supply systems. Similarly, with a larger share of food in the diets that is vulnerable to degradation, there is an obvious need to ensure supply chain efficiency.

Many of the components in the diet that are on the increase are high in energy use as well as water intensive. Diets that are high in energy use but low in diversity contribute to obesity and chronic diseases, which particularly affect poor people in the emerging and least developed countries. Recent trends show an increase in these problems, indicating a need for strategies to advance sustainable diets with lower impact on water resources and that exert minimal pressure on the environment.

Actions to achieve Target VIII will include coordinated efforts from many actors. At the local level, it will be essential to invest in post-harvest technologies and associated institutional arrangements. Better market contacts presume involvement of food industry and agents that are dealing with distribution to and from wholesale, retail and food outlets. Finally, consumer organizations, in cooperation with food industries have a great responsibility to promote sustainable diets and reduction in the waste of food.

A move towards sustainable diets will have multiple benefits for public health and environmental sustainability, with synergies felt across a number of sectors. The development of guidelines on sustainable diets would have to counsel the need to reduce the intake of highly processed energy-dense foods with high water demand. As a basis for coordinated, acceptable and effective efforts by key actors in the supply chain, it will be important to:

(a) produce reliable empirical information about the level of losses and waste in different societies and how they vary over time;
(b) make calculations about water requirements for sustainable diets;
(c) make calculations on how much water can be potentially saved from the current situation;
(d) assess the procurement of nutrients in different sustainable diets in terms of cost in water.

Next steps could include an analysis of who does what, i.e. what can farmers and consumers do; what can national and local agencies do; what can international organizations do; what can the corporate sector do; what can educational and communication experts do, etc.

Finally, cost benefit estimates are valuable for motivating policy interventions, investments and not least, changes in perceptions, paradigm and human behaviour.

Target IX. Improve water management for more food production and increased access to water for smallholder farmers

Under Target IX it is of importance to conserve, manage and value agricultural water in sensitive rural areas, either socially or physically, in order to maintain or improve goods and services production, including environmental services, and revenues. In light of this it is proposed to elaborate by 2015 international agricultural water-related guidelines for national strategies, and elaborate by 2020 10 agricultural water-related national plans aiming to support the smallholder farmers and 20 innovative pilot programs. These national plans will be elaborated in close consultation with the stakeholders, and in particular the smallholder associations.

Under this Target it is advocated towards political decision-makers, to favour agricultural water access of smallholder farmers, both in the South and the North, to hold down their situation deterioration, guarantee their water rights and increase their goods and services production and revenues.

In a context of increased agricultural prices since 2008, the stake is important because smallholder farmers are among the main victims and the main solution against the

scourge of hunger and malnutrition. Smallholder farming is characterized by a high productivity by surface unit thanks to availability of low quantity resources optimal management: land and water. However, the question of agricultural water access and effluent treatment by smallholder farmers is too often neglected. Governments and development aid organisations often favour capital and inputs in high intensity agriculture, guessed to be more productive while its environmental impacts and water withdrawal are negative.

The agricultural water access defence in favour of smallholder farmers and minimum investments to improve water collection, management and distribution farming practices are two important measures to contribute to world food security and to facilitate vulnerable population adaptation.

It is also recommended to measure the impacts of producing and paying for environmental services: water conservation and reduction of soil erosion and flooding, clean water production for downstream users, system resilience to drought improvements and carbon capture.

The cost benefit ratio is advantageous because those investments are often not very costly. This needs anyway a determined action to strengthen the smallholder farming capacities and a legal and institutional accompaniment. Take several innovative solutions in favour of a more equitable water sharing, which takes into account the smallholder farmers needs such as: improvement in management of agricultural water services and resources, innovation in water technologies to support smallholder farmers in order to better manage agricultural water to produce more goods and services and the promotion of the concept of an agricultural water governance for smallholder farmers in nations.

The support of smallholder farming presents in the end undeniable social and economical benefits, because it holds down the drift from the land, creates or maintains employment in the rural areas and equilibrates food offer and demand between towns and countries in a context of population increase, global warming and poor water access competition between users.

This advocacy should lead to recommendations shared first between direct water users, then secondly between political decision-makers. It is necessary to take into account gender, because women represent a majority of smallholder farmers in many countries.

As an example, Coordination Sud proposes seven actions in favour of equitable water sharing, which take into account the smallholder farming needs:

(a) guarantee water usage historical rights and equitable access to agricultural water;
(b) inscribe the water right to ensure food security, in the national and international rights;
(c) support the set-up of water management concerted spaces and instruments multi-stakeholders assuring the participation of smallholder farmers representatives;

(d) reinforce smallholder farmers capacities and associate them to water management decision making;

(e) increase and re-orientate state investments, international public development aid and collectivities toward modest cost programs in favour of agricultural water;

(f) favour investments which aim at another water-related modernization of smallholder farmers, by already existing practices of collective and individual management of resource improvement and adaptation;

(g) promote agricultural water control efficient and affordable techniques: both those of the South and adapted technologies of the North.

3.2 Examples of promising Solutions in need of further commitments

During the Forum preparation process a significant number of Solutions were submitted. These Solutions were forwarded to the Target Group Coordinators for their consideration and were analysed by the International Forum Committee (IFC) in consultation with the Core and Target Group Coordinators. Finally 216 Solutions have been accepted for Theme 2.2 they can be accessed on the website of the WWC.

3.3 The sessions during the Forum

The Core Group organised three 2 hours sessions during the Forum, being:

(a) opening/introduction session;
(b) multi stakeholder panel;
(c) synthesis session.

In addition each Target Group conducted a session of 2 hours as well. These sessions were shown in the Target Session Proposal Reports. It was agreed that Target V and Target VIII would hold combined sessions with respectively Target VI under Theme 2.1 and Target IV under Theme 3.2. This implied that the programmes were jointly prepared and that 4 hours were available for these sessions. In the synthesis session all Target Groups have presented the results of their work and their session.

A summarised overview of the results of the sessions is presented underneath.

Opening Session

In the Opening session it was stated that adequate and sustainable food production using less water is a key challenge for the 21st century. For optimal use of water, appropriate interventions (technological, institutional, policy) are needed in the food chain from producers to consumers. Not only adequate water availability for food production is important but also its easy access to all is of equal significance. A range of agriculture water management options is available but their implementation is a challenging task. In some emerging countries, there will be sizable expansion of irrigated area for increasing food production for their growing population. In rainfed areas, supplementary irrigation generally improves the crop yields considerably. Enhanced investment is needed for

modernization of irrigation infrastructure and services. The area under water saving irrigation systems like micro and sprinkler irrigation, piped water conveyance is likely to increase faster in the coming years. Water productivity of most public surface irrigation schemes is generally quite low and can be enhanced by adopting modern irrigation technologies. Successful examples of water management practices and PIM in Asia need to be up-scaled in the region. Appropriate water pricing is required for addressing its scarcity value and not necessarily for water saving. Better availability of water related data and information, transparency and increasing efficiency through the food chain is the key for sustainable agricultural water management.

Making smallholder agriculture sustainable and profitable for millions of farmers across the World is a daunting task. Smallholder farmers have to face many risk factors like: unfavourable weather and fluctuating and low market prices. Providing crop insurance can reduce such risks. In African countries - especially Sub-Saharan Africa - invigorated focus on agricultural water management; especially in expansion of irrigated area is needed. Finding the right solutions, however, is important and their up-scaling will be a challenging task.

Private sector involved in food production is actively engaged and investing in increasing water productivity of crops and in supporting farmers in many countries. Many water scarce countries are increasingly engaged with the issue of wastewater use for agriculture. Challenge, however, is to make wastewater treatment feasible and affordable. Education of farmers about safe use of wastewater is urgently needed. Knowledge sharing and capacity building of young generation farmers is necessary to understand the complexity of agricultural water management. Rural water and agriculture water management strategies would have to be integrated into national poverty alleviation programs of countries.

Target I. Increasing rainfed agriculture

In the session of Target I it was recommended to implement conservation systems for land and water in order to: i) increase investment in water management; ii) secure land and water rights; iii) improve diversification of rainfed crops. According to economic sustainability of rainfed crops, it was recommended to implement soil conservation systems adapted to climate change and to implement research and development methods on a large-scale, including the environmental costs. Development of rainfed crops needs to be managed in a sustainable way considering the full value chain. Investment and management costs would have to be shared between private and public sectors. Enhancing rainfed crop systems would have to commensurate with local organisations, local practices for land tenure and landscapes.

Target II. Increasing productivity of irrigated agriculture

There is a need to gather precise and localized data related to weather, soil conditions and cultural practices in order to provide guidance for producers and policy makers about steps to increase productivity of irrigated agriculture. Accurate scientific data

would have to be made available to smallholder farmers as well as to medium and large farmers. It is important to ensure that within the coming two decades agriculture/ irrigation technology will be thoroughly utilized by even the smallest land holders. It was stated that an encouraging consensus has developed among a widely varying group of stakeholder representatives about the utility of the global yield gap atlas in all sectors' to increase productivity. The solutions that were presented demonstrate that efforts to improve productivity per unit of water need to take place at various scales, from the farm level all the way through national and river basin level. Water for Food solutions need to be derived from crop improvement and water management strategies.

Target III. Lowering cost of water management

The term affordable needs to be linked to effectiveness in costs and sustainability in production and not only to lower costs. Incentives for farmers need to address economic revenue or gains for themselves. Irrigation water or the services to provide water need to have a fair price, which varies per country. In general, water would have a price that creates awareness among users owing to the fact that it cannot be provided for free due to scarcity and the costs associated to its withdrawal.

It is possible to feed more people with less water by providing technologies with affordable prices, taking into account the crop type, soil conditions and the irrigation system in place. Smallholder farmer initiatives can improve the livelihoods of millions of people. With respect to this preference would have to be given to local/native technologies like spate irrigation management. Investments can also be in terms of capacity building of people and training to use new technologies. It is crucial to organize farmers and enhance their participation in farming activities. The participatory process in irrigation water management systems would have to be linked to a package of policy reforms. Well organized farmers can negotiate in a strong and effective manner with the government. For instance, in the Netherlands, farmers decide crop prices on their own since they constitute a strong association.

It is needed to aim at increasing food productivity with respect to inputs like land area, water volume, seed, fertilizer, pesticide, labour, etc .However, the challenge remains as how to achieve the lower cost of management and affordable prices for food in view of the current trend of rising prices of energy and fuel.

Target IV. Using non-conventional water for agriculture and aquaculture

Nowadays use of non-conventional water is more accepted and widely used in many countries across the World. Perceptions of stakeholders range from ignorance is bliss to a transparent approach where knowledge is power. In the former, the approach is to provide treated wastewater without complete disclosure of its origin. In the latter the approach is to reveal all the details in terms of its origin and how it has been treated. Although perceptions are important, these can be altered to a certain extent by the use of appropriate nomenclature, for example, using the term recycled water rather than treated wastewater. The term recycled water implies that it is acceptable and safe for human use.

An additional aspect which requires promotion is that treated wastewater gemerally may be a desirable and valuable resource when it contains nutrients and other inputs for crop production that would have to be purchased from commercial sources. Furthermore, the environmental benefits are advantageous because otherwise wastewater would become an environmental contaminant.

Target V. Increasing capacity of water storage systems

Per the 2007 worldwide estimates there is an additional need for 1504 BCM (billion cubic metres) of storages without irrigation rehabilitation and improvements, and about 766 BCM with irrigation rehabilitation and improvements. So there is a need to evaluate the storage requirements by country.

Tools are available for integrated design and management of reservoirs, including for community/stakeholder involvement. While planning storages, it will be of importance to incorporate spatial dimensions so that the benefits will be spread to all stakeholders and beneficiaries. In relation to this the wide range of benefits including rights to food, safe drinking water, employment, flood control, environment protection would have to be considered and stressed. During the development of the overall objectives focus would have to be on governance and management of systems.

There is a role for all types of storage including groundwater and soil water storage. There is now wide recognition and acceptance of the need for all typologies of storage (from large dams to small farm ponds) for crop production and food security. Thus there is no longer a differentiation between small and large storage. In many places rainfed and dry land agriculture has shifted to supplemental irrigated agriculture using a variety of rainfall and runoff harvesting techniques.

Target VI. Regional visions and local agricultural plans

So far most regions did not see a need for developing a vision at the macro-scale. A vision for optimal use of water for food security would therefore have to be a part of a broader integrated water resources management (IWRM) plan and to take into consideration the other water uses as well. The future of smallholder farmers would have to be an important element in visions or action plans. There is a strong need to promote environmental and other multiple benefits of storage, especially in view of climate change impacts on water resources availability.

While formulating food security plans, focus needs to be on developing and adopting action plans at the sub-regional level rather than visions at the macro-regional level. Commitment for developing visions and action plans would primarily be the responsibility of governments at the highest level. Where applicable, river basin authorities are the appropriate bodies to develop action plans. If it is not yet the case regions/countries, which developed already their vision for water use, need to revisit those visions to incorporate food security aspects. Arab countries have proposed a Centre of Excellence for Food Security that can integrate work of research and development institutions like FAO, International Centre for Agricultural Research in the Dry Areas (ICARDA) and

Arab Centre for the studies of Arid Zones and dry lands (ACSAD). Qatar is developing a master plan for water and food security through desalinized water by using solar energy and keeping its groundwater as strategic reserve. Farmers in India are influencing the government policies and decisions about the priorities of water uses for different sectors.

Target VII. Groundwater for agriculture

There is an urgent need to delimit aquifer systems at user level and to have credible water accounting. Participatory monitoring of groundwater is seen as key soft instrument versus hard (economic) instruments in managing groundwater sustainably. Identification of hotspots and preparation of action plans is important to achieve sustainable functioning of a number of aquifers. It was proposed to develop by 2018 national strategic action programmes for key hotspot aquifers exploited by intensive agricultural use (% aquifer depletion, % pollution), including local determination of the maximum admissible drawdown (MAD) and of the maximum admissible pollution levels (MAP) for agricultural uses.

Countries, such as Iran, would need about six years to cover all national aquifers. To set quality limits is more complex than to set preferred groundwater levels, so one needs to be careful in interpreting quality parameters in aquifers (for example, nitrate concentrations depend on natural de-nitrification potential).

User engagement is critical but how to organize groundwater users associations is a challenge. Groundwater information is complex/ theoretical and therefore it has to be clear and easily accessible to users. Educating farmers about groundwater enhances their understanding and may avoid misconceptions. Groundwater institutions are generally weak, and there is often a need for stronger institutions for groundwater management at national level.

Target VIII. Reducing post-harvest losses and food waste for multiple gains

High volumes of food waste in rich countries contribute to higher prices on food commodities with multiple implications. There is a linkage of post-harvest losses and food waste to water waste and sustainable diets. It was recommended to strengthen the focus on least developed countries' issues; post-harvest losses due to lack of storage facilities, processing, transportation and on marketing. There is no single global solution, i.e. no one size fits all; extensive and/or household animal production can be sustainable. Different methodologies to calculate the water footprint are available. However, one needs to be careful in using/interpreting the data. It was recommended to encourage exchange of best practices and prioritization of issues among different stakeholders. The urban triple challenge - supply chain, diet, and waste of food - would have to be kept in view. Issues of agriculture subsidies and economics of food waste need to be addressed. Labelling of food - expiry date and best before - is generally not based on food safety or health issues, but on commercial gains. Finally it was recommended to encourage disclosure on waste by retailers and food industry in annual sustainability reports.

Target IX. Improve access to water and water management for smallholder farmers

In the session of Target IX it was recommended to develop a roadmap on how to build successful socially constructed processes to support clever smallholder's access/use of water for agriculture, including livestock and fishery. Tailored and flexible approaches that can be adapted to very diverse local levels would have to be further developed. Farmers initiatives and own investments/support in terms of access to upfront investments and capacity building would have to be promoted. Clever ways of agricultural water management would have to be promoted and access rights to land and water would have to be protected. In particular support to women farmers' organizations would have to be strengthened. It is important to focus agricultural policies on needs/benefits of small-scale agricultural water management.

A range of options adaptable to situations of smallholder farmers would have to be offered. With respect to this the range of actors, gender dimension and need to understand and recognize the diversity of actors and characteristics of each system's reality, costs, risks, benefits and services provided needs to be acknowledged. There is a need to work at different levels and to integrate the range of interested actors, users, managers, planners and to stimulate their interaction – local, basin, groundwater systems, regional up to the national level and beyond. The need to integrate agricultural water management to policy would have to be recognised.

Agricultural water management solutions - technical, social, institutional and financial for smallholder farmers - have to be integrated. Changes of practice, their adoption and innovation take time and require support. Social structures are essential for facilitation/ help to get farmers organized, to work together and to overcome differences.

Multi stakeholder panel discussion

In the multi-stakeholder panel discussion several issues were brought to the attention while debating on how to find effective measures to increase food security by the optimal use of water. Issues like education and creating awareness about the issue, improvement of management and institutional mechanisms to ensure efficient operation of irrigation schemes, acquisition and expansion of farmlands, protecting interests of the poor, and participation of stakeholders were discussed, among others.

A few institutional and management approaches were proposed. Mention can be made of education of politicians to get the desired policy reform package, mobilization of the main actors involved in participatory water management processes, increase of diversity in terms of production at local level to increase livelihood opportunities and incomes, to look forward for diversity on production and quality seeds. The on-going switch to drip irrigation systems and green/plastic houses has increased water productivity levels and increased crop production in many countries.

Use of non-conventional waters for irrigation needs to be encouraged, while keeping in mind ecological and financial aspects. Use of affordable and ancient local technologies would have to be encouraged, as well as measures at local level adapted to climate change.

Financial and institutional improvements in development and management of irrigation and drainage systems, investments in technology for water conservation; establishment and/or strengthening of water user associations (WUA) for participatory irrigation management, public-private partnership in capacity building and infrastructure development would have to be promoted. Establishment of autonomous water regulatory authorities and empowerment of small-scale farmers and rural women would have to be encouraged.

Synthesis session

In the Synthesis session the reports of all the previous sessions have been presented by the session coordinators.

4. Outline limits of the approach and areas to be further investigated

In the period 2010-2012 the number of undernourished people in the World has been 870 million. During the preparation of the Forum an analysis was made of the countries where undernourishment occurs, what the cereal production in these countries is, to what extent these countries have developed their water management systems and finally to what extent improvement in water management systems can contribute to eradication of undernourishment. Based on recent data this analysis has been updated during the preparation of the Synthesis report on which the present publication is based. In the analysis only the emerging and least developed countries have been taken into account, while in the developed countries there were in the same period an estimated number of 16 million undernourished people. However, in the latter countries the reason of undernourishment is not unavailability of food, but the inability of the concerned people to pay for it. The results with respect to undernourishment are summarised in Table 3.

Table 3. Relations between types of countries undernourishment and water management, based on data of the period 2010-2012 (data FAO)

Item	Emerging countries	Least developed countries
eople in countries with more than 5% undernourished people	4082	698
Number of countries	36	30
For the concerned countries		
Number of undernourished people	566	197
Undernourished people in percentage of total population	14	28
Total cereal production in million tons	956	102
Total cereal production in kg/person	234	146
Net export of cereals in million tons	-47	-11
Net export of cereals in kg/person	-12	-15
Arable and permanently cropped area in million ha	556	102
Irrigated area in million ha	172	10
Irrigated area in percentage of cultivated area	31	10
Area with drainage in million ha	44	2
Area with drainage in percentage of cultivated area	8	2
Without a water management system in million ha	348-392*)	90
Without a water management system in percentage of cultivated area	63-71*)	88

*) Range caused by the problem that the overlap of irrigated and drained area cannot be determined

Based on the analysis it was found that most of the undernourished people - about 550 million - live in the emerging countries. Of them about 400 million live in China, India and Pakistan. In the least developed countries about 200 million undernourished people could be identified. However, the actual number may be significantly higher, while for several countries no data are available. Table 4 shows for the countries with most undernourished people how they have developed their water management systems.

From Table 4 it can be derived that eight of the countries with more than 10 million undernourished people are emerging countries. Only five of the countries belong to the group of least developed countries. With respect to undernourishment it is of interest that Brazil, India and Pakistan are net exporters of cereals. The other countries are net cereal importers. The Asian countries have generally well developed their water management systems. This will make it quite complicated for these countries to cope with the required increase in food production. For the five African countries and Brazil the situation is quite different, while they have only to a very limited extent developed their water management systems. In principle this implies that there is quite some room for significant improvements.

Table 4. Development state of water management in the countries with more than 10 million undernourished people

Country	Type of country	Under-nourished people (million)	Net export surplus of cereals			Irrigation		Drainage*)		No system	
			million tons	kg/person	% of own production	million ha	%	million ha	%	million ha	%
India	Emerging	217	5.3	4.2	2.5	62.0	36.6	5.8	3.4	101.5	60.0
China	Emerging	158	-9.9	-7.3	-2.3	60.0	46.1	21.1	31.7	48.9	37.6
Pakistan	Emerging	35	3.0	16.7	9.1	19.4	81.6	7.5	16.3	0.0	0.0
Indonesia	Emerging	21	-8.4	-34.3	-14.6	6.7	18.1	3.4	9.0	27.1	72.9
Philippines	Emerging	16	-5,2	-53.9	-29.7	1.5	16.6	2.7	29.7	4.9	53.7
Nigeria	Emerging	14	-5.1	-30.6	-21.2	0.3	0.8	0.0	0.0	33.1	99.2
Kenya	Emerging	13	-0.9	-21.1	-25.0	0.1	1.8	0.1	0.5	5.1	98.1
Brazil	Emerging	13	2.1	10.6	2.9	3.5	5.3	1.3	2.0	61.8	92.8
Total		487	-5.2	-1.5	-0.6	122	27.4	42	9.4	282	63.2
Bangladesh	Least developed	25	-2.3	-27.6	-12.2	5.2	60.0	1.5	17.2	2.0	22.8
Ethiopia	Least developed	34	-1.0	-11.6	-5.8	0.5	3.7	0.0	0.2	13.9	96.1
Sudan	Least developed	18	-2.1	-46.0	-42.9-	1.9	10.7	0.6	3.2	15.0	86.1
Tanzania	Least developed	18	-0.8	-16.8	-10.8	0.2	1.7	N.A.	N.A.	10.8	98.3
Uganda	Least developed	12	-0.7	-20.1	-28.0	0.0	0.1	N.A.	N.A.	7.3	99.9
Total		**107**	**-6.9**	**-18.7**	**-10.4**	**7.8**	**13.2**	**2.1**	**3.5**	**49**	**83.2**

N.A. = not available; *) part of the drainage system may be in the irrigated area

5. Recommendations for follow-up post 2012

The recommendations for follow-up beyond the Forum can best be derived from the Targets and Milestones as presented in the Action Plans of the Target and Solutions Groups. The relevant Actions and Milestones for the period beyond the Forum are summarised in Table 5. From Table 5 it can be observed that although several Milestones are mentioned by the Target and Solutions Groups they are formulated in general terms. Several of these Milestones cover a long period of time. It was expected that the Target Group coordinators would initiate the follow-up actions. With respect to this, it will be useful that the progress will be reported during the 7th World Water Forum in 2015 in the Republic of Korea.

In fact optimal use of water for food security would have to be further developed on a regional basis. Information on the regional aspects can be derived from the results of the Regional Process that was developed in parallel to the Thematic process. These results are available on the website of the WWC. It is expected that the Target Group coordinators will take these results into account when elaborating the formulated Actions, Targets and Milestones.

Table 5. Targets and Milestones that require Actions after the Forum

TARGET I. By 2020, rainfed land productivity (yield per unit area) will sustainably increase by 25% in Africa and by 15% in Asia - as compared to 2005 - 2007 baseline. water productivity (yield per unit of water) of rainfed agriculture will sustainably increase for grains by 20% in Africa and in Asia by 15% compared to 2005-2007 baseline.
Milestone 2. by 2015 Policies and developmental objectives approved in a certain number of countries of Sub-Saharan Africa (SSA) and West Asia and North Africa (WANA)
TARGET II. By 2020, sustainably increase by 15% - as compared to 2005 - 2007 baseline - water productivity per unit land and per year (yield per m^3, per ha and per year) of irrigated agriculture (for specific crop categories).
No specific follow-up Actions after WWF6 were formulated
TARGET III. Increase sustainable productivity and lower costs of water management (yield per ha, per m^3 of water and per unit production cost) in such a way that by 2025 there is food security at affordable prices for all.
Milestone 3. December 2013: to be checked in which countries there is the risk that the objectives of the MDG on hunger will not be achieved and if insufficient water management may be the cause of it. If yes, to provide an overview with measures in the field of water management that can be recommended for direct application under different geographic conditions, as well as for research on potential measures that need further elaboration before they can be applied in practice.

Milestone 4. Food prices would by 2020 not exceed present day levels, in spite of energy crisis and climate change, thanks to improved and newly developed risk management tools for governments, firms and farmers, in order to build capacity to manage and mitigate the risks associated with food price volatility, in particular in the least developed countries.
Milestone 5. December 2020: to be checked in which countries there is the risk that the Target to provide food for all at affordable price will not be achieved and if insufficient water management may be the cause of it. If yes, to provide an overview with measures in the field of water management, based on current technologies and on potential innovative Solutions that can be recommended under different conditions.
TARGET IV. By 2015 increase by 25% - as compared to 2005-2007 baseline – the safe use of non-conventional waters, either treated wastewater or saline water, in agriculture and aquaculture, together with an increase in the number of countries recognizing the WHO-FAO-UNEP Guidelines for wastewater use in agriculture and aquaculture where insufficiently treated wastewater is used.
Milestone 4. By 2013, ministries and government departments in the target countries sign a voluntary agreement recognizing the potential of the safe use of non-conventional water in agriculture to improve food security and agree to increase its use where appropriate
Milestone 5. By 2014, ministries and government departments in target countries have increased the use of non-conventional water in agriculture
Milestone 6. By 2015, ministries and government departments in target countries have increased the use of non-conventional water in agriculture b 25% and reporting mechanisms are embedded.
TARGET V. Increasing capacity of water storage in support of irrigated agriculture in an environmentally sufficient and socially sound management.
Milestone 3. December 2013: to be checked in which countries there is the risk that the objectives of the MDG on hunger will not be achieved and if insufficient water Storage could be the cause of it. If yes, to provide an overview with measures in the for storage creation (in all forms) that can be recommended for direct application under different geographic conditions, as well as for research on potential measures that need further elaboration before they can be applied in practice.
Milestone 4. Because of improved and newly developed risk management tools for governments, firms and farmers, in order to build capacity to manage and mitigate the risks associated with food price volatility, in particular in the least developed countries, food prices will by 2020 not exceed present day levels.
Milestone 5. December 2020: to be checked in which countries there is the risk that the Target to provide food for all at affordable price will not be achieved and if insufficient water management may be the cause of it. If yes, to provide an overview with measures in the field of water management, based on current technologies and on potential innovative Solutions, that can be recommended under different conditions.
TARGET VI. By 2015: develop and adopt at least two macro-regional visions optimizing water use for food security; and by 2020 develop 200 sub-regional (national, local, large area, etc.) sustainable agriculture plans.
Milestone 6. Follow up on Visions and plans development beyond WWF6.

Milestone 7. Progress by World Water Forum 7.
TARGET VII. By 2015, develop national strategic action programmes for key 'hotspot' aquifers exploited by intensive agricultural use (% aquifer depletion, % pollution), including a local definition of maximum admissible drawdown (MAD) and local definition of maximum admissible pollution levels (MAP) for agricultural uses.
No specific follow-up Actions after WWF6 were formulated
TARGET VIII. By 2015, define water-related components of a strategy that will improve food supply chain efficiency by 50% and promote sustainable diets, including steps for its implementation by 2025.
No specific follow-up Actions after WWF6 were formulated
TARGET IX. Improve water management for more food production and increased access to water for smallholder farmers
Milestone 1. succeeding the 6th World Water Forum; a) succeed to run the TSG229; b) obtaining an official launch by the political declaration of an action plan targeting the smallholder farmers.
Milestone 2. writing international guidelines by 2013.
Milestone 3. convincing 10 countries to write a national plan addressing the smallholder farmers and their access to water by 2016.
Milestone 4. elaborating 20 pilot programs within these 10 countries to measure the benefits of the proposed actions on the field by 2018

6. Conclusion

At the moment global food production is sufficient to feed the Worlds' population. Food shortages are of a regional and local nature and although they may be caused by drought or other climatologic phenomena they can be prevented when sufficient action is being taken. First responsibility to take action rests with the National and/or Regional Governments in accordance with the international human rights law.

Over the past years an impressive increase in food production has been achieved. However, the growth of the Worlds' population and the increase in the standard of living, especially in the emerging countries requires that food production will have to be doubled over the next 25 – 30 years. It is therefore required that governments have a clear policy on the level of food self sufficiency that they would like to achieve and on the measures that would be required to achieve this. In addition it will be of importance that they enable that the remaining food can be imported and sold at affordable prices.

There is a common understanding that 80-90% of to increase in food production will have to come from existing cultivated land and that the remaining has to come from land reclamation. This will require a significant improvement in water management measures and their operation, maintenance and management. In principle this can be achieved and quite some governments consider that nowadays as a key priority.

As far as could be identified there is no clear link between undernourishment and food production in a certain country. For example, about half of the undernourished people live in China, India and Pakistan, while these countries are food self sufficient or even net exporters. In such countries the solution to undernourishment rests therefore with the government and doesn't in principle require international action, unless special circumstances would arise.

During the Forum preparation process clear sets of Actions were formulated by the Target and Solutions Groups and Milestones have been set for their implementation. In addition there is a wide range of Solutions existing or new ones provided to the Forum organisers. In addition, based on the issues as outlined in this publication the following conclusions can be drawn:

1 food security became high on the political agendas of the last few years;

2 there seems to be a convergence of actions in the response to food security needs, and they encompass four major constituents of the food pathway:

   (a) increase the supply (productivity enhancement);
   (b) improve the efficiency of the value-chain from producer to consumer;
   (c) reduce unnecessary demand and avoidable degradation;
   (d) enhance the capacity to manage risks and uncertainties derived from crises.

The enabling environment to make these changes to happen needs to be provided through policy, institutions (capacity building), private partnerships, faire trades and other measures:

2 when investigating the water management implications for these actions, we may find an analogous approach:

   (a) increase efficiency and productivity of water use;

   (b) enhance capacity of especially rainfed agriculture to cope with climate variability and change;

   (c) increase supply through wastewater reuse, rainfall harvesting, storage, etc.;

   (d) reduce demand;

   (e) importance of use of facilitation and conflict resolution techniques in discussions among stakeholders;

3 translation of these implications and linkages into the follow-up process of the Forum. Table 5 may serve as departing point for further development. The results of the Regional process of the Forum may create the basis for regional differentiation of criteria and specific regional actions, which would have to be defined.

7. References

Note: this reference list includes all the references that are shown in the Core Group and Target and Solutions Groups reports. It may therefore serve as reference for the various important issues with respect to Food security by optimal use of water

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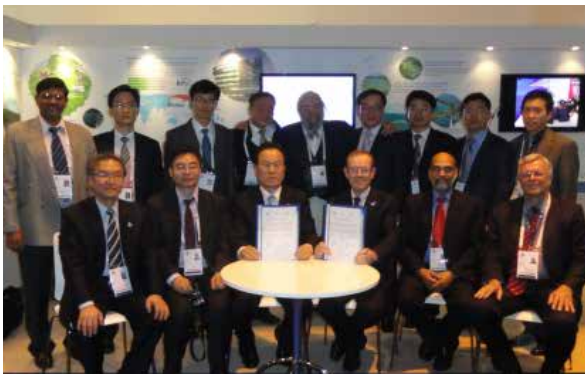

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ICID
48 Nyaya Marg, Chanakyapuri, New Delhi 110 021, India
Tel : +91 11 2611 6837, +91 11 2611 5679, +91 11 2467 9532, Fax : +91 11 2611 5962
E-mail : icid@icid.org, Website : http://www.icid.org
/iciat /icidonline