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Water and Food Security

facing global change: what challenges, what solutions ?

Contribution to the international debate

Preface by the FAO

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Disclaimer
This document is based on the views of a multi-stakeholder group co-piloted by Yves Richard (CCFD / Coordination Sud) and Guillaume Benoit (MAAPRAT / CGAAER). The views expressed are not necessarily those of the French ministries of agriculture and of foreign affairs or those of the various institutions which have contributed.

Cover photo : GRET

EDITORIAL

We all have in mind the tragic famine that hit the Horn of Africa last summer and today another crisis is looming in Sahel countries.

We must admit that we have been unable to resolve the scandal of hunger in the world and we know that we ought to increase by 70% the world agricultural production by 2050 if we are to adequately feed the world.

At the same time, we must pay attention to protection of soil, climate change impacts and water ressources scarcity. To produce more and to produce better: that is the equation we must solve. The Action Plan on Food price volatility and Agriculture, adopted in June 2011 by the G20 ministers of agriculture, allowed us to provide an initial response.

We know how intertwined the issues of water and agriculture are: without water, there is no farming. Without water, there is simply no life. If we want to tackle the challenge of food security, we must first meet the challenge of water.

The following report presents the French contribution to the international debate on this issue. This is the result of a collective effort which has brought together many French experts from various backgrounds: French interbranch agricultural organisations, development NGOs, Ministries in charge of Agriculture and Foreign Affairs, the French Development Agency (AFD), the French Association for Water, Irrigation and Drainage (AFEID), the Foundation for Agriculture and Rural Life (FARM), the French Water Partnership (PFE). It follows on from the G20 work on agriculture with a view to the « Rio+20 » Conference.

The 40 examples of solutions that are presented show that it is possible to feed the world while preserving water ressources. This report emphasizes solidarity and interdependence between urban and rural areas. It offers three principles: increasing ecosystem productivity, supporting small-scale agriculture and promoting territorial governance at different levels.

The implementation of these principles is feasable. It depends on the political will to do so. The Marseille Forum should be the Forum of solutions. What we have here are examples of success: we should follow them.

Bruno LE MAIRE
Minister for Agriculture, Food, Fisheries, Rural Affairs and Spatial Planning

CONTENTS

FOREWORD 5

SUMMARY 7

WATER AND FOOD SECURITY : PROBLEMS, ISSUES AND THE RISKS OF AN UNSUSTAINABLE SCENARIO 15

1. Food security, A major challenge with more than one dimension 15
- The links between food security and water 15
- The challenges to be met for a sustainable balance supply and demand 16

2. Agriculture and water 17
- The water that feeds humanity 17
- Invaluable expertise sometimes under threat 18
- Actors in the management of agricultural water, their relative weight and the importance of «Smallholder agriculture» 20

3. Unequally distributed resources, demographic and water-related imbalances and growing regional interdependence 21
- The crucial issue of drylands: growing problems of water shortages 21
- Expected major increases in regional food dependency and virtual water trading 23

4. Coveted resources under threat 25
- Weaknesses of water rights for farmers, uncontrolled competition and the importance of « land grabbing » 25
- Water erosion and the degradation of agro-ecosystems 26
- Weakening of irrigated systems 26
- Droughts, floods, heat waves and climate change 28
- Under-utilization and waste 28

5. Dangers of cascading social and political instability 30
- The 2007-2008 food crisis: a wake-up call 30
- Serious consequences for households and vulnerable countries 31
- New needs to be met by 2050 31
- The risks of a catastrophic «cascading instability» scenario 32

6. The need for a new agricultural paradigm 33
- The paradigm of agricultural progress under renewed questioning 33
- The need for systemic approaches: local governance and arriving at compromises 34

SELECTING TARGET: WHAT PRIORITIES FOR DEVELOPING AN ALTERNATE SCENARIO ? 37

THE 7 PRIORITIES AND 40 EXAMPLES OF SOLUTIONS 39

1. Increase the productivity (efficiency) of irrigation systems, improve incomes and sustainability 39
- Agronomic progress 39
- Organizational and institutional progress at the correct levels 41
- National policies for managing water demand, and regional cooperation 43

2. Increase Storage and mobilize new resources 46

3. Rain-fed agriculture: Promote conservation agriculture 49

4. Support smallholder agriculture to enhance agricultural and pastoral water supplies and facilitate sustainable rural development 51
- Recognize and defend the water rights of family agriculture and support its development 51
- The «territorial» (Landscape) approach, vector for sustainable rural development 53
- National policies to support small-scale agriculture 56

5. Reconciling agricultural development and protection of natural resources (hot spots) 57
- Control abstractions and overexploitation of aquifers 57
- Agricultural commitments to help regain water quality in catchment areas 57
- Develop irrigation while protecting environments of high ecological value 59

6. Taking on the water challenge upstream and downstream of production 60
- Protect farm land and water from urban sprawl 60
- Reduce losses and wastage (food and water) «from farm to fork» 60
- Innovate in social safety net policies 61

7. Develop visions and strategies for a sustainable agriculture at regional and macro-regional scales 63
- At the level of «local regions» (sub-national) 63
- At the level of «international Regions» (supranational) 65

CONCLUSION 67

Water for food and water for the city : towards a new contract between agriculture and society 67
Three broad priorities or principes for a «sustainable world» 68
- Make water resources and eco-systems more productive 68
- Redure poverty (and hunger) by supporting smallholder agriculture and vulnerable regions 68
- Improve governance at five levels 69

The challenge of «smart investment» for sustainable agriculture 70

CREDITS, CONTRIBUTIONS 71

NOTES 73

FOREWORD

For more than 10,000 years, farmers across the world have successfully harnessed nature and have progressively managed to raise the capacity of the Earth to feed its population. The rapid population growth of the last century has been matched with remarkable progresses in agricultural production: today, farming systems across the world produce more and more diversified food than ever in the past. Until very recently, a long period of abundance and low food prices distracted policy makers' attention from the many remaining problems faced by agriculture, not the least its impacts on the natural resource base.

In this sense, the food crisis of 2007-2008 was a wake-up call and reminded us of the limits of the current agricultural models. Available projections concur in predicting that the world should be able to feed a population of 9 billion in 2050, but people don't eat or drink on a global plate: it is the growing discrepancy between food importing and food exporting regions which is of concern, with serious consequences for the environment and the lives of the poor, increasingly left out of the modern economy.

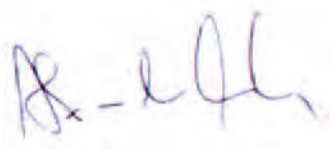
In the last decades, unprecedented claims for land and water resources have pushed many agricultural systems across the world to their environmental limits. The encroachment on forests and marginal lands, the degradation of soils, the depletion of aquifers and rivers, salinization and the loss of aquatic biodiversity have reached levels that now clearly impinge on the capacity of ecosystems to produce food and other environmental services.

Although there is no global water scarcity as such, an increasing number of regions are now chronically short of water. Today, more than 40 percent of the world's rural population live in river basins that are physically water-scarce, and by 2025, two-thirds of the world population could be in conditions of water stress. A global crisis doesn't necessarily stem from a single cause, but can also be made up of a large number of local incidents. The water crisis is a case in point.

Water scarcity induces competition for water that can lead to conflicts. In the absence of clear and well-established rules, power plays an excessive role, leading to inequitable allocation. In semi-arid regions, an increasing number of rural poor now see their entitlement and access to water as their primary cause for concern.

Clearly, past models of agricultural development have reached their limits. Time has come for new models that bring together the three pillars of sustainability: economic, environmental and social, in a much more effective way than in the past. To be successful, such models must necessarily consider the large variety of local conditions across the world and the populations they serve.

This report, prepared under the direction of the French Partnership for Water, is timely and welcome. It provides a rigorous analysis of the linkages between water and food security, of the issues associated with increasing competition for water, and of the challenges ahead. It offers insights into possible new approaches to agriculture, and illustrates this with a series of concrete examples from the field. In so doing, it represents a valuable contribution to the debate about the future of water for agriculture, and the way we will design future agricultural development models.



Alexander Müller
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SUMMARY

The subject of this report is "*water for food*" as a key issue for food security. It relates to water as a "*resource*" for irrigated and rain-fed agriculture – a fundamental resource since food cannot be produced without it. While a person may drink as much as 3 litres of water per day, it requires 3,000 litres per day to produce the food needs of that person. Agriculture and livestock farming are therefore by far the biggest users of water; irrigated crops utilise approximately 2,700 cubic kilometres of "blue water" per year, or 70% of all the water collected for various uses. Rain-fed agriculture receives a total of around 5,600 cubic kilometres of "green water" from precipitation.

Proper conservation, management and use of these resources are critical for food security. This is the condition for achieving sufficient global production while avoiding excessive deforestation. It also determines the quality of water and foodstuffs, which is another major food security concern. Good management of natural resources is potentially a way of increasing incomes and improving access to food for vulnerable rural dwellers. It can help reduce risks of local and regional instability. The report covers these different aspects of food security but it does not seek to address the entire scope of the linkage between water and food security: specifically, it does not deal with issues of health and safety.

This report has been produced by the group set up in December 2010 to address the theme of water and food security at the request of the French National Committee of the 6th World Water Forum (Marseille, March 2012), of the French Partnership for Water and the French Ministry for agriculture and food. The latter tasked the CGAAER (the General Council for food, agriculture and rural spaces) with a mission to carry this out.

The group set up around the CGAAER brought together French farmers' organisations (FNSEA, APCA, SAF, technical institutes), the major development NGOs which are members of Coordination Sud (CCFD, GRET, AVSF), the government ministries responsible for agriculture and for foreign affairs, the French Development Agency (AFD), the French association for water, irrigation and drainage (AFEID), the Foundation for World Agriculture and Rurality (FARM), the French Partnership for Water (PFE), the International Centre for Agronomic Research and Development (CIRAD) and a number of prominent experts. The report has benefitted from contributions from a number of institutions and experts, including experts from outside France, as well as an input from GISA (the French inter-ministerial group on food security) and a session of the CGAAER section responsible for water and regions. The group met on seven occasions from December 2010 to January 2012. It has helped to advance international discussion on the theme of water and food security, led by the FAO and the International Commission on Irrigation and Drainage (ICID), suggesting several of the nine "targets" chosen for the 6th World Water Forum and coordinating the contributions from French actors to working groups on those targets. Alongside this, it has enabled an analysis and forward vision specific to the French actors to emerge and this is presented in this report. Reciprocally, the report has derived substantial benefit from input and review by the FAO and experts from other international institutions.

The 6th World Water Forum sets out to be a "*forum for solutions*". This report therefore gives much attention to highlighting concrete case studies of solutions carried out in France, as well as outside France and the European context. 40 examples of solutions have been documented in regions and countries where French actors in agricultural water are developing and fostering the continuation of active cooperation (the southern Mediterranean, Sub-Saharan Africa, Latin America, Southeast Asia) and which are success stories in terms of advancing knowledge and processes, as well as bring solutions (see table below). These examples are not intended to cover every situation in the world: in particular, they only address indirectly problems and solutions in some major areas of the world, such as China and India.

Table of the 7 Priorities and the 40 Examples of Solutions

(With references made to the targets adopted[i] by the 6th World Water Forum under Theme 2.2)

1. Increase irrigated systems productivity (Targets No 222 productivity and No 223 economics of irrigation systems)

➔ **Agronomic innovations**

Case study No 1: Sensors and modeling for optimal use of irrigation water (France)
Case study No 2: The SRI (intensive system for rice cropping) from Madagascar to Asia and Africa

➔ **Professional organisation and institutional strengthening**

Case study No 3: ASA (public associations of landowners) and SAR (company for regional works) in Provence (France)
Case study No 4: The irrigated perimeters of the Senegal River (Senegal)
Case study No 5: Prey Nup perimeter (Cambodia)
Case study No 6: Alifif perimeter (Ethiopia)

➔ **National policies of demand management (GDE) and regional cooperation**

Case study No 7: Foresight 2025 by the Blue Plan and the Tunisian strategy for water saving in irrigation
Case study No 8: The RIM project: networking Mediterranean irrigators

2. Increase storage and mobilize new water resources (Targets No. 2.2 4: Non conv. water and 2.2.5: storage)

Case study No 9: Supplemental irrigation in the Sourou Valley (Burkina Faso)
Case study No 10: Dams in North Rakhine State (Myanmar)
Case study No 11: Urban wastewater reuse for agriculture in Limagne Noire (France)
Case study No 12: Boreholes in the desert, Tidene Valley (Niger)
Case study No 13: The multifunctional importance of irrigation: the example of the Juanon reservoir (Drôme, France)

3. Rain-fed agriculture: promoting conservation agriculture (Target No 2.2.1: Productivity of rain-fed agriculture)

Case study No 13: The Nouricia Cooperative (Aube, France)
Case study No 14: The PADAC plan in Kampong Cham (Cambodia)

4. Support small-scale agriculture to secure, maintain, manage and valorize agricultural and pastoral water and promote sustainable rural development (Target No. 2.2.9 support for small-scale agriculture)

➜ **Recognize and defend the rights of access to water for family farming**

Case study No 16: The Angat dam (the Philippines)
Case study No 17: Cauca Valley (Columbia)
Case study No 18: Chambo Valley and social water management (Ecuador)
Case study No 19: Water management and pastoral hydraulics (Mali)
Case study No 20: A pilot project for the Kayes region (Mali)

➜ **The "terroirs" territorial approach, a vector for sustainable rural development**

Case study No 21: The promotion of regional “terroir” products in Morocco
Case study No 22: PRODESUD, a participatory development project in arid pastoral lands (south-eastern Tunisia)
Case study No 23: The local “terroir” operations for vulnerable territories, La Réunion island (France, Indian Ocean)

➜ **National policies for small-scale agriculture**

Case study No 24: Empowering 10.4 million agricultural families and reducing food insecurity in Viet Nam

5. Hot spots: reconcile agricultural development with protection of natural resource and the environment (Target 2.2.7)

➜ **Control aquifer overexploitation**

Case study No 25: The Beauce aquifer (France)
Case study No 26: The Souss Massa aquifer (Morocco)

➜ **Engage in agriculture to protect priority catchments from diffuse pollution**

Case study No 27: The commitment of agricultural schools on the "Grenelle de l'environnement" (France)
Case study No 28: The partnership between chambers of agriculture and water companies (France)
Case study No 29: Projects at Fontaine du Theil, Peron and Aisne to reduce pollution by pesticides (France)
Case study No 30: Contripol, a project to reduce pollution by nitrates in the Orval Valley (France)
Case study No 31: Joint research project "Aqual", research and agricultural pollution, city of Reims (France)

➜ **Develop irrigation while protecting fragile and valuable environments**

Case study No 32: Water management to both produce organic rice and protect mangroves in coastal Guinea (Africa)

6. 6. Acting for the resource upstream and downstream of agriculture

➔ **Preserve land and agricultural water from urban sprawl**

Case study No 33: Recent measures to protect agricultural lands (France)

➔ **Reduce losses and wastage in the food chain** (Target 2.2.8)

Case study No 34: Mobilisation to reduce food wastage in Europe. The example of a food aid donation exchange platform (France)
Case study No 35: The perception of water issues by Nestlé and communication on the action it has taken

➔ **Innovation in the policies of social safety nets to protect water resources and help get out of poverty**

Case study No 36: Strategic thinking for food security in Morocco – towards revenues from environmental services?

7. Develop visions and regional strategies for sustainable agriculture / food security (Target 2.2.6)

➔ **At the scale of sub-national regions (NUTS 2: Länder, generalitat, region, state ...)**

Case study No 37: the strategy of Region Souss Massa Draa (Morocco)
Case study No 38 regional plan for sustainable agriculture in Region Languedoc Roussillon (France)

➔ **At the scale of macro-regions (e.g. West Africa, Euro-Mediterranean, ...)**

Case study No 39: The scenarios of the Blue Plan for the Mediterranean
Case study No 40: The Common Agricultural Policy of the EU: from food security to "greening"

These case studies illustrate the seven major priorities for action that are highlighted later in this report, namely: i) increasing the efficiency of irrigation systems, ii) developing water storage and mobilising unconventional resources, iii) enhancing crop productivity in rain-fed agriculture, promoting agro-ecology and "conservation" agriculture, iv) supporting smallholder farmers to better conserve, manage and utilise water as an objective of sustainable rural development, v) managing "*hot spots*" affected by overexploitation and/or pollution, vi) reducing wastage of agricultural water upstream and downstream of production, and vii) implementing strategies for sustainable agriculture at the relevant geographical scales (regions and macro-regions).

This document is a contribution to the work of the "core group" (coordination group) in charge of this the theme 'water and food security' for the 6th World Water Forum[1]. It is also a contribution to international thinking on this complex but key question in line with the request of the most recent meeting of the G20 (Cannes, November 2011). It throws light on this question on the basis of French and international experiences observed by French stakeholders in agricultural water and overseas cooperation. The findings of the report have been used by the core group, to organise solutions in the nine target areas chosen for the Forum on this topic, turning them into action plans.

Why is this issue important?

Do we have enough water and land to produce sufficient food over the next fifty years to meet the needs of a growing population? The answer given by the "Comprehensive Assessment of Water Management for Agriculture (Water for Food, Water for Life)", published in 2007 and which mobilised more than 700 experts was: « *it is possible to produce the food* »; However, *without better water management in agriculture:*

➔ **"the Millennium Development Goals for poverty, hunger, and a sustainable environment cannot be met,**

➔ **today's food production and environmental trends if continued, lead to crises in many parts of the world."**

The food crisis of 2007-2008, which triggered riots in 37 countries, demonstrated that for the first time in decades global food supply was struggling to meet rapidly rising demand. Given that the causes of the crisis were structural and not due simply to cyclical factors, it should be taken as a "*wake-up call*".

Water as a resource cannot be dissociated from soil, land and ecosystem issues. The report which is the reference on this subject, "The State of the World's Land and Water Resources for Food and Agriculture in the World: Managing systems at risk" (SOLAW) published by the FAO in 2011, considers that the risks are great and that if present trends continue "*a series of major land cultivation and water systems, and the food outputs they produce, are at risk*". Other international documents support this finding that meeting new food needs over the coming decades raises challenges at the technical level as well as on the feasibility of doing so in ways that are environmentally sustainable and socially equitable.

This document too contains warnings as to the risks observed under current trends. Unless there is radical change soon to preserve, manage and utilize crop and pasture ecosystems more effectively, and the water, land and soil associated with them, there are grounds for fearing cascading instability. These risks are not some far-off possibility; they are only 40 years away. Changes in resource management need to be made in the short term if we are to head off rising insecurity of access to water and food, prevent more riots and feed the billion people who are hungry, 70% of whom are rural dwellers, and in large part women and young people, along with the extra billion people expected to arrive over the next fifteen years, which means another 180,000 mouths to feed every day.

[1] Group led by Steduto Pasquale of the FAO and Bart Schutlz of the ICID

Better management of agricultural water and productive ecosystems can bring multiple benefits. In addition to higher and more sustainable production, it generates environmental and community services that will benefit society as a whole: carbon capture, flood prevention, urban/rural balance, poverty reduction, more secure water supplies for the towns and other sectors of the economy.

What are the trends?

Resources for sustainable production under threat

Water resources are degraded and their availability for production in sustainable crop and pasture ecosystems is not assured in many regions and "hot spots". Erosion, largely due to water, causes a loss of 2-5 million hectares of land every year, lowers yields, and leads to desertification and the rapid silting up of reservoirs. Countries of Asia and the Southern Mediterranean are particularly hard hit. These regions, and some others in North America, are also severely affected by salinization and increasing overexploitation of renewable groundwater, estimated at a total of about 150 cubic kilometres per year. These phenomena are already leading to losses of investment, jobs and to migration - and they are getting worse. The deterioration in water resources is also qualitative (pollution problems) with significant impacts on health in many cases.

Growing competition with other sectors for land and water resources is another cause of production losses. Irrigated agriculture is obliged, in many areas, to give up a growing part of its water to urban and industrial uses, while urban sprawl is taking out large areas of excellent farmland - including irrigated cropland, estimated at 1.6 million hectares per year. Loss of farm land has accelerated with mass motorisation; it is particularly significant in the industrialised countries of Europe and North America, despite their low population growth. This is a non-sustainable model of urban development.

Actions can be taken to recover significant amounts of resources, through reducing erosion (improved conservation of soil and water), improved efficiency of irrigated and rain-fed systems (enhancing productivity of resources and ecosystems), increasing storage capacity and mobilization of new resources, reduction of urban sprawl and reducing losses along the entire food supply chain. The levels of loss and wastage are indeed high (30% in the food supply chain and often 50% in irrigated systems...).

Climate change and weather-related incidents are affecting agricultural production in many areas of the world. Droughts and floods, which recur increasingly frequently, have had severe effects in recent years on a number of major production areas. Droughts are the most frequent cause of food shortages, e.g. in the Horn of Africa. Developing countries will be particularly hard hit by climate change, with a reduction in agricultural production potential of 9% - 21% by 2050. Sub-Saharan Africa will bear the full brunt of this.

Such climate-related issues are one of the factors in the declining growth in yields worldwide: the annual rises of 1.86% in the years 1980-2000 could fall to only 1% by 2030, or even to 0.5% by 2030/2050.

Sharp growth in demand

Growth in food and non-food demand (fibres, green chemistry, biofuels) is, in contrast, rising sharply. To satisfy the demand for higher-quality diets stimulated by the growing wealth of the emerging economies, FAO estimates that an increase in production of 70% to 2050 will be necessary. Rain-fed agriculture will be under very great pressure to meet this demand, since the room for progress in irrigation – in terms of both efficiency and expansion in area – cannot provide more than a partial solution.

Rising yields could, according to the FAO, meet 90% of the extra food needs. However, for the other 10%, new land would have to be brought into food production to meet non-food requirements and to offset losses due to erosion and urbanisation. The cost of this extension of the global agricultural area might however be very substantial. According to some research, the inroads into forest land, savannah and pasture might in fact exceed the limits that must not be breached if major planetary balances are to be preserved (climate, biodiversity, water cycle...).

Smallholder agriculture continues to be widespread but mainly marginalised

The global agricultural population is not declining despite rapid urbanisation and strong economic growth in emerging economies. According to the United Nations, this population is likely to remain in the region of 2.6 billion by 2020, with the rural population continuing to expand. These figures show the importance of land-related issues and the substantial and continuing role of "*smallholdings*", which account, according to IFAD for 50% of world production (70% if small-scale urban producers and hunter-gatherers are included).

A large part of the rural areas and smallholder farmers are marginalised. The consequences of this are low yields, difficulties in selling products on markets that are disorganised, and high levels of poverty and illiteracy. Moreover, the number of people suffering from hunger, 70% of them in the rural areas, rose considerably with the food crisis of 2007-2008. Structural rises in prices and price volatility also point to serious dangers of a worsening in this situation.

Weakening agricultural policies

One of the main reasons for this situation is that many people thought in the years 1970/1980 that the surplus production of the 'North' could feed the 'South' at global prices which would remain low, and that agricultural policies should in consequence not necessarily remain a priority in many countries. This resulted in a significant fall in support to rural areas, which can be seen by the collapse of official development aid dedicated to agriculture, which fell from nearly 20% in the 1970s to 4% in 2006. Many agricultural policies have proved incapable of developing into genuinely effective tools for the professionalization of smallholder farming and for participatory, and environmentally sound, rural development. The weakness of local institutions and infrastructure have meant that the men and women who work the land have been unable to invest in order to better manage and utilize their natural resources more effectively, and water in particular. Training and education is inadequate, as is research and extension. Farmers do not have secure land and water rights, or financial security (absence of market regulation and/or subsidies to maintain income levels in many vulnerable countries). There is lack of rural infrastructure, especially roads, storage and processing facilities. Access to credit, to information, to agricultural inputs and to markets, is all absent or inadequate.

This marginalisation often results in insufficient recognition – and event contestation - of the rights of smallholder farmers to community resources including agricultural water.

Worsening problems for drylands and growing interregional dependence

"*Dry lands*" (arid and semi-arid areas) receive only 2.5% of continental water at the planetary level: however, for several decades they have been experiencing population growth that is almost double that seen in the rest of the world. This is leading to a sharp increase in the proportion of the population affected by water shortages. The population of these regions rose from 370 million in 1950 to 1.2 billion in 2000 and is projected to

rise to 1.8 billion by 2025. The Maghreb, which is already in a critical situation, will be hit all the harder by water shortages as a result of climate change. A decline in regular water supplies of some 30% is expected by 2050. Additionally, drylands are the areas worst affected by problems of overexploitation of aquifers, salinization, desertification and the rapid silting up of reservoirs.

High levels of population growth in regions which lack water (Middle East & North Africa), or land and/or water (South and Southeast Asia), or financial and institutional capital (Sub-Saharan Africa) explain the worsening structural inability of these three major regions to feed themselves. The outlook by 'Agrimonde' for these three regions (the average of four scenarios) points to a fourfold increase in net overall food deficit (and therefore expansion of net imports of virtual water) by 2050. The Americas and greater Europe (i.e. including Russia and Ukraine) will therefore need to produce much more food in order to maintain global stability, and this should justify a revisiting of the vision and priorities embodied in their policies on natural resource use and sustainable development.

The danger of inappropriate responses

The growing inability of more and more countries to produce enough food to meet their domestic needs may lead those which have the means to try to secure their supplies by making large-scale agricultural investments in countries whose natural resources are relatively unexploited as yet. Despite the fact that the scale of such land and water "grabbing" by large corporations is already substantial in Africa (involving 20 million hectares over three years), it has been demonstrated that investment of this kind generally makes no improvement to local food or energy security, despite Africa's crying need for both.

The subsidisation of consumption of basic food and energy commodities is leading to sharply rising public sector costs in many countries. While justified by the desire to preserve social peace, public support often has defect of subsidising imports and encouraging overexploitation of groundwater (this is also the case with gas and electricity subsidies). If they are inappropriately targeted, their cost can exceed 5% of GDP and will increasingly be untenable as prices rise, thereby reducing the ability of States to fund their development policies.

A paradigm shift is necessary

Escaping from a scenario involving unsustainable trends require a paradigm shift in approaches to growth models, especially in cities, in food supply systems and in agriculture and water resource management. The report notably promotes discussion of the need to move towards "sustainable agriculture", a key concept that merits greater clarity. While it is urgent **to make agriculture a priority once again, the aim must also be to reconcile agriculture with regional goals and issues (local, regional, global) for water and food security**. This entails doing all of the following:

➔ **Ensure global food availability in order to maintain affordable prices for consumers**, which in turn entails **an increase in the productivity of rain-fed and irrigated crops** (the goal of "more crop per drop"), a reduction in other forms of wastage and misuse of agricultural water (including utilization upstream of agricultural production, involving a challenge to urban development, and utilization downstream, involving less wastage in the agri-food chain from field to fork), increased water storage capacity and mobilisation of additional resources,

➔ **Improve access to food for poor and vulnerable rural households. This goal is not based simply on productivity growth.** It implies *defence and recognition of rights to resources for the population groups concerned (access to and management of agricultural water), a revisiting of crop choices made by major investors ("what crop?")* and raising income levels ("*more income per drop*") by adding value to products or through *payment for environmental* services deriving from good resource management,

➔ **Ensure that the dual goals of food security and water security go hand in hand**, the latter being a condition crucial to the former.

This requires progress, particularly in the seven broad priority areas listed below.

Seven priority fields for action and 40 examples of solutions: recommendations

1/ Increase the productivity of irrigation water resources and improve the efficiency of irrigated farming systems

The solutions to be promoted are both technological (progress in agronomics, genetics and techniques) and organisational and institutional in character.

One potential way forward is to promote *precision agriculture*: for example, use of new tools for fine-tuning irrigation currently under development in France point to possible efficiency gains of 20%. In Africa, *new varieties* of rice can, under certain conditions, bring additional yields of 50% 200%. *Ecological intensification* is another avenue for progress that can be encouraged and may make even higher yield increases possible. A recent evaluation across eight countries in Asia (India, China and Indonesia among them) of new Intensive Rice Farming (IRF) systems useable by smallholder farmers shows higher average yields of 47%, water savings of 40%, cost savings per hectare of 23%, and increases in income per hectare of 68%. IRF involves pricking out young plants at low densities, the use of organic manures, and regular drying out periods and weeding.

Progress in terms of organisation, institutions and "processes" in irrigated agriculture more important -this is also true for rain-fed agriculture and livestock farming systems. It enables productivity and income to be raised and cost recovery to be improved, thus reinforcing the economic and environmental sustainability of irrigated farmland. The Prey Nup project in Cambodia is just one of many examples of this: the democratic election of village representatives to build a community of users of irrigation water (which now has 15,000 members), securing land tenure, establishing 22,000 property titles, and access to credit - individual or collective - have enabled production to be increased from 12,000 to 27,000 tonnes in eight years (+165%), and has raised the proportion of households that are either self-sufficient or in surplus to 74%.

Implementation *of national policies* can bring progress on quite another scale. The Tunisian strategy for economic use of irrigation water is a successful example of a shift from a traditional supply-based policy (the building of hydraulic infrastructures), which had more or less reached its limits, to a new agricultural policy based on "water demand management" (WDM), which restores a central role for people. WDM is aimed at reducing waste and inefficient usage: it is therefore focused on prudent and effective management, and can involve all user sectors and consequently urban and sectoral policies (agriculture, tourism, industry, etc.). The Tunisian WDM agricultural policy has proved itself to be capable of skilfully combining tools for raising awareness and training, economic incentives prudent use of irrigation water, income support measures, decentralisation to 1,200 self-managed agricultural development groupings (compared with 178 in 1990) and water pricing. Progress based on new bottom-up approaches of this kind, rather than top-down action alone, has led to a

gradual catching up on cost recovery and a significant increase in production and agricultural value-added. At the same time it has stabilised demand for water, which in turn has freed water up for tourism - a source of foreign currency - and for cities, sources of social peace.

2/ Increase storage capacity and mobilise additional water resources, including the reuse of waste water

Several examples of solutions demonstrate the strategic importance of consolidating or developing irrigation by mobilising additional resources, including the reuse of urban "*grey water*" and "drainage water", and increasing water storage capacity, *on the surface, in the soil or in the subsoil* (aquifer storage). This can bring people out of poverty and hunger (e.g. in Sub-Saharan Africa, Myanmar...), secure supply chains and often improve both agricultural performance and the state of aquatic ecosystems (e.g. Juanon and Limagne Noire reservoirs in France). Supplemental irrigation has major potential for increasing water productivity and income levels.

In many regions where rainfall is likely to become more unpredictable owing to climate change, storage can and must be considered as a tool for "risk management" and adaptation to provide essential water supplies for supplemental irrigation. In regions affected by worsening shortages, development of water reuse is increasingly necessary. Progress of these kinds does however require precautions to be taken to forestall potential problems for the environment or health.

3/ Enhance productivity of rain-fed agriculture; promote "agro-ecology" and "conservation agriculture"

Progress for rain-fed agriculture will be even more crucial than progress for irrigated farming. This is because rain-fed agriculture has been more neglected than irrigated systems and so it has greater room for improvement, and also because the availability of water for irrigation is limited by the increasing share of water required for other uses (drinking water, industry, tourism, energy, etc.) and by the quantity of useable resources available.

Easier access to high-quality seeds (notably with improved root systems) and fertilizers can bring major gains in yield and income. However, from the standpoint of water and the "sustainability" of development, the first priority must be more effective conservation of water and soils, reduction of erosion, successful ecological intensification (producing more with fewer external inputs: energy, chemicals) and the adaptation of agriculture to climate change by enhancing the "resilience" and "sustainability" of productive systems. Agro-ecology, and especially "*conservation agriculture*", based around three principles – reduction or elimination of tilling, permanent soil cover, and crop rotations – can, in various forms that need to be adjusted to suit individual contexts, be a source of major progress with multiple benefits. Conservation agriculture has developed strongly in South America and other countries subject to high risk of erosion or drought.

There are good reasons to make the promotion of agro-ecology a priority for small-scale agriculture in Asia and Africa. This requires suitable agricultural extension services, research and support policies. Significant development of "no-till" farming in Europe, and experience with innovative cooperatives such as Nouricia in France, show that this new "agricultural revolution" can also have advantages for farming in temperate climates. Restoration of degraded land and the reduction by at least 50% of losses of farmland due to erosion also deserve to become clearly stated objectives.

4/ Support "smallholder farmers" to conserve, manage and make good use of agricultural and pastoral water, and promote sustainable rural development

Smallholder farmers often live off crops from both rain-fed and irrigated agriculture as well as products from areas under natural vegetation (pastoral livestock farming, forest products, hunting and gathering, etc.). This is notably the case in mountain areas, where good resource management is crucially important for irrigated farmland downstream. Good management of this kind presupposes successful sustainable rural development for which it is a primary factor.

The *marginalisation* of a large part of smallholder farmers worldwide is one of the major causes of lack of development and food insecurity. The failure to listen to or consider rural people is frequently the cause of low productivity and lack of official recognition of resource uses (social and land-related uses, uses of agricultural and pastoral water) in communities and the "rights" and duties of good resource management that should stem from this. This can lead to encouragement of unsustainable resource mining. In numerous vulnerable areas, smallholders – farmers, herders, fishermen – can also see their rights of access to resources (water and/or land), and capacity for community management undermined by privatisation decisions (agricultural water services, for example) or land grabbing. Several instances of this illustrate the potentially serious consequences at local level: significant loss of production and food security, growing conflict with other users of the resources and deterioration of distribution networks and ecosystems.

In the face of such difficulties, efforts have been made that show that effective solutions can be found if more attention is paid to the views of rural people and if there is intermediation between the actors. For example, in the Chambo Valley in Ecuador, a local NGO - with support from a French NGO and a French water catchment agency - has assisted in creating a consultation process enabling diagnostic analysis of the region and negotiation of mutually beneficial agreements between the town and Indian irrigators.

Fortunately, policies are being put in place in some countries to support smallholder farmers and enable them to improve their management of natural resources, gain access to markets and credit and raise their income levels. For example, "*Pillar 2*" of the "*Green Morocco Plan*" launched in 2008 supports smallholder farmers, the emergence of self-help cooperatives and the generation of value-added products from the "local soil". The innovative project for rural development in south-eastern Tunisia, "*Prodesud*", which has IFAD support, is a good example of "participatory" and "sustainable" development that has been negotiated with pastoral communities. The process of building this project has allowed them to take effective responsibility for the restoration and sustainable management of resources at the appropriate regional level (the "landscape of utilisation"), based on their own proposals and with the assistance of local facilitators trained in these new approaches. Vocational training for smallholder farmers and their organisations in managing water and supply chains is also an important tool. This requires novel methods of design in which research/action plays an important role (e.g. the project for a network of Mediterranean irrigators in the Maghreb).

Countries that have made a political choice to support their smallholder farmers can reap significant benefits. One example is Vietnam, whose policy to empower 10.4 million agricultural households farming an average of 0.3 hectare on the Red River delta and 0.7 hectare on the Mekong delta, has led to a doubling of rice production over 20 years and lowered the percentage of the population affected by food insecurity from 31% to 11%.

5/ Manage "hot spots" (overexploited and/or polluted aquifers)

The overexploitation of renewable aquifers stems from the uncontrolled development of motorised pumping systems and therefore from the absence of governance of the resource capable of providing collective discipline for the farmers concerned at the appropriate regional level. Experience with the Beauce water table in France illustrates the potential merits of "contract-based water use management". Farmers organised in irrigation associations at the level of the French *department (province)*, and all equipped with water metres, agreed to limit water take-off to a total volume determined by the government each year in early spring that takes into account the level of the aquifer. The situation is much more worrying in dry land areas. For example, the dramatic fall in the level of the Souss Massa Draa aquifer in Morocco, made worse by the increasing aridity of the climate, is a threat to the entire economy and to the stability of a highly dynamic region of the country. Recent progress is the result of growing awareness of the risks (based on predictions by the water catchment agency), and collective efforts that owe a great deal to the on-going process of decentralisation in Morocco. Indeed, this has enabled the regional council to develop a new vision for agriculture, to mobilise government ministries (water and agriculture), along with the region's agricultural agencies and organisations, and persuade all of these interested parties to commit to a "framework agreement". To avoid the disastrous scenario indicated by on-going trends, the objectives of the agreement are: to combine progress on efficiency (a switch to drip irrigation, support for research, introduction of economic tools, different crop choices...), transfers of water from another catchment area with higher water levels, a ban on new water take-off points, inspections and sanctions and regular oversight of progress by a monitoring body.

Other examples show possible solutions for: reducing pollution from agriculture at certain 'hot spots' (e.g. sites that supply predominantly drinking water), or the reconciliation of development and protection of habitats of high ecological value (e.g. maritime Guinea). In these different cases, the first thing to be done is to demarcate the aquifer systems and the users concerned.

6/ Act on resources upstream and downstream of production: food wastage, urban sprawl, social safety nets

When food or land is wasted, the water used in production is also wasted. It is therefore important to take action upstream and downstream of production in order to reduce the wastage of agricultural water, and at the same time strengthen food security by reducing wastage. Downstream food losses "from field to fork" (accounting for of 30% of total production according to the FAO) are mainly losses in the fields in developing countries, while in the industrialised countries the losses are at the level of consumers and the retail distribution sector. Lack of storage facilities (silos) in developing countries, and consumer behaviour or inadequate mechanisms to recover unsold products in time (in particular for the benefit of disadvantaged social groups) in industrialised countries, are the main factors causing this situation. Fortunately, innovative solutions are beginning to emerge. Important savings in water use are also possible in the agri-food industry.

Upstream food losses can be reduced by means of urban densification and long-term protection of agricultural land. While certain countries have set thresholds for the maintenance of agricultural land (e.g. Vietnam) or targets for the reduction of annual losses, the mechanisms for land protection and urban densification are still in many cases inadequate. Curbing urban sprawl is not yet the big issue that it deserves to be both worldwide and in many countries.

Reform of "social safety net" policies is potentially another avenue for action to preserve and manage productive ecosystems and water resources more effectively. Countries that subsidise consumption of basic food and energy commodities could for example be inspired by those policies involving direct cash transfers to less-fortunate families. These have been applied with success in several Latin American countries (e.g. Brazil and Mexico). Such policies, which are best targeted at disadvantaged population groups, are less costly and avoid encouraging the overexploitation of water tables, unlike financial support for consumption of gas or electricity. The social compliance requirements for receiving these subsidies (effective attendance of children at school and at health examinations) also help families to emergence from poverty. Financing such programs, using an approach of "*payments for environmental services rendered*" in rural areas suffering from desertification, could become a strikingly effective method for restoring vulnerable and degraded ecosystems (mountain areas, arid zones) and for the long-term elimination of poverty. Restoration of plant cover (conservation of water and soils) in ecosystems, negotiated with village leaders and pastoral communities, restores the productivity of their land so regaining sustainable access to vital local resources: wood fuel, water and food, while at the same time "producing" more water for the benefit of irrigated crops downstream. It would also reduce the hardship of the lives of rural women tasked with fetching water and wood for the household.

7/ Develop visions and strategies for a sustainable agriculture at regional and macro-regional scales

The example of the Souss Massa Draa region referred to above illustrates the strategic importance of the "*regionalisation*" of visions and planning at sub-national levels (local government regions, *Länder, Generalität*, State, etc.). This is because most countries contain highly diverse areas in terms of climate, water resources and agriculture. Regionalisation can then better take into account the specificities and needs of each territory, to give much better coherence and effectiveness to sectoral polices (water, agriculture) defined at national level, and to better develop local resources or arrive at realistic, shared compromises to ensure that food security and water security goals go hand in hand. Indeed, France has recently started a process of definition of "*regional plans for sustainable agriculture*" at this geographical level. Such regionalisation of strategies also makes it possible to integrate more effectively knowledge and visions developed at different levels of governance of major watersheds and major farming areas. This regional focus should also be taken into account by the large agro-industrial groups, notably those that invest in low-income countries. It is no longer acceptable that many of these groups continue to give little attention to the regional aspects of food security (access to food for the poor), or indeed to the imperatives of water security. It is not sufficient to announce progress on efficient resource management to claim to be pursuing sustainable development.

Countries sharing a "*common destiny*" (e.g. West Africa, Euro-Mediterranean countries) would also gain from building shared visions among themselves and, where applicable, putting in place common strategies or policies across such "broad regions". Indeed, uncoordinated national responses can make problems of water and/or food insecurity worse. Being divided is neither conducive to having influence in international negotiations nor to setting up new "*deals*" between groups of neighbouring water-rich or water-poor countries. The EU is a good historical example of success in regaining food security by means of a shared vision and a common agricultural policy. The current "greening" of this policy will allow it to better integrate water issues. Will it be capable tomorrow of building a sustainable Euro-Mediterranean region, alongside its southern neighbours?

Conclusion

Without a rapid and resolute change in direction, the world could become the "passive victim" of radical change, bringing with it high costs and major risks. It is therefore in its interests to engage as soon as possible in a process of "actively chosen" radical change. This requires a clear vision of the sort of world we want for the future and a common commitment by all to take responsible and mutually-supportive action at every regional level, from local to global.

> **Greater awareness on the part of the urban world of its dependence on the rural world is probably the first condition to be met for a change in scenario.** For the last thirty years, high-speed urbanisation worldwide and environmental and economic thinking has led to a marginalisation of rural communities.

Under-development, poverty and hunger, perception of agriculture as an "adjustment variable" (control of water and land resources, the imposition of constraints, uncontrolled expansion of the "urban shadow"), very limited attention paid to "water for food" in the global debates on water, and worsening water and food crises can all be explained to a large extent by this urban bias. What is required therefore is a new awareness of interdependencies and issues of "development" and "sustainability" in all their complexity: interdependence and solidarity between town and country, between agriculture and water, between regions that are water-rich and those that are water-poor, between large irrigated areas and rural mountain areas, between different levels of governance.

The world will not be able to make the necessary changes if it continues to waste its vital resources and exclude a third of humanity from the benefits of progress. What is necessary is to adopt strong, motivating goals for sustainable development focused on three objectives:

➔ **Increasing productivity of water and ecosystems: sustainable intensification of agriculture and reductions in wastage and misuse.**

➔ **Support for smallholder agriculture and vulnerable rural areas** to conserve, manage, and make good use of water, as well as to achieve inclusive development based on knowledge and a strengthening of social capital in order **to make effective inroads into poverty and hunger.** Such support is in fact a fundamental condition for higher productivity and the availability of sufficient food worldwide. Farmers' organisations (cooperatives, associations of irrigators, and the like) are key vehicles for promoting participatory development, and they must be supported.

➔ **Regional (territorial) governance of agricultural water.** Strategies and actions must succeed in giving due consideration to the "**complexity**" of the issues, of the different levels of governance and the different stakeholders, by encouraging strategies and actions at the five interlocking levels of governance (global, macro-regional, national, regional and local). Taking this complexity into account requires much greater attachment to bottom-up approaches and, by the same token, to the principle of "subsidiarity". The examples of solutions given in this report point to the crucial importance of the recognition of rights and to the establishment and consolidation of farmers' organisations, institutions and local processes that enable stakeholders to manage resources more effectively and collectively across basic geographical levels (specific local producing areas, water catchment areas, pasture land, water tables, etc.). The importance of having national food security policies also needs to be stressed, and especially policies for agricultural and rural development, which must also become policies for "**water demand management**" (WDM).

Such policies could benefit substantially from being "regionalised" on the basis of NUTS 2 regional levels (landscapes), the preferred scale for "planning". The macro-regional level, the most relevant for cooperation on conflict-prevention, is also fundamental because what is ultimately at issue where questions of water and food security are concerned is to avoid cascading social and political instability and uncoordinated national responses as a result of a lack of shared vision, leading to an aggravation of the risks.

This report consequently recommends avoidance of ultimately unproductive "State control alone" or "market forces alone" postures, so that integrated territorial responses can be pursued at all levels of governance, adapted to different contexts, motivating and empowering the actors and stimulating innovation, whether technological, organisational or institutional. Free trade seen as an end in itself is manifestly unable to overcome the challenges identified here, as is policy administered from on high and stifling the spirit of enterprise and the capacities of the actors in the farming sector, rural communities and other relevant local actors to organise themselves effectively on the ground for efficient, fair and sustainable management of resources. **The strengthening of human and social capital** (farmers' organisations, empowered collaborative management of the natural resources that are agriculture's factors of production, the capacity for enterprise and innovation) can be seen in the light of this to be fundamental to progress. New partnerships must be established between national and/or local authorities and sectoral and local actors, since progress requires that farmers and rural communities – the managers of regional resources - should be considered as the core actors in achieving change. While there is a crying need for reinvestment in agriculture and water for food, the aim today must also be to ensure that it is "smart investment".

1 - WATER AND FOOD SECURITY : PROBLEMS, ISSUES AND THE RISKS OF AN UNSUSTAINABLE SCENARIO

1. FOOD SECURITY, A MAJOR CHALLENGE WITH MORE THAN ONE DIMENSION

→ The links between food security and water

Global food security is a major challenge for public policies. In fact, the reduction of poverty and hunger is the first MDG (Millennium Development Goal). The state of natural resources, especially water, is becoming an increasingly limiting factor in dealing with this challenge. Therefore, the relationship between natural resource management and food security has increasing importance in the international political agenda. The decisions of the G20 in Cannes in November 2011 included, for the first time, an agricultural section and called in particular for deeper consideration to the question of water.

Food security is assured "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). It refers to the "right to food", a fundamental, individual right established since 1948 by the United Nations as part of overall human rights (Resolution 217 A, 10th December 1948: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food").

Attaining food security means acting in many different areas. However, the question of water appears to be a subject worthy of particular attention and political decisions at the highest level. The relationship between water and food security is complex and significant. It touches on all four dimensions of food security, as defined by the FAO:

→ Water is first of all a key factor in the **availability** of food (production and imports). It is a fundamental resource for agricultural production, including livestock rearing and aquaculture. Irrigation can contribute to the intensification and the diversification of food supplies. There is also significant room for improving the use of rainwater in agriculture, particularly for the benefit of family farming. Better access to water, and a concerted and sustainable management of water resources, including the sharing of water among its various uses, is essential to increasing crop, animal and fish production, and so their availability. Moreover, beyond the use of water for drinking and meal preparation, food-processing activities require large amounts of water as a technological or energy input. A profitable processing sector therefore needs on a regular supply of water, which must be of sufficient quality to guarantee the food safety of final products. Ensuring water availability depends on actions upstream and downstream of the food production sector - "from farm to fork". It also depends on the development of the relationship between agriculture and the cities, through an integrated analysis of consumption and production patterns, through reducing losses and waste, through using high-quality water, and through treating any pollution caused by these activities.

→ Good water management can also allow for improvements in **physical and economic access to adequate food and nutrition**. It enables poor households to produce more to better feed themselves, and it may also improve their incomes. The creation of jobs and the improvement of incomes can lead to increased supplies of farm products and processed foods. Good water management can lower farm operating costs and produce environmental services that benefit downstream users or society as a whole, thus justifying environmental payments. Lack of access to drinking water slows down economic development. It is one of the limiting factors for the development of agribusiness activities on the industrial, semi-industrial and village levels, where water is a technological resource. In addition, drawing and carrying water can sometimes make accessing drinking water a heavy daily burden, often assumed by women. This represents a potential income loss that weighs heavily on family revenues and thus their capacity to ensure nutrition security in their households.

→ Water and its relation to food security is also fundamentally a question of **stability**. Water is an unevenly distributed resource (in terms of time and space). Many societies and economies are now victims of the growing problems of water shortages, droughts and floods. Irrigation can contribute to increasing income and thus to a greater resilience to climatic shocks, creating greater stability. The development of irrigation can bring problems too, generating disputes over ownership and usage of land, moving surface or underground water, and it can also bring to question rights of access to water: a source of conflict and instability. In addition, the development of irrigated agriculture often results in a redistribution of tasks, creating new socio-economic relations and environmental impacts in both the short and long term, which may cause conflicts over usage and have consequences for stability. Stability can therefore be found in a system of management of the water and sanitation networks that is regulated and coordinated between the various water users, or by the inclusion of water in corporate social responsibility.

→ Finally, water in relation to food security is also an issue in terms of **nutrition and health** through everyone's access to drinking water, and to basic sanitation and hygiene. Dirty water and poor sanitation are the main causes of water-borne diseases, like cholera and diarrhea, and some vector-borne diseases such as malaria and dengue fever. Surface water is also a cause of diseases such as bilharzia and Guinea worm. Poor water quality, inadequate sanitation or poor hygiene therefore contribute strongly to malnutrition or poor health and so to stunted growth, especially in children. Irrigation schemes may have negative effects on nutrition and health: firstly by increasing the presence of surface water, potentially a source of disease; secondly by a redistribution of tasks that could have consequences on nutrition since activities linked to irrigation usually involve more women, especially in Africa, making them less available at home and for feeding young children. Furthermore, exposure to dangerous levels of chemical pollutants in drinking water, as a result poor management of municipal and industrial wastewater and water run-off from agriculture, is also a factor likely to affect peoples' health. And all the negative effects of poor water quality on health have a significant impact on labour productivity, particularly for agricultural work.

The role of water in food security is therefore multi-faceted in its implications and effects. It affects health and nutrition, agricultural production, aquaculture and food-processing. Only by a multi-sectoral approach can water policies deal with these effects, both positive and negative, on food security and nutrition. They must be taken into account in the design, conduct and evaluation of policies and actions in the water sector. Water as a resource for food production and processing, and as a key factor in health and nutrition, should also be fully incorporated in policies and programs concerning food security and nutrition.

This report focuses on *water as a resource*, a resource that must be conserved, managed and developed to help respond to the challenges of *availability*, *access and stability*. It covers the questions of *land*, soils and ecosystems, which cannot be separated from those of water, and it covers the question of *reducing losses and waste upstream and downstream of production*. However, it does not address issues of nutrition and health, nor changes in consumption patterns or growth models outside agriculture in countries deprived of water: issues that also deserve more attention.

→ The challenges to be met for a sustainable balance between supply and demand

The issue of *water as a resource* is indeed fundamental. Water is essential to:

- *Feed the billion people who are currently suffering from hunger,* ¾ of which are rural; the remaining ¼ are essentially new urban poor resulting from the rural exodus;
- *Feed the extra billion people expected in the next 16 years* (over 180,000 more mouths to feed every day) and the extra billion people expected by 2050, with in particular, a doubling of the African population;
- *Meet the new demand from emerging countries and of new urban residents,* within an economy which, faced with the depletion of hydrocarbon resources, will increasingly have to call on agriculture to satisfy its non-food needs (energy, fibre and 'green' chemistry);
- *Prevent "food riots"* and the growing risk of social and political instability that could result from water and food insecurity.

All this needs to be done, but in a difficult context where:

- Several countries, such as Somalia, are already faced with acute food crises owing to conflict or climatic disasters; crises for which there are no easy solutions in either the short or long term;
- Natural resources (water, land), the productive bases of agriculture, are limited, unevenly distributed, and are not secure;
- Supply is no longer structurally higher than demand, resulting in a new era of high price volatility and rising price trends, after several decades of low food and energy prices;
- Ability to meet new demands in the coming decades, and amidst significant global change, is questionable both on a purely technological and agronomical level, and in terms of ecological sustainability and social justice.

Ensuring food security in the context of global change (climate, energy and demography etc.) is therefore without a doubt the *biggest challenge we face in the coming decades*. This huge challenge will require *food and water security to go hand in hand*, the latter being a condition of the former (the concept of water security has been namely addressed during the 2nd World Water Forum[ii]). Achieving this will require, in particular: better conservation of water resources, the very basis of agricultural production, as well as the necessary freedom for farmers - men and women - and rural communities to undertake entrepreneurial activity, live decently from their work, and invest in and develop their water resources. This question is, of course, also one for the cities which, in an ever-urbanizing world, should remember their dependence on the rural areas.

2. AGRICULTURE AND WATER

→ The water that feeds humanity

There can be no agriculture where there is no water, nor by the same token can there be any livestock farming: animals need water to drink as well as feed to eat. Water is in fact a decisive factor for agricultural production and for the survival of livestock herds both directly and indirectly through the production of fodder. This can in some cases lead to conflict over access to water between pastoralists and farmers.

In terms of quantity utilized, by far the leading service rendered by water is for *food production* (see Table 2). Please note:

→ The total quantity of "*green water*"[2], the basis for non-irrigated production stands at approximately 5,600 km³[iii]. The vast majority of producers are dependent on such *rain-fed production*.

→ *Irrigated agriculture* mobilises approximately 2,700 km³/year, or 70% of the total quantity of "*blue water*"[3]; the other sectors using water are: local communities (notably drinking water) 381 km³, industry 250 km³, and thermoelectric energy production 535 km³.

Table 1 - Water volumes by type of use

Water used by agriculture (evapo-transpiration)		
Natural watering by rainfall	5 560 km³	78%
Irrigation	1 570 km³	22%
Total water used by agriculture	7 130 km³	100%
Water mobilised by human populations (blue water)		
Water take-off for irrigation	2 664 km³	70%
Water for domestic uses	381 km³	10%
Water for industry and electricity generation	785 km³	20%
Total water mobilised by human populations	3 830 km³	100%

Source : Water for food, water for life, IWMI, 2007

What is involved here is not water that is "*consumed*" but water that is "*utilized*" or "*mobilised*". This is so because part of the rainwater that falls on fields and waterways, and which is mobilised to irrigate plots of land, filters through the soil and feeds into aquifers downstream or returns to the atmosphere by evaporation or transpiration from plants.

Table 1 shows that approximately 60% of the water used for irrigation (1,570 km³ from a total of 2,664 km³) is either consumed by crops or evaporates from soil and water courses, while the remaining 40% drains back to the aquifers (underground, or on the surface). The total utilization of water by agriculture (7, 139 km³ /year) shows that 3,000 litres of water per day per person are needed to produce our food supply.

The water cycle is a cycle in which, generally speaking, the transfers between the oceans and the continents are in balance, although with delays of several months before water from evapo-transpiration is once again available for the various uses.

The following is also worth noting:

→ Irrigation, a technique as old as farming itself, requires expertise and methods for proper management of the water: where and how irrigation is applied cannot be improvised.

→ Irrigated zones comprise two sorts of systems: large areas created mainly in the 20th Century by governments and their engineers, and areas covered by "small to medium hydraulic systems". "*Smallholders*" dominate in the latter areas. They can also play a major role in large modern irrigated areas.

→ From 1961 to 2009, the global cultivated surface area increased overall by 12% and agricultural production has increased by a factor of 2.5 to 3. The expansion of the cultivated surface area is a result of increases in the irrigated area, rising from 139 million hectares to 301 million hectares over this period, an increase of 117%. In contrast, over the same period, the total area of rain-fed crops has remained stable, going from 1,229 million ha in 1961 to 1,226 million ha in 2009. Although most of the good quality agricultural land suitable for irrigation is already being irrigated, the area under irrigation is still increasing at a current rate of 0.6% per year[iv].

→ The total irrigated area accounts for 20% of the global agricultural area (5% in Africa and 35% in Asia). It provides 40% of the world's production: irrigated agriculture is therefore on average three times as productive per hectare as rain-fed agriculture.

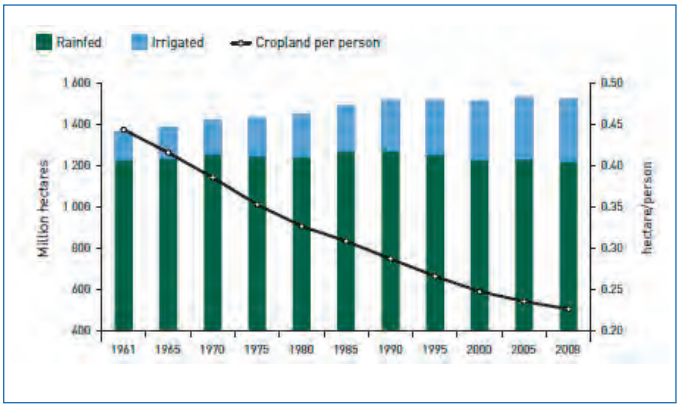
→ The shift from rain-fed to irrigated agriculture usually results in a sharp rise in rural income (a doubling in India) and therefore to improved *access to food*.

[2]. "Green" water is water provided by rain and retained in the soil, making rain-fed agriculture possible

[3]. "Blue" water is water flowing in rivers or captured in underground water tables that can be mobilised for a diverse range of uses, including drinking water and irrigation. Blue water is therefore water that can be transported; green water must be consumed where it is.

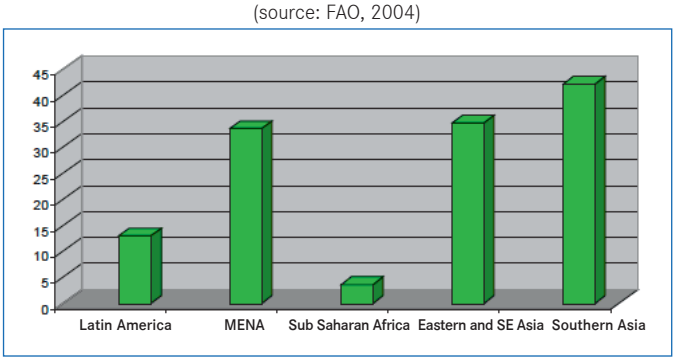
The contribution of irrigation to global and local food security (availability and access) is therefore decisive. The FAO SOLAW report[i] shows (Figure 1) the variations of indicators related to surface areas in farmands recorded from 1961.

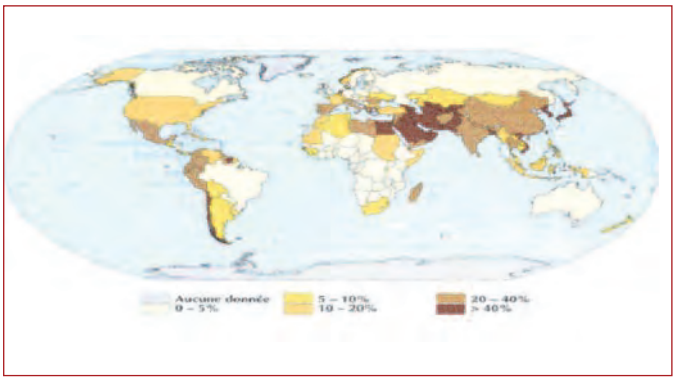
Figure 1 : Change in irrigated versus non-irrigated areas
(source FAO SOLAW 2011)



Map 1[vi] Illustrates the distribution and relative sizes of the zones equipped for irrigation around the world. Irrigation has undergone major development in South Asia for rice production and also in drylands where water is the primary limiting factor of production. While irrigation is still relatively undeveloped in Sub-Saharan Africa (3% of land area), it has expanded to an astonishing degree in the Netherlands and Denmark where, although it is not strictly necessary, it is an important factor for the profitability and quality of agricultural supply chains (vegetables, flowers, fruit).

Figure 2 et Map 1 : Areas equiped for irrigation
in % of farmed land per country in 1998
(source: FAO, 2004)





The FAO predicts that food production will need to increase by 70% from 2009 to 2050 (100% in developing countries) in order to feed 9 billion people by 2050. It estimates that more than 80% of it should result from productivity increases. However, Irrigated areas would increase by only 6%, from 301 million ha to 318 million ha, and the volume of water abstracted for agricultural purposes would increase by 10%, reaching nearly 3,000 km^3/year[vii].

The scenarios in IWMI's Comprehensive Assessment (Water for Food, Water for Life) have explored a variety of contrasting possible futures by evaluating their consequences on water. The scenario without any productivity increase would require an extra 5,000 km^3 of water for agriculture (blue and green), i.e. total water needs in agriculture would go from 7,130 km^3 to over 12,000 km^3 by 2050. However, the report confirms, as does the FAO, that significant progress is possible in increasing productivity, particularly for rain-fed crops. The report notes that for irrigated agriculture, progress would mainly result from productivity increases in water use rather than from an extension of irrigated areas. The "comprehensive assessment scenario", a scenario considered as most desirable, addresses these opportunities and regional issues. It shows a 16% increase in irrigated areas, a 10% increase in rain-fed crops, and increases in water productivity of 31% and 38% respectively (irrigated and rain-fed farming). It also shows an increase of 20% in water used by agriculture (which would reach a total of 8,515 km^3 per year) with an increase of 13% in water for irrigation (2,975 km^3/year). This presupposes a solid increase in irrigation efficiency in Southern and the South East Asia (with aquaculture, fishing or farming often being associated) as well as increases in productivity of rain-fed agriculture in Sub-Saharan Africa for the benefit of smallholder agriculture ; irrigated areas would increase at the same time by 80% in this region. However, other scenarios are possible; they are less optimistic and result in more pressure on natural resources.

These projections and scenarios demonstrate the importance of more efficient management of irrigation water and green water. They also raise the question of the shifting frontier between farmed land on the one hand and forest, savanna and grazing land on the other. We shall return later (in Chapter 5.3) to the issue of the different needs that must be met in 2050, the yield increases and expansion in farmed land area that could result from this, and our collective capacity to respond sustainably to what are enormous challenges.

➔ Invaluable expertise sometimes under threat

Farming is much more than just another user of water resources. Agriculture is a vital activity since it provides food for all. It is also, by definition, an activity involving "*management of the biosphere*". As the primary manager of natural resources (water, soil, vegetation) and farm and pasture ecosystems, agriculture can be both a cause of irreversible damage to natural capital, and a producer of essential "environmental services": carbon capture, conservation and enhancement of water and soil fertility, reduction of erosion and flood risk, prevention of forest fires, production of clean water for users downstream, management and conservation of agro-ecosystems and farmed landscape (wetlands, mountain farming, etc.) which have major ecological value (biodiversity, water cleansing) and tourist value. Agriculture is also a source of jobs and wealth. It must therefore integrate the demands of society for food to be produced in sufficient quantity and quality for all with the conservation of natural resources - on the assumption that it is economically possible. In certain cases, where this necessary integration leads to disproportionate economic cost for communities and private actors, or where those communities and actors find themselves caught up in a vicious circles of poverty, hunger and damage to resources and ecosystems, farmers must be helped to modify their production systems or change their farming practises, or they must be remunerated for delivering specific environmental services.

Agriculture as an activity involving management of the biosphere is also, according to the adage a "*science of local space*". For it to exist in a sustainable manner, it has had to develop expertise adapted to every context. And today it must assimilate new knowledge, local or otherwise, to enable water use to be optimised.

Traditionally, its expertise has related very much to water, a resource that requires a degree of "mastery" since it is at one and the same time irregular, a key factor of production, and frequently also a destructive force. Since water is also by virtue of its very nature a "common good" that flows down the steepest slope, such expertise has often required complex collective management that takes into account the needs of other users,

including users downstream. Remarkable solutions for development and management have thus been designed in order to:

→conserve and add value to land and water,

→capture and store an irregular resource in order to irrigate plots to produce more, and to provide protection against drought and famine,

→ensure fair allocation of the resource among producers and with communities further downstream,

→provide protection against flood risks,

→adjust to new climatic, démographic and economic conditions.

Where these forms of expertise have been lacking, or where they have been incapable of evolving and modernising, entire civilisations have disappeared[4].

This expertise relates to both irrigated and rain-fed forms of agriculture as well as to regions and more complex systems of production, which may be of the agro-sylvo-pastoral type. This is notably the case for *mountain farming*, where societies often live from a mix of irrigated production, products of rain-fed agriculture, and from areas with natural plant cover (grazing areas and forests): wood, the products of hunting, fruit gathering and pastoralism. Good conservation and management of water is essential here because it is crucial not only for the wellbeing of mountain communities but also for that of the societies and economies further downstream. Without proper water management in the mountains, downstream users may fall victim to the rapid silting up of reservoirs, or flooding, which can result from poor agricultural or pastoral practices upstream. Conversely, downstream societies and economies can reap direct benefits from good management of grassland, farmland and forests since this can prevent or slow down water run-off and facilitate water infiltration into the soil, thus feeding unpolluted water over the long term into aquifers and reservoirs. The production of such ecological services, where it exceeds the minimum demands of good resource management practises and entails changes in practices for the benefit of external actors, could logically justify remuneration. Where applicable, *innovative financing mechanisms* could be provided to mountain farmers by downstream beneficiaries. These would also help to improve food security in mountain areas, areas which frequently suffer from high levels of poverty and the cumulative deterioration of natural resources and ecosystems.

The obligation to provide good management of water and other natural resources (soil, pasture, and forest) may also require "*governance*" capabilities to be deployed at the relevant regional levels. Those levels are:

1. "*Local village areas*" (the agrarian village space), a level fundamental to the management of water, grazing and forest resources in many countries. It is a level that corresponds to "*basic communities*" responsible for a large part for how resources are managed, a level that may be broadened to include "*pastoral areas*" for the management of grassland, livestock herds and pastoral hydraulics. It is also the level where *inter-village agreements* (upstream/downstream) for water management could be established;[5]

2. *Water catchment areas and aquifers, irrigated areas ans water distribution areas* (cf box 1).

BOX 1 : WATER CATCHMENT OR WATER DISTRIBUTION AREA ? THE LESSONS OF THE ISIIMM RESEARCH PROJECT

The Euro-Mediterranean ISIIMM project (Institutional and Social Innovations in Irrigation Management in the Mediterranean) has demonstrated that the catchment area, a rational hydrographical unit for the assessment of primary water supply, is in fact inadequate to account for the complexity of demand for water across a regional social fabric that is difficult to represent and understand.

As a consequence of this, the ISIIMM group, led by IRD (*Research and Development Institute*, France) was led to reintroduce the regionally-based notion of the "*bassin déversant*" or water distribution area, that is to say a region of water use, defined as "an area of hydraulic and hydrological influence dependent on constructions and networks using water". This concept, proposed by Martin when discussing Fayoum as long ago as 1799, turns out to be relevant in both the Northern Mediterranean area (Provence, Catalonia, etc.) and the Southern Mediterranean.

Each management area is indeed built up in its own particular way on the basis of a subtle mix of different traditions and conceptions of networks and modes of access to land and water. The water distribution area or "bassin déversant" can be seen as a regional level at which water management can be pooled, a level at which associations can be organised in the common interest for the management of irrigation water and the preservation of farmed ecosystems and their environment, and by the same token the level at which local bylaws laying down rights and duties and local arbitration arrangements for dispute settlement can be established. This level, as well as watershed levels, are to be considered, since are linked.

The state of affairs currently observed is unfortunately often as follows:

→Inadequate recognition of the relevant regional levels for the management of agricultural water resources, with approaches that are still all too often both ill-suited and top-down,

→Inadequate consultation of local populations to derive the best possible benefit from their expertise and to give them the possibility of acquiring new expertise suited to their regions and the new issues,

→Disaffection for agriculture on the part of young rural dwellers, leading to a regression in the handing down of expertise and ultimately its loss,

→Difficulties for the men and women working the land to acquire new expertise, either individual or collective, that would enable them to manage agricultural water in more efficient ways,

→Rights of access to water and land that are still precarious in many cases, a fact that blocks investment and does not help set in train a virtuous circle of development.

This explains in many cases why low productivity and sustainability are observed in both rain-fed and irrigated systems (see below).

[4]. One example that might be cited is that of Mesopotamia, whose collapse is often put down to deforestation, overexploitation of pasture, erosion and salinization of irrigated soil (inadequate drainage).
[5]. On example is the well-known custom of the Dioro, determining the conditions for herd movements across the Niger River according to the seasons

→ Actors in the management of agriculture water, their relative weight and the importance of «smallolder agriculture »

There are many actors with a stake in agricultural water. Technical progress and poorly regulated globalisation have led to the specialisation of production and high concentration in the sectors upstream and downstream of agriculture (agricultural supplies, retail chains and a large part of the world food industry are today in the hands of a very small number of large transnational corporations). However, developments in agriculture are different between countries and even within the same country. Worldwide, the agriculture and food sectors are highly pluralistic.

The vast mechanised farms to be found especially in the "new world" (e.g. Brazil, Argentina, United States, Canada, Australia) and certain post-collectivist countries in Europe (e.g. Russia, Ukraine) can be contrasted with the family and "post-family" farms in Europe and the vast mass of small and micro-holdings in Asia, Africa and elsewhere. Good water management requires progress to be made in all these types of farming systems.

Despite globalisation, rapid urbanisation and a sharp reduction, in percentage terms, of rural and agricultural populations, the statistics show that there continues to be very large farming populations in developing and emerging countries, including those experiencing high levels of economic growth. For example, while the agricultural population of Turkey has begun to shrink, although it is still very large, that of China is currently stabilising and that of India is continuing to grow significantly (see Table 2). These developments are significantly different from those seen in the industrialised world, which have low rates of population growth – France, for example, where the size of the agricultural population has been cut by a factor of 3.5 over the period from 1970 to 2010. At the global level, the agricultural population is likely to continue to number 2.6 billion over the next decade, even though the rural population continues to expand, reaching 3.5 billion in 2020.

The world's agriculture is therefore in the main still made up of "*smallholders*" farming by hand or with draught livestock power. According to IFAD, this type of agriculture provides 50% of the world production (70% if small urban producers and hunter-gatherers are included), provides a living (often a poor living) for two-fifths of humanity. It uses 200 million hectares of land to feed its 400 million animals, which amounts to a land area very much greater than the 35.7 million hectares dedicated to biofuel production in 2008. These are not however the same hectares, since those used for the production of biofuels are of much higher quality than those used to raise draught animals.

Continuation of smallholdings in countries with high demographic growth rates testifies to the difficulty of other sectors in the economy in providing enough jobs for the massive numbers of young people entering the labour market, and to the lack of access to training for poor rural dwellers. This continuing state of affairs does contribute to urban/rural balance and collective stability. However, it brings with it social risks and a danger of massive migratory flows if rural populations are marginalised, are unable to share in the benefits of economic growth or suffer the impact of unfair free trade or the deterioration of ecosystems and natural resources.

Table 2 - Agricultural populations: World, China, India, Africa, Turkey, France : 1980-2020 (millions)

	World	Africa	China	India	Turkey	France
1980	2 203	319	743	439	18	4,5
1990	2 453	383	842	504	19	3,1
2000	2 584	447	864	559	17	2,0
2010	2 619	513	834	592	14	1,3
2020	2 601	582	776	605	12	0,8

Source : United Nations Population Division (FAO Stat)

Although they can be highly productive, smallholdings are also often marginalised, are vulnerable and are the victim of "vicious circles" in which insufficient development, investment and productivity combine with poverty and hunger to cause spiralling deterioration in water resources, soils and agro-ecosystems. This can lead eventually to insoluble situations and the massive migration of untrained populations out of rural areas. However, strategies other than uncontrolled outward migration are possible if rural dwellers are given training, or if the efficiency of productive systems is enhanced particularly for water management, or if new systems are introduced to diversify or add value to products. This presupposes however a "professionalization" and "restructuring" allowing producers to organise themselves and gain access to information and technology (drip irrigation, for example), modern inputs (e.g. high quality seeds), credit and markets. Professionalization also has the major advantage of being able to generate numerous non-agricultural rural jobs (cottage industries, services) and broaden domestic markets, which is conducive to growth. Indeed, the World Bank has recognised that investment in the agricultural sector is twice as productive for growth in developing countries as investment in other sector (special report 2007).

Agriculture, in addition to its responsibility for food security and good management of water resources and ecosystems, therefore has great importance for employment and reduction of urban and rural poverty, for economic and social development, for ensuring a proper balance between regions and for maintaining stability of all its forms. In contrast, inadequate production, deterioration of natural resources and high levels of price volatility can lead to riots and famine.

The conclusion to be drawn from this chapter is that good management of agricultural water for "sustainable development" requires the involvement of professional actors at very different levels. The following actors are all concerned concurrently:

- → Transnational corporations, especially in the agri-food sector, and other major investors and actors in the various "supply chains",
- → Large and medium-sized agricultural holdings, which are generally well-advanced in applying "modern" methods,
- → The substantial number of smallholdings, and sometimes also micro-holdings (holdings whose production may be less than the consumption of the household), many of which are marginalised.

The first two of these broad categories of actor logically now enjoy rights of access to resources that are well established, have good access to information, to markets and to technology and have substantial ways and means for action. However, their strategies and techniques may be in definite contradiction to the complex and multiple issues surrounding the dual need for water and food security. Food security is not only a global requirement, but also a local and regional requirement. Progress is therefore necessary to achieve better integration of the actions in these categories to achieve sustainable development.

The third major category, smallholders, does not in many cases yet enjoy, especially in the developing world, clearly established rights to resources and such easy access to modernity, and they may find themselves to be excluded from new modes of distribution (the "supermarket revolution"). They must therefore be supported in managing and using their water resources effectively and in gaining access to markets in order to: i) make their own indispensable contribution to increased global production (*availability*), ii) improve their living standards and access to food, given that three-quarters of the billion people suffering from hunger are peasant farmers, and iii) avoid being led by deteriorating resources and social, economic, commercial and cultural marginalisation to join massive migratory flows that generate unmanageable social and political instability.

3. UNEQUALLY DISTRIBUTED RESOURCES, DEMOGRAPHIC AND WATER-RELATED IMBALANCES AND GROWING REGIONAL INTERDEPENDENCE

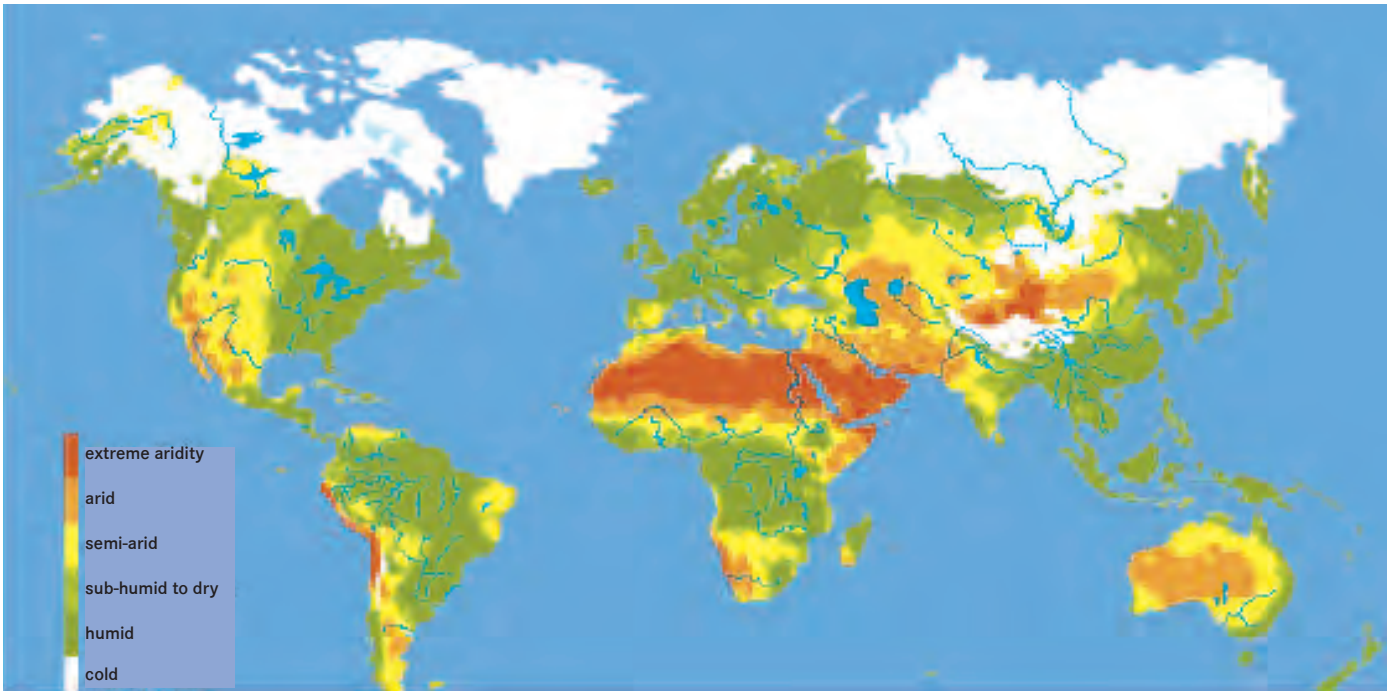
➔ The crucial issue of drylands; growing problems of water shortages

Water does not have the same value everywhere: it has strategic importance in *drylands (arid, semi-arid, sub-humid areas*) where water is a scarce resource, and therefore under intense competition with other uses, and it is the primary limiting factor for agricultural production. Arid and semi-arid areas account for 30% of the world's land area but receive only 2.5% of continental water, to which can be added an approximately equal amount of external input (this is notably the case for the Nile in Egypt). Irrigation has naturally received close attention here: indeed, it accounts for 89% of the total quantity of blue water (compared with 70% worldwide).

Water is also an issue of central importance in regions with a "*Mediterranean*" type climate, even those that do not fall into the "drylands" category. These are regions that suffer from "*water stress*" in the summer[6] and from rainfall that is often violent during the rest of the year, causing devastating floods. Major efforts to extract maximum value from water (irrigation and drainage, river overflow protection, earthworks on slopes, etc.) have had to be made over the long term both to reduce risk and to increase food production.

Arid and semi-arid areas (see Map 2) are to be found in the Middle East, Central Asia, Northern China, Australia, Northern and Southern Africa, as well as in the Americas (Mexico, Chile, the Mid-West of the United States and elsewhere).

Map 2: The world's drylands (arid, semi-arid, and sub-humid)

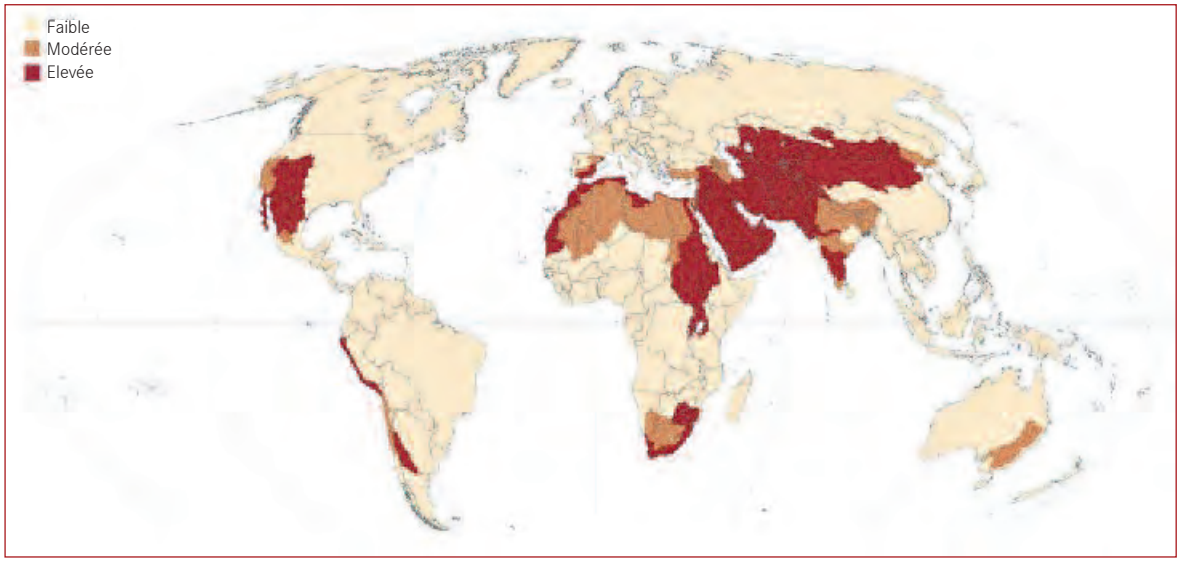


Source : CRU/UEA, UNEP/DEWA

The arid zones can be compared with Map 3 from FAO on the physical scarcity of water.

[6]. Which distinguishes them sharply from the areas in Sudan, where the rainy season coincides with the growing cycles

Map 3: Global distribution of physical scarcity of water in large river basins



Source : FAO; SOLAW report, 2011

The severe *water shortages found in several countries*, giving rise to high food dependency, can be compared with population growth. The population of arid and semi-arid areas in the 20th Century has grown almost twice as fast as that in humid areas. Their total population, which was 373 million in 1950, reached 1,187 million in 2000 and is projected to reach 1,792 million by 2025 (see Table 3).

Table 3 - Attempted estimation of populations and potential renewable water resources (internal + external) in countries and regions characterised as "arid" or "semi-arid"

Countries and regions arides et semi-arides or «semi-arid»	Population (Millions)			Water resources (km^3/year)	Per capita water resources (m^3/year)		
	1950	2000	2025		1950	2000	2025
Africa	81	268	417	430	5 283	1 603	1 031
Of which: North Africa	44	143	200	95	2 159	665	475
Asia	223	747	1 154	1 134	5 090	1 529	982
Of which: China	30	100	150	210	7 000	2 100	1 400
India	90	250	340	130	1 444	520	382
Middle East	40	181	308	249	6 194	1 379	809
North America and Canada	31	100	135	188	6 065	1 880	1 393
South America	17	46	57	246	14 471	5 348	4 316
Australia	0,25	0,6	0,7	40	160 000	66 667	57 143
Europe	21	30	27	406	3 269*	2 267*	2 519*
Total	**373**	**1 187**	**1 792**	**2 106**	**5 642**	**1 775**	**1 175**

(* = not including Russia and Ukraine). Source: Margat, 2011; unpublished

Potential average "internal" renewable resources per capita and per year in arid and semi-arid areas in 2050 are estimated at only 450 m^3/year /per capita/per year, which is below the "shortage" threshold (500 m^3)[7]. This compares with a comfortable average worldwide of 4,820 m^3. The global water problem is therefore not a problem of shortage of water, but rather its uneven distribution.

Looking now at the addition of potential renewable water resources, both "internal" and "external", per inhabitant, which is the figure that counts in dry zones, it becomes apparent that while the level was comfortably high in 1950 (5,600 m^3/year /per capita), it fell to 1,775 m^3 in 2000 and is likely to be no more than 1,175 m^3 in 2025. This is well below the "stress" threshold (1,700 m^3).

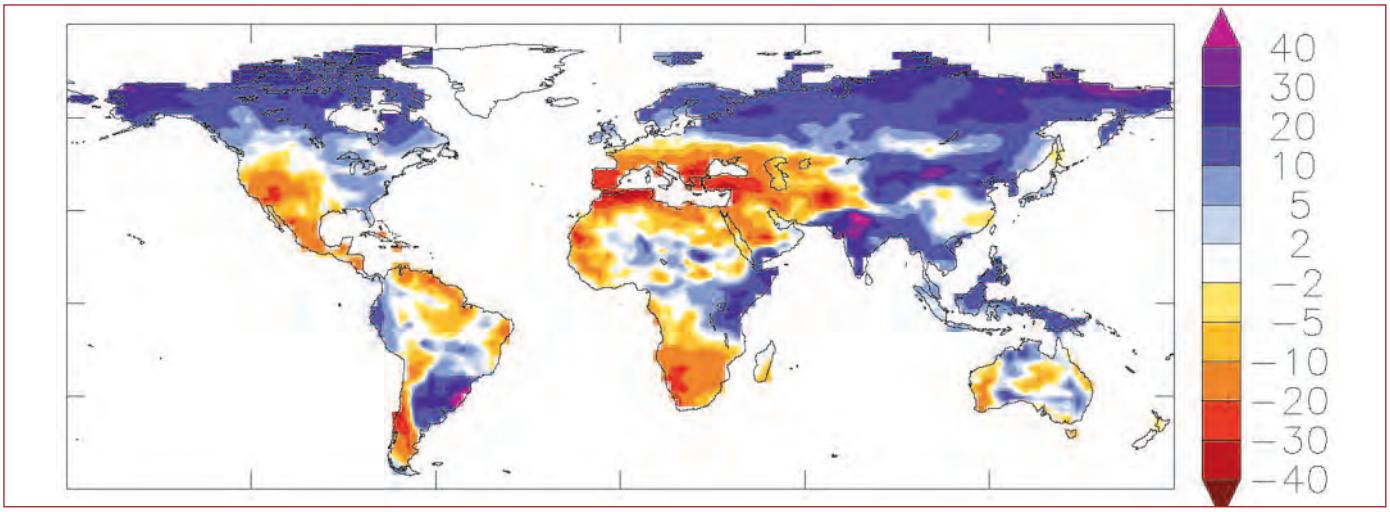
[7]. The three scarcity levels "water stress", "water poverty" and "water shortage" were defined by Falkenmark in 1997

Furthermore, the following must be emphasised:

1. **These overall figures are based on the optimistic assumption that resources will be kept at their present level**, which will very probably not be the case owing to the risk of increased water take-off by countries upstream and to the decline in precipitation announced by climate models. Map 4 shows that very many dryland areas will experience, with global warming, major falls in their water supply conditions, with flows reduced by up to 30% in the Maghreb by 2050 compared with 1950. Climate change will also lead to changes in the *agricultural geography* of the countries concerned, with a large portion of the land area moving from the *sub-humid* to the *semi-arid* category or losing its agricultural use completely since it will be suitable only for pastoralism.

Areas not currently in the "dry zone" category will also be affected, especially in Southern Europe, the sharp "Mediterraneanization" of which is likely to put the question of irrigation very much back on the agenda.

Map 4: The effects of climate change on water run-off (2041-2060 / 1900-1970)



Source: Global warming and water availability, P.C.D., Milly, United States geological survey (USGS)

2/ **These figures mask large differences between countries and their respective population dynamics.**

Table 3 shows in particular that the dry part of India and the Southern Mediterranean appear, according to demographic projections, to be two major "planetary hot spots" for the quantity of per capita renewable resources. The resources in those areas, both internal and external – 520 m^3 and 665 m^3 respectively in 2000 – are in fact likely be as low as 382 m^3 and 475 m^3 by 2025, figures which are significantly below the "poverty" or "relative shortage" threshold (1,000 m^3) and even below the "shortage" threshold which is sometimes labelled "absolute shortage" (500 m^3).[7] However, the situation in India appears less serious than that in the Southern Mediterranean and other vulnerable countries in Central Asia and the Middle East because these countries consist entirely of "dry zones" and their water resources will decline with global warming.

→ Expected major increases in regional food dependency and virtual water trading

The primary consequence of growing demographic and water-related imbalances in regions that have water or land shortages and high population growth (Asia, North Africa, Middle East) will be a *worsening in their food dependency* from imports. This would lead to a major expansion in global trade in food products, and trading in "*virtual water*".

The joint outlook analyses of the OECD and FAO (2020 horizon,) the work done by the FAO alone (horizon 2050), and the "*Scénarios Agrimonde*[viii]" defined by CIRAD and INRA - two French agricultural research institutes - explore possible developments in global food and agriculture. «Agrimonde» compare a normative sustainable development scenario (ecological intensification and changes in consumption patterns) with a "global orchestration" scenario by the Millennium Ecosystem Assessment, and seek to quantify the employment/resource balances in the major regions of the world over the period to 2050, expressed in terms of calories.[8]

The main conclusions are as follows (see Table 4):

- → MENA (Middle East & North Africa), Asia and Sub-Saharan Africa (which has land and water available, but is experiencing rapid population growth) are regions that should see a substantial worsening in their agricultural trade deficits, and therefore increases in their net imports of virtual water. The cumulative trade deficit for these three regions is estimated at 4,751 Gkcal/d, (gigakilocalories/day) in 2050 compared with 1,224 Gkcal/d in 2003 (the average for the two Agrimonde scenarios with their two variants), which is an increase of almost four times.

- → Europe, including Russia and Ukraine, and the Americas will for this reason need to provide for a major expansion in production. This is essential for the maintenance of regional and global stability. The different scenarios also show that regions suffering from food deficits must be able to finance their imports, the cost of which will rise with the expected increases in global food prices and imported quantities.

[8]. The assumptions applied in the "Agrimonde" scenarios for gains in crop yields in the various regions are consistent with those chosen for the recent strategic foresight analyses of FAO-OECD, IAASTD (International Assessment of Agricultural Science and Technology for Development), the MEA (Millennium Ecosystem Assessment) of IFPRI and M. Griffon.

Table 4 - Food resource/employment balances by major supra-national regions, in GKcal/d.
Situation in 2003 and "Agrimonde" scenarios to 2050 (averaged 4 scenarios)

Region as defined by Agrimonde	Resource/employment balance in 2003			Resource/employment balance in 2050
	Regional production	Regional employment	Regional balance	Regional balance 2050 (average of the 4 Agrimonde scenarios)
Middle East & North Africa	1 388	2 138	- 752	- 1 436
Sub-Saharan Africa	2 031	2 299	- 268	- 1 830
Asia	12 833	13 037	- 204	- 1 485
Former USSR	1 816	1 800	+ 17	+ 1 911
OECD 1990	10 674	10 106	+ 567	+ 2 172
Latin America	4 143	3 503	+ 639	+ 1 325

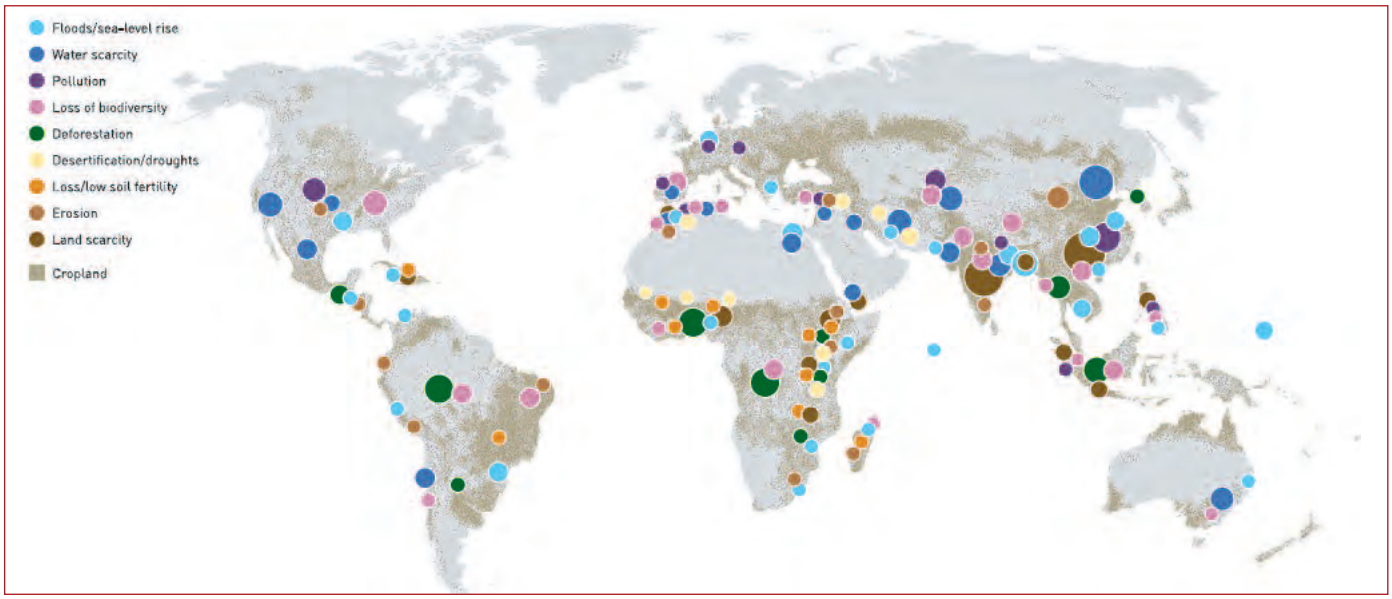
(Source : INRA and CIRAD, 2009

There is much at stake for Europe, which is located just 14 km from the coast of Africa. The EU and its neighbours need to rethink their growth models and the objectives of their agricultural, environmental, trade and cooperation policies. Avoidance of instability in the region will require development of the productive base of their agriculture (water and land), assuring sustainable supplies of grain, and organising partnerships for action and investment - and/or welcoming a much greater influx of migrants.

4. COVETED RESOURCES UNDER THREAT

Water resources for agriculture are both coveted and threatened by various factors. Map 5 shows the global distribution of the main risks facing agricultural production systems and their soil and water resources: water or land scarcity, desertification / drought, loss of soil fertility, erosion, pollution, flooding, deforestation and biodiversity loss. One can see those regions that are particularly affected by a combination of several risks - Southern and South East Asia, sub-Saharan Africa, Northern Africa and the Middle East.

Map 5: World Distribution of risks associated with agricultural production systems



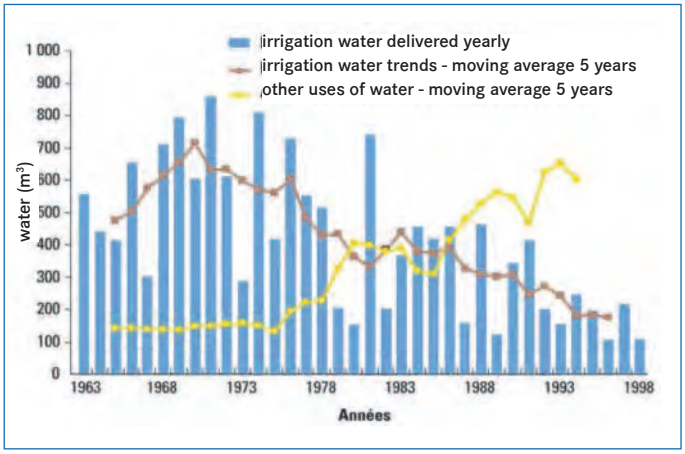
Source FAO, SOLAW report, 2011

→ Weaknesses of water rights for farmers, uncontrolled competition and the importance of "land grabbing"

We are living at a time of intensified, if not "unbridled", competition for water and land resources, which often has dramatic repercussions for local food security.

In areas where water and land are scarce but needs are increasing, such competition, which is naturally intense, generally works to the detriment of aquatic environments and water resources as such. It also puts pressure on agricultural environments, often at the expense of traditional systems of production with high social and heritage value. Traditional oases and many wetland areas thus fall victim to agricultural, urban or tourism projects. As for the volumes of water allocated to irrigation, these have diminished sharply in numerous catchment areas owing to growing competition from other users (households, industry, tourism, energy). This is true of Zanghe in China for example since 1975 (cf. Figure 3).

Figure 3 : Competition for water resources at the expense of agriculture : the example of Zanghe (China)



Source: Molden, unpublished

Competition for resources also affects countries that are under-developed but whose potential in terms of natural resources (land and water) is attractive to countries, and large companies, that are money-rich but resource-poor. Foreign investment continues to be generally low and inadequate in the agricultural sector; its effects on the ground can differ greatly from case to case. And in certain cases, such investment does not necessarily improve local food security. It has been demonstrated that the "land grabbing" phenomenon[9], which has recently expanded substantially in Africa (reaching 20 million hectares over the last three years) can impact the local population without improving local food or energy security in any way, and this despite the tragic need for investment on the African continent[ix]. Typically, under such investments:

- The production is usually for export exclusively (to the investor country) and sometimes for non-food products (biofuels, fibres)[10],
- The investment may have the effect of displacing local populations living off resources on marginal land, which may then lead to overgrazing and impoverishment or to situations of conflict around land and water use,
- The jobs created are poorly paid and sometimes few in number.

The joint report of the ILC (International Land Coalition), CIRAD (International Cooperation Centre for Agricultural Research and Development) and IIED (International Institute for Environment and Development) of December 2011 has confirmed that large-scale land transactions, while they can create opportunities, are, under current conditions, most likely to cause problems for poor rural communities, threatening their rights and livelihoods.

The overall situation at the present time is therefore as follows:

- Inadequate recognition of property rights or usage rights (land, water, grazing areas) for local populations; inadequate rules for governing agricultural investment; lack of public policies to support the development of smallholder agriculture,
- Growing pressure on the use of agricultural land and the rights of access to water for smallholder farmers and livestock rearers in competition with other users of water and land who are politically better represented and economically more powerful,
- A need for better control of investment through rules that promote "*development*", as was the case fifty or so years ago for smallholder farmers in Europe and more recently in many emerging countries in Asia. That is to say, rules that facilitate the transition of smallholders and smallholder groups into entrepreneurs to allow a country to enter the modern era, to consolidate its food security, to enlarge its domestic market and to succeed in its rural and industrial development and so "climb the economic ladder".

➔ Water erosion and the degradation of agro-ecosystems

Poor "conservation" of water and soil and diminishing soil fertility are serious problems in several of the world's important agricultural regions.

Erosion, largely caused by water, affects more than 1.1 billion hectares of land. It is the cause of annual losses of arable land of between 2 and 5 million hectares, resulting in yield and production losses of 12% to 27%[xi]. Erosion is also a major factor in desertification, a phenomenon affecting drylands areas and directly concerns 70% of land areas and over 1.5 billion people worldwide.

FAO's SOLAW report of 2011 divided land into four categories. Highly-degraded lands, or lands with a strong tendency towards degradation, account for 25% of the total land area. The regions hardest hit by erosion are Sub-Saharan Africa and the Middle East & North Africa, but South and East Asia are also affected. For example, in China, 30% of the land is affected with a 12% relative reduction in yields. In India, 43% of arable land is suffering from "severe damage" and 5% has become unusable.

A number of factors may contribute to this, notable among them are:

- Overgrazing and the "mining" of natural resources (soil, pasture, forest). Putting land that is normally used for pasture under crops contributes indirectly to overgrazing by moving livestock farmers back into marginal areas. Accelerating the speed at which land is brought back under crops in itinerant agricultural systems, to cope with population growth, also has catastrophic consequences for the status of natural resources.
- Lagging rural development, along with poverty and the failure to recognise or clarify social land uses and rights of access to resources (water, pasture, forests) and the duties that should be associated with them, can lead to the arrival of new and powerful actors on the scene to take advantage of the situation in order to "grab" resources unduly for over-intensive exploitation.
- Agricultural practises that do not permit proper conservation of water and soil, for example, the use of inappropriate mechanisation, the inadequacy of small-scale units for conservation of water and soils and the absence of nitrogen-fixing plants.

The result of this is worsening social inequality and major losses of the services rendered by agro-sylvo-pastoral ecosystems: declining food and energy (wood) production, rapid silting up of reservoirs and increased risks of flood. Grazing land in the Maghreb has, for example, lost 90% of its productivity in the space of a century.

➔ Weakening of irrigated systems

Numerous irrigated systems, especially the collective networks set up during the 20th century, are faced today with a number of threats that may call their "sustainability" into question, these being:

- *Difficulty in adapting these systems to changing needs and techniques*, which requires a major effort to modernise them, the funding of which may be problematic,
- *Network deterioration* resulting from lack of upkeep due notably to lack of adequate resources for maintenance and operating expenses, and insufficient collection of user fees, thus leading to major network leakage (40%),
- *The silting up of reservoirs*, reducing water resource availability for irrigation,
- *Excessive take-off from aquifers* leading not only to a fall in the level of the water table[11] but also to greater risk of *salinization*,
- Water table pollution,
- *Lower allocation of water to agriculture* and *changes in land use* (urbanization).

A large part of the reason for these developments stems from weak agricultural policies and the difficulty of repositioning the role of the State in relation to farmers, rural communities and other stakeholders.

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[9]. It would also be possible to refer not only to "land" grabbing but also to "water" grabbing, with investors seeking out land with abundant rainfall and/or access to irrigation water

[10]. Of the 71 million hectares of transactions that the authors of the study ILC, IIED, CIRAD have referenced in December 2011, 78% were for agricultural production with ¾ related to biofuels

[11]. The piezometric level is the level of free water observed in a well or borehole compared with a reference level

Large "modern" irrigated systems were often conceived for centrally-controlled economies in which the authorities played a major role both in water management and in the choice of what was produced and marketed. Today that model is largely obsolete as a result of the liberalisation of land use and the emergence of global supply chains, the privatisation of factories and the withdrawal of the State. In this new context, *irrigation networks, frequently deteriorated*, no longer meet the needs of farmers. Local, unconventional initiatives have emerged to respond to such problems (development of individual pumping systems - often uncontrolled, drip irrigation based on second-hand, inefficient equipment, and so on). These initiatives, which ignore the strict rules of network management, have often been conducted with the tacit, or even formal, approval of the authorities, to keep the agricultural sector happy at little cost. This radical change in the situation, described as a "*groundwater revolution*" or the "*groundwater economy*" is "generalised and without precedent in the history of irrigation"[i]. Individual irrigation, which has become the most widespread solution in France and is extensively used in the Maghreb, now accounts for half of all irrigated land area in South Asia[xii]. Development of individual irrigation systems, private and informal, has thus become the norm in many countries. In Ghana, for example, it is thought that this type of irrigation - facilitated by the development of motorized pumps - covers 120,000 ha, while official statistics show only 30,000 ha of irrigated crops.

New and positive agricultural dynamics have thus been set in train, but at a cost. The chaotic spread of motorised pumps, the absence of effective collective rules and, in many countries, subsidies for gas, oil or electricity consumption, have led to *serious overexploitation of the resource*. The level of this overexploitation is estimated to be 150 km^3/year worldwide for renewable resources. This figure is substantial for the regions concerned, to which we can add the exploitation of fossil water through deep drilling, estimated at 30 km^3 of water a year, reserves which will inevitably diminish as they are exhausted.

Overexploitation affects many aquifers that are important for food security. The regions and countries particularly hard hit by overexploitation of renewable resources are notably India (overexploitation estimated at 50 km^3 by some experts), China (30 km^3/year), the United States (Arizona, California's central valley, High Plain-Ogallala aquifer), Iran (16 km^3/year), Mexico (13.9 km^3/year), Spain (3.9 km^3/year) and other Mediterranean countries and regions: Libya, Portugal, Morocco, Jordan, Israel, Tunisia, Algeria, the Palestinian Territories, Cyprus and Malta[xiii]. If there is no change in the near future in this scenario across the various hot spots, there could be major losses of investment, generating situations without viable social or economic solutions in several highly populated regions with a danger of mass migration and conflict.

Aquifers can also be polluted by nitrates and plant protection products. This issue is one for countries practising highly intensive rail-fed agriculture, such as England, Germany and the Netherlands, along with Denmark, Egypt and China. In France, in 2002, of 1,048 sites inspected for nitrate levels in subterranean water, 62% showed levels above 10 mg/litre. However, only 10% indicated water unsuitable for drinking and requiring treatment (50 to 100 mg/l) and 1% indicated water unsuitable for drinking (levels in excess of 100 mg/l)[xiv].

The salinization of soil and water, due most notably to inadequate drainage, is another factor of deterioration that is causing concern. It affects approximately 400 million hectares of land worldwide[xv]. Countries such as Iraq or Syria are particularly hard hit by this: over 50% of irrigated land on the plains of the Euphrates is affected[xvi]. In the case of Iraq alone, the area is estimated at 8.5 million hectares, or 64% of all its arable land; between 20% and 30% of irrigated land has even had to be abandoned[xvii]. The overexploitation of coastal water tables also contributes to the phenomenon. For example, in Northern China in the 1990s, the area affected by intrusion of seawater due to overexploitation covered 1,430 km[xviii]. The coastal aquifer system of the Gulf of Guinea, covering a dozen countries, is also affected.

The silting up of reservoirs due to water erosion (see above) is one more factor endangering the future of irrigated agriculture in several countries where irrigation is vitally important. Current average losses represent 1% at global level. However, the rates of sedimentation vary: 1.6% in Tunisia, 2-3% in the Mediterranean catchment areas of Algeria and Morocco, over 2% in China and 2-4% in some Spanish reservoirs. It is usually in locations where a dam is most necessary, in arid and semi-arid areas, that they are most under threat from sedimentation. In the countries where the threat is worst, 10-20% of the initial capacity of established reservoirs has been lost, and at the current rate of silting, many such reservoirs will have ceased to exist before the end of the century. This will be the case notably in the Southern and Eastern areas of the Mediterranean despite the fact that there are no other sites available[12]. Without a change in scenario, irregular surface water resources, especially in arid and semi-arid areas, must be considered in large part as resources that are "non-renewable in practice"[xix].

The urbanization of high quality productive land for irrigated or rain-fed farming is, finally, another very serious factor in the loss of productive capital. The average loss of land (and agricultural water) due to urbanization over the period 1995-2002 has been estimated at 1.6 million hectares/year[13]. This affects land that is of much higher quality than that taken from forests or pastures to be put under crops. Urban development renders the soil impermeable, reducing water infiltration and increasing flood risk. Urbanization is extensive in developed countries (Western Europe, United States and elsewhere) despite the fact that their population growth is low. For example, in France, loss of farm land to urbanization is estimated at 65,000 hectares/year[xx]. Developing and emerging countries are also affected by the phenomenon: in Vietnam, for example, the area covered by paddy fields is reported to have fallen from 4.47 million ha in 2000 to 4.11 million ha in 2010, a loss of 380,000 hectares in 10 years due to urbanization through the building of infrastructures and industrial parks.

The loss of rain-fed and irrigated crop land is one of the factors in the massive shrinkage of the cultivated area since 1960 in Europe (25%) and North America (4%), losses which should be compared with the expansion of land under cultivation in South America (83%), Africa (46%) and Asia (36%), which is one of the causes of global deforestation. Over the last ten years, deforestation has continued at a rate of 13 million hectares of forest every year; a total of 40 million hectares of primary forest has now been lost. The net loss of forested land, 7.3 million hectares a year over the period 2000-2005, compared with 8.9 million from 1990 to 2000, has nevertheless been mitigated by the natural expansion of forests and plantings[xxi]. Loss of farm land and forests are also a major cause of global warming. They accounted for 20% of all carbon emissions during the years 1989-1998[xxii].

[12]. With the notable exception of the Aswan Dam, which has a life expectancy of 2100 years
[13]. Or the disappearance every 8.5 years of an area of agricultural land equal to the size of a French department

→ Droughts, floods, heat waves and climate change

Recurrent droughts have in recent years have hit several areas of major importance for food security (e.g. Australia, Argentina). Drought is also the most widespread of the causes of food shortages in developing countries.

Floods have also seriously affected important agricultural countries (Burma, Bangladesh, Pakistan and Thailand, for example). And grain production in Russia was reduced by a heat wave in 2010.

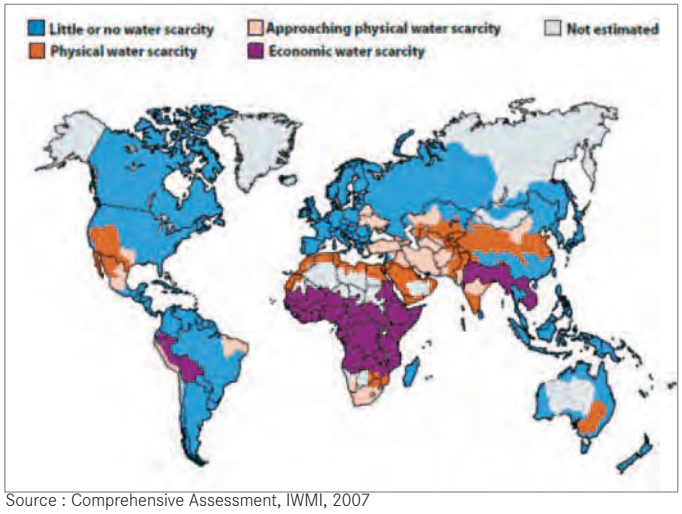
Climate change will amplify extreme climate events, affecting ecosystems, agricultural production and rural societies. The FAO has warned of particular risks facing Asia (Himalayan snow and ice, important sources of agricultural water in Asia, could decline by 20% by 2030) and agriculture in Africa, where climate change, over the period to 2080, will probably "have the following consequences: 75% of the African population could be exposed to famine and 75 million hectares suitable for rain-fed agriculture could disappear in Sub-Saharan Africa". River deltas of great agricultural importance (the Nile, the Ganges, and the Mekong, for example) will also be directly affected, as will dry zones (see above).

→ Under-utilization and waste

Although water resources are often overexploited, they are also often underutilized or wasted.

Map 6 shows that water scarcity is a "physical" problem in North Africa (exploitation of more than 75% of surface water resources) and an "economic" problem in West, Central and Eastern Africa: major water resources are present but access is limited owing to insufficient social, financial and institutional capital. Globally, the FAO considers that only half the total potential for irrigation in developing countries (402 million hectares) is currently being used.

Map 6: Areas of physical and economic water scarcity worldwide



Source : Comprehensive Assessment, IWMI, 2007

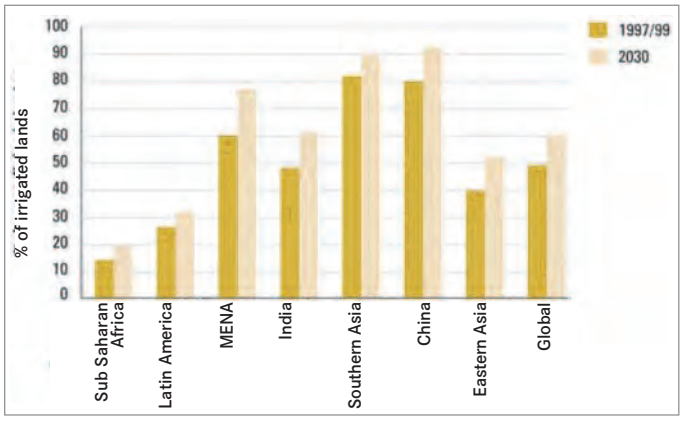
Figure 4 confirms that the potential for water resource development in **Sub-Saharan Africa** is very substantially underexploited compared with other world regions:

→Only 7 million hectares are irrigated out of a total of 183 million hectares that are cultivated, i.e. less than 20% of the potential irrigated area and a ratio of irrigated to farmed land of 4%, compared with 20% worldwide and 38% in Asia.

→Water take-off for agriculture represents less than 2% of total renewable resources.

→Only 4 million hectares of new irrigated areas were created in 40 years compared with 25 million in China and 32 million in India. This is a trend that is in danger of persisting (FAO 2008). In fact the target set by NEPAD for 2015, i.e. a 60% expansion in land equipped with irrigation systems (compared with 7 million hectares in 2002) seems to be a very long way from being achieved. In addition, many irrigated soils were rendered unproductive by salinization owing to lack of sufficient drainage.

Figure 4: Percentage of irrigated area compared with irrigation potential in developing countries



Source FAO, 2004

Such underutilization may also relate to other countries, including those that are water-poor.

To this situation of underutilization, the following must also be added:

→*The quantities of water lost during transportation in the various user sectors (agriculture, cities, industries) are high even in countries that are short of water, due to lack of effective and prudent management*[14].

→*Losses in the food supply chain from "farm to fork"* are also high. They are estimated at 1.3 billion tonnes, or 30% of all food production. In developing countries, these losses are essentially in the field -losses due to inadequate storage and transport equipment and infrastructures, whereas in the industrialised world such losses, the level of which is generally comparable to that of developing countries, are largely due to waste at the end of the supply chain - in the retail distribution sector and in consumer households. Each year, industrialized countries waste between 95 kg and 115 kg of food per capita, a figure more or less equal to net food production across the whole of Sub-Saharan Africa[xxiii] (FAO, 2011).

To the above large volumes of water that could be recovered and mobilised, the following may be added:

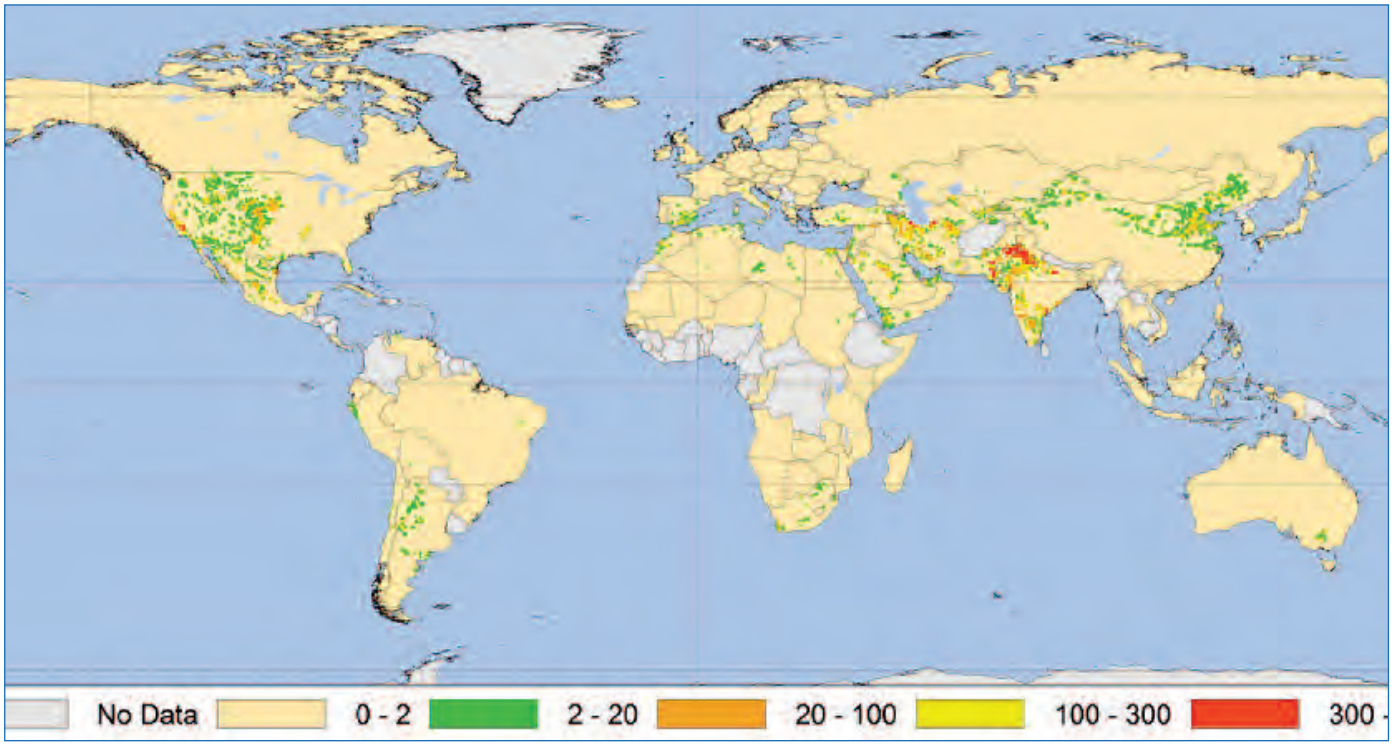
→*The substantial productivity gains that could be achieved* ("more crop per drop") in irrigated and in rain-fed agriculture.

[14]. For example, the Blue Plan (UNEP Regional Activity Centre / Mediterranean Action Plan) has assessed at 34 km3 the total volume of water in the Mediterranean catchment areas of countries in the Southern and Eastern Mediterranean (from Morocco to Turkey) that could be collected with better management.

→ *The production of "unconventional" water by using desalination and reusing grey water and drainage water.* Studies show that this type of resource can be substantial at the local level, especially in very water-poor countries, but that in the main the quantities involved will continue to be limited, including in those countries[15].

→ The possibilities for storage in aquifers, the *artificial recharging of aquifers* by infiltration of water from dams used to regulate river overflow, may allow part of the irregular volumes of surface water to be converted into regular volumes of water in aquifers[16].

Map 7: Nonrenewable groundwater abstraction for irrigation for the year 2000 (106 m3 yr-1)



Source : Nonsustainable groundwater sustaining irrigation : A global assessment - Yoshihide Wada et al. - 2012

[15]. The production of water by desalination in the Mediterranean area, which is at high levels in some countries (Malta, Cyprus, Israel, Algeria, Spain, for example) could stand at 30 to 40 Mm3/d by 2030, or between 11 and 14 km3/year, which represents no more in fact than 3-4% of total demand for water as projected to that horizon.

[16]. Tunisia for example plans to increase such transfers based on the artificial recharging of aquifers from 65 million cubic metres in 1996 to 200 million in 2030

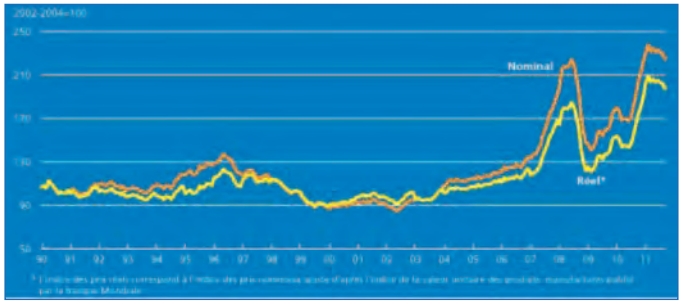
5. DANGERS OF CASCADING SOCIAL AND POLITICAL INSTABILITY

→ The 2007-2008 food crisis : an early warning notice

The 2007-2008 food crisis led to "*food riots*", which were in actual fact riots protesting the rising cost of living, in 37 countries. This crisis is considered by numerous experts as being structural in character, since both financial speculation in the markets (fuelled by the increased financial operation in the derivatives markets) and export restrictions amplified this situation.

The imbalance between supply and demand that led to a sharp reduction in stocks and a sharp rise in food prices (Figure 5) had a number of causes.

Figure 5: FAO food price index 1990-2011



Source : FAO

On the *demand* side, population growth, urbanisation and improved standards of living in emerging countries (rising consumption of meat and dairy products leading to rising grain consumption) have generated a very sharp increase in demand for agricultural products. However, the production of first-generation biofuels is also partly to blame for the crisis. Indeed, the demand for biofuels in 2008 came on top of a situation of bad weather and low stocks of agricultural products. Expansion of ethanol production from maize in the United States[17] impacted grain prices while the development of biodiesel production from rapeseed in Europe impacted those for vegetable oils.

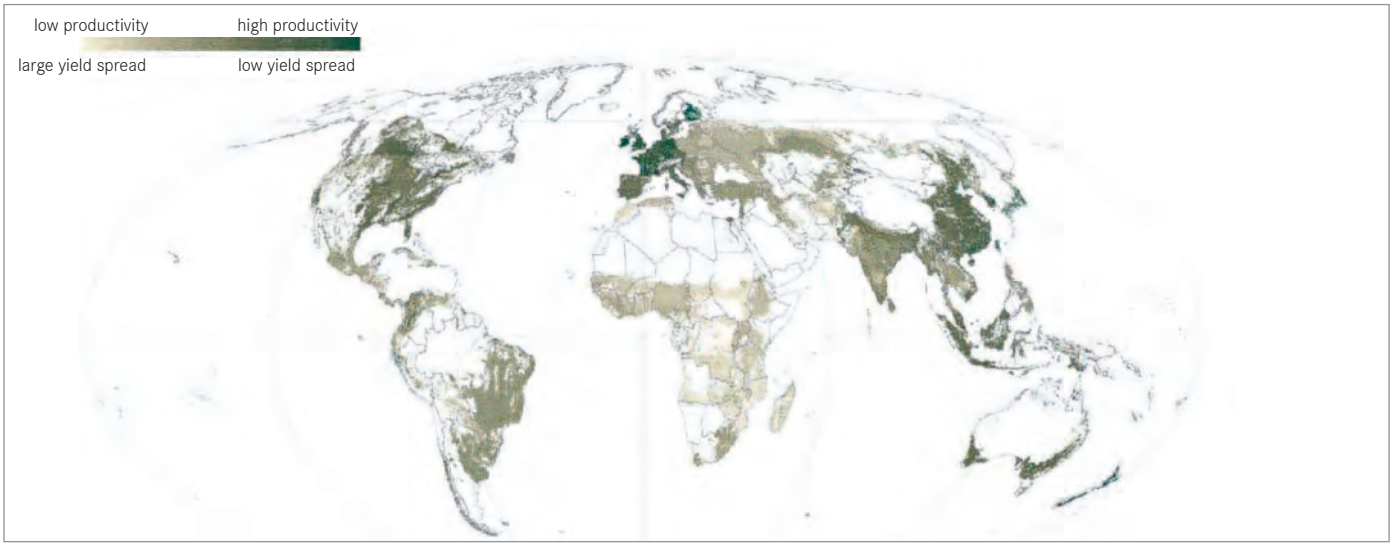
On the *supply* side, the difficulties of production in responding to growing demand can be explained by the following:

→ *Reduced priority for agriculture in public policies and public opinion* polarised by urban attitudes,

→ *The low productivity of a large part of world agriculture* with average grain yields still at extremely low levels in Sub-Saharan Africa (13 quintals of wheat per hectare). Several causes contribute to this, including the sharp decline in public support for agriculture, of which the cut in official development aid for agriculture provides an illustration. Water and land resources were therefore not mobilised, managed or used effectively. Map 8 shows the considerable differences in yields that can be seen for major crops,

→ *A slow-down in the increase in grain yields since the 1980s in the major countries using modern agricultural methods* (i.e. Europe, United States, etc.), which may stem from a number of causes: imposition of additional environment-related regulatory constraints, decoupling of support from production, climate change, biological limits, etc.

Map 8: Yield spreads for a set of arable crops



Source : HASA/FAO, 2010

[17]. 8 million hectares of maize out of a total of 35 million in 2007-2008

→Losses in resources and production resulting from:

- urban sprawl (loss of land and water for irrigated and rain-fed agriculture) affecting industrialised countries in particular,
- erosion and desertification affecting a large part of Africa and Asia, as already pointed out,
- the exhaustion of water resources (Asia, Mediterranean, United States) or declining allocations to agricultural production (Asia, Mediterranean),
- drought and flooding (Asia, Africa, Australia, etc.).

While the imbalance between supply and demand for food products triggered the rise in prices, this was also impacted by the increasingly important link between the prices for agricultural commodities and the prices of energy and inputs, which are themselves driven by a structural upward trend.

This means that:

→The 2007-2008 crisis demonstrates that, following several decades of surplus worldwide, *there is no longer a structural excess of supply over demand*. This crisis should therefore be understood as a "*wake up call*", that is to say as a symptom of a structural problem of concern for the long term. Indeed this subject has been addressed by the major international organisations and the G20, which put agriculture on its agenda for the first time in 2011, and adopted an "Action Plan on Food Price Volatility and Agriculture",

→The "*water factor*" in all its various aspects – inadequate irrigation and wastage of water, low productivity per cubic metre of water mobilised, poor techniques for the conservation of water for rain-fed agriculture and water erosion, droughts, floods, loss of land and water to urban sprawl, overexploitation of aquifers, etc. – has a major share of responsibility, direct or indirect, in the new imbalance between supply and demand now being observed.

→ Serious consequences for households and vulnerable countries

One of the specific features of agriculture is its potential for high price volatility, aggravated by the absence of market regulation mechanisms. We know that a 20% smaller harvest leads to an 80% increase in prices (ref. King-Davenant law dating from the early 19th Century on the impact of lack of supply of wheat on the price for wheat). The OECD-FAO outlook shows that by 2020 a fall of 5% in yields of wheat or rice worldwide would trigger price increases of the order of 25% for those products.

The slightest imbalance between supply and demand can therefore trigger substantial movements in relative prices. Movements in food prices should also be seen in relation to movements in oil prices, which are trending structurally upwards, the two now being strongly correlated.

For poor and middle-income households, and for importing countries, the consequences can be dramatic. Food can absorb over 50% of household expenditure in developing countries. Thus a food crisis can result in:

→A major deterioration in family budgets, aggravating poverty and malnutrition, especially for subsistence farmers in low-income countries producing less than their families consume. The number of undernourished people has grown by 150 million in the space of two years,

→"*Food riots*", especially in cities, and increased migratory flows.

For the governments of vulnerable countries that are water-poor and therefore food importers, the situation may become difficult to manage. With rocketing price, the cost of subsidies for basic commodities (energy, grains, sugar, oil, etc.) - which are justified to help maintain social stability – could take up as much as 5% of GDP and exceed public investment budgets.

The paradox here is that such subsidy policies for basic commodities:

→frequently benefit the richest (who consume more) more than the poorest,
→may include subsidies for imports to the detriment of local production,
→can encourage overexploitation of water resources: e.g. electricity and gas subsidies.

Other social safety net policies that are much better targeted, and include sustainable development goals (local production, fairness, resource sustainability), must therefore be promoted.

The issue of subsidies and their impact on natural resources and society is an international concern which may involve many a country and household, more or less vulnerable. The FAO states that the first thing to do to manage land and water more efficiently is to eliminate the distortions which encourage the degradation of resources, such as energy subsidies that keep on inefficient agricultures with high energy consumptions or excessive exploitation of groundwater "(FAO, 2011).

→ New needs to be met by 2050

Recent planning, projections and foresight analyses give the order of magnitude of the new needs to be satisfied worldwide by 2050, and thus the level of the overall challenge facing agriculture.

The primary need will naturally be food. The FAO says that a *70% expansion in global food supply by 2050* is necessary. Other figures can be cited. They may be lower where the scenarios include an assumption of a change in dietary patterns in the rich countries, but they may also be higher with some experts saying that food production must at least double.

To overcome this challenge will require an increase in the efficiency of agricultural production systems and an expansion both in the land area under crops and in international trade flows.

The increase in supply will come largely from growth in yields (around 90% according to the FAO) even if the pace of yield increases is slowing down. In fact, average growth in crop yields, which was *1.86%/year over the period 1980-2000, could fall to 1%/year over the period 2000-2050 (Hubert, 2010)* [xxiv], or even to 0.87% by 2030 and to 0.5% between 2030 and 2050 (UNEP, 2009)[xxv]. The greatest uncertainty relates to Sub-Saharan Africa. While this region has major potential for agricultural progress it will be hit hard by climate change, as indeed will all developing countries. The potential for agricultural production in these countries might well decline by between 9% and 21% by 2080, whereas it will generally be maintained in the industrialised world[xxvi].

The development of irrigation will make its own contribution to increased yields. For the FAO, the total land area under irrigation could expand by 17 million hectares (6%) from 2009 to 2050. This moderate increase would be entirely in the developing countries. Because of only slow improvements in the efficiency of water use and a shrinking of the area under rice, the take-off of water for irrigation is likely to increase by no more than 10% to reach 3,000 km3/year by 2050. In spite of this limited expansion, irrigation will play an increasingly strategic role, with important developments in supplemental irrigation and pressurized irrigation systems on private farms (FAO SOLAW, 2011).

Greater expansion in irrigated areas cannot be ruled out. For while the expansion of irrigation has come up against growing resistance to developing new water storage infrastructures in recent decades –seen as expensive and disruptive to aquatic ecosystems, social demand for irrigation could increase significantly in regions where climate change will alter the potential of agriculture, which will be the case in Europe. Most of the investment in irrigation worldwide will most likely be devoted to upgrading and modernisation ageing irrigation equipment rather than building new systems.

Increased yields will however not be enough to feed the expected population of 9 billion people. Extra land will need to be put under crops (and therefore taken out of pasture and forest). This has been estimated at 120 million hectares (12%) by the FAO for developing 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. However, this figure, as well as that for yield increases, does not take into account losses from erosion and urbanization - which will need to be offset, nor the expansion that will be required to meet new non-food demand.

A recent overview of the available projections[xxvii] shows that the land to be put under crops by 2050 might in fact total between 301 million and 1,049 million hectares, a figure that breaks down as follows:

- compensation for losses due to urbanization: 72 million hectares assuming that this is also productive land),
- compensation for losses due to erosion: between 90 and 225 million hectares,
- expansion for food production: between 71 and 300 million hectares,
- expansion for the production of biofuels: between 48 and 313 million hectares,
- expansion for the production of bio-materials: between 20 and 139 million hectares.

Any change in land use on this scale is in danger of exceeding the limits necessary to maintain broad planetary balances (climate, biodiversity, water cycle, etc.). Thus, a recent study[xxviii] considers that the extension of the cultivated area should not exceed 400 million hectares. And of we include urban sprawl and the expected increase of 250 million hectares in farm land taken by urban development by 2050[xxix], the actual amount could happen to be much lower.

Faced with these challenges, *better management and "control" of water* is an unavoidable necessity. Indeed, it is clear that:

- The world will gain if it makes the choice of a more sustainable pattern of development. Such action would help to conserve the productive base of agriculture, improve productivity and reduce all the forms of loss and misuse: loss of resources and production due to poor productivity, erosion, desertification, and urbanization, along with wastage in transport, in the field and throughout the food supply chain up to and including consumers themselves. Everything that can be gained in this way through reductions in losses and/or enhanced efficiency will mean that much less land to be out of forests and pasture,

- Faced with climate change, the risk of growing price volatility and increasing risks of water and food insecurity, the strengthening of water storage capacity will also need to be envisaged – *on the surface, in the soils and in the aquifers*. Water storage should be given the same priority as grain storage and financial market regulation, as a means for "risk management".

→ The risks of a catastrophic "cascading instability" scenario

Both retrospective and foresight analyses clearly show that there is a possibility of a "black scenario" involving a cascading series of different forms of instability.

A scenario of this kind would happen if the international community and the various stakeholders failed to take the steps required for a successful transition to a new paradigm of development.

In the absence of adequate policies, finance or support (e.g. agricultural research and extension, access to credit, subsidies), as well as institutions and processes conducive to the professionalization and restructuring of smallholder agriculture and the promotion of sustainable intensification, agricultural and rural/regional development in Sub-Saharan Africa and other regions would continue to be very insufficient. In parallel, it is likely that poorly-controlled private foreign investment ("land grabbing") would be encouraged by rising prices and the anxieties of countries that are money-rich but resource-poor. Such investment, ignoring as it usually does the food security imperatives of the target countries and regions, would bring very little benefit to Africa, whose food insecurity would be made worse. This scenario might also include the continuation of speculative activities in the markets and inappropriate responses such as export restrictions or a broadening of free trade agreements to include agriculture between countries that are highly unequal in terms of their levels of development and the competitiveness of their agricultural systems, and taking insufficient account of what is required for a successful transition. These factors can in fact be a factor conducive to the pauperisation of low-productivity peasant farming communities and loss of production and food security for vulnerable countries, as well as being a source of massive illegal emigration.

Under this scenario, in industrialised countries with abundant resources, city-dwellers, now the great majority, would continue to under-estimate their dependence on the rural world, the importance of irrigation, and the necessity of interdependence and solidarity worldwide. The waste of vital resources, land and water, due to the urbanization of land (or by the running down of irrigation systems) would continue, to the detriment of agricultural production, thus directly and indirectly worsening global food insecurity, deforestation in tropical zones and deterioration of the climate.

Numerous countries and/or regions and "hot spots" would be hit by shortages and degradation of their natural resource base and ecosystems. Most affected would be large parts of Asia, the drylands (arid or semi-arid) and countries with fast-growing populations. They are likely to see a sharp worsening in their situation owing to water shortages, droughts and damage to soil and vegetation, plus uncontrolled emigration. Rising world prices would place their public finances and household budgets under severe pressure. New food riots could result, and in the countries and regions hardest hit by drought, massive emigration, and consequently cascading urban and political instability, would have repercussions for neighbouring regions, countries and continents.

6. THE NEED FOR A NEW AGRICULTURAL PARADIGM

→ The paradigm of agricultural progress under renewed questioning

Throughout the second half of the 20th century, agriculture has made a great deal of progress in order to feed fast-growing populations at low cost. The *first green revolution* was decisive in terms of the development of irrigation systems, chemical inputs, genetic improvements and energy. However, this progress has left many producers by the wayside and the social situation in agriculture is frequently catastrophic (child labour, poverty, illiteracy, disease, suicide, and so on).

The "modern" food supply system is under renewed scrutiny with regard to its "sustainability", especially regarding its impact on climate change. If one takes into account carbon from production, transport and packaging, changes in land use, poor energy efficiency (it takes 5 to 10 calories to produce one calorie that reaches our plate) and its consequences for natural resources, for ecosystems, for biodiversity and for health (e.g. obesity, certain illnesses), then the carbon footprint of the food system is considerable.

As for the agricultural intensification model of recent decades, this has been questioned for the following reasons[xxx xxxi]:

- → Natural resources are increasingly scarce and the cost of farm inputs (water, energy and mineral fertilisers, the cost of which is based essentially on expenditure on energy) is rising.

- → The search for new crop protection products to counter pests and diseases in the major field crops requires very high levels of investment over long periods of time. Under pressure from consumers and environmental associations, official approval procedures are likely to become increasingly stringent. At the same time, there is a greater risk of new forms of genetic resistance emerging.

- → The growing concentration of seed companies as a result of globalisation and the financial requirements necessary for research. The growing importance of return on capital is leading these companies to concentrate on a limited number of species offering a wide area of potential distribution. Marketing regulations could become stricter and more complex.

- → Rising yields have been accompanied by a decline in soil fertility[18]. This point is however contested.

- → Intense utilization of mineral nutrients has led to an annual NPK deficit. Of the 562 million hectares under wheat, rice, maize or barley worldwide in 2000, the NPK deficit has been estimated at 20 Tg (tetragrams), equivalent to a cost of $80 billion. This deficit is considered by some experts to be the main challenge facing the planet's future food security, especially in the light of the progressive exhaustion of deposits of mineral phosphate and potash.

- → Soil deterioration and urbanisation are affecting crop land that is often of high quality, whereas the expansion of farmland into forests, savanna and grazing areas will affect marginal land or land producing useful nutrients e.g. for the production of animal manure. This brings with it costs and risks at global level that are not insignificant (impacts on biodiversity, climate change, water cycle, etc.). To continue down this road would lead to a costly scenario and a risk of major deforestation.

"Integrated" agricultural systems need to be promoted, especially "*precision agriculture*". These provide enhanced efficiency in the use of external inputs, water in particular through fine-tuned, automated irrigation systems. Agriculture must also be able to benefit from plants selected for their drought tolerance.

Nevertheless, progress of this kind will not be enough and there is a risk that it will be of very unequal benefit to the world's farmers, without providing an adequate response to problems of "sustainability". For these reasons, many international experts, institutions and strategic foresight reports (IIASTD, FAO, UNEP, CIRAD, etc.) call for a *change in agricultural paradigm*. Specifically, their analyses point to the necessity of moving towards a "*doubly green*" revolution, meaning a shift to "*ecologically intensive*" agriculture (the terms "*agro-ecology*" and "*conservation*" agriculture are also used; cf. definitions). The aim of this form of intensification, which is more accessible to smallholder farmers than is precision agriculture, is to conserve water and soils more effectively, to restore fertility, to manage resources sustainably and to add value to the diversity of natural and farmed environments in order to enhance the productive potential and the resilience of agro-ecological systems. A report from UNDP/IWMI[xxxii] in August 2011 demonstrates this point, with examples, that the combination productivity/ecosystems is the only way to feed the planet tomorrow. This does not mean however that ecological intensification excludes all use of external inputs (e.g. seeds, mineral fertilisers, and pesticides).

More generally the challenge is to move towards "*sustainable agriculture*" (cf. definitions and below).

The doubly green revolution presupposes a double encounter between agronomics and ecology, and between formal knowledge and local knowledge. It also requires an ability to intervene at two levels:

- → *At the level of the agricultural holding* and its component plots of land. Techniques such as no-till farming, the incorporation of crop residues, crop/livestock rotations or under-sowing can for example help to restore soil fertility, along with other related functions: water, carbon capture.

- → *At the level of the «terroir» (specific locality)*, and at other levels relevant to the sustainable management of natural resources (e.g. aquifers, water distribution areas) and agro-ecosystems.

[18]. The proportion of mineral fertilisers in the input of nutrients supporting global production was 39% in 1970. It rose to 60% in 2000 and is projected to reach 70% in 2020 if there is no change in farming practice, compared with 48%, 30% and 21% respectively for the proportion of direct inputs from the soil, and 13%, 10% and 9% for the proportion deriving from organic fertilisation (Tan 2005).

An increasing number of farmers around the world have adopted these new *sustainable intensification* approaches (*"precision" agriculture, "conservation" agriculture*). Some are also combining conservation agriculture with precision agriculture. In South America, for example, conservation agriculture is widely accompanied by the use of GMOs.

BOX 2: DEFINITIONS

"Precision agriculture" is "a farming management concept based on observing and responding to intra-field variations. It relies on new technologies like satellite imagery and information technology. Precision agriculture aims to optimize field-level management with regard to crop science (matching farming practices more closely to crop needs), environmental protection, by reducing the footprint of farming (e.g. limiting leaching of nitrogen) and economics: by boosting competitiveness through more efficient practices (e.g. better management of nitrogen fertilizer costs)". Achievement of the desired level of "precision" presupposes however the application of costly investment and highly effective technical "supervision" of farmers, most notably on the basis of a sophisticated alert system (water, treatments, manuring, etc.) which exists only in part in the developed world and in most cases not at all in developing countries.

"Organic farming" is a form of agriculture characterised principally by a refusal to use "chemicals" and which seeks to return to traditional techniques.

The concept of the **"doubly green revolution"** was introduced in 1993 by CGIAR and CIRAD (the international centre for agricultural research for development, France), with the term "doubly" being intended as an indication of the necessity of simultaneously preserving both the productive goals of the green revolution and making ecology its principal rationale in bringing about the required changes to farmed ecosystems and support policies. The choice of ecology as the underlying rationale relates to the need for integrated management of the whole range of natural resources which compose a "farmed ecosystem" (water, soil, nutrients, pathogen-system, etc.), leaving behind the exclusive reference to a "system of production" alone. In this new vision of agriculture, the traditional distinction between *ager* and *saltus* tends to fade: optimisation is no longer in fact sought at the level of the field, but rather at that of the "region".

This concept subsequently led CIRAD to propose another term: **"ecological intensification".** The means "i) designing sustainable production systems that save on inputs and are less harmful to the environment, ii) developing varieties better suited to their environment and inventing new pest and disease control techniques, iii) understanding how nature functions so as to exploit its resources without destroying it, and iv) breaking with practices based on intensive, massive use of pesticides, chemical fertilizers, water and fossil fuels".

Conservation agriculture (CA), a concept promoted notably by the FAO "aims to achieve sustainable and profitable agriculture and [...] improved livelihoods for farmers through the application of the three CA principles: minimal soil disturbance; permanent soil cover and crop rotations". "CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labour shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability and it has been proven to work in a variety of agro-ecological zones and farming systems. It is been perceived by practitioners as a valid tool for Sustainable Land Management (SLM)".

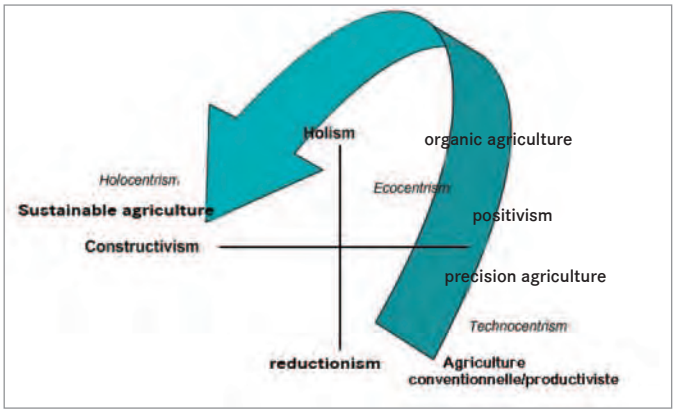
"Agro-ecology" can be at one and the same time a scientific discipline, a movement or a technique. As a science, agro-ecology studies agro-ecosystems. As a technique, agro-ecology essentially promotes ways of working the soil that do not disrupt its structure and natural organisation, the use of green fertilisers and composting, natural and biodegradable plant protection treatments, and the like.

At the present time there is no internationally agreed definition of **"sustainable agriculture".** For the RAD (*Réseau d'Agriculture Durable* / Sustainable Agriculture Network, France), it is "entirely different from a model: it seeks to provide local answers to questions arising in a holistic perspective relating to the functions and the role of agriculture in society. Sustainable agriculture is founded on sustainable development. This means that it must meet the needs of today's generations without compromising development for future generations, guaranteeing that they will enjoy the same opportunities for progress".

→ The need for systemic approaches: local governance and arriving at compromises

Figure 6 offers a schematic summary of the paradigm shift now under way in agriculture.

Figure 6 : The historic paradigm shift towards sustainable agriculture now under way (1950-2020)[19]



This shift involves a move away from the reductionist approach of the 1950s (conventional intensive agriculture), through the techno-centric or eco-centric approaches of the 2000s (precision agriculture and organic farming), towards a new holistic approach to progress as a precondition for "sustainable agriculture".

"Sustainability" requires agriculture to:

- → Take into account local, regional and inter-regional food security issues (access, availability, stability, nutritional aspects). This may mean, for example, questioning certain types of biofuel production,
- → Contribute to combating climate change (reduction of emissions, carbon storage),
- → Reconcile productivity and conservation of natural resources and habitats,
- → Preserve and add value to biological and crop diversity for greater resilience and adaptation of agricultural and food-related systems,
- → Develop a dialogue between traditional and formal bodies of knowledge; intensive knowledge systems,
- → Make itself part of new forms of interface between the rural and urban worlds,
- → Escape from socially unacceptable situations, build the capacities of farmers - men and women – and build human and social capital,
- → Preserve regional balances.

[19]. Figure reprise de Guilhem Calvo, expert auprès de l'UNESCO

Because the aim is to:

- be able to meet in a sustainable manner the basic needs of humanity, i.e. to begin by achieving the first two Millennium Development Goals (MDGs), which are to reduce poverty and hunger,

- avoid separating in terms of vision or action the four dimensions of sustainable development (economic, social, environmental ,and governance), but rather systematically seek ways of generating positive synergies or reasoned choices between options,

Food security, in its links with water and therefore with the land, is a goal that should be placed at the centre of the concept of "sustainable development". Indeed, sustainable development is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland Report, 1987), and it presupposes, as the OECD emphasises, the promotion of "a set [...] of processes [...] *which integrates the economic, social and environmental objectives of society, seeking trade-offs where this is not possible"* .

Reconciling these three objectives with regard to agricultural water, which is a "common good" by definition, requires progress that is not only agronomic or economic, but also organizational and institutional. The sustainable exploitation of common goods requires effective systems of territorial governance based on "cooperation", which can be complex. The work of Elinor Ostrom[XXXIII], who received the 2009 Nobel Prize in economics, shows that these systems were actually very numerous in the field. She drew a stimulating theoretical synthesis, challenging conventional economic theories (Box 3). Meeting the challenges identified and successfully completing the "paradigm shift" requires an understanding of these scientific achievements, based on observation of reality, and to innovation in terms of visions and cooperation in order to successfully achieve 'positive sum games' at all relevant territorial levels, from local to global, and from global and local.

BOX 3: THE ACHIEVEMENTS OF ELINOR OESTRUM'S WORK ON THE GOVERNANCE OF COMMONS

Elinor Ostrom, an American political scientist, has devoted her career to issues of managing and governing common goods, such as collective renewable resources (irrigation systems, groundwater, meadows pastures, fishing sites, forests, internet, etc..), which differentiate from public goods as well as private goods. She committed herself in understanding the diversity and the complexity of situations and modes of organization that lead people to manage these resources sustainably either in responsible, productive and innovative ways, or, conversely, mining and destructive . She received for her work in 2009 the Nobel Prize in economics.

Her analyses, which initially focused on specificities of water management system in California, are based on an impressive amount of field data. Claiming a return to reality, her work shows the need to fully accept that governance in economic and ecological systems builds on complex mechanisms and interactions that mobilize mostly human commitment among stakeholders, while identifying the structural factors that promote or otherwise reduce the likelihood of increased social cooperation. Showing that voluntary associations of individuals or collective action groups can manage effectively and share equitably a common resource, she fundamentally challenges the traditional predominant idea that the fate of a common goods is necessarily poor management and would lead to collapse, therefore claiming that matters would rather have to be taken in hand by external mechanisms such as the public authorities for some, or the market for others.

But actually, practical evidence shows, assuming that "communication" is properly established among stakeholders, high levels of cooperation (collective action) are possible, thus identifying flaws in the official theory known as "the tragedy of the commons", according to which individuals would rather maximize their own short-term interest so that, in situations of tension, no one will work for the common good, leading irresistibly the commons toward ruin. Repeated results confirm on the contrary that i) participants in a situation of dilemma do cooperate effectively when they are in relationship with other participants, they take care together of all difficulties, they trust in a reciprocal and responsible behaviour from all members, and that ii) the cooperation which so develops increases mutual benefits significantly and sustainably. Conversely, the disastrous effects of the nationalization of formerly communal forests have been extensively documented by the scientific community, for example in Thailand, Niger, Nepal or India.

Despite substantial differences between situations of common resources (e.g. institutions for huertas irrigation systems in Spain, common property for pastures and high mountain forests in Switzerland and Japan, the irrigation community in zanjeras, the Philippines), Elinor Ostrom found that all are sharing fundamental similarities. So she brought out eight main design principles which are common to sustainable institutions for natural resources:
1 / clear limits (limits of the common resource, individuals or households who have access rights);
2 / adaptation of the rules for resource use to local conditions;
3 / local processes for making collective choices (most individuals affected by operational rules can participate and adapt them);
4 / supervision (supervisors are accountable to users / managers, and / or are themselves users);
5 / graduated sanctions (users who break the rules will be exposed to graduated sanctions and to the moral pressure exerted by other users and / or agents working for or on behalf of users);
6 / mechanisms for solving conflicts at the lowest level, with low transaction costs;
7 / a minimal external recognition of local organizational rights (the rights of users to develop their own local institutions are not challenged but facilitated by the government or the administration)
8 / interrelated and interactive business: activities of appropriation, provision, monitoring, rule-enforcement, conflict resolution and governance are organized in multiple layers of nested enterprises and enable low costs .

Elinor Ostrom also emphasizes the important positive role that regional and national governments can play in enhancing the capacity of local natural resource managers to engage in effective institutional systems. For example, it is doubtful that the operators of the aquifer Raymond would have been able to forge the institutional innovations they have developed without the information provided by the Geological Service of the United States and by the California Department of Natural Resources. They were also able to benefit from a court hearing concerning equity to complete a negotiated agreement considered legitimate by all participants. Finally, local government agents were able to supervise and strengthen the enforcement processes so that the solutions decided locally remain fair and avoid excesses.

2 - SELECTING TARGETS: WHAT PRIORITIES FOR DEVELOPING AN ALTERNATE SCENARIO ?

If the negative trends highlighted in the first part of this report are not promptly corrected, then they will lead to growing systemic risks of multiple deadlocks at environmental, social, economic and geopolitical levels. These risks will first emerge at the local level, then move to the regional level before becoming more global.
Table 5 provides a summary of the challenges and possible ways to find solutions.

Table 5: Challenges and possible ways to solutions

Challenges	Situation, current trends and risks	Directions for possible solutions (relevant to water & food security)
Overexploitation of groundwater (and other hot spots: pollution, wetlands)	High levels of overexploitation (150 km3/year), rising strongly. Risk of local / regional economic and social crises. Subsidies (energy) encouraging overexploitation	Territorial approaches designed specifically to each critical site / region (governance, efficiency gains, controls, transfers...): reconcile agriculture and water security. Reform of subsidy policies
Soil erosion	Land losses through erosion of 2- 5 million ha / year (Africa, China, India, MENA ...). Yield losses 27%.	Ecological intensification (conservation agriculture), local/territorial governance for sustainable management of pastoral resources, conservation of agricultural water and soils.
Sediments retained in dam reservoirs	Losses of over 2% / year (MENA, China ...). Sedimentation of reservoirs before the end of the century, while no other sites are available (MENA),	Responses adapted to each territory
Urban dévelopment on farm land	Losses of prime agricultural land to urbanization of 1.6 million ha/year, including in irrigated systems	Protection of farm land in peri-urban areas. Urban densification (coupling transport & densification)
Loss and waste of food products	30% loss in food products Water losses in agri-food industries	Reducing losses and waste from 'farm to fork'
Aging of existing irrigation systems	Low efficiency, wasted water, low cost recovery. Increasing competition with other user with decreasing allocations to agriculture. Salinization (water and soil)	Increased efficiency (water productivity).Territorial governance adapted to each territory and empowering irrigators Drainage
Insufficient storage and mobilization of alternative waters	Significant potential for non-mobilized resources in Africa (economic scarcity) Little increase in irrigated areas (additional 17 million ha by 2050). Development of reuse (grey water). Little storage in aquifers	Increasing storage capacities (a risk management tool for adapting to climate change, including in aquifers. Solutions tailored to each territory, developing regional labels in territories which justify it, like Africa.
Slowing of increase in crop yields	1.86% /year from 1980-2000, falling (1% or 0.5%) from 2030-2050	Sustainable intensification: access to water, seeds and fertilizers, ecological intensification. Development of irrigation
Climate change	High and increasing impacts of climate change on agriculture in Africa, MENA, South and South East Asia. Droughts and floods more frequent. Fall in water availability (Maghreb...)	Ecological intensification (carbon sequestration, adaptation to climate change results in improved resilience). New varieties Solutions tailored for each territory
Inappropriate investments; land and water «grabbing»	Very little access of smallholder agriculture" to markets, technology, credit and subsidies. Big private investment is challenging water access rights of smallholder farmers. Investment often used for growing crops that do not improve food and energy security in the regions, but which they tragically need.	Policies to support smallholder agriculture Recognition of traditional land rights Supervision of investments Strategies tailored to each region.
Neglect of smallholder agriculture	Weakness and decline of agricultural and rural policies. 1 / 3 of humanity left out. Weakness of capital (human, social, technological, financial). Under-valued water resources, low productivity, vicious circles of unsustainable development (hunger, poverty, erosion and desertification). Risk of mass exoduses to shanty towns increasing poverty, urban problems and illegal emigration.	Agricultural and rural development policies to improve living conditions, productivity and incomes. Agricultural extension, access to credit and information, building social capital, grouping products for market access. Ecological intensification (low-cost technologies). Adaptation to each local context. Policies to add value to local knowledge and local resources. Payments for environmental services

Challenges	Situation, current trends and risks	Directions for possible solutions (relevant to water & food security)
Achieving global food security	Strong growth in demand for food and non-food products. Supply no longer structurally larger than the demand. Risk of extending the cultivated area to the detriment of forests, savannas and rangelands, exceeding ecological limits (climate, biodiversity, water)	Reducing all losses and wastages. Increasing efficiency in all types of agriculture (thus including support to small-scale agriculture and Africa), and throughout the food chain.
Volatile food prices	Increasing volatility, and strong structural price rises	Mobilizing new water resources and water storage facilities (surface or otherwise)
Access to food by the poor (physical and economic)	Aggravation of access difficulties for food due to higher prices, to land grabbing and degradation of water resources, to degradation of agro-ecosystems, and to climate change (vulnerable regions). Lack of social safety net policies	Sustainable agricultural and rural development Better targeted social safety net policies Payments for environmental services
Regional challenges	Large regions without agricultural policies to regulate markets and secure incomes. High population growth and concentration of the problems in "drylands". Worsening situation in several critical areas (MENA, South Asia, Sub-Saharan Africa). Increasing food dependency (imports of virtual water multiplied by 3 to 4 times by 2050) but insufficient awareness about the growing interdependence between-regions	Awareness of the important regional and inter-regional issues. Regional visions and strategies for water and food security Regional "new deals" (between water-rich and water-poor countries) to secure supplies

This table shows that the issue is not only how to restore political priority to agriculture or only of "*more crop per drop*" (efficiency, resource productivity). Nor is it only a question of more water storage capacity and more mobilization of water resources. The challenges and responses must be much broader. They compel us to commit to the *fundamental aim of reconciling agriculture (including its upstream and downstream sectors) with the territorial issues of water and food security* in all their dimensions -the types of territories and ecosystems to be considered having multiple dimensions.

This means ensuring that water security and food security are treated as whole. It also means striving for inclusive development by helping smallholder farmers to better manage water supplies and so increase water availability ("*more crop per drop*") and increase their incomes ("*more income per drop*"). This would have positive effects on access to food and on employment ("*more jobs per drop*") in countries where resources are scarce and population growth is high. This double, and joint, challenge facing water and food also requires a change in the strategies of major actors. The question of "*what crop?* " needs to be asked, since cropping systems must be compatible with the local, regional and global potential for producing energy, water and food.

Examination of the table leads us to identify the following seven major priorities for action:

1. 1.Increase the productivity of irrigation systems and improve their cost-effectiveness;
2. Strengthen water storage capacity and the mobilization of new water resources;
3. Sustainably intensify rain-fed agriculture: increase productivity, promote conservation agriculture;
4. Support smallholder agriculture, especially in developing countries, to secure, maintain, manage and valorize agricultural and pastoral water , and to promote sustainable rural development;
5. Reconcile agricultural development with the objective of protecting natural resources and the environment in the "hot spots" (overexploited aquifers, priority watersheds;
6. Take action to conserve water supplies both upstream and downstream of production: reduce losses through urban sprawl and throughout the food chain; develop social safety nets policies;
7. Develop visions and strategies for sustainable agriculture at sub-national and international levels.

It is understood that institutional aspects have to be examined in the same way as technical and economic aspects.

Chapter III which follows presents 40 examples of solutions proposed by the Group on Water and Food Security of the French Water Partnership. There is a matrix that summarizes both the 7 priorities and these 40 examples of solutions in the beginning of the report (in the Summary). These are presented according to the 9 targets for theme 2.2 (water and food security) of the 6th World Water Forum.

Among the 40 examples documented, 17 are from France and Europe, 8 from the Mediterranean and its southern rim (Mediterranean Basin, Maghreb, Tunisia, Morocco), 7 from sub-Saharan Africa (Mali, Niger, Senegal, Guinea, Ethiopia), 6 from Asia (Southern and Eastern Asia, Vietnam, Cambodia, the Philippines) and 2 are from Latin America. They show that practical progress in the 7 priority areas is both possible and necessary at different administrative levels (local, sub-national, national, regional). It is however important to note that:

- The transition to a sustainable development scenario will require concurrent advances in the 7 priorities identified (and also in other directions not covered here, such as energy efficiency) and to work at several territorial levels;
- Working simultaneously on the 7 priorities will most often greatly increase the chances for success in each area.

For example:

- Territorialize' policies by developing visions and plans for sustainable agriculture at the relevant administrative level and notably at regional NUTS 2 (local) scale which gives more chance to increase productivity, improve the resilience of crops in irrigated and rain-fed systems, and to seek appropriate ways to effectively combine efficiency and sustainability.
- Work upstream, in mountains areas, by supporting smallholder agriculture to better conserve and manage natural resources (irrigation water, rain water, water from pastures and rangelands). This would increase the productivity and the economic sustainability of large downstream irrigation systems, as well as increasing the overall productivity of agricultural water.
- Improve social safety net policies to increase their efficiency, to reduce public costs, and to better serve the "sustainability" agenda by shifting from non-specific subsidies for electricity consumption to targeted payments for environmental services. This can be an important condition to reduce overexploitation in hotspots (stop subsidizing overexploitation, help recharge the aquifers).

3 - THE 7 PRIORITIES AND 40 EXAMPLES OF SOLUTIONS

1. INCREASE THE PRODUCTIVITY (EFFICIENCY) OF IRRIGATION SYSTEMS, IMPROVE INCOMES AND SUSTAINABILITY

In a context of fast growing demand for food and non-food agricultural products, and of increasing scarcity of natural resources which are often already overexploited, progress is needed to increase *efficiency in water management* both for irrigated and rain-fed crops. The objective must be to increase water productivity ("more crop per drop") and rural incomes ("more income per drop"). Further, climate change requires further research into improved resilience, namely to drought.

Agricultural progress through efficient and economical water management is an absolute priority for countries that are short of water, or risk shortages in the future. This means major changes in policies to move to "water demand management ". These changes are also likely to provide, at low cost, more security to the needs of water users in other sectors, thus demonstrating that agriculture, which is sometimes considered a source of problems, is often the “solution”.

The eight case studies presented below show that significant progress is possible on irrigated crops (productivity and income) in three ways that can be complementary:

- *Agronomic progress*: in breeding new varieties which need less water and are more drought-tolerant, in fine-tuning irrigation systems, or in new methods for ecological intensification;
- *Establishment of institutions, professional organizations and "processes" for working at appropriate territorial levels*. Four success stories are presented (one in France, two in Africa and one in Asia), which demonstrate the central importance of organizational and institutional structures in achieving good levels of productivity and economic sustainability in irrigation systems;
- *Putting in place regional cooperation agreements and national policies for water savings in irrigation systems (water demand management)*. The two examples of solution presented are from the Mediterranean area where increasing water scarcity requires new visions, new policies and new practices. The outstanding example of Tunisia shows the importance of going beyond the project level to the elaboration of national agricultural policies for water that are adapted to the challenges.

→ Agronomic progress

Several ways are possible for developing agronomic progress to increase the efficiency of irrigation water.

One way, which is as old as agriculture itself, is through plant breeding so that crops make the best use of available water resources and develop a higher tolerance to drought. This is currently the focus of several important research and development programs (see Box 4).

BOX 4 : BREEDING R&D PROGRAMS FOR MORE WATER-EFFICIENT AND DROUGHT-RESISTANT PLANTS[XXXIV]

Plant breeding has sought since the beginnings of agriculture to select plants which best utilize available water. This has led in particular, during the 1970s, to the selection of plant for the quality of their roots. In this way, it was possible to create rain-fed rice varieties that have proved as productive as irrigated varieties while having lower water needs. Nowadays, research is using new tools based on biotechnology.

Maize is the plant on which most research has been done. Several seed companies in the U.S. have announced the release in 2012 of new varieties with higher yield under drought conditions (yield gain from 6% to 15%), obtained either by conventional breeding or by transgenics (GMOs). In addition, the WEMA project (water efficient maize for Africa) funded by the Gates Foundation and led by the Consultative Group on International Agricultural Research (CGIAR), public research institutes in Africa, and seed companies aim to develop by 2017 improved maize varieties that should yield increases of 20 to 35% under drought conditions. These varieties can be obtained by conventional breeding and breeding assisted by genetic markers. Genetic modification will also be explored.

Rice breeding is also the focus of much research but the genetic characteristics to increase tolerance to water stress are not yet clearly identified. Several years ago, the Africa Rice Center (CGIAR, IRRI - International Rice Research Institute) developed through conventional breeding the NERICA varieties, which gave yield increases of 50% to 200%. Using project funds from the Gates Foundation, the Africa Rice Center is trying to develop in Africa and Southern Asia, using selection assisted by genetic markers and / or transgenics, new rice varieties that are tolerant to several major environmental stresses, including drought and salinity (an issue which is comparable in importance to water stress tolerance for rice). The project is working with local varieties in each participating country.

Prospects for varieties of *wheat* that are more tolerant to drought are more distant. Because of the complexity of its genetic structure compared with other cultivated plant species, the wheat genome has not yet been completely sequenced and it is difficult to obtain molecular markers. Wheat research is not focused on tolerance to drought, so progress in this area is unlikely for 10 years.

Research is on-going on *sorghum* and *millet* but there are no release announcements to date for varieties more tolerant to drought.

Thus, progress is gradual and new varieties will not provide miracle solutions. Besides, the local, variable and random nature of drought requires solutions tailored to each region. In addition, it is not possible to exploit the potential of improved seeds without also developing appropriate agronomic practices and associated funding...

Significant progress is also possible through fine-tuning of irrigation applications (Case Study No. 1) or through new approaches of ecological intensification (Case Study No. 2 on “The System of Rice Intensification" SRI).

Case study No 1: Sensors and modeling for optimal use of irrigation water (France)[20], implementation at the Pot au Pin Company (Gironde)

Capacitance probe to measure soil moisture: fine-tuning of irrigation - Gironde (France)

If in the past, the availability of water in France has not been a problem. Today, competition for water with the needs of urban areas along with increasing regulatory constraints and the increasing frequency and magnitude of droughts and floods as a result of climate change, make it no longer possible to manage water in a random manner.

French farmers who use irrigation for field crops are looking for with tools and methods that allow for an optimal use of water. In response, ARVALIS, along with the Chambers of Agriculture and INRA (national agricultural for research institute), has developed IRRINOV ®, a method of irrigation management for protein peas, small grains, potatoes and maize. This tool enables farmers to manage irrigation by providing a set of decision rules for starting, continuing and ending irrigation applications automatically based on indicators of the soil water status (voltage measurement), climate (rainfall) and crop needs (development stage, rate of growth), measured at pilot sites equipped with voltmeter sensors and rainfall gauges. The voltage thresholds and the ‘dosage –frequencies’ cycles are calibrated for each soil and climatic environment on the basis of field trails. They have been adjusted using simulation tools (IRMA MODERATO) to improve the robustness of the decision rules in different climatic scenarios. Tests carried out with 30 to 50 farmers using irrigation in all of the regions concerned prior to diffusion confirmed that this tool could be used by farmers to improve water management.

The South-West of France is particularly exposed to increasing competition between different water users and to consequences of climate change on water resources. While farmers in the valley of the Garonne have turned to non-irrigated winter crops at the expense of maize, in the Landes the choice was rather to fine-tune the use of irrigation to the needs of the plant.

The agricultural enterprise POT AU PIN, which produces 400 hectares of carrots south of Bordeaux, illustrates this transition towards "precision agriculture". The POT AU PIN water management system involves placing sensors in the ground at depths of 10cm, 20cm, 30cm, 40cm and 50 cm to measure twice daily the humidity profile and temperature of the soil. A computer-driven irrigation system then delivers automatically to the plants the exact amount of water for their growing needs, according to their stage of development. The irrigation water also helps to limit the rise in temperature of the soil - black soils of the Landes can become very hot and cause crop losses.

For this company, the use of sensors and modeling of plant growth has reduced water demand by 20% on the farm and has resulted in an increase in the average length of the carrots by 1.5 cm. This technology can be applied to any irrigated crop (maize, asparagus ...). Other countries, including China and the United States, have shown an interest in this technology.

Case study No 2: The SRI (System for Rice Intensification) from Madagascar to Asia and Africa[21]

Weeding in intensive rice production (North Rakhine State) (Myanmar)

The SRI (system for rice intensification) is a method of ecological intensification for irrigated crops discovered "by accident" in 1983 in Madagascar[22]. The year was low on rainfall, and at the same time the local nursery found itself in a position of not being able to produce rice plants for the area of paddy which had increased strongly. This obliged farmers to the plant their paddies with very much younger plants.

The method, discovered under exceptional circumstances (it was in fact already been used in Japan) and then refined, is to transplant seedlings which are only 15 - 10 days old, or even 8 days old, instead of 20 – 60 days old. The seedlings are planted, one by one and not in clumps, and at a greater spacing (of 30 cm between plants instead of 10 – 20 cm). Also, they are planted in "squares" and then irrigated with a minimum of water. This method[xxxv] avoids trauma to the young plants and it allows the oxygen of the air to reach all parts of the plant. Young plants can express their full potential leading to a rice tillering, i.e. the multiplication of stems or tillers, which goes exponential[23]. The method avoids the cost of external inputs (fertilizers, pesticides, seeds) as when compared to improved rice production systems (IRPS). However requires particular care: meticulous planting – transfer of the seedlings to the paddy field in less than one hour while keeping soil around the plant roots, aeration of the soil through regular drainage periods, 4-6 weedings and organic manure applications. For supporters of the SRI technique, rice is a plant that should be respected and maintained as a living being with a high potential.

The productivity gains observed in Madagascar are substantial: the SRI technique, when implemented according to the standard technique developed, gives yields of 6-17 t / ha (average of about 8 t / ha) against the National average of 2t/ha. - an increase of 400%. Approximately 100,000 Malagasy farmers have now adopted SRI, though often only in part.

[20]. Case study documented by Arvalis (Institut du végétal) for sensors and models, and by SAF (Société des agriculteurs de France) for implementation at Pot au Pin
[21]. Case study documented by CGAAER from various sources
[22]. By Henri de Laulanié, a Jesuit father and French agronomist who devoted the last 34 years en his life to help Malagasy farmers
[23]. According to the model described by the Japanese researcher Katayama

Several studies have also shown that the SRI technique using compost and local seeds gives better results than the IPRS technique using mineral fertilizers in terms of yield, and especially of net income and labour productivity. Promising tests (yields of 4 t / ha) are already underway to adapt the SRI concept to rain-fed rice in upland areas, using compost instead of slash and burn, and using pulse cuts (Crotalaria and Tephrosia) used in a thick layer as mulch to suppress weeds.

The SRI technique, tested in Cambodia since 1999 by an agronomist[24] who had read an article from a Malagasy colleague, has rapidly spread in this country. CEDAC, organization created at his initiative with support from GRET, managed to harness energies and organize numerous training sessions. In 2007-2008, 100,000 farmers (5% of farmers in the country) had already adopted SRI at least in part, over a total acreage of about 20,000 ha.[xxxvi].

The development of SRI, which is usually applied only in part, is also significant today in India, Vietnam, Mali and China. A recent evaluation in eight Asian[xxxvii] countries quantified its benefits: yield increases of 47% on average, water savings of 40%, production costs per hectare reduced by 23%, income per hectare increased by 68%. The benefit in terms of efficiency in irrigation water management and food security is therefore considerable. For countries like India, where in 20 years' time some 60% of aquifers are likely to be in critical condition, the promotion of SRI could be an issue of strategic importance. SRI techniques also allow for carbon sequestration, reduced emissions of methane, to avoid use of mineral fertilizers, pesticides and commercial seeds while increasing plant resistance to drought and disease.

Despite all its merits, the global development of SRI has been slower than expected by its discoverer. In addition to sociological, cultural and psychological concerns among farmers, SRI has long suffered from disdain or indifference from international research institutions and donors. The absence of state support in the field (dismantling of extension services), along with a lack of training and access to funds for rural people, are also major obstacles to a rapid diffusion of SRI in many countries.

→ Organizational and institutional progress at the correct levels

Organizational and institutional issues are often the most decisive for progress as is shown below in the four examples of solutions. Good management of irrigation water requires collective rules that are shared at appropriate territorial levels, and, often, innovations in "territorial governance". While in some countries well-established management institutions still operate efficiently and have the recognition and necessary powers, in other countries, much remains to be done in this direction.

Case study No 3: Approved territorial associations of owners (ASA : "associations syndicales autorisées") and a company for regional development (SAR "société d'aménagement régional") in Provence (France)[25]

In Provence, as in other regions of the Mediterranean, water and food security has always been and remains a vital issue. Collective efforts in this direction have been a strong unifying element in the collective identity of these territories. Two major types of institutions were successively created to build and then to maintain and sustainably manage canals and water infrastructures for feeding the territories: ASAs (territorial associations of the land-owners concerned in common by the infrastructure) whose scope has been recently enlarged beyond agricultural issues and are nowadays called ASP, territorial associations of landowners), and SCP – The Canal de Provence Company - which has the statute of a SAR (regional development corporation).

The ASAs have a collective power to engage works on the lands of all the owners within a clearly delimited zone. These organizations work on those bases coming from traditional law, and several of them date back in some cases to the Middle Ages. The land areas they covered are relatively small, on a human scale (infra-departmental), which makes it easier to adopt collective rules for management or changes in behavior when there is a drop in water supplies or a crisis to manage. Uses, often primarily agricultural in origin, are now more like "multi-uses", with the scopes of associations and their missions differing for relevance their to territory. Those ASAs which are gifted by law with considerable autonomy are now legally public utilities, with the corresponding rights and obligations. An ASA can be created after a public inquiry upon request of at least two thirds of owners representing at least half of the perimeter area, or at least half of the owners representing at least 2/3 of the area. The perimeter is officially recognized by the administration, which exercises a supervisory and control role. Management rules, decided democratically by the ASA, are binding on all owners within the perimeter. If the administration sees that the public interest is taken into account and that the weak are protected against abuse of power, they do not interfere in the day-to-day management decisions.

The ASA, by nature of their statutes, are well suited for creating public works and ensuring their management and maintenance within a homogeneous territory. They cannot be a solution for sharing water beyond their territorial boundaries or for the implementation of regional-level investments. That is why in 1907 the CED "Executive Commission of the Durance" was established with a mandate from the government to regulate water allocations between users in case of shortages. This was followed in the 1950s by the establishment of the SAR "The Canal de Provence Company", a private company with public shareholders, now acting on behalf of the Region after having been acting on behalf of the State (Ministry of Agriculture). The larger-scale infrastructures created provide pressurized water supplies to territories that was not accessible by traditional systems, to make up for the deficit in local water supplies, or allow for opportunities to supplement or replace limited local resources. Further, the pricing of water encourages users to switch to more efficient irrigation methods to save water and to shift to crops with higher value added.

Over time, the complementarity in the region of the SCP and the ASAs, which are featuring differentiated socio-economic and technical characteristics but are linked through common issues, is a valuable opportunity for exchange, collaboration, research, and cooperative implementation of solutions to enhance the efficiency and sustainable reliability of the public water service.

A joint analysis of future risks of water shortages in the context of climate change has led to design an original technical and financial partnership to strengthen the overall security of supply in the region and to reconcile all uses with available resources. This partnership seeks to make significant water savings in the perimeters of traditional ASAs and mobilize them for other uses. The objective of the partnership was to achieve these water savings without financial loss for irrigation joint-owners associations. The necessary technical adjustments are much cheaper than the development of new resources. However, they benefit all water users in the region, and represent a significant investment for the ASA without direct economic return. Public support remains limited, so the partnership had to limit the amount of ASA contribution to expenses by calling for contributions from all stakeholders interested in improving the security of overall supplies: cities, energy producers (EDF) and industrialists as well as the Water Basin Agency. The first pilot project elaborated on these principles was on the ASA Canal Saint Julien which is 700 years old. The objective is to reduce the annual abstraction of water by 20 million m^3 for a total investment of € 2.5 million, the ASA committing to operate and sustainably maintain the works built.

[24]. Yang Seng Koma

[25]. Case study documented by Jacques Plantey (AFEID) and Denis Baudequin (CGAAER)

This example, as that of Tunisia described below, demonstrates that the commitment of the agricultural sector can help to provide solutions of great interest to all water users, and thus justify the development of innovative partnerships with non-agricultural users with specific public funding.

Case study No 4: The irrigated perimeters of the Senegal river (Senegal)[26]

For 40 years, 90 billion CFA francs have been invested by the Senegalese government to develop 95,000 ha of the 240,000 potentially irrigable ha in the Senegal River Valley. However, in the 1990s, the situation is discouraging : one third-of the equipped areas is not cultivated, 20 000 ha being abandoned, and 15 000 ha farmed in poor conditions, the yields are poor and local rice product is not competitive, while Senegal imports 80% of its needs. In 1997, donors decided that no new investment in infrastructure would be financed as long as the four points of the "Ndiaye plan" will not be met: good water management, land tenure security, policy for maintenance and durability of infrastructure , agricultural diversification and intensification.

AFD (French Development Agency) as a result decided to support the pilot program to reinforce the Rural Communities (PACR) launched in 2006 by a grant of € 7 million. The idea is to facilitate the institutional changes needed to sustain investment and production, to support the Rural Communities (RC) in the River Delta to better valorize their land and economic potentials.

The measures taken include four components:

- *water management:* a Water Charter and Charter of Irrigated area is defined to provide an institutional and technical framework of long-term management of the resource, and to strengthen local actors for whom concertation works well for the sharing of water among uses and users.
- *land and tenure,* the main pillar of the program: the responsibility of reallocating un farmed land is entrusted to Rural Communities. Documents and transferable titles for securing land use are established with administrative and legal recognition, through a land map and a land registry.
- *local development* by reinforcing the capacity building in project management of the rural communities for launching a coordinated plan for local development and for infrastructure maintenance.
- consolidation of the Centres for Management and Rural Economy and the establishment of contractual and transparent relationships between irrigators , water- (SAED) and earth- (RC) providers.

The results achieved, yet difficult to quantify, are fundamental to increase and secure production. Indeed, greater cooperation between people, secured water land and building have already allowed to increase the area developed and cultivated, focusing on product diversification, including perennial crops (banana , mangoes ...), to increase agricultural investment, to increase cropping intensity, and to stabilize and professionalize the producers.

The donors resumed infrastructure investment at seeing the improvements achieved in the institutional situation: this is also a good indicator of success. Each actor assuming now a clear role, it is again possible to extend the area irrigated further on. This will be provided for by the Program for Promotion of Rice Partnership in the Delta launched in 2008 which intends to develop additional 2500 ha to consolidate the rice sector and to enhance food security, while ensuring a smooth integration of the industry (relating producers to processors) and its independent funding (in partnership with “Caisse Nationale du Credit Agricole du Senegal”).

Case study No 5: The Prey Nup perimeter in Cambodia: an example of democratic management of water that restores social cohesion and water use efficiency [27]

Cambodia is a country scarred by the collectivist Khmer Rouge period which devastated population and destroyed social links. In the agricultural sector, much of the population has been forced to work in cooperatives to build dams and canals of poor quality in dire conditions. After 1985 and the rejection of collectivism, the irrigated areas, already inefficient, are even more difficult to manage because they require a collective management of the resource that people are not willing to accept. It will take 10 more years for the project to rehabilitate the Prey Nup perimeter to build up, emphasizing the associative organization of water and polder management.

The project will benefit over 3 years from AFD grants totalling € 10,8 million. It includes five pillars: rehabilitation of 11,000 ha of polders by stopping salinization of lands with a dike; access to credit; regularization of land allocation; development of production; transfer of management to the associative structure.

The transfer of management started with the election of the village representatives for the developing future users' association. The debates focused mainly on 3 items: rules and sanctions, water management, and maintenance. This will lead to the creation of the CUP (Community of polder users) dedicated to water and polders management. CUP is in charge of collecting yearly the financial contribution from its members, develops close relationships with local authorities (police) for the application of sanctions, maintains polders and applies rules forbidding deterioration of dikes. After a somewhat chaotic and weakening starting phase, CUP has now accumulated a wide legitimacy and a good knowledge of needs, taking into account all users including their differentiation by altitude.

The results are already excellent: i) security of tenure with 22,000 land-allocation titles issued over the total 24,000, ii) access to credit, individual or in common, iii) increase in acreage of 14%. with 2700 ha returned to farming, while one third of the land was not being cultivated, iv) production increased from 12,000 to 27,000 tons, an increase of 165% in 8 years with yields increasing from 1.3 t / ha in 1998 to 3t/ha in 2003, v) increase in revenues, vi) 74% of households becoming food self-sufficient or surplus against 44% before the project and vi) a viable CUP community of 15000 members electing their representatives by direct suffrage, recognized by the State and local authorities, and managing water operationally, recovering water charges up to 83% in 2003, and financially becoming more and more independent.

The Prey Nup project, and other similar projects being implemented with support from the AFD (Stung Chinit project, North West Irrigation Sector Project) showed that investment in water management has resulted not only in significant increase in efficiency and in production, but that they participate also in developing a new governance mode by building up a living and democratic network of associations, helping to restore cohesion within a blown-up society.

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[26]. Case study documented by AFD
[27]. Case study documented by AFD

Perimeter Alifif (Ethiopia)

Case study No 6: Modernization and expansion of the Alifif perimeter (Ethiopia)[26]

To address the problems of chronic food insecurity and extreme rural poverty, Ethiopia has established a policy for developing irrigation by means of upgrading water infrastructures for both expanding irrigated areas and increasing productivity. The example of Alifif, however, shows that the sustainability of irrigation systems, once they have been modernized, cannot be achieved unless an organizational and institutional support is made to rural communities.

The small irrigated area of Alifif (440 ha), is located at the foothills of the Hararghe Mountains, Eastern Ethiopia, in a semi-arid area subject to recurrent droughts, and is functioning for over a century. The traditional management of water is based on historically constructed rights. The local traditional system organizes water allocation, maintenance and conflict resolution. However, faced with rapid population growth, the system reaches its limits and there is a demand for technical improvement. To reduce seepage losses, the project elaborated by the "Bureau of Water" identified as targets: to protect the source; to cement canals and to build aqueducts that can cross natural water courses. If the project has effectively increased water availability, it also changed the traditional management ways, requiring substantial renegotiations of water rights and redefining the rules of system management.

In this context an Ethiopian NGO, ODA (Oromyia Development Association), has, with the support of a French NGO (GRET), supported the process of organizational and institutional restructuring towards both the rural community and the Bureau of Water's engineers and technicians. This led to the formation of a users' association from the traditional water committees but that is officially recognized by the state, and to reformulated rules for water allocation combining traditional and new principles. The process used has also resulted in a very positive local support both political and social to the new system,. If there are still challenges, especially for water fees recovery, the process is going forward.

Rehabilitating the irrigation scheme has allowed for significant productivity increase, agricultural diversification and greater resilience of populations to drought periods. This project has made clear that irrigation is a powerful solution for food security, provided that the expertise of local communities can be recognized and taken into consideration, and that the communities are supported into building up their capacity. It also shows that the technical services of water and agriculture should be trained in participatory methods for application to the social management of water, and to support farmers in the process of adaptation.

➜ National policies for managing water demand, and regional cooperation

Case study No 7: Outlook 2025 by the 'Blue Plan' and the Tunisian strategy for saving water in irrigated systems[27]

In many countries, water policies, inherited from a long traditional process, are still mostly "supply policies", i.e. policy of "public works" (dams, transfers) and large hydro-agricultural infrastructures.

This is especially true in areas with dry climates where irrigation development has been considered a priority. This is particularly true in the Mediterranean basin where more than 500 large dams were built during the 20th century, totaling over 230 km3 of storage. However, many Mediterranean countries are now faced with limits in their exploitable natural resources. Malta, Cyprus, Israel, Syria, the Palestinian territories, all the countries of North Africa and the Mediterranean side of Spain are concerned. Blue Plan's "Index of unsustainable water production" is already exceeding 10% in Israel and Cyprus, 20% in the Palestinian territories and reaches more than 30% in Malta and in Libya.

The population is still growing significantly in the southern and eastern Mediterranean (+ 92 million inhabitants announced between 2000 and 2025).[xxviii] Prospective work by Blue Plan (1985/1989 and 2005 scenarios) has:

- ➜Drawn attention to the risk of meeting deadlocks in the baseline scenarios constructed from country planning documents, which always tend to give priority to water supply policy without taking enough account of the potential for gains in efficiency, nor the requirements for sustainability and for the environment,

[26]. Case study documented by Coordination Sud / GRET
[27]. Case study documented by A Hamdane (INAT Tunis) G Benoit (CGAAER) and G Thivet (Blue Plan)

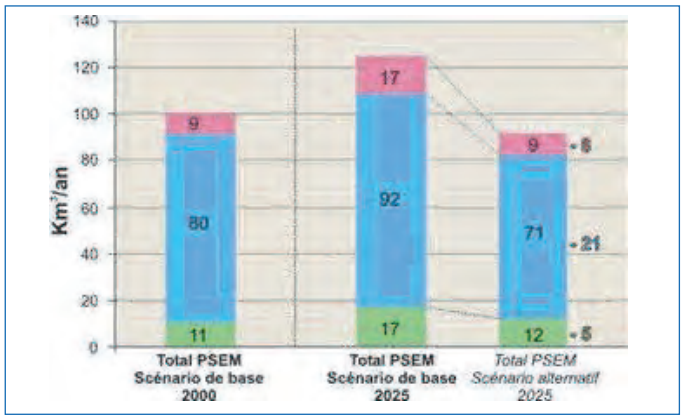
→Attempted to quantify the extent of water losses and "misuse" in each sector and each country,

→Explored an alternative to the scenario, that these losses would be progressively reduced by 2025 through more efficient and sober water management,

→Estimated at 34 km3 / y the total possible savings by 2025 for the southern and eastern Mediterranean watersheds (from Morocco to Turkey) from the baseline trend scenario (Figure 7), the largest amounts of recoverable resources being in the agricultural sector.

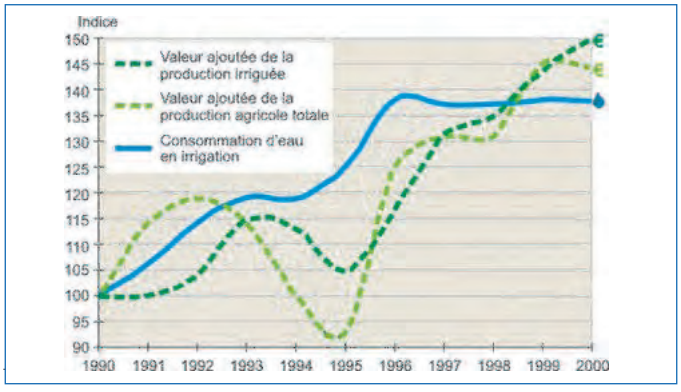
→Conducted the MCSD (Mediterranean Commission on Sustainable Development) in 1997 to invite the Mediterranean countries to adopt changes in depth in their water policies (and in consequence also in their agricultural, urban, industrial and tourism policies) and to get involved in " water demand management " (WDM or in French GDE) policies, a concept similar for water to "energy efficiency" for energy. " Water demand "is here referred to as the total amount of uses and losses.

Figure 7: Demand for water in Southern and Eastern Mediterranean watersheds (SEMC)
The two scenarios for 2025 studied by the Blue Plan



Several countries have also started on this new path, which led them to develop important agricultural policies for irrigation water demand management, driven by the Ministries of Agriculture. This is the case of Tunisia, who committed early (since 1993 on) in a national water-saving strategy for both urban and agricultural needs. With this policy, the demand for irrigation water could be stabilized in 1996 while the value of production continued to increase (Figure 8). Thus, the demand for irrigation water, as compared to GDP in irrigation, fell by 23% from 1990 to 2003 while the value added in irrigated production, relative to the demand for irrigation water, increased the same period by 29%. Besides the benefits in agricultural production, the policy also helped to secure needs in the tourism sector, source of foreign currency, and in cities, source of civil tranquility.

Figure 8: Changes in water demand and the added value of agricultural production in Tunisia



Source : Hamdane

The success of the strategy[xxxix] was based on:

→extensive outreach program for farmers, specific training of extension technicians and engineers, organization of daily radio programs, TV spots, etc.

→promotion of water-saving facilities and technologies while shifting from isolated technical measures to an integrated approach for promoting modern irrigation equipment supported by subsidies at 40, 50 and 60% for large, medium and small farms. The rate of equipment in water saving equipment in the plot rose dramatically from 20% of the total area irrigated in 1990 to 80% in 2007, with sprinkler irrigation and drip irrigation on over 68% of the irrigated area. The resulting increase in irrigation efficiency is estimated to 20%, with a decrease in water applied to crops ranging from 9% for arboriculture to more than 30% for vegetables.

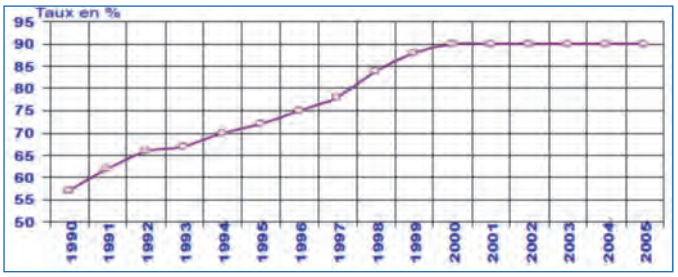
→progressive nature of the various reforms and adaptation to local contexts.

→decentralization and water local management through promoting participatory and empowering methods for irrigators organizations. Thus the number of GDA (groups for Agricultural Development) for irrigation increased from 178 in 1990 to 1200 in 2007. GDA operated and managed at that date 68% of the lands in public irrigation schemes. GDAs are self-managed structures that are fully qualified to build and collective manage their works.

→measures for sustaining farmers' incomes in order to anticipate and to secure both agricultural investment and work.

→a pricing system combining openness and flexibility, closely articulated with national goals for food security, allowing gradual improvement in cost recovery (Figure 9). From 1990 to 2000, a steady increase in water prices was carried out at a rate of 9% per year in real terms. Considerable effort was made in parallel to generalize installation of water meters on irrigated farms.

Figure 9: Pricing for irrigation water in Tunisia (in percentage)



The Tunisian experience shows that success requires to give again to man, and first to the farmer, the heart of the concerns, since he is much more than a mere user in a given sector, but rather a holistic actor responsible in managing water as an asset. It also shows the strategic importance of elaborating more complex agricultural policies for water demand management (WDM) in order to be effectively able to combine a series of tools adapted from different disciplines : namely economic (subsidies, tariffs), information and awareness, technical and organizational. WDM, which is an "art", invites to a fundamental change in agricultural policy and it's follow-up. The State is moving from the role of a Builder-State who commands and controls, to a State who mobilizes and gives responsibilities to farmers by encouraging their collective organizations with larger local autonomy and taking into account the imperative of sustainability.

In the future, more radical reforms will be needed in the water sector in the Mediterranean. Despite the progress made by WDM, it is not yet a key ingredient for water policies in many countries exposed to water scarcity, and water pricing remains still a taboo in several of them. It will therefore be necessary to extend the approaches of WDM to all countries facing shortages or risks of shortage, and further strengthen the capacity of all stakeholders: awareness of the value of WDM, reshaping training programs for engineers, education, building local capacities for management, encouraging group towards more autonomy while ensuring proper inclusion of the sustainability imperative.

It also important to aim and attain, at a second stage, for WDM *to increase the efficiency of inter-sectoral water use*. The second stage, that of "the water demand management in the strong sense", should be to disconnect the water demand curve from economic growth and population growth. This disconnection will require measures that will apply on re-allocation of water between different sectors to give priority to sectors with high performance in economic social and environmental domains, with more rational water allocation mechanisms.

Irrigated agriculture is to let more water to other uses. This will finally open the floor to major policies for rain-fed agriculture for which sustainable development is, in most countries, a primary condition for food security and for producing positive externalities (environmental services) for the water cycle.

Case study No 8: The RIM (Mediterranean Irrigators Network) project : cooperation and training to increase efficiency of irrigation water[28]

Debates on the rules of water management in an association of irrigators (Morocco)

The conversion from surface irrigation to drip irrigation can reduce agricultural water demand up to 50%: it is a necessity for many irrigated areas on the southern shore of the Mediterranean. Expensive and technical option for farmers, drip irrigation techniques require however an intensification of existing crops or the introduction of crops with higher value added. Small and medium sized family farms do not have the advantages of larger farms. They must be accompanied in this mutation to successfully develop both water savings and product transformation and trade.

The RIM project contributes in providing training / actions for local groups (agricultural cooperatives and water user associations) on the basis of three principles: participatory diagnosis to identify and support the needs of farmers for training, mobilizing trainers from different backgrounds (researchers, private sector, consulting firms), including farmers (peer training), progressive appropriation of training issues directly by producer organizations.

Trainings conducted since 2011 involved five major irrigated areas in Morocco and two regions in Algeria for a total of about 400 farmers. The project offers the advantage to mobilize many partners[29] and to facilitate the development of cooperatives and irrigators' associations networks both at national (Morocco, Algeria) and at regional levels (experience sharing between Morocco and Algeria).

[28]. Case study documented by Billy Troy (FARM Foundation) and Marcel Kuper (CIRAD)

[29]. Agricultural Organizations in Morocco (Raccord association), in Algeria and France (Chamber of Agriculture of the Lot), FARM, AFEID, consulting firms specializing in participatory approaches (Cap Rural Morocco, El Itkane Algiers, LISODE, France) and research institutes & Training Centres of the northern and southern Mediterranean (CIRAD, ENA Meknes, ENSA Algiers, Cemagref, Montpellier SupAgro, Institute for warm regions, UMR-G eau)

2. INCREASE STORAGE AND MOBILIZE NEW RESOURCES WHILE SEEING TO ENVIRONMENTAL AND SOCIAL ASPECTS

Meeting the challenge of food security also means developing water storage capacity (surface and groundwater) and mobilizing new water resources, including non-conventional resources (reuse of grey water, of drainage water...), while always taking into account environmental and social aspects. The issue is crucial for Africa which has unutilized water resources and must facing considerable increasing needs. It is also critical for all the other regions that will become drier with climate change and for which storage will have to be considered a risk management tool.

The five examples of solutions presented below demonstrate the strategic importance of increasing water storage and mobilizing new water resources.

Case study No 9: Supplemental irrigation in the Sourou Valley (Burkina Faso)[30]

Agriculture is still mainly rain-fed in the Sahel: in Burkina Faso, for example, there are 3 million rain-fed ha. versus 40,000 irrigated ha. However, the high spatial and temporal variability of rainfall, which will worsen with climate change, strongly constrains the performance and future for agriculture.

In this context, the National Burkina Committee on Irrigation and Drainage and the FARM Foundation have joined forces to support the cooperative Socadis (Sourou Valley), to develop access to credit and training for supplemental irrigation on maize crops in the rainy season. Supplemental irrigation was developed with support from the development authority of the Sourou Valley; it involved 63 ha, then 151 ha, then 227 ha over the seasons 2008-2010 respectively.

The project led to: average increases in maize yields of 3.3 – 4.0 t / ha compared with 1 t / ha in rain-fed agriculture; maintaining performance in a dry year; to sharp increases in water productivity with an average of 0.43-0.64 kg/m3 versus 0.10-0.15 kg/m3 in rain-fed situations. Average margins are quite good, but could be improved through a better organization for collectively marketing products.

Case study No. 10: Construction of dams and intensive rice cultivation in the North Rakhine State (Myanmar/ Burma)[31]

In 1992, driven by poverty and by the discriminations exerted by the authorities, 250,000 people from the ethnic Muslim Rohingas group migrated to Bangladesh. Under the auspices of UNHCR, GRET, a French NGO, facilitated, from 1996 on, the social reintegration of returnees through support measures for agriculture.

The program was intensified in 2003 with financial support from the EU. It resulted in the construction of 11 "dams" between 2004 and 2008 for the cultivation of 164 irrigated ha with 1200 farmers benefitting, incorporating 40% landless farmers. The construction operates as part of a "food for work" program. Each dam costs about $ 200,000 and provides on average 12 irrigated ha for a hundred farmers. The creation of each dam comes along with a management committee responsible for operation and maintenance as well as introduction and dissemination of the SRI technique (System of Rice Intensification) through "Farmer Field Schools" and " farmer-led experiments."

Rice paddies (Burma)

The results measured for the 2008 season over eight dams are: appropriation by farmers of the SRI technique which is ideally suited to this region where water resources and land are limited, average yields of 3.8 t / ha, (+1.4 t / ha as a result of SRI), total paddy production 1,034 Mt, providing food for 840 households (7,900 people) for 4 months, a crucial input for giving poor families a chance to go through food lean season.

[30]. Case study documented by FARM (Foundation for agriculture and rurality in the world)
[31] . Case study documented by GRET

Case study No 11: Black Limagne (Puy de Dôme, France) or how irrigation can recycle urban water[32]

Black Limagne, north of the city of Clermont Ferrand, is a land of grain and sugar beet. Producers, engaged in high quality production under contracts, had to find a suitable water resource to reduce their exposure to weather variability that would affect production and ability to fulfill their contracts. Out of range from any conventional and sufficient water resource, they had the idea, with the support of SOMIVAL (development corporation for Auvergne and Limousin), to consider using part of the treated wastewater issued from the neighboring city. Farmers created for this purpose in 1989 a land owner association in the form of ASL (free owners' association) with collective access to wastewater, that became in 1992 an ASA (see Case Study 3) and the association rules apply therefore to all owners within the public approved perimeter. This project, introduced in 1989 was the first of its kind in France and there was at that time no technical nor regulatory references. This led the Medicine and Pharmacy faculties in Clermont-Ferrand to specify the scheme implementation details, and national health authorities in 1992 to elaborate appropriate recommendations.

The ASA perimeter includes nowadays 1,400 ha of equipped fields, 700 ha of which are irrigated each year on 51 farms. The need for irrigation during peak periods is 18,000-24,000 m3/day while the wastewater treatment plant used to reject 50,000 m3/day in August. Water from the plant shall stay shallow lagoons over 12 ha for at least 13 days. The cost of the operation, € 5.3 million, was funded 35% by ASA, 6% by Bourdon Sugar Company, 14% by the EU (through LIFE program), 13% by the water basin Agency, 13% by the Department of Puy de Dome and 17% by the state.

Since 1996, a monitoring committee consisting of representatives of municipalities, Departmental Health Council experts, government and other stakeholders, meets 2-3 times a year to monitor and guide management. The water used for irrigation is checked every 15 days. Since 1996, it is consistent with the quality "A" recommended by the Board of Public Health of France. An epidemiological survey was also implemented to verify system harmlessness to health hazards among the surrounding population of 17,000.

This project, supported by the Life European program, was the first European project of this nature by its size. The techniques used and the partnership established, serve as an example in France and abroad. It participated directly into maintaining local medium sized farms as well as the vitality of regional agro-industrial operators representing 2000 jobs in the region. It also helps to fight against the degradation of rivers, since fertilizer materials, up to 15 tonnes of nitrogen and 1 tonne of phosphorus, are valorized by crops and are no more conveyed to the river Allier.

Case study N° 12: The «Well of the Desert» in the Tidene Valley (Niger)[33]

Tidène Valley, one of 13 main valleys of the Aïr Mountains, is located in northern Niger. The valley, stretching for more than 100 km by 40 km width, is sparsely populated. The groundwater resource, relatively abundant, is considered "under exploited" by the regional office of hydraulics. Groundwater is close to the soil surface (wells are 15 m deep), and recharged by rainfall (rainfall of 50-200 mm/ year). The main activity is the traditional nomad livestock herding. The creation of the first wells for market gardening dates only from the years 1990-2000.

During a humanitarian air raid, the President of a French NGO working in the health field happened in 2002 to meet the Tuareg of the valley. This accidental meeting, and the discussions that followed, led the NGO to change its name into "The Well of the Desert" association and a group of Tuareg men and women who have decided to take their future in hand decided to create the "Tidène " association recognized by the government of Niger. The two associations adopted objectives to support the development of rural populations to the north of Niger through access to water and health since 2004 and are working in full partnership for greater efficiency in the field. The scope of the French NGO is to find partners and is guaranteeing the proper use and allocation of funds. Tidène association collects requests from people, sends them and does projects application and monitoring. A French engineer in Rural Engineering, Water and Forests, expatriate, assists the Tidene association. She prepares reports and supports the President in his relations with the authorities and the major foundations in Niger. The accounts of Tidène NGO are verified and validated by an accountant. Through this outstanding partnership, over 170 wells have been created to date, including 90 wells for vegetable cropping, together with a school and a dispensary. The 90 wells for vegetables are sufficient to meet the needs of 270 families representing 2,300 people.

The creation of wells has many merits. Being made in fenced agricultural land ("gardens") preventing animals from getting in, it allows families to have access to quality drinking and domestic water. It also allows for varied vegetable, tree and cereal irrigated production according to seasons. Incomes and food security are secured by the sale of products (including onion). There are few figures on income. It is felt that a medium-sized food garden (0.5 ha) can provide a family the equivalent of two minimum wages, or 70,000 FCFA / month. Farmers in Valley Tidène who could install a well and develop a garden consider that their income has increased by 10, and larger gardens, devoted to cash crops, return easily several million FCFA per year to their owners. For the entire valley, there are now 771 families with a garden, out of a total 1162, revenues from gardens contribute by 70% in household income. The vegetable agro sector which has structured through cooperatives contributes more significantly to socio-economic life of the region. It promotes a whole series of new jobs and income-generating activities: small retailers, well drillers, transporters, and it enabled the development of trade to other parts of the country.

Development of market gardening enabled farmers to diversify their activities to enjoy a basic income less subject to climatic. Veterans from rebellions in the North could settle as farmers. It also helps to support the settlement of the population around health centers and schools: children, relieved of the task fetching water, can use them more easily and so diversify their skills and their future.

[32]. Case study documented by FNSEA

[33]. Case study documented by Christel Pernet, Chair of the ONG «Les Puits du désert»

Case study No 13: The multifunctional importance of irrigation in France, the example of the Juanon storage basin (Drôme, Mediterranean France)[34]

Irrigated products represent a total turnover of € 3.8 billion in France. Irrigation ensures high productivity and better use of inputs, resulting in reduced risk of pollution and improved plant resistance to various stresses. It also helps meet the market requirements (quality, regularity) and promotes diversification on the farm with value-added products. It generates more jobs: for every 100 ha of irrigated land in the French Mediterranean region, it is an average direct 13 ETP (equivalent full time employment) in farms and an indirect additional 9 ETP generated in upstream and downstream sectors[xl].

Water can be stored when the resource is abundant and released from storage when l periods of shortage, both for the people, for natural environments and for various economic activities. It is vital in the Mediterranean part of France. It also represents a challenge for adapting to climate change: storage of the resource will indeed help meet these new conditions, while taking advantage of the conditions in France, a country where water is not scarce.

The Juanon storage reservoir, founded in 2005 with a capacity of 700,000 m3 covering 10 ha, is a good example of a possible multifunctional interest of irrigation in a Mediterranean climate. Farmers in the lower valley of the Drôme, associated in two unions of 600 ha each, producing cereals, maize seeds, sunflower and garlic, fruits and herbs and they all need water. Until the creation of the storage basin, farmers were pumping into the river Drome, which was not really satisfactory for them or to the river. In fact, three years out of 4, in dry period (July and August) when water demand is highest and available water resources is minimum, the river flow was below the "instream flow" that is the flow fixed by law as the minimum flow to maintain the natural course of a river to ensure continuously life, circulation and reproduction of the species living in these waters. This was harmful to aquatic life and agriculture, the Prefect being in this context often led to prohibit irrigation 4 days out of 7.

Since no connection to neighbouring irrigation networks with abundant water resources was possible, the only solution was storage. It turns out that upstream the two water-deficient associations, lies the union of southern Valence (SISEV), irrigating 1,600 ha, could access a much more abundant resource, that of the river Bourne, part of which could be easily stored and transferred downstream. Solidarity between basins and between farmers upstream and downstream could and should therefore develop, benefiting also the natural environment.

The Drôme River is the subject of a SAGE (territorial schema for managing and planning water), the President of SAGE therefore asked in 1996 to investigate at SISEV a solution that would allow one hand to meet the needs of two water scarce associations downstream, and, secondly, to support the river in periods of low flows. It will take 10 years of struggle and work to the project team to achieve it - a competent engineer surrounded by a core of highly motivated elected municipals ans farmers -. The first fight will be that of information, the first decisive action is the realization of a 45-minute film, which screened in all villages and towns of the area concerned, will explain the challenges of the project. This will avoid later disputes which have stalled the project, as was often the case in recent years in France. The other battle will be that of financing,. The total project cost amounts to € 3.3 million, or € 5 per m^3. This is supported by the water agency (60%), region, county and state, and 22% of the total amount is borne by farmers, which allowed project realization.

Since the filling of the reserve in 2006, farmers in both associations can irrigate every day in summer, even during the periods of restrictions decided by the prefect. Through irrigation and solidarity between the unions of farmers, irrigated agriculture has been saved in this territory, and the engagement to support the low flow of the Drôme adopted in the SAGE was widely held, providing 1 million m3 to the river.

[34] . Case study documented by the FNSEA (Union of French irrigaties) and by the Union of town councils of South-East Valence (SISEV)

3. RAIN-FED AGRICULTURE: PROMOTE CONSERVATION AGRICULTURE

The growth of the productivity of rain-fed agriculture is even more important than that of irrigated agriculture. Much of agriculture, particularly in Africa, has not yet benefited from the achievements of the first green revolution; access to quality seeds and mineral fertilizers can lead to significant progress. However progress is also possible through agro-ecology. The way forward is important for water resources and food security as it can greatly reduce soil erosion, restore fertility and store carbon, and also reduce the use of external inputs (oil, fertilizers, pesticides), which can also improve the income of farmers.

"Conservation agriculture" based on integrated management of the soil and its fertility, and on three principles - reduction or elimination of tillage, permanent vegetative cover and crop rotations-, has expanded greatly over the last twenty years in countries of large, mechanized agriculture in the tropics or dry areas (Brazil, Australia, Argentina....). In these countries with unstable climatic conditions (heavy rains and / or droughts) and fragile soils, conservation agriculture has made it possible to preserve the productive base of agriculture (soils and water) while making substantial cost savings by eliminating cultivation of the soil. In addition, the use of specially-adapted seeders and herbicides facilitates the management of vegetative cover without generating significant additional costs.

The principles of conservation agriculture (and more generally ecological intensification) may be particularly interesting for the "smallholder farming" in developing countries. Indeed, this type of intensification does not necessarily require large investments and high costs of chemical inputs, and it allows restoration of soil fertility - an imperative in tropical countries. Their inherent fragility, the intensity of degradation processes of organic matter, population pressure limiting fallow and low use of fertilizers, often condemn farmers to low yield, which declined rapidly after the development of new lands. For these reasons, the French territory of Reunion Island, particularly prone to erosion problems (see Case Study No. 23, presented in the next chapter), has been at the forefront of innovation to the new forms of agriculture.

Conservation agriculture (or "sustainable agriculture") is also attracting increasing attention in temperate agricultural areas. It permits a reduction in operating costs while giving agriculture a new culture of innovation, helping to adapt to global change and allowing it to take better advantage of the productive capacity of soils and ecosystems.

The following two case studies show that: i) new interest generated by "sustainable agriculture" in France, and ii) the importance of introducing these new approaches in developing countries in the tropics, here the case of a project in Cambodia.

Case study No 14: The *nouricia* Cooperative, Aube, France[35]

The *nouricia* Cooperative brings together 2000 farms in an area close to Paris, formerly known as "Barren Champagne". Field crops (wheat, barley, sugar beet) are relatively recent: they were introduced after land clearing work in the years 1950-1960 on poor and thin «rendzine» soils (6% organic matter). From 1960 to 1990, yields have made outstanding progress with the help of chemistry, genetics and mechanization reaching about 8 tons / ha for wheat. However, from the 1990s, cereal yields began to stagnate and then decline, while yield variability (from one plot to another and between good and bad years) increased substantially, which appeared abnormal.

This decline in yields and increase in variability was due mainly to drier and warmer springs as a result of climate change (according to Avalis). However, soils are also involved, although erosion, important and even visible, is often denied by the farmers. Levels of organic matter have in fact fallen by two thirds (only 2.5% today). Soils that are now more prone to erosion have become more sensitive to rain and wind. At the same time, prices for phosphorus and nitrogen inputs have undergone variations ranging from 1 to 3. In addition, India and China have developed a dominant position as buyers, which could, in times of crisis, put in difficulty supplies to Europe.

Cooperative leaders concluded in 2007 that they had to "totally rethink the fundamentals of agriculture." They were encouraged in this by the experience of Brazil and Argentina. They learned that in these countries there has be a permanent shift to new agricultural practices (larger farms have their own agronomist), bringing solutions (permanent cover, no-till) that gave rise to a reduction in operating costs while benefitting from the productive potential of ecosystems. The President of *nouricia* had already shifted to no-tillage for 17 years on his own farm thanks to ability to carefully observe his soils. Later, he decided to propose to the cooperative and then to its farmer members to engage in a process of "sustainable development", an example which was immediately followed other French cooperatives.

Beyond changes in practices in the cooperative itself (which received an A+ rating in 2011), the goal is to change practices on the farms of its members. Achieving this was not so easy, because even if the new crop management practices proposed are indeed better, including financially, their adoption requires a real "cultural" change. The cooperative has therefore made it a top priority to convince a hundred farms, in the first instance, providing technical support to the farms that volunteered (4 young agronomists were hired), as well as eco -diagnostics (1 week per farm) and a 100 € / ha additional margin on the area of products grown under «sustainable agriculture» practices. The new farming practices that they must adopt to benefit from this support include permanent vegetative cover, a decrease of 30% of the IFT (an indicator of frequency of applications of crop protection products) and a reduction of 10% in greenhouse gas emissions. Thus, besides the decline of erosion (improved water and soil conservation), the approach adopted will lead to a significant reduction in impact on water and biodiversity. The cooperative seeks in parallel ways to valorize its "sustainable" products in the marketplace, which corresponds to consumer expectations.

[35]. Case study documented by the CGAAER from information transmitted by Christian Rousseau, president of cooperative *nouricia*

The process aims finally at transforming a "constraint" into an "opportunity", with several advantages: access to new markets, a reduction in expenses and an increasing in income, convergence towards the goals of the plan Ecophyto 2018, acquisition at all levels of a culture of innovation, and the transition from an approach where the environment is a "constraint" (one knows how difficult it can be to get results in such situations) to a "active" approach to work with the environment.

Case study No. 15: The PADAC in Kampong Cham (Cambodia)[36]

Agriculture is dominated in Cambodia by lowland rice cropping. However, high population pressure leads to saturate land availability in the lowlands and to expand rain-fed agriculture in peripheral areas. Failure in supporting the "pioneering front" had resulted in letting develop unsustainable practices, water erosion phenomena, stronger dependence on weather conditions and rapid decrease in soil fertility.

Introducing concepts of conservation agriculture in Cambodia was supported by AFD (French Development Agency) first along with projects for developing smallholder rubber plantation farms from 2003 to 2008, then in the PADAC (Agricultural Development Project of Cambodia) since 2008. The first stage with € 1 million invested, has developed and successfully tested the adaptation of the three principles of conservation agriculture (minimum soil disturbance, maintenance of continuous coverage by mulch or plants, crop diversification) in the area of Kampong Cham. The second, with a € 2.5 million support by AFD, aims at moving to a higher development scale although still modest (a few hundred hectares). The project is to consolidate the development of crop management methods, to train researchers and technicians to analyze the socio-economic constraints that curb adoption of these systems, and to develop a "political" advocacy support. The expected benefits for the water cycle are important. Changes in soil structure, development of living organisms for improved retention, better penetration and better distribution of water. These systems have indeed the advantage to help smooth out variations in rainfall, increase crops resilience to climate, and ultimately, increase average yield and income, while allowing greater aquifer recharge.

The experience in Cambodia and other countries in Southeast Asia has shown the relevance of such innovations. It also showed that:

- without effective rules for tenure security, it is difficult on the long-term to preserve the natural capital,
- transition from conventional unsustainable system to DMC (Direct seeding under vegetal cover) is tricky. It requires that producers access and integrate new knowledge and build their capacity, and a significant public support, technical and financial, to benefit from the positive externalities they will develop for water resources and food security.

Mulching of pineapple crops with sugar cane bagasse in Reunion (conservation of soil and water)

[36]. Case study documented by AFD

4. SUPPORT SMALLHOLDER AGRICULTURE TO ENHANCE AGRICULTURAL AND PASTORAL WATER SUPPLIES AND FACILITATE SUSTAINABLE RURAL DEVELOPMENT

Out of the seven priorities for action proposed in the present report, support for developing "smallholder agriculture" is an absolute necessity for our common future. Smallholdings in developing countries do not generally easy access to information, credit, technology or markets, unlike the large modern farms. Given to the number of people involved and the strategic importance of the sector, smallholder agriculture needs to be supported. This is a condition for the countries concerned to be able to develop their water resources and achieve "inclusive" development, and so escape from poverty and make progress in the three dimensions of food security, "availability”," access "and" stability ". The challenge is global because the world will not be able reduce hunger and poverty, or maintain stability, while continuing to leave a large part of mankind out of progress.

Achieving "*inclusive development*" may require better regulation of major private investment by obliging them to *include positively* smallholder farmers in the territories concerned. However, many areas in developing countries are not attractive to such investors. In addition, small family farms can grow significantly and invest by themselves, providing they become more professional and structured (building *social capital*) and have to access technology, credit, subsidies and markets in order to increase yields and incomes.

The 9 case studies that follow confirm the risks of further marginalization of smallholder agriculture, and, on the other hand, the potential for considerable progress in all dimensions of sustainable development, on condition that there is good support on the ground.

The first 5 examples focus on the central question of "*rights of access to resources*" and on the importance of the "*negotiation*" process. The following 3 examples show the importance of promoting territorial approaches as vehicles for sustainable agriculture and rural development. These approaches, which are based on the recognition of collective rights and responsibilities in the management of resources, make it possible to improve the incomes of the rural poor while ensuring restoration of productive ecosystems and production of environmental and territorial services (maintaining balance between urban and rural areas for stability, reducing erosion and loss of biodiversity) for the benefit of the public interest. The last example, at the scale of a whole country (Vietnam), shows the great benefits that a country may derive from an overall agricultural strategy including support for family farming.

→ Recognize and defend the water rights of family agriculture and support its development

The first three case studies show that the trends at work in many countries (privatization of water services, marginalization of smallholder agriculture, lack of recognition of their rights of access to water) can cause significant loss of production as well as deterioration in food security and conflicts between water users. These three examples also show, however, that sustainable solutions can be found with appropriate support for intermediation and for resource mobilization. The next example, that of Vietnam, contrary to what some believe, shows that very small sizes of farms do not preclude the possibility of considerable economic progress. It also underlines the strategic importance for a country to give consideration to family farming, properly supporting the sector to develop into commercial agriculture.

The last two examples relate to the specific issue of water allocation between farmers and herders in the Sahel. They confirm the key importance of local intermediation in the search for win/win solutions between the different users.

Case study No. 16: The Angat reservoir (the Philippines)[37]

The Angat reservoir in the Philippines supplies irrigation water for 30,000 ha of rice fields, and it provides electricity and 97% of drinking water for the city of Manila.

Water rights allowing 22,000 farmers in the area to irrigate their plots were established in 1976. Under pressure from international financial institutions, management has been privatized and the allocation of the resource has developed at the expense of agriculture. This has been accompanied by decentralization of management to agencies with very low management capacity. The irrigators' associations were then mandated to collect the taxes and manage the infrastructure, but did not have any support to do this. The result was that agricultural production dropped by 50% in 10 years and that farmers, were unable to pay the irrigation fees necessary for maintaining canals; many fell below the poverty line.

Faced with this situation, the IRDF (Integrated Rural Development Fund) produced and widely distributed a comprehensive study that showed the consequences of structural adjustment policies. A strong mobilization of farmer organizations and other actors of civil society ensued. It led the Supreme Court to halt the process of privatizing the public electricity distribution company, and to decide that water shall be available to farmers during the critical 10 days of the growing season.

[37]. Case study documented by the NGO CCFD (Catholic Committee Against Hunger and for Development), member of the collective "Coordination SUD"

Case study No 17: The Valle del Cauca (Colombia)[38]

The water service in the Cauca Valley of Colombia, established in 1930 mainly by coffee producers, is organized into "aqueduct services". The dominant agricultural model is today that of sugar cane production for biofuel. Poor farmers work on the slopes.

In villages, the aqueduct services are based on "community" management: the beneficiary population owns them collectively and the management bodies define the usage, which is multi-use (fields, gardens and livestock, drinking water, local industry), and the tariff. Small-scale, informal, irrigation sprinkler is widely used: it lacks collective management and more water-efficient technologies (drip irrigation).

In April 2005, a draft national law was drawn up to privatize the aqueduct services and water markets. The project planned to expropriate local communities and allow the private provider to fix the price as he wished. This led IMCA, an NGO founded in 1962 by the Society of Jesus that supports rural development in the valley, to organize in 2005 the first regional meeting on "water, heritage of the villages," followed in 2007 by the first national meeting of community aqueduct associations. Following this mobilization, the government decided to withdraw the Bill and NGOs started to develop proposals. Thus 2.2 million signatures were collected in support of a text laying down the following basic principles: water as a fundamental human right, the non-profit, public service character of community water systems and sanitation, representation of users in the steering committees, and protection of ecosystems.

Case study No 18: Chambo Valley and social management of water in Ecuador[39]

photo : Kawensky

On the watershed of the River Chambo in the Central Andes (Ecuador), as in many other parts of the world, the problem lies less in the amount of available water than in the way to share and manage it. In a political context of water in turmoil at national level (new law debate, new state institutions), rural communities and the city of Riobamba, the expanding provincial capital of 150,000 inhabitants, as well as businesses and families farmers, are competing for access to water, in the frame of power relations, however, still very asymmetric.

NGOs CESA (Central Ecuadorian Agricultural Services) and AVSF (Agronomists and Veterinarians Without Borders, France) decided in 2007 to support the establishment of a consultation mechanism to negotiate mutually beneficial agreements and the pooling of technical and financial resources and the collective means for protecting the resource. This led to a diagnosis of the situation, transparent delivery of information accessible to all and an exchange of experiences with various actors in water management in France, including the Water basin Agency Seine Normandy.

The long process of animation finally allowed a calm debate to take place which lead actors into building concrete ways to address key bottlenecks identified and shared between all. The results are promising today: creation of a basin committee consisting of representatives of the various users, establishment of a financial tool, beginnings of political agreements between city and Indian irrigators for water sharing, collective elaboration of a management plan for water resources.

Case study No 19: Management of water and pastoral water systems in Mali[40]

Pastoral water in Mali (photo: Apollin)

In Mali, livestock accounts for 13% of GDP and 80% of rural incomes of the rural populations concerned. Pastoral wells (or drills) are essential for transhumant herds during the dry season and water points can help manage the seasonal complementary of rangelands. However, competition over resources has increased, the pastoral areas are colonized by agriculture, conflicts are increasing and the wells get increasingly overcrowded, increasing the pressure on already degraded pastures. In addition, wells are also used by man for drinking are polluted and can cause diseases (diarrhoea, typhoid fever, parasitic diseases) with high mortality rates.

In this context, the NGO AVSF and ICD Implemented from 2007 to 2011 a project for joint management of pastoral resources, especially water, to secure livestock transhumance in the regions of Mopti and Timbuktu. The project has developed an intervention strategy adapted to the reality of socio-pastoral systems, showing namely the importance of: i) knowledge of social and historical systems for controlling the water resources, ii) inputs from main well users and consideration for their positions and historical rules, iii) time to be invest in consultation with users, iv) with frameworks for multi-players to be provided at the "Circle" to collectively identify priorities for water development by incorporating a broader territorial scale, and to promote local consensus, v) legal recognition of pastoral rangelands vi) training for elected representatives, technicians and support to herders' organizations.

The project has demonstrated the need to find a water management system able to reconcile on the one hand the need to take into account the pastoral way of life (customary organizations) and, on the other hand, the regulatory framework of the state.

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38. Case study documented by the CCFD
39. Case study documented by ONG AVSF (Agronomists and Veterinarians without borders)
40. Case study documented by ONG AVSF (Agronomists and Veterinarians without borders)

Case study No. 20: A pilot project "Water Governance and Food Security" in the Kayes region (Mali)[41]

The Kayes region, hard hit by food insecurity, is dependent on weather conditions, the vulnerability to climatic hazards being exacerbating tensions for access to water and land. Taking advantage of the potential of existing water resources in the region, infrastructure access to resources (wells, boreholes, thresholds, irrigation schemes) have been built in recent years. However, coexistence between agriculture and livestock for access to water is often confrontational and the presence of animals makes it difficult for farmers to practice counter seasonal cropping. With decentralization that is ongoing in Mali, water and "land" competence were transferred to municipalities, but they are lacking means and must be supported.

The Kayes pilot project, in this context, has focused on the development of innovative methods for managing water points involving and empowering all stakeholders, including farmers' groups and elected officials. It has, within the three municipalities involved, supported concerted development in municipal management rules aiming at a better sustainability of equipment and a rational and sustainable use of resources through equitable access for all users, including women and young people.

For agricultural wells, the project identified:

- establishment of management committees for irrigation schemes bringing together groups of producers, landowners and ranchers to set common management rules, reduce the risk of conflict and organize the collection of fees to finance maintenance and reclamation of water points,

- capacity building for farmer groups and communities to manage water points and for producing grain and market gardening. The introduction of new crops is particularly promoted: winter rainfed cereals, falling river level cereal cropping,, irrigated cereals or gardening - and new varieties more suitable and productive. About 400 male producers and 400 female producers were trained in particular to help setting up the frame of producer associations.

The project is implemented by the three municipalities concerned and farmers' groups with the support of GRDR (research and achievement group for rural development), and of three French institutions: FARM Foundation, the water basin Agency Picardy and Artois the Water Foundation France Libertés. In addition to a sustainable improvement in the local situation, it is expected that the project can develop a methodology for developing ways of managing multi-purpose water points that could be used in different parts in West Africa.

→ The "terroir"[42] approach, vector for sustainable rural development

If support for agriculture must target "development", it must also target "sustainability" of resource use through the promotion of "participatory approaches" conducted at the correct level of territorial governance and within reasonable time scales.

The 3 following examples show the strategic importance of the concept of ("*terroir*"), an area of interaction between rural communities and the environments in which they live, and the importance of adopting broad objectives for *sustainable rural development*. This requires an intelligent combination, in the framework of genuine "participatory" approaches, of short term progress (infrastructure, production and promotion of products, market access, diversification of the rural economy...) with long-term sustainability of natural resources and ecosystems.

The first example documented demonstrates the recent and remarkable commitment of Morocco in adding value to its rich potential of "local products (produits de terroirs)" as a tool for rural development. The two next examples of solutions relate to the island of La Reunion (OLAT), and Southern Tunisia (PRODESUD). All three show both that *participatory approaches for sustainable development* giving good results are possible on the condition that local people are really involved. The key to progress lies in strengthening the "social capital" (collective organizations), which, as regards the proper management of shared natural resources (agricultural water, rangelands...), needs to take place at relevant territorial levels. This requires technical support in the field by trained facilitators in participatory management of natural resources (local intermediation) and effective delegation of responsibilities, including financial, to the farmers organizations in the "terroirs".

Case study No. 21: Increased incomes in vulnerable rural areas of Morocco through adding value to regional products (" produits du terroir")[43]

For 50 years, agricultural Policy in Morocco has given priority to large irrigation systems with a target towards a "million irrigated hectares", which has now been reached. The policy has been renewed and expanded since 2008 with the new momentum generated by the «Plan Maroc Vert» (Green Morocco Plan). This Plan has the goal of establishing "one million farm business" and an "agriculture for all". It includes a "Pillar 2" specifically dedicated to support for the development of smallholder agriculture, particularly in difficult rural areas (mountains, semi-arid areas, Saharan / oasis zones) which cover 80% of the agricultural and rural population of the country.

The promotion of "local products (produits du terroir)" has become one of the major, and innovative, components of the Green Morocco Plan to help in particular the less-favoured areas. These areas have a wide range of expertise and products with a strong local identity, qualities which are increasingly valued and sought after by both Moroccan and foreign consumer, but which remain under-valued.

The new law on "distinctive signs of origin and quality" of 23 May 2008 has four basic objectives: to preserve the diversity of production, promote agricultural development locally, increase product quality and improve incomes of local operators.

The first products to benefit from a protected designation of origin were mainly in under-developed regions of great diversity. These include: the Argan oil, Beni Guil lamb, Chefchaouen goat cheese, Tyout Chiadma olive oil, and Taliouine saffron.

Olive oil from Tyout Chiadma (a 100 ha irrigated olive grove with 120 farms) and saffron from Taliouine are the two first products to have benefitted from a protected label of origin (AOP). This recognition was achived through working together on a small-scale (village or inter-village lands) over several years. In both cases, core groups of motivated farmers engaged in projects to set up local cooperatives managed under strict rules in terms of production and quality. The result was a remarkable valorization of products. This local commitment was helped by a major facilitation effort provided in Tyout by the Provincial Directorate of Agriculture of Essaouira, the local extension service and an INRA researcher, and in Taliouine by the Franco-Moroccan NGO "migration and development". The valorization of saffron also received support from the Ministry of Agriculture, which has held a saffron festival for several years, and from the Regional Council of Souss Massa Draa which helped develop the specifications of the AOP.

In the two cases, the momentum generated has allowed the cooperatives to establish direct relationships with operators that are a long way downstream (direct access to national or international markets). The consequence for these less-favoured areas has been a doubling of both the sale

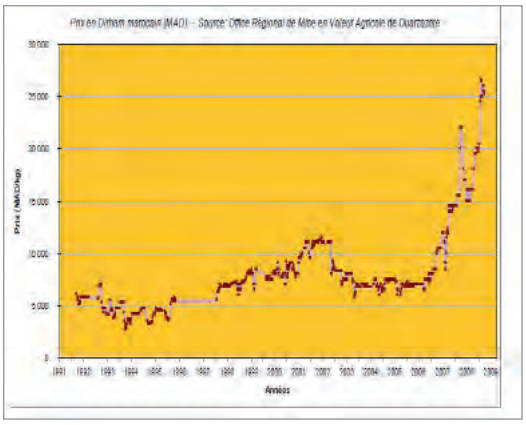
41. Case study documented by the Fondation of agriculture and rural life (FARM)

42. "Terroir" is a French word that has no equivalent in English. According to the definition used in the UNESCO by "Terroirs & Cultures International", a "terroir" is "a limited geographical area, defined as where a human community has built during its history a set of distinctive cultural traits, knowledge, and practices based on a system of interactions between the natural environment and human factors. " The know-hows brought into play may confer a typicity and induce a wider recognition for the products and services originated from this area.

43. Case study prepared from the document of the General Council of Agricultural Development, Morocco (Joint publication with the CGAAER France) entitled " Terroirs et origine: Lessons from an exchange of experiences between Morocco and France», May 2010

prices of the products and the income per m^3 of water utilized. All saffron producers benefited from rising prices (see Figure 10).

Figure 10: Changes in the price of Taliouine Saffron (producer prices in the souk) 1991-2009



With appropriate support and direction, such new dynamics could result in much more sustainable management of natural resources and ecosystems. Besides, several products, or project specifications, with geographical indications recently developed in Morocco provide explicitly for the objective of sustainable resource management. This is the case for geographical indications on quality sheep and goats.

The momentum generated has also led to the organization in Morocco, in 2010 in Chefchaouen, the 3rd International Forum "Planète Terroirs".

Case study No 22: The project PRODESUD: experience of participatory development in pastoral arid zones, south-east of Tunisia[44]

Tunisia has initiated for years several Integrated rural development projects. A new opportunity was given in implementing the PRODESUD (Program for agro-pastoral development and local initiatives promotion in Tunisia South East) to offer a renewed approach, both more ambitious and more effective. PRODESUD innovated in approaching the problems in this small region rather in terms of "local development". The approach has been negotiated and adopted after a real scale experiment in participative processes for planning and managing natural resources in the pastoral lands.

The idea was to identify populations groups having rights on pastoral areas that could become responsible actors for managing natural resources. With no surprise, it was found that those groups already exist and they conform to the territorial organization managed by the ancient pastoral communities, having rights on natural resources, and known as the "Arouch". Finally, 25 socio-territorial units were identified in the project, involving 65 000 rural inhabitants.

A key test was developed with the participation of ICARDA/INRAT[45], towards one of these communities: the Ouled Chehida of 6500 rural population on 135 000 ha, mostly of travel land. The test experience enlightened:

→ The sound experience of rural people in sustainable natural resource management processes,

→ The ability of inhabitants to self-organize and to design locally a diversified development program.

New development tools for mapping resource management units based on data from populations' knowledge ("LSFT method for a "*lecture socio-foncière des terroirs*" : «social and territorial land based» computer tool")

Those results could convince the Tunisian authorities of the sound approach that was initiated with this program.

The innovation was in deciding to transfer to each unit in charge of socio-territorial development, collectively organized in GDAs (Groups for Agricultural Development), the direct responsibility of implementing the integrated development processes for pastoral areas (for 30% of PRODESUD cost). Local programs were developed with the help of "facilitators" specifically trained on disseminating these new approaches. The point was very innovative, since it resulted in transferring to the populations (GDAs) several activities for managing the resource which were formerly implemented and controlled at the State's level.

Other features of PRODESUD included: (i) public sector investment in infrastructure (roads, pastoral livestock boreholes, new irrigation perimeters) , (ii) professional organization investments to promote agricultural products, and (iii) economic diversification including establishment of very small firms benefiting to women and to young people[46].
On the whole, the PRODESUD project was financed by IFAD (17 M US $), OPEP (5 M US $) and Tunisian Government (20 M US $).

The new approach enabled the concerned communities to design their long term management planning for pasture itineraries, including pasture fallow reservations for 50 000 ha after 5 years and rehabilitations programs to be decided and controlled locally by pastoral people.

The early available results helped compare pasture paths in and out of the program. They show significant benefits in terms of *biomass, rain water use efficiency, soil and water conservation, pasture valorization and livestock farmers' revenues*.

PRODESUD in that way has demonstrated that the restoration and sustainable management of natural resources in much degraded ecosystems was possible under the condition to definitely encourage and facilitate locally driven "participative" frames for solutions. The pragmatic contribution of several Tunisian administrative staff, at times debating with internal adverse forces, proposed that : (i) a durable management of pasture itineraries was only possible on the basis of old recognized territory common law, (ii) the limits of community should be accepted even if they would differ from administrative rules, (iii) the community GDA frame should be proposed recognized and empowered by government for controlling the pastoral aspects of the project , (iv) the new extension approach developed, with the importance of facilitators, should be supported; the target being no more to tell farmers what they should do and how they should behave or not, but on the contrary to listen to their problems and to help them formulate and build their own projects while taking into account sustainability issues.

The success of this project owes much to the action of 2 innovative personalities in FIDA (international fund for agricultural development). These did support the project, and find the finance for experimenting it, while keeping in mind the durability issues.

[44]. Case study documented by Grigory Lazarev (France) and Ali Nefzaoui (ICADRA international center for agricultural research in dry areas)
[45]. International centre for agricultural research in dry areas, institut national de la recherche agronomique (Tunis)
[46]. Finally the PRODESUD programm was financed with FIDA/IFAD International fund for Agricultural Development (15 million US $, opec (5 million US $) and a counterpart from the Tunisian gouvernment for 20 million US $.

Case study N°23: Local land use planning (OLAT : «opérations locales d'aménagement de terroirs») in the mountains of Reunion Island (Indian Ocean)[47]

Small-scale farming in Les Hauts, La Reunion

La Reunion is a volcanic island in the Indian Ocean. French inhabitants first arrived in 1642.

The population is young and numerous with a fast population increasing rate. 160 000 out of 800 000 live in "les Hauts" (in the mountainous part of the island). Since 1978 the island benefits a specific rural development program initiated by the Direction of Agriculture. The objective was to support the marginalizes population from "les Hauts", marked at that time by high rates of analphabetism and poverty, in order to valorize the productive potentials of rural economy (agriculture, livestock, tourism, craft) and thus prevent massive migrations towards the coast, which would have threatened regional stability. This target has been reached on the whole. Volunteering commitment from "the Hauts" population, installations of trained young farmers, development of infrastructure, innovative economics, development of product trading organizations, product diversification, village development and overall, support and training towards the needs of rural populations, were key actions.

One of the most important problems on the island is the one of water erosion from floods. An innovative approach was developed. The island is mainly exposed to tropical rains and cyclones, penalized by steep slope rates, suffers catastrophic erosion rates (average 30t/ha that can locally amount to 20 cm drawdown after a single rain episode. On the other hand, the island is exposed to deficit or lack of rainfall precipitations during months. The management of soils and waters is thus a major issue for development and even for the survival of agriculture there. The adverse effects of erosion often results of production systems not adapted to territories that concur to increase difficulties rather than helping solve them. So it was important to bring innovation in helping small framers to adopt more sustainable agricultural systems.

Using the financial flexibility embedded in "Les Hauts" specific conversion plan (the use of these funds, approximately 2 M€/years at that time, being fully decided at regional scale within the frame of government/region planning agreements), and the advances made in concertation, a new plan approach was adopted in 1988 by the commissioner at "LesHauts", a public government administration (with a mission from DATAR, a service of French Prime Minister) in charge of scheduling. The (simple) idea was that no problem would be solved but through associating and giving responsibilities to farmers in the frame of local projects able to improve their situation on the short term, while looking forward on long term restoration of ecosystems.

This issue could not be solved either at farm scale, too small, or at watershed scale, far too large. The idea was to support volunteering groups of farmers established on small sub-watersheds that remain at human scale (i.e. 10 to 30 farmers, on 100 ha maximum) which are invited to develop free syndical associations ("ASL" in French) with the idea these associations would become the head of projects, from its definition to its implementation, including financial decisions. The ASL administrative status allows land owners and water users to organize to achieve collective investments in the private lands included in the approved project perimeter. The projects, to be quality values, should of course be those of farmers themselves, supported by the facilitators and trainers warranted by government and regional administration.

To date 33 specific soil perimeters, of 370 farmers and 2510 ha benefited from the program at the cost of 3.5 M€, of which roads and rain water disposal infrastructures 46% of actions and 74% of amounts, water storage 24% of actions (mainly small dams), and works against erosion, to reclaim soil fertility, or to allow for prudent fallows (30 % of actions). ASL perimeters are actually distributed over the Hauts and cover all agricultural sectors. Farmers always contributed to works (by roughly 10%) often through manpower. Naturally the work program in each OLAT is specific to the territory needs, and it is not rare that a significant local support in facilitation, for 6 months or 1 year, is needed to achieve it in a participative way. The program may for example protect sloping areas through stabilization by forage crops, to intensify production rates where it is locally feasible through irrigation or through ecological intensification practices (such as level line planting to better control erosion, organic matter incorporation, no tillage sowing...)

After 22 years, very positive results have been observed:

- Important changes have been observed in agricultural systems; farming conditions were significantly improved; the dynamics induced by population and organization local support, by reinforcing social capital, and by project financing allowed for converting systems to durable agricultural systems.
- Innovative agronomic techniques (agroforestry, crops under cover, ...) were successfully implemented, with the help of agronomic research (CIRAD).
- A number or former perimeters are going on with collective actions after the end of financed works: the associations continue on new ideas related to new situations and problems to be solved.
- The maintenance of infrastructure is mostly well-done. Problems can appear with new incomers unaware of the collective challenge, taking farms after formerly engaged retiring farmers.
- Numerous contacts observed between old and new associations, stimulations towards success between neighboring territories, and inter-perimeter collective actions were developed, such as negotiating with towns about public infrastructure for roads, electric networks ...;
- Some farmers could take responsibilities at regional level, including in the Reunion's Rural Development Association, which was put since 2007 in charge of local rural development.
- This program is nowadays supported by European Union (program LEADER) this since several planning periods, indicating a recognized success, together in the environmental, economic human and social domains.

Success, however, requires time, commitment and strong facilitation: technical, administrative and financial management, and "maintenance" of human relations. It also calls for enterprising producers and production that is well adapted, structured and effectively valued in the market, which may explain the differences observed today from one territory to another.

[47]. Case study documented by Alain Hebert (AD2R Réunion) and G. Benoit (CGAAER)

→ National policies to support small-scale agriculture

Case study No. 24: Empowering 10.4 million farm households and reducing food insecurity in Viet Nam[48]

Vietnam is a recent and remarkable national example of how food insecurity was reduced through family farming and on access to free enterprise by smallholders.

The country had 87 million inhabitants in 2009 with a population that is 70% rural. Agriculture, forestry and fisheries alone accounts for 60% of the workforce, 20% of GDP and 28% of exports (2010). Water and irrigation play a key role in production and rice has a strategic position: it alone accounts for 60% of cultivated area and 70% of food calories consumed. The size of rice farms is less than 0.3 ha in the Red River Delta (where pluri-active activity rice farming explains rural densities which are among the highest in the world: 1,000 inhabitants per km2), and 0.7 ha in the Mekong Delta. Each farm has 4 to 6 plots. "Large" farms (average 4.5 ha), employing external labour, represent only 0.05% of total farms.

The " Đổi Mới " reforms ("market economy with social orientation") have, after 1988, shifted Vietnam's position from deficit to agro-exporter, by empowering over 10.4 million farm households. For paddy rice, yields increased from 3.18 t / ha in 1990 to 5.32 t / ha in 2010, production from 19,000 tons to 40,000 tons and exports from 1,600 to 6,800 tons. The doubling of production in 20 years, despite the loss of 380,000 hectares of rice paddies to urbanization, was made possible by increasing yields, intensification (short-season varieties), and an increase in the number of production cycles per year (2 to 3). Meanwhile, average incomes per capita in the country increased from $ 400 in 2000 to $ 715 in 2009.

These results have contributed to a sharp reduction of food insecurity. The average food intake increased from 2,090 kcal per capita per day in 1990-92 to 2,770 kcal in 2005-2007, the proportion of food insecure people dropped from 31% to 11% of the population, and numbers of hungry people from 21 million to 9.8 million. The most food insecure people are still: rural producers in isolated mountain areas, artisanal fishermen in the central coastal region, urban workers without stable employment, and landless or near landless farmers.

New directions for agriculture and food security are to: i) ensure rice farmers a profit of 30% over production costs, intensify livestock production, protect over the long-term 3.8 million ha of rice fields (the current total is 4,1 million ha, ii) implement the three axes defined by the new policy of Tâm Nông (2008): "the construction of new rural landscapes," adaptation to climate change and building capacity of human resources.

[48]. Case study presented at the conference in Cerisy on agriculture and food worldwide, Sept.2011 by Didier Saunier (CIRAD) and DAO The Anh (CASRAD), Vietnam Outlook Conference (IPSARDI).

5. RECONCILING AGRICULTURAL DEVELOPMENT AND PROTECTION OF NATURAL RESOURCES (HOT SPOTS)

While reconciliation between agricultural progress and water management is desirable and necessary everywhere, particularly to prevent water erosion and pollution and to increase productivity, it is particularly important in certain "hot spots": over-exploited aquifers, drinking water supply areas threatened by pollution, wetlands of national or international value.

➔ Control abstractions and overexploitation of aquifers

Case study No. 25: The Beauce aquifer (France)[49]

The Beauce aquifer, south of Paris, is an enormous reservoir, 100 m deep, holding about 20 billion m3 of water, and covering an area of approximately 10,000 km2. Recharge is 120 mm / year on average (620 mm of rainfall minus evapotranspiration 500 mm), but could be zero in some dry years. Water withdrawals for drinking, industry and irrigation have increased from the 1960s to reach the maximum allowed of 520 million m3 per year, with an average 260 million m3/year. The result was that in 1992, after only six years of drought, the aquifer had fallen to the same level as in 1906 after 15 dry years; several local rivers fed by the aquifer ending up dry, including the Conie River.

Faced with this situation, a concerted management effort was put in place. Initially, the administration proceeded to restrict pumping to certain days in certain areas (departments). The result was that users increased their pumping capacity, making such measures inoperative. This led to a second set of measures focused on management of water volumes differentiated for four sectors of the aquifer, each having its own behavior. After a new study of the Beauce aquifer, farmers organized into departmental associations of irrigators, agreed to reduce the extraction rate from 525 - 420 million m3 in a dry year, and to respect an average of from 200 - 250 million m3/year. Today,, the allowed volume for each sector is defined each year in early March depending on the level of the water table. Every farmer knows the volume of water allotted to him and has an individual water meters to ensure observance of the annual contract. Meanwhile, measures have been taken to move water foraging further away from the rivers to reduce the impact of water withdrawals on the flow rate of rivers.

The implementation of this volumetric management is considered a success. It was however set up when the climatic conditions again became favorable. For the time of the next severe dry spell, the quality of the participatory process and of management planning will be essential. In such times, austerity measures would be intensified while farmers need stability and sufficient income.

Case study No. 26: The water of the Souss-Massa (Morocco)

This case study is documented under Case Study No. 37 (The agricultural strategy of the Souss Massa Draa).

➔ Agricultural commitments to help regain water quality in catchment areas

Case study No. 27: Involvement of agricultural schools to reduce diffuse pollution in France[50]

On the occasion of the "Grenelle de l'environnement", France set ambitious goals in terms of reducing agricultural pollution of water : protection of 507 priority catchment areas among the most exposed to diffuse pollution from agriculture, reduction - where possible by 50% in 10 years - of pesticide use through the "Ecophyto 2018 Plan ", an increase in the area under organic farming to 6% by 2012, 50% of farms engaged in plans for environmental certification in 2012, 1 million ha of wetlands to be managed sustainably under extensive agriculture in 2012.

French agricultural schools are concerned by this because they: have to provide proper training to future farmers, set a good example on their farms, and work for sustainable local development. Indeed, 10 of them are located on a "Grenelle" perimeter, 80 contribute to experiments and references for "Ecophyto 2018," 12% of the cropping area of agricultural schools is under organic farming or is under conversion, 20 farms participated in experiments to establish environmental certification, and many agricultural schools have undertaken actions of restoration or of sustainable management of wetlands.

To permit the appropriation of new issues and means of action by the learners and other concerned local stakeholders, a national system has been set up. It supports the adaptation of buildings and farms, the development of training courses to ensure learning, understanding and implementation of practices and investments for sustainable water management. This system supports innovative projects (e.g. conservation agriculture, "water classes," culture changes, and reductions of water consumption ...). The "alexia" database, open to the public, provides information and illustrates the win / win principle for new management. These innovative initiatives relate in particular to agricultural schools in Dax, Chartres, Angers, Gouville, Brie-Comte Robert[51].

[49]. Case study documented by P. Hurand (CGAAER)
[50]. Case study documented by the "network management and water protection" MAAPRAT / PRB / SDI / BIPI
[51]. and many others, on line at www.educagri.fr/wakka.php?wikii=initiativesLocales

Case study No. 28: The partnership of APCA (Permanent Assembly of Chambers of Agriculture) with FP2E (Federation of Professional Water Companies)[52]

Following publication in June 2009 of a list of 507 priority catchment areas of the "Grenelle de l'environnement", APCA and FP2E signed a partnership in October 2009, which resulted in the publication in September 2010 of a guide with 21 recommendations for the protection of water catchment areas, based on a study made on 10 pilot sites. The dissemination of the guide was strongly supported by the Seine Normandy Water Basin Agency.

The aim of the partnership was to bring together two sets of actors which did not know each other very well before to work to protect the quality of drinking water supplies, while maintaining the economic balance of surrounding farms.

The guide, prepared on the basis of interviews with the chambers of agriculture, water companies and local authorities, puts particular emphasis on: i) signing contracts between the main actors involved, technically and financially, in the plan to restore water quality, and ii) the need to develop appropriate economic commodity chains. It also calls for revising some measures of PDRH (National Plan for Implementing the Second Pillar of the CAP) and to open the possibility to initiate new ones.

Case study No. 29: Projects in Fontaine du Theil, Peron and Aisne (France) to restore water quality (pesticides)[53]

Starting in 1997, Arvalis (Technical Institute of the plant) has, along with the Chambers of Agriculture, cooperatives, local governments and water agencies, supported three specific experiments to reduce water contamination by pesticides from point and diffuse sources. These three experiments have focused successively on: i) a basin of 20,136 ha involving 20 farmers in Fontaine du Theil, north of Rennes (Brittany), ii) Peron, a watershed area of the department of Aisne covering 14,000 ha and concerning 76 farmers and iii) a project Agriper'Aisne covering 480,000 ha and, in the first instance, 300 farmers focused on the water capture areas identified as a priority by the "Grenelle de l'environnement", and later extended to all farmers of the Department of Aisne (Picardy). In these three cases, the process was conducted in three phases: i) Spatial diagnosis of types of transfers and sources of pollution, ii) A plan of action and iii) Monitoring of indicators to measure improvements made (adjustments undertaken, changes in practices) and the state of water quality.

Measures to reduce pollution pressures, that are not necessarily the same from one site to another, included in particular: advice on changes in practices, training of project managers in the diagnosis tool Aquavallée®, operational diagnostics if necessary through the use of the tool DAEG (Agri-transfer territories and resources), training of farmers to adjust sprayers and better control weeds, the establishment of buffer zones (grass filter strips, hedges and embankments, fallow and permanent grassland), the management of farmyards to prevent leaching during storms, the establishment of a demonstration farm "zero faults on accidental pollution" and a watershed demonstration area , replacing the chemical maintenance of field and streams edges through mechanical maintenance with tillage performed perpendicular to the slope, the establishment of plant cover in winter, reducing the number of parcels at risk of pollution transfer, establishment of spring crops,...

The results observed were encouraging. In Fontaine du Theil, the level of active substances measured in water samples fell from 22% in 1998-99 to 5% in 2005-2006 and the legal limit of 5 micrograms/litre for drinking water has not been exceeded after the third year of the project. In the Peron area, only herbicides used outside agriculture were detected in the river in 2007.

Case study No. 30: The Contripol project, Orval Valley (France) to restore water quality (nitrates)[54]

The water catchment area of Dormelles (departments of Seine et Marne and Yonne, France) covers 23,000 ha, of which 14,300 ha is usable agricultural land managed by 170 farmers. The aquifer that supplies the 7 water capture points has a relatively high nitrate content (37.5- 50 mg /litre) which has been steadily increasing since 1970.

The project "Contripol" (individual contribution to pollution) was set up to develop a methodology to evaluate at field level the contribution to nitrate pollution, to provide advice to farmers to on how to minimize this pollution, to transfer this methodology to agricultural extension organizations and to study the feasibility and desirability of agri-environmental contracts. The plot-scale modeling of pollution was done through the use of agronomic and hydrological modeling software ("burns", "epicles" and "watermodel").

The project includes three phases: i) a classic study of the catchment area of a water supply point with the testing of 50 individual farms, construction of a database of geo-referenced agricultural practices across the plots, territorial diagnosis and development of an action plan to restore water quality, ii) hydrogeological modeling of the basin, validation of calculations of leachable mineral nitrogen, modeling and validation of the transfer of nitrate in the basin, and finally calculating the reduction of pollutant inputs per plot, iii) a socio-economic study to define how the farmer should be remunerated for his actions with a comparison in terms of cost and effectiveness relative to a traditional AEM program (agri-environmental measures).

The project facilitated the conception and prioritizing of changes in practice to optimize the allocation of resources in relation to expected environmental outcomes. The financial incentive, which is proportional to the reduction of pollution and not to the reduction of the right to produce, allows for a greater commitment by farmers since it respects the entrepreneurial dimension of farming while incorporating environmental issues, giving economic clarity to actors (quantification of costs and benefits) and reducing the overall cost by targeting actions to where the cost/benefit ratio is most favorable. The method, destined to be used primarily on the 507 priority catchment areas identified by the "Grenelle de l'environnement", aims to substitute a positive approach of value creation, which is familiar to the farmer, for an approach based on regulation.

Case study No 31: Joint research project "Aqual", on agricultural pollution, city of Reims (France)[55]

The water supply of the city of Reims depends to a large extent on aquifers in the watershed of the River Vesle (7,200 km^2), a watershed with both field crops (wheat, sugar beet) and viticulture.

At the request of the city of Reims, the General Council of the Marne and the Departmental Chamber of Agriculture, the "Aqual" research program was launched in 2003. By combining academic partners, INRA (National Institute of Agronomic Research) and the Water Agency Seine Normandy, Aqual brought together multidisciplinary teams (agronomists, geographers, hydrologists, chemists, physicists, biologists, computer scientists and sociologists) around a joint project with three objectives: understanding cultural practices and cropping systems, describe the mechanisms of degradation and transfer of pollutants from soils to aquifers and model the functioning of the watershed to test scenarios of changes in agricultural practices compatible with economic activity.

Farmers' organisations were brought in to make a survey of 191 farms to identify in particular the conditions for the propagation of innovations in farming practices. A participatory observatory of phyto-sanitary practices was then created with the municipal association of the Vesle. This resulted in a

[52]. Case study documented by APCA (Permanent Assembly of Chambers of Agriculture)
[53]. Case study documented by Arvalis, Institute of plant and proposed by the SAF (Society of farmers in France)
[54]. Case study documented by Arvalis and the SAF (Society of farmers in France)
[55]. Case study documented by Ghislaine Grenier de March, Europol'Agro-Carinna; agency for research and innovation in Champagne Ardennes

work of co-construction among researchers, development actors and farmers, through workshops, selection of indicators, integration of pilot sites and the introduction of a shared software tool made accessible to all actors.

The project is innovative in the close association created between researchers and farmers, and by the voluntary commitment of farmers for becoming involved in water protection through the development of access to digital technology on their farms.

→ Develop irrigation while protecting environments of high ecological value

Case study No 32: Control of water (fresh and salt) to produce organic mangrove rice in coastal Guinea, and reduce environmental impacts[56]

Rice in coastal Guinea is predominantly produced on the slopes under a slash and burn cultivation system that is very intensive in use of natural resources. Mangrove Rice was also practiced in the north for centuries. The traditional system is based on the construction of dikes to protect against the entry of sea water and a method of slash / burn / fallow. It puts at risk the mangroves because it implies a gradual clearing of mangroves and causes soil acidification which can make them completely ineffective.

AFD, involved since 1980 in the development of major rice growing areas in Guinea proposes in 1996 to work on smaller perimeters, better appropriated by farmers, by rehabilitating an ancient technique of the Balanta ethnicity, using a controlled entry of sea water (and sediments from the mangrove) in the dry season, which will allow on one hand, to limit acidification of soils and on the other hand, to produce a completely "organic" rice

The project, conducted in three phases (1997-2003, 2005-2011, 2012-2015) for a total grant of € 21 million is based on three technical principles: i) a protection dike to prevent intrusion of seawater for the growing season, ii) drainage equipment (reversible valves) for better control of water in the rainy season, iii) admission of sea water in the dry season to reduce weeds and maintain soil fertility without mineral fertilizers. It has already permitted (first 2 phases): i) to develop a management plan that took into account environmental issues and identifies 49 priority schemes for an area of 9100 ha, ii) to construct 100 km of mechanized trails, iii) to develop perimeters on a total of 4900 ha with gates constructed of local materials and iv) to monitor maintenance over 3,600 ha.

The results are significant: doubled yields without addition of imported inputs, rehabilitation of rice fields previously cultivated while reducing the temptation to clear new areas of mangroves, production of such rice quantities and quality that could stabilize the domestic demand for rice in slopes and reduce the intensity of deforestation.

The project addressed the village communities who have for them a detailed knowledge of their «*terroir*» and the water cycle, who master rice cultivation in mangrove area and varieties adapted to these environments. Its ultimate success will depend on the organization and professionalization of the Committees for management of perimeters.

[56]. Case study documented by AFD

6. TAKING ON THE WATER CHALLENGE UPSTREAM AND DOWNSTREAM OF PRODUCTION

Loss of water resources for food do not only come from losses and misuse in transportation and in the fields. They include also, as stressed in the first part of the report, losses of farm land to urban development and losses at all levels of the food chain "from farm to fork".

➔ Protect farm land and water from urban sprawl

Case study No. 33: Recent measures to protect agricultural land (France)[57]

Loss of agricultural land (and water) by urban sprawl is a growing concern of the public authorities in France. However, the phenomenon remains poorly measured and actions taken have not had the desired efficiency. There are numerous decision-makers in urban planning (36 000 communes), their decisions are not closely constrained, and the fight against urban sprawl has not yet become a major national cause.

To strengthen the protection of agricultural areas, three instruments were successively created by laws on agricultural and rural policy in 1999, 2005 and 2010: protected agricultural zones (ZAP), perimeters for protecting agricultural and natural areas (PAEN) and the departmental commission on the disappearance of agricultural areas (CDCEA). ZAPs are defined by the prefecture on the proposal of, or in agreement with, the municipalities concerned. They are a public utility that strengthens the protection of agricultural land from urbanization. Today, about 30 ZAPs have been set up. PAENs are designed to extend the policy instruments of departmental administrations to control land use, which they already have for urban planning, to conserve and develop agricultural and natural areas. The action plan of each PAEN specifies arrangements and management guidelines aimed at promoting farming, forest management, conservation and enhancement of natural areas and landscapes. The CDCEA (departmental commission on disappearance of agricultural land) established with the prefect, is consulted for advice on any schemes and plans to do with urban planning or construction projects that result in a reduction of agricultural land in the municipalities without urban planning documents.

The law of 12 July 2010 pertaining to the national commitment to the environment (Grenelle 2) obliges urban planning documents to include measures to limit the consumption of green space by setting targets, relative to the level of disappearance observed over the ten previous years. The “factor 2", which was discussed and would have introduced a global constraint to halve the rate of disappearance of agricultural land, was unfortunately not adopted.

➔ Reduce losses and wastage (food and water) “from farm to fork”

Case study No. 34: Mobilization to reduce food wastage in Europe. The example of a food aid donation exchange platform (France)[58]

Food wastage is at a high level in Europe and represents a major loss of natural resources: when a kilogram of flour is thrown away, what is also thrown away is the 1,500 litres of water needed to produce it.

In France, as in other European countries, there is insufficient information on the quantities that are wasted: the figures available are in fact few and far between and are frequently contradictory due to differences in the definition of “food wastage”. Studies of household waste in France have revealed losses of 20kg per year per head, or a total of 1.2 million tonnes for the country as a whole, including 7kg still in its packaging. The quantities of foodstuffs wasted in industry, in large retail stores (approximately 300,000 tonnes) and in catering – in restaurants especially, but also in institutional contexts (approximately 150,000 tonnes of food are wasted in school canteens) are also high. And this is in a context in which three million people have recourse to food aid in France.

There is beginning to be an awareness of the need to take action to reduce this waste. There are many possible ways forward: information, education and awareness-raising campaigns, dual dating on product packaging (the authorized limit for selling the product and a second date specifying a time limit for its consumption), promotion of donations to food banks, sales of certain products at reduced prices, more diverse packaging formats, and so on. A report was adopted on this in the European Parliament for the first time on 19 January 2012 and 2013 is to be the “European Year against Food Waste”. Many innovative local and national initiatives are also emerging. In France, an electronic exchange for donations has been recently set up under the national food programme following the passing of the law on the modernisation of agriculture and fisheries in July 2010, and this involves several government ministries. The purpose of the donation exchange is to expand the practice of making donations by agri-food companies or the withdrawal of products from the market by producer organisations to provide assistance to charities. Conceived in partnership with economic operators and the charity sector, this exchange is an interactive platform (bourse-aux-dons.fr or alimentation.gouv.fr/bourse-aux-dons) enabling its various users to deposit offers and post requests for donations, and then getting directly into contact with one another.

[57]. Case study documented by Ph. Balny (CGAAER)

[58]. Case study documented by Eric Zunino, assistant director for food policies (MAAPRAT)

Case study No. 35: Agroindustry facing the water problem. How these issues are seen by Nestlé; how it communicates on the action it has taken

Nestlé, made water one of its major lines of communication. The group which has a long history in France with a turnover of SFR 110 billion and a workforce of nearly 280,000, is one of the main actors in the agri-food industry worldwide. Their communication line on water focuses on their perception of international risks and on actions taken, both interenal and extenal. The group considers that the planet will need to cope with a very serious water crisis over the coming years and that this will have major consequences for food security. While the actors in the food supply chain from agricultural production to product processing and consumption have a high level of responsibility for the environment and natural resources (in terms of quantity and quality), they are also highly dependent on the latter. Indeed, Nestlé considers that the lack of availability of water resources and access to water is already affecting its corporate development and that climate change will aggravate these difficulties in coming decades.

The company, in its communication, sets out the ambition to continuously improve its environmental efficiency. It publishes a series of indicators of its environmental performance on its website[61]. Its water take-up has declined from 213 to 144 million tonnes over the years 2000 to 2010 (down 32%) and from 8.4 to 3.3 cubic metres per tonne produced (down 61%). Other indicators measure the progress achieved in terms of the quality and quantity of the water discharged. This example, among others, testifies to the substantial progress that can be made in the efficient use of water and confirms the importance of action at every level in the food supply chain.

Nestlé also presents itself as a global actor engaged in the public debate for the restoration of the balance between water demand and water supply. In 2009, Nestlé was the driver of a joint project, notably with IFC (international financial company in the World Bank group) and consultants McKinsey for the production of a document entitled "Charting Our Water Future: A new economic framework to decision making" and supporting willing governments in identifying the possible options over the period to 2030 for balance between water supply and demand at the country, catchment area and regional levels.

In light of the fact that the availability over the long term of water of good quality in sufficient quantities is essential to its plants, its Water Resources Review (WWR) programme has set an objective of raising awareness at local and operational level, especially in regions subject to water supply stress and shortage, doing so with five focuses: the quantity of water, its quality, its compliance with regulations, protection of sites and relationships with the other stakeholders. To date the WWR covers sixty-seven of its sites. Nestlé considers that the dialogue between water users must be a key component of its strategy, despite the fact that this can sometimes be problematic.

Nestlé also mentions they have developed partnerships with local farmers and growers to protect the spring waters it bottles (Vittel in France, Mount Uludağ in Turkey, the area near Mendoza in Argentina) and it has conducted studies in India on the "water footprint" of various agricultural production systems and agricultural methods that could be promoted in regions affected by resource overexploitation.

→ Innovate in social safety net policies

"Social safety nets" policies can represent today a very important part of public budgets. These policies, needed to secure access to food (provision of food, financial assistance to buy basic commodities, revenue support for poor households) must also be reviewed to help achieve a sustainable end to poverty and avoid encouraging over-exploitation of groundwater (as is generally the case for subsidies on the consumption of electricity or gas). Could they also become a way to better manage water?

Case study No. 36: Strategic thinking on food security in Morocco: towards payments for environmental services?

Morocco was particularly affected by the food crisis of 2007-2008. Imports of agricultural and food products increased by 78% in value from 2006 to 2008, and by more than 160% for cereals alone. The net food trade situation (exports / imports including fish products for which Morocco is a large net exporter) declined from 116% in 2006 to 79% in 2007 and 67% in 2008; the share of the food bill in the trade deficit increased from 20.9% to 25.8%.

Strategic thinking conducted by the CGDA (General Council of Agricultural Development, Morocco) on food security concluded that three requirements were necessary for a "sustainable solution", namely: i) securing the productive base, ii) securing access of vulnerable populations to food, and iii) securing the food supply with, for each one of these requirements, a number of possible lines of action (Table 5). Securing the productive base requires a better management and use of green and blue waters; securing the food supply could be through a "new deal for the Euro-Mediterranean region ".

Table 5: Options for a sustainable response to the food crisis in Morocco

Securing the productive base	Securing people's access to food	Security of supply
- Saving agricultural land - Increased productivity - Management and efficiency of green and blue water - Restoration and sustainable management of rangeland and forest - A culture of quality and innovation - Appropriate research and development	- Fight against poverty - Safety nets - Payments for environmental services - Risk management instruments - Management of forced migration and intermediate urbanization, - Training and development of human capital	- Regulation of price volatility: security stocks, compensation - More aggressive Trade Policy - Active participation in the reform of the governance of the world agri- food system - " New Deal for the Euro-Mediterranean region"

Source : M Aït Kadi, CGDA, 2011

[61]. www.nestle.com

An outlook study conducted by CGDA has explored three contrasting scenarios to find out what could be the optimal mix between subsidies on the one hand, and the transmission of international prices to domestic prices, on the other.

- Scenario no 1: "*Removal of subsidies*" (i.e. removal of subsidies on imports) would increase the incomes of small and medium-sized farms by almost 9%, but penalize heavily the urban and rural poor - which would result in a decline in cereal consumption by 5%.

- Scenario no 2: "*Subsidies on imports amounting to 7.5% of the budget to compensate poor urban and rural consumers*", who would make substantial gains while small and medium-sized farms would suffer large losses (income falls of 8%).

- Scenario no 3: "*Direct cash transfers amounting to 7.5% of the budget targeted at poor rural and urban consumers*" would benefit both the poor rural and urban consumers (consumption increases of 4.8% and 6.8% respectively) and also small and medium-sized farms (income increase of 1%).

This analysis therefore calls for a gradual transition from current food subsidies to a system of conditional direct cash transfers, as successfully implemented in many Latin American countries (see Box 5 on the Mexican example). In these countries, conditionality is a *social conditionality*: the money is given to families on the condition that children attend school and follow regular medical visits - basic education and health being regarded as the best way to eradicate poverty in the long term.

BOX 5 : EXAMPLE OF PROGESA / OPORTUNIDADES MEXICO

The PROGRESA program for education, health and nutrition in Mexico, aims to fight in an integrated way against the root causes of extreme poverty in aiming at developing the human capital of youngsters living in the most vulnerable families. It was initiated in 1997 at a time when several poor rural areas were heavily affected by the effects of structural adjustment and the free trade agreement signed in 1994 with the United States and Canada. Based on poverty mapping (defined only by its economic dimension), it initially focused on certain rural areas, with the aim of avoiding a transmission of poverty from one generation to another.

The program is innovative because: it is addressed in an integrated manner to all dimensions of human capital; it is targeted at the poorest rural families (selection of villages and families based on indicators), money is given only to mothers, once their ability to effectively manage the basic needs have been recognized, money and food aid is subject to regular attendance of children at school and at health consultations free health center. This is a national program, independent of local authorities. Highly targeted, the cost of the program is very small (originally it was $ 90 million for 2.3 million families). It involves direct financial assistance ($ 11 per month), in food supplements, and in educational scholarships and health services. Total family benefits are capped and take into account household income and the poverty threshold.

The assessment conducted by IFPRI from 1998 to 2000 showed that: the integration of interventions on food, health and education had a significant positive impact on human development; children had to work less to bring money to their families and their presence in schools has been significantly improved. The health of children and adults has also been significantly improved with a decrease of days lost or diseases of 12% and 17% respectively. The food situation improved markedly with a diversification in diets - including increased consumption of fruits, vegetables and meat, and the administration of the program was very effective with an administrative cost of only 9% for such a complex program.

If progress in education reduces poverty and inequality, they are not sufficient by themselves to get out of extreme poverty. In addition, PROGRESA which consists only of individual assistance has not succeeded in bolstering social capital. However, the results were sufficiently convincing for the program, renamed "Oportunidades", to be maintained after the change of government in 2000 and extended to the urban poor. In mid-2005, the program was benefitting 5 million families; it enabled 98% of school-age children to be literate, and reduced child labour by 25%. The program was also improved by taking into account the results of the evaluation, as decision makers had a better understanding of conditions for success. For example, the assistance given not only takes into account attendance at school but also the performance attained. Bonuses are awarded when children succeed in exams.

Nevertheless, the eradication of poverty in the long term in rural areas also requires an end to cumulative degradation of natural resources and agro-ecosystems on which the survival and well-being of communities depends. Conditionality could therefore, in rural marginalized, degraded and vulnerable regions, also include *environmental conditionality* with cash transfers becoming "*payments for environmental services*." Concretely, the financial assistance given to poor rural families would be conditional upon not only the commitment to ensure the academic progress of their children, but also respect of rules for the restoration and sustainable management of natural resources (soils, water, vegetation) in the framework of, for example, land management charters negotiated and signed with the village communities in a participatory manner. In this way, the productive base of these degraded ecosystems and thus the vital resources (wood, agricultural and pastoral production) of poor families could be secured for the greater good inclusive of the sustainability of downstream irrigation systems, and thus the future food security of the whole country.

7. DEVELOP VISIONS ANS STRATEGIES FOR A SUSTAINABLE AGRICULTURE AT REGIONAL AND MACRO-REGIONAL SCALES

Ensuring sustainable food security, in its relationship with water, requires both national policies and local actions. However, the sub-national level of the "region" (territory at the NUTS 2 level: region, Länder, state, province ...) and the supra-national level of the "great region" (e.g. European Union) can also be very relevant, without of course forgetting the level of the “water catchment area”.

Indeed, the NUTS 2 (which can overlap with that of the great agricultural basin and that of the great river basin) is typically the relevant scale for "planning", the one that can be successful for the "territorialization" / adaptation of national strategies and policies. This "regionalization (territorialization)" of visions and strategies is fundamental because the possibility of reconciling agricultural and territorial issues - those of sustainable management and use of water as well as of food security - depends upon it. It should logically be required in all countries whose size and climatic / water and agricultural diversity requires it, which is generally the case. It can also give much greater consistency and convergence to water and agricultural policies, which when set at the central level are often contradictory. It can therefore make a contribution to finding the conditions for both water and food security.

The” territorialization” of visions and strategies at the regional level should not only be the business of States and / or regional authorities. It should also be a priority for the large companies investing in developing countries; these will have to take much better into account the territorial challenges of food and water security in the regions concerned.

The scale of the "macro-region", that of the major regional groups which have a "common destiny", is another important level to consider. This level is indeed one where visions and concerted strategies can come together to secure supplies, weigh on global negotiations, and prevent conflict. The historical experience of the European Union and its Common Agricultural Policy, which is in the process of "greening" (Case Study 38), shows this. Other major world regions (e.g. West Africa, East Africa ...) may also have an interest, given the new global context, to share visions and ambitions at these levels. For Europe and the Southern Mediterranean, linked by their proximity and their environmental, economic and commercial interdependence, this could justify thinking in terms of a "new deal" to strengthen common stability and prosperity, which is threatened by high insecurity both for water and for food in the south.

→ At the level of "local regions" (sub-national)

Case study No. 37: The strategy of the Region of Souss Massa-Draa (Morocco)[59]

Morocco, a country of great geographical diversity, recently committed itself to a process of devolution and of decentralization to achieve better "territorialization" in strategic planning.

The "Souss Massa Draa" Region, located in the South-West West Morocco, is characterized by a semi-arid climate with average annual rainfall not exceeding 250 mm. With its 3 million inhabitants and its main town, Agadir, the country's second largest city after Casablanca, it contributes 18% to national GDP and ranks first in production and export of citrus fruits and early vegetables. Agriculture, the main economic activity is mainly directed to irrigated crops which occupy 120,000 hectares, or 53% of the UAA and utilizes annually almost 1 billion m3 of water -from surface water (28%) and from groundwater (72%).Its development has benefitted much from infrastructures built by the State.

While irrigated areas are continually increasing, Morocco has experienced since 1985, a succession of droughts and a drastic fall in its water reserves. Although the reservoir is extremely large, its recharge level is low (about 400 hm3/year) compared with the volume taken from the aquifer estimated at 650 hm3/year, a shortfall of more than 200 hm 3 / year. The lowering of the water table has consequently been dramatic: from 2 - 3 m / year - the cumulated drop can exceed 100 m in some areas. Water resources throughout the Region have therefore been put under unprecedented pressure. The imposition of more restrictive legislation did not correct this tragic situation and so the water catchment authority sounded the alarm by developing "scenarios" of possible developments.

Significant advances have been as a result of:

- →Creating the collective network of El Guerdane that brings water from the Aoulouz Dam to irrigators in the sector, so taking pressure off the aquifer,
- →Launching by the Regional Council of Souss Massa Draa of an ambitious strategy to improve water governance and water efficiency, and local products. This strategy has led to the development, initiated in 2005 by the Agricultural Committee of the Regional Council, of a "Framework Convention for the preservation and development of water resources in the Souss Massa Draa region" (or aquifer contract).
  Its development, which was the result of multiple episodes of intense consultations, brought together the representatives of 24 political, financial, professional and technical institutions. The action program covers: water conservation, control on the digging of wells and boreholes, organization of the profession, control on extending irrigated areas, and awareness raising of farmers and the general public in the region on issues of saving water and water pollution.

The originality of the approach stem from the ideas of:

- →Coupling the implementation of a project (here the Guerdane project) and the introduction of more virtuous practices in the use of water resources,
- →Passing from a system of policing that was purely authoritarian but virtually ineffective, to a system of voluntary commitment by users.

[59] . Case study documented by Lahcen Kenny, Agrotech Souss Massa Draa (website: agrotech.org), with a contribution from Patrick Hurand (CGAAER)

The convention specifies the commitments and the means used to achieve the objectives set out. This experience is in the process of being duplicated in other parts of the country.

Considerable efforts have therefore been made for saving irrigation water among farmers who were encouraged to equip themselves with drip irrigation systems and to rationalize water applications. To date, more than 50 Water Users Associations in Agriculture (AUEAs), covering an area of over 12,300 ha, have benefited from the program. The Commission "aquifer contract" has also played a key role in the development and adoption of legislative amendments to adjust the fees paid by farmers for the use of irrigation water.

To support the implementation of the regional strategy, it was decided to create the association 'Agrotechnologies-SMD (Agrotech)' which has played - and continues to play - a key role in coordinating the actions of government departments, private companies and professional organizations in the management of water and local agricultural resources. Agrotech is mandated by its Board of Directors to lead clusters (poles of competitivity) oriented towards innovation, transfer of agricultural technologies, and conservation of water resources. The association is also responsible for facilitating the Commission "aquifer contract."

In the field of scientific research, Agrotech's actions since 2006 have focused on the creation of multidisciplinary and multi-institutional research teams working on themes identified as priorities by growers. A common regional fund was created specifically for this purpose, which is a first for Morocco because the funding of scientific research comes exclusively from State funds. Agrotech, in collaboration with several institutional and private partners, has also created a regional network of weather stations to gather climate data needed for irrigation scheduling. The project includes 35 stations of which 16 are already operational. This is important because the experience of the last four years has shown that the integration of weather data into irrigation scheduling saves about 20% of water used. For the next two years, this project will cover 55,000 ha of citrus and vegetable crops.

The other pillar of the regional strategy is the promotion of regional products («produits de terroirs») such as argan oil, saffron, prickly pear, aromatic and medicinal plants and honey. These products require little water. They are exceptional in local characteristics, nutritional quality and taste, and are well-adapted to local climate and water stress. The program, launched in 2006, focuses on labeling and on technological and commercial development. Initial results show a marked improvement in incomes of smallholder farmers. Through this regional project, the whole small-and-medium agricultural sector is placed at the centre of food security programs.

The lesson to be drawn from this experience is that one can achieve a national success through the combination of many regional initiatives that bring together visions and projects inspired by realities of on the ground. The new agricultural strategy of the country adopted in 2008, the "Green Morocco Plan (Plan Maroc Vert) ", which includes an important component for water conservation and the development of local products (*«produits de terroirs»*), is also based in large part on decentralized planning at regional level.

Since the launch of the regional strategy, the Regional Council has also pioneered programs involving exchange of experiences and collaboration with the Aquitaine Region and the Department of Herault in France, as well as the region of Almeria in Spain and the Kef region in Senegal. Through these programs, regional managers and partner institutions have benefited from French and Spanish experience and skills in the field of water conservation and enhancement of local products. They were then able to transmit, through South-South cooperation, their own experiences to African partners, establishing thus a fine example of North-South and South-South networking.

Case study No 38: The draft Regional Plan for Sustainable Agriculture (PRAD) in the Languedoc Roussillon (France)[60]

France is a country of great climatic and agricultural diversity, in which irrigated crops represent an important multi-functional challenge.

The PRADs (regional plans for sustainable agriculture), established by law for the modernization of agriculture and fisheries on 27 July 2010, set the broad policy guidelines for agricultural policy of the State for the regions, taking into account the specificities of the territories as well as the economic, social and environmental issues. They must be able to contribute to the triple challenge of French agriculture: the food challenge (contribute sustainably to meeting global food needs), the territorial challenge and the environmental challenge.

The Languedoc is a region of fragile Mediterranean agriculture (farm incomes are the lowest in France and agriculture is under strong urban pressure) situated in the south of France, between the Mediterranean Sea, Spain, the Cevennes mountains and the Rhone river. The regional capital, Montpellier, became in 2011 the new headquarters of the global agricultural research system (CGIAR). The 31,000 farms of the region produce wine, fruits and vegetables, products from extensive husbandry (sheep, goats, cattle) and cereals (durum wheat), for a total production value of € 2.4 billion and agro- food sales of € 8.6 billion. The PRAD project, developed from April to December 2011 under the authority of the regional prefect assisted by the "regional commission of agricultural economy and rural society," should be adopted in February 2012.

Out of the discussions emerged five strategic priorities: i) a dynamic agricultural sector, attractive to young people, competitive and environmentally-friendly, ii) a water resource available for agriculture while preserving the water quality and anticipating climate change, iii) preservation of agricultural land, iv) promotion of quality food and recognized local products, v) building on the exceptional potential of regional agricultural research and training to prepare tomorrow's agriculture.

For water resources, the PRAD highlighted the specificity of the Mediterranean climate that justifies the storage of excess winter rainfall to be released in spring for agricultural use; needs will be strongly amplified by climate change. Since 1980, the changes observed in Montpellier are as follows: Summer average temperatures +2.3 ° in 30 years (+ 0.8 ° in winter), a sharp increase in inter-annual rainfall variability, a shift from "Mediterranean sub-humid" climatic category to the "Mediterranean semi-arid" category, very strong growth in evapo-transpiration: + 240 mm on the plains (+ 20 to 30%) and + 125 mm on the plateau (+ 15 to + 20%), which is considerable. The overall loss of production estimated by INRA was 0.9 tons of dry matter per ha, or 11% in 30 years.

In this new context, support to farms and organizing their environment for better adaptation to climate change are seen as key objectives. The PRAD will give particular priority to integrating the specific characteristics of the Mediterranean region (aridity index) into criteria for zones of natural disadvantages, to supporting the effort to adapt the plant material, and to have water resources available, which implies: i) ensuring consideration of agricultural issues in arbitrations relating to resource sharing, ii) developing new resources through the project Aquadomitia (water transport from the Rhone river to local ASA) and the completion of 50 water storage facilities annually, iii) ensuring sustainability in public irrigation investments, and iv) promoting water-efficient farming practices.

For the preservation of water quality, the PRAD adopts the objective of the national "Ecophyto 2018" plan which aims to halve by 2018 the utilization of plant protection chemicals, namely through actions in training, innovation, agri-environmental aid and strengthening the organic farming sector which is growing strongly in the region.

[60] . Case study documented by the Regional Directorate of Agriculture and Forestry (Montpellier)

The PRAD has also set a target to prevent fires and floods, by maintaining open areas (support to pastoralism) and wetlands and to halve the rate of disappearance of agricultural land by 2020 in each of the five departments constituting the region. There will be total preservation of lands with the best potential (land developed for irrigation and the restructuring of land, land identified in the work of Cemagref and INRA). To this end, it will: develop community awareness, refer to the CDCEA (the new "departmental commission on the disappearance of agricultural areas") before developing any urban planning documents and implementation of new tools for local sustainable land protection.

The PRAD has also defined a set of indicators that will permit progress to be measured over time.

→ At the level of "international regions" (supra-national)

Case study No 39: The 'Blue Plan' scenarios for the Mediterranean and the new concept of "water demand management"

Created as part of the Barcelona Convention for the Mediterranean Sea, the Blue Plan is a regional activity centre funded by all riparian countries and the European Community. Responsible for developing a systemic and prospective analysis of the Mediterranean region on various territorial scales (all riparian countries, Mediterranean Basin, Mediterranean coastal regions), the Blue Plan has mobilized experts from northern and southern shores. In 1989 and in 2005, it published scenarios for the region on key issues for policies on environment and development. Water has been from the beginning an important subject of discussion for the Blue Plan. The prospective work helped to draw attention to the risks of continuing along current trends, and called for a transition towards water demand management policies. The main results of this outlook work on water are included in Case Study No. 7, which illustrates this concept using the Tunisian example of water savings in irrigated agriculture.

Case study No 40: The Common Agricultural Policy (CAP) of the EU: from food security to "greening"[61]

Following the food shortages of the Second World War, the European Community remained in deficit for most agricultural products up to the late 1950s. Increasing agricultural production was therefore a priority for European countries. While agriculture has been from the beginning closely associated with the construction of Europe through the combined efforts of the Netherlands and France, it soon became apparent that a special policy would be necessary for both its successful inclusion in the Common Market and to achieve the objective of food security. Thus the Treaty of Rome, signed on 25 March 1957, established the five objectives of the Common Agricultural Policy (CAP): increase productivity, ensure a fair standard of living for the agricultural community, stabilize markets, guarantee security of supplies and ensure reasonable prices for consumers. The common agricultural conference that followed in Stresa (Italy) affirmed the unanimous desire of the 6 countries to preserve the family character of the farming while stressing the importance of improving their structures. The tools used to achieve these objectives were first the common organization of markets (Community preference and an agricultural guarantee fund) to guarantee prices and secure income levels and thus encourage investment. Later, there were tools to improve structures with assistance for farm modernization. This assistance was extended in 1985 to assist the establishment of young farmers, and the first agri-environment measures were brought in. These tools allowed a very strong growth in output.

Rapidly, the management of agricultural surpluses became an excessive cost burden and provoked increasing criticism in the WTO. Negative impacts were also noted on the environment and particularly water resources. This was the result of certain subsidies that encouraged corn silage production at the expense of grass and, conversely, it was an effect of the absence of common market organizations for indoor and vegetable productions, resulted in high concentration of production sites (near sea ports and major consumption areas), causing heavy pollution.

The reforms of 1999 led to sharp declines in support prices - replaced by direct payments - and greater integration of environmental issues, further strengthened in 2003 by the imposition of environmental conditionality of direct payments. In 2008, the "second pillar" on rural development was strengthened to meet new challenges such as climate change and water management. While the EU is now facing the biggest crisis in its young history, the main challenge for the CAP will be to remain a driving force for the European construction, which means better responding to the needs of both farmers and other citizens, both groups being more attentive to environmental and food quality.

The work undertaken by the Commission for the CAP "post 2013" offers hope for further progress. The global food crisis of 2007-2008 highlighted the strategic importance of food and the relevance of a common agricultural policy, from which other parts of the world could draw inspiration. The Communication adopted by the Commission on 18 November 2010 for the future reform of the CAP entitled "The CAP towards 2020: meeting the food, natural resources and territorial challenges of the future" identifies three major challenges: food security, environment and climate change and regional balance. The Commission also proposed three options: i) the extension of the current CAP with a better distribution of aid, ii) a major overhaul to make it more "sustainable" and iii) a radical reform based on environment and climate change aspects, with, as a corollary, the phasing out of income support and most market measures. The Commission noted that Option 2 "would address the challenges in the economic, environmental, and social areas and strengthen the contribution of agriculture and rural areas to the objectives of the 2020 strategy for economic growth that is smart, sustainable and inclusive.

Commissioner Ciolos in his presentation to the European Parliament of 12 October 2011 on the "CAP 2020 legislative package" stressed the importance of being able to lay the foundations for a new long-term competitiveness, which would be both economically and ecologically oriented. Heightened priority for the sustainable management of natural resources, water and soil, would lead to better targeting of assistance and to a strengthening of "knowledge-based agriculture" through closer links between agricultural and scientific communities.

The time has come for "greening the CAP", the condition for a new partnership between the civil society - that finances this public policy - and farmers. European citizens are increasingly aware of the strategic importance of an agricultural policy. 70% of citizens believe that the CAP budget is adequate or insufficient, a significant increase compared with the 2007 EuroBarometre survey.

[61] . Case study documented from the historical analysis of the CAP developed by B. Bourget, *ingénieur général honoraire*

CONCLUSION

Feeding the billion men and women who suffer from hunger, feeding the extra billion people expected to be born on our planet over the next fifteen years, adapting to climate change and helping mitigate it, preventing further "food riots" and curbing risks of instability and choosing to go down the road of "sustainable development"... all these major challenges to food security require better management of water, if they are to be overcome.

The task is not merely to improve management techniques. What is needed a *paradigm* shift in agriculture, in food supply systems and in models of urban and rural development.

WATER FOR FOOD AND WATER FOR THE CITY: TOWARDS A NEW CONTRACT BETWEEN AGRICULTURE AND SOCIETY

There is just one water cycle and, at local level, there is often just one source of water to be shared. While agriculture needs water and land for its production, towns and cities need water for drinking and food to eat: which means that they are doubly dependent on good management of water on farms. Given that the greatest potential for savings is in agriculture, good management of water, soils and agricultural ecosystems is a basic condition to be met for food production. Good management of water in agriculture can also free up water resources for other uses. This is demonstrated by a number of documented examples of solutions (e.g. France, Tunisia). In addition, good agricultural and pastoral management can slow water run-off and increase infiltration, thus "producing" more water for downstream uses and simultaneously reducing risks of flooding. Thus, agriculture, which has been and can be a factor in water-related problems, must now be seen as *a key solution to water* problems. In many instances, it can even be said that agriculture is, or must be, "the solution".

Inversely, farming is dependent on the city because it must be able to obtain a decent living from what it produces. It is also dependent on the city because urban expansion, if poorly controlled, threatens it directly: every hectare taken from agriculture means that much less water, nutrients and living soil left in the countryside to enable production to meet the food requirements of city dwellers. This in turn means that much larger areas of tropical forest will need to be put under crops.

"Sustainable development" thus presupposes a shared vision for a "win/win" relationship between the city and agriculture, between farmers and society, and between water for food and water for the city. In reality, very rapid urbanization worldwide has led to a growing rift between them. Many city dwellers no longer have the ties that once bound them to the countryside and they have forgotten all too often how very vulnerable they are and how dependent they are on the rural world and water for food. Many of them no longer know where their food and drink comes from, and too often they have forgotten lessons from world history marked by famine and riots, and environmental and climatic crises. After all the crises that marked history yesterday, and those that mark several of the world's regions today, what will tomorrow bring?

Economic and environmental thinking have also become "urbanized" over time. Certain supporters of neoliberal ideology wanted to make free trade an end in itself rather than an instrument for progress. They prefer to import basic commodities which they thought, wrongly, would continue to be available at low prices, instead of developing their domestic rural resources (human and natural); they even questioned the need for agricultural policies. In contrast, others wanted to protect so-called "natural" habitats (most of which were in fact transformed by human activity long ago and cannot be "conserved" without production activity) rather than farmland. The result of this is that in many countries rural areas, which no longer have the political weight they once did, no longer receive the support they deserve. Of the billion human beings suffering from hunger, 700 million are from rural areas, especially women and young people; agriculture being increasingly just an "adjustment variable". Cities, cut off from their rural roots, have become predators for space and resources: the "shadow of the city" is ever longer, bringing with it all the resulting costs: financial (infrastructure, family expenditure on transport, etc.), social and environmental (energy consumption, pollution, greenhouse gas emissions).

Agriculture, despite being fundamental to life (management of water and productive ecosystems, "development" and reduction of rural and urban poverty, rural/urban balance, carbon capture, food security, etc.), has been subsequently marginalized in the major debates around water and sustainable development. It is also true that it was never able to stress sufficiently its multiple roles or to assimilate sufficiently as yet the new goals and issues of "sustainability" and therefore "greening". However, the rapidly changing world, characterized by population growth, increasingly scarce resources, rising prices (energy, fertilizers, water, etc.) and by the return of crises in the food, energy, climate and environmental sectors, now requires far-reaching changes both to agriculture itself and the ways in which it manages water and ecosystems and, more generally, to "food supply systems". Fortunately, the examples shown in this report demonstrate that many innovations are underway for a more sustainable agriculture.

The first condition to be met for a change in scenario is therefore to gain a greater *awareness of the new state of global affairs and the multiple interdependences*. We are all living in the same house, we are all in the same boat, and this requires a new contract between agriculture and society.

Ties of interdependence and solidarity need to be re-established between the city and the countryside, and between water up on the mountains and water down on the plains. Further, ties need also to be created, and this is both novel and essential, *between countries and regions that are water-rich and countries and regions that are resource-poor*. The growing structural inability of several major world regions to feed themselves makes this an urgent issue. The future and the responsibility of several major global regions need therefore to be rethought:

- *Regions rich in water and/or land*: this is the case for greater Europe and the Americas because they must take the full measure of the scale of their natural resources and their global responsibilities. The implications of this should be considered for the various policies that relate closely or more distantly to those resources, to take the new food-related issues more into account wherever applicable.

- *Arid and semi-arid zones*: because their population is growing twice as fast as in the rest of the world and most of these areas are subject to compounded risks and issues: desertification, overexploitation of aquifers, the silting up of reservoirs, the impacts of climate change and heightened dependence on food imports,

- *South and Southeast Asia*: because strong economic growth in the region is confronted with shortages and serious degradation of resources and ecosystems, which will be aggravated by global warming,

- *Sub-Saharan Africa*: because this region faces many major problems and challenges (explosive population growth, degradation of resources, climate change, under-development in rural areas, weak institutions and lack of finance). Nevertheless, this region does have a large number of young people, major land and water resources, and significant potential for productivity increases. Will it be able to put them to good use to curb the expected rapid rise in its dependence on food supplies?

The scale of the many and growing challenges and the multiple forms of interdependence means that it is time to take the following actions:

- Restore to "water for food" and all those for who live from it – men and women working the land and rural communities the consideration they deserve,

- Agree on a few key priorities and principles for action.

THREE BROAD PRIORITIES OR PRINCIPLES FOR A "SUSTAINABLE WORLD"

Analysis of the issues and examples of solutions documented in the report leads to the proposal of three major objectives, or principles for shared action. These are:

➔ Make water resources and eco- systems more productive

To meet the challenge of "sustainable development" in the context of global change, i.e. satisfying society's present and future needs, it is necessary to *increase the productivity of ecosystems and water resources* through "sustainable intensification". This will involve, in many cases, producing more with less.

The solutions that need to be implemented include:

- **Promotion of technical and agronomic innovations** (e.g. fine-tuning of irrigation systems), training of irrigators and the setting up or consolidation of effective organisations structured at the right level (strengthening social capital) to enhance the efficiency and economy of irrigated farming systems ('more crop per drop'),

- **Increase productivity of rain-fed agriculture** through: training for farmers - men and women, strengthening of social capital, improved access to markets and agricultural inputs, promotion of agro-ecology and different forms of conservation agriculture. Promotion of these new approaches to agriculture is essential since it is a matter of urgency to reduce soil losses from erosion, to improve water and soil conservation and to maintain, foster and make good use of the natural fertility of soils and ecosystems,

- **Increase water storage capacity and the mobilisation of additional water resources**, including those that are unconventional,

- **Reduce wastage (direct and indirect) of resources upstream and downstream of production**, losses due to urban sprawl and wastage "from farm to fork".

The switch from an economy focused on the productivity of work to one focused on the productivity of resources is all the more necessary given the increasing scarcity of many resources and the correspondingly higher costs of using them. The increasing scarcity of non-renewable resources requires much higher priority to be given to "bio-economics". This applies to all productive ecosystems. If the challenge of food security is to be overcome, it will notably require special efforts to be devoted to agro-ecosystems that are degraded through erosion and desertification or which are fragile and threatened by climate change.

➔ Reduce poverty (and hunger) by supporting smallholder agriculture and vulnerable regions

The world obviously cannot make the necessary transformation to a new paradigm if it leaves nearly a third of humanity, and large portion of the rural world (mountain regions, arid and semi-arid zones), by the wayside. Smallholder farmers, as the main actors in water management, must be supported if inclusive rural development is to be achieved. Improving water management is a basic condition for improving the production and/or income of smallholders. This may also lead to production of environmental services for the direct benefit of the irrigated agriculture and the towns situated further downstream.

The solutions that need to be implemented for successful "*sustainable rural development*" are as following:

- **Renewed attention to the concerns of the rural world** and therefore the presence of effective local organisations/front offices (agricultural

extension) that are trained in new approaches to intermediation, facilitation of participatory development, responsible management of natural resources and support for preparing individual and joint projects,

→ **Recognition and enforcement of the rights of access for rural communities, farmers and growers** to natural resources (agricultural and pastoral water, grazing land, etc.), and support for local organisations capable of defining and enforcing rules for the sustainable and democratic management of resources and ecosystems at the appropriate geographical levels (local village lands, pastureland, irrigated areas, inter-village agreements, etc.),

→ **Improved access to information, training, markets, credit, subsidies, agricultural inputs, public services**... to help professionalize and restructure small-scale agriculture. Development of infrastructures where necessary (rural roads, irrigation, storage, processing, etc.), and help to diversify the rural economy,

→ **Financing "environmental services"**, where applicable, to help eliminate poverty while also restoring ecosystems for better resource conservation and to "produce" clean water for the benefit of irrigated agriculture and urban areas downstream.

The time is therefore right to put in place strong *agricultural and rural/regional development policies* where these do not already exist. Only in this way will the first of the Millennium Development Goals (reduction of poverty and starvation) be achieved.

→ Improve governance at five levels

In order to enable all actors to mobilise their efforts effectively, bring forward appropriate responses that take into account the complexity and diversity of different situations and issues, reconcile agricultural development with regional food and water security issues, combine efficiency and "sustainability" and thus arrive at a sustainable increase in the productivity of ecosystems as well as reducing poverty over the long term, it is critical to promote good "territorial governance" at all geographical levels.

Moving from global to local, we can distinguish five major levels. These are:

1. **Global**, the level for protection of global public goods, is appropriate for proposing a vision of the world that takes into account the new challenges for water and food security, which defines the broad priorities or principles for "*sustainable development*". The goal of reducing poverty and hunger has already been asserted: what needs to be done now is to take the decisions that will allow this to be effectively realised. The goal of enhancing the productivity of ecosystems and resources also needs to be asserted, since this is the crucial condition for sustainable development. As for the principles for action, the many examples of solutions documented in this report demonstrate the necessity of taking "*complexity*" into account and therefore the necessity of abandoning simplistic, monolithic visions. Solutions will not come through "market forces alone" or "State control alone", or "technology alone" or "local products only", or even simple correction of market failure through economic instruments to reduce negative externalities or fund positive externalities. To be successful, policies, institutions and processes all need to be strengthened and integrated at different levels of governance. This will empower rural communities and farmers to be more entrepreneurial and organise themselves to ensure sustainable and effective management of their natural resources.

2. **The "major region"** is the appropriate level for conflict prevention. Shared visions can be defined at this level, and "deals" could be agreed between neighbouring countries that share a common destiny. This would have the advantage of avoiding an accumulation of uncoordinated and inconsistent national responses to regional problems. The scenarios of the Blue Plan for the Mediterranean for example have provided warnings of the risks of water shortages and arguments for a switch from traditional supply-based policies to policies based on "water demand management" (WDM). The European Union has built its Common Market, accompanied by a common agricultural policy and a framework directive on water. Many world regions, including Europe with the Southern Mediterranean area, would benefit from defining new, shared visions and, where appropriate, translating them into strategies, conventions or policies.

3. **National**, the level for cohesion, solidarity and the definition of public policy. This level is fundamental because it is usually where food security policies are defined. The examples of solutions documented here show how important it is to be able to promote projects adapted to water and food security concerns and to move forward with national policies and doctrines for action. In countries with limited resources, agricultural policies should promote "*water demand management*", accompanied of course by policies for sustainable rural and agricultural development. This should be done through providing support for smallholder farmers, enabling them to increase the productivity of their resources and ecosystems. Agricultural policies on water will gain from becoming "food" policies and so generate buy-in from consumers. They should be part of "policy mixes" that include other major policies for the conservation and proper use of water resources (town planning policies, water policies, energy policies, etc.).

4. **Infra-national**: this is the level between the local and the national levels, and is frequently the appropriate scale for "*planning*" purposes. It includes *water catchment areas for water* planning, agricultural production areas for the agricultural economy, and landscapes at the level of *NUTS 2 regions (i.e. regional councils, Länder)*. It is particularly important for planning and action, where particular attention can be given to the specific features and issues facing particular areas and to link policies for agriculture and water to specific sites, thus enhancing their coherence and effectiveness. Several examples of solutions illustrate the advantages of *promoting visions, strategies and plans for sustainable agriculture at this level*. The major corporate groups that are investing in developing countries should also endeavour to promote strategies negotiated at these levels to better integrate the local issues affecting food security (access to food for vulnerable population groups) and water security.

5. **The local level**, where natural resources are managed, is absolutely essential. It is the level for local expertise and innovation and the level at which regions are actually "inhabited". It can notably enable forms of collective local governance to be defined that can guarantee responsible, sustainable and fair management of rural water. Organisations of irrigators at the level of the "water distribution area" in France (authorised federations) and in Spain, groupings for agricultural development in Tunisia, the community of users of the Prey Nup polders in Cambodia, community aqueduct services in the Cauca valley in Colombia, pastoral cooperatives, and the like, are all examples of community and farming systems that are well suited to the issues of sustainable – and in many cases multiple-use – management of rural water.

These numerous examples show the importance and the validity of the principles highlighted by the work of Elinor Ostrom, a Nobel Laureate for economics in 2009. They confirm the feasibility of solutions for collective, effective and sustainable management of water resources and therefore of the necessity of abandoning simplistic, dogmatic postures based on "market forces alone" or the "State control alone", which have shown their limits and their inadequacy. These examples therefore argue for priority to be given to social innovation, to a strengthening of "social capital" and to the principle of subsidiarity. Recent developments in technology (large-scale hydraulic projects, motorised pumping systems, use of plant protection products in agriculture...) nevertheless broaden the range of what is possible and the range of possible dangers (pollution, overexploitation). This suggests a real need for further innovations in institutions, organisations and partnerships for the governance of resources. Several examples illustrate ongoing progress, albeit it slow, in but which does effectively involve the primary stakeholders, namely the farmers and rural communities in the regions concerned, as well as, where applicable, other actors (cities, agronomic research, industry, water boards...). What is needed now is to speed up the application of these innovative responses. In any event, the public interest is well served from better organization of local and professional actors for good management and use of natural resources in their areas. The ways forward to real progress are many. They include: abandonment of

"command and control" postures, attentiveness to complexity by rejecting unitary solutions, agreement on the territorial levels to be taken into consideration, recognition or support where applicable for rights of access to resources and collectively determined rules for the sustainable management of those resources, mobilisation wherever possible of additional water resources and support and encouragement for innovation and change in methods towards achieving sustainable agriculture, and respecting the many interests involved.

One of the essential conditions for making progress at the different levels is to be able to accurately assess the reality of different situations and to measure their changes over time (tasks of diagnosis and monitoring progress), and thus have the ability to account for one actions (accountability). The establishment of' observatories' to measure continuously the situation and to tailor responses to identified needs is vital.

THE CHALLENGE OF "SMART INVESTMENT" FOR SUSTAINABLE AGRICULTURE

Reinvesting in agriculture, and in the management and proper use of water for food, is imperative. However, the quality of this investment is also crucial. It is not enough to only raise more financial resources, whether private or public. Meeting the challenges that have been identified also entails extensive innovation, not only in technology and agronomics but also in terms of models of economic and ecological development supported by strategies, policies, institutions, organisations and processes.

The complexity of the interrelations means that each actor must play his role in his own context and at the relevant levels of governance.

It is clear that the progress recommended by this report can only be achieved if:

→ **Farmers and rural communities are recognized as the key actors in the solution**, because it is they who are the principal managers of the water for food and for the ecosystems, and it is they who feed the world,

→ **Clear priority is given to strengthening human and social capital** (farmers' organisations, cooperatives, associations of irrigators, etc.).

The ability to manage water for food well, thus helping assure food security, will depend on the ability of men and women, companies and rural communities to be enterprising, innovative and committed both individually and collectively in efforts to progress towards "sustainable agriculture".

Capacity-building must also take place in schools and in research institutes, particularly for agricultural research. It must also target all the actors whose involvement at the various geographical levels is a prerequisite for progress.

CREDITS, CONTRIBUTIONS

This report was prepared by the General Council of Food, Agriculture and Rural Areas (CGAAER), a body of expertise, forward thinking and support for the definition and evaluation of public policies within the French Ministry of Agriculture, Food, Fisheries, Rural Affairs and Planning (MAAPRAT). It is the result of analysis and multi-stakeholder discussions, conducted from September 2010 to January 2012 under the French Water Partnership (FWP). This is a work of shared expertise to which many institutions and qualified individuals have made valuable contributions.

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NOTES

[i] The targets set out for Theme 2.2 "Contribute to Food Security by Optimal Use of Water" at the 6th World Water Forum, are:
1. 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;
2. By 2020, sustainably increase by 15% - as compared to 2005-07 baseline – water productivity per unit land and per year (yield per m3, per ha and per year) of irrigated agriculture (for specific crop categories).
3. 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 year 2025 there is food security at affordable prices for all;
4. 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;
5. Increasing capacity of water storage in support of irrigated agriculture in an environmentally sufficient and socially sound management;
6. 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;
7. 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;
8. 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;
9. Improve water management for more food production and increased access to water for smallholder farmers

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- February, 2012 -

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ET DES ESPACES RURAUX

"Water is life! is a universal motto. Without water there certainly can be no agricultural production, thus no food production. But practically the relationship between water and food security comes out to be much more complex than that: first, because the ecosystems, both natural and artificial, are central in water management processes: they collect rainwater, store it, transfer it, they make it available in the best conditions for serving sustainability ecosystems, agricultural production and for meeting the needs of domestic populations. Secondly, because mankind constantly tried their best, since the beginning of agriculture, to interfere into these processes by more sophisticated technology , though more or less successfully. The report "Water and Food Security" takes stock of the current thinking on this issue from a review of forty cases across twenty countries and while looking forward to meeting by 2050 the challenge of feeding in a sustainable way a global population of 9 billion people." **Hervé Bichat**, founder director of the French Center for International Cooperation in Agronomic Research for Development (CIRAD)

"By highlighting the critical role of water management in food security issues, this study makes a decisive contribution to the World Water Forum. Improving water management is a priority to increase not only the production but also the incomes of small farmers. The documented examples show that these goals can be achieved, provided that there can be put in place to effective organizations of farmers and food processing sectors, and to institutional frameworks for facilitating cooperation among partners at all levels, from local to regional ". **Gérard Viatte**, past Director of Agriculture in OECD.

The report, prepared by the High Council for Food, Agriculture and Rural Areas (CGAAER), a French resource to the Ministry of agriculture for forward-thinking and support-providing in definition and evaluation of public policies, is the result of a collective multi-actor process, conducted from September 2010 to January 2012 under the French Water Partnership (FWP). Many institutions and qualified individuals have contributed their valuable experience and expertise. The report deals with the "water for food" as an issue in food security. It warns on the risks related to continuing the current trends, and highlights 40 examples of solutions illustrating seven priorities for action. It points out three comprehensive priorities for a sustainable world: produce more and better, support and include small-scale agriculture, promote appropriate governance processes at all relevant levels in territories.

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