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# Irrigation for Agricultural Transformation

Paper written by **Fethi Lebdi**

**BACKGROUND PAPER FOR**

African Transformation Report 2016:
Transforming Africa's Agriculture

**FEBRUARY 2016**

JICA

Joint research between: African Center for Economic Transformation (ACET) and
Japan International Cooperation Agency Research institute (JICA-RI)

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# Contents

## 1. Introduction

Agriculture is one of the major social and economic sectors in Africa since farming accounts for two thirds of livelihoods and food for two thirds of poor people's household budget (Africa Progress report, 2015). The consequence is that improved people's wellbeing depends for a major part on the performance of the agricultural sector in Africa. Still today and despite rapid economic growth in Africa over the past years (more than 5 percent in many countries in Sub-Saharan), the performance of agricultural sector is low and hunger continues to be a risk, in particular in the Horn of Africa and Sahel region. Rural vulnerability, low resilience to climatic effects and poverty are still deep in rural areas and nutrition is poor. Agricultural transformation is needed in Africa to address these challenges and irrigation is one pillar to contribute to such transformation.

Agriculture is the main pillar mentioned in several African Union reports (Strategic and Operational Plan, 2014-2017: Fostering the African Agenda on Agricultural Growth and Transformation and Sound Environmental Management, AU/DREA January 2014) and Regional Economic Communities (RECs: IGAD, ECOWAS, …etc.), in National Investment Plans of African countries (NIP) and in National Agricultural Investment Plans (NAIP), and within UN agencies reports (e.g. FAO). Thus, a high level of political and strategic will is expressed through the Comprehensive African Agriculture Development Program (CAADP) of the New Partnership for Africa's Development (NEPAD), and whose implementation is through the CAADP Compact Process for each country, validated by governments and civil society organizations and supported by technical and financial partners. CAADP Pillar 1 concerns land and water management and irrigation is one main sector underlined.

To develop irrigation for African agriculture, it is necessary to address the following constraints:

- Climatic uncertainties and change.
- Water and land resources scarcity, soil fertility and the sustainability in use.
- Cultural, social and economic factors (population growth, increasing food demand, pressure on land and water exploitation, customary rules for land tenure and water rights).
- Technical skills, institutional capacities.
- Development of value chain activities, including market accessibility and services, to complement irrigation development.
- Capacities of countries to undertake heavy investments in agricultural and irrigation sector.

In Africa, most agricultural land is rain-fed and subject to erratic rainfall and recurrent droughts, leading to low agricultural sector performance. This includes low resilience of rural people to climatic effects, irregular production and low productivity, low intensification and crop diversification, and weak value chain and market development.

It is important to underline the importance of CAADP in Africa and the CAADP Compact Process in countries, since action is taken mainly in this framework, in particular CAADP's Pillar 1. The key-irrigation-specific elements of CAADP's Pillar 1 are:

- Investments at small-scale and for smallholders who account for 80 percent of farmers.
- Policy of Integrated Water Resources Management (IWRM) (e.g. the Irrigation Initiative for the Sahel Region, 2015, an irrigation plan for six Sahel countries (ECOWAS/CILSS and WB).

- Large scale irrigation systems: to develop, modernize or rehabilitate irrigation schemes.
- Water harvesting combined with soil moisture management, where deficit and supplementary irrigation techniques are adopted in rainfed areas (e.g. a community-based watershed management in the Amhara region of Ethiopia).

The African Union (AU) has also developed an "African Water Vision" for equitable and sustainable use of water for socioeconomic development, which highlights water for urban and sanitation (WASH) and also irrigation as key elements (Africa Water Vision 2025, AU and AfDB). The AU's African "Agenda 2063" (http://agenda2063.au.int/en/vision), which outlines a framework for African transformation and over the next 50 years, also highlights agricultural transformation.

In the context of the climatic and natural resources situation in Africa and the political will expressed by its leaders, this report discussed how best irrigation can be developed to support agricultural transformation in Africa.

## 2. Objectives of the study

The main objective of this study is to examine, based on review and synthesis and analysis of available material, experiences, and data, how irrigation could contribute to African agricultural transformation and thereby help address the major issues of hunger, food insecurity, and poor nutrition.

The report will:

- Review the current context and trends of irrigation in Africa and discuss African experience
- Understand, the factors behind the low investments in irrigation on the continent.
- Document the major failures and successes according to agro-ecological typology (FAO, Aquastat 2005).
- Examine the major issues related to irrigation and the main strategies for the future.
- Assess the potential for irrigation development and management, including its performance, constraints and challenges.
- Analyze the investments for the irrigation sector.
- Propose actions based on analysis of the evidence on successful experiences and the lessons learnt.
- Identify externalities and their impacts on irrigation's potential contribution to African agricultural transformation.

Since irrigation is well developed in North Africa and a large part of the available irrigable land there is already under irrigation, this report focuses mostly on Sub-Saharan Africa.

## 3. Current Situation and trends in Irrigation sector

Agricultural production has increased slowly in Africa, and for number of reasons the irrigation sector has not yet played a major role to cover the imbalance between food demand and supply, to benefit farmers and generate jobs for the youth in particular. In general, donors and decision-makers are aware that that Africa has significant land and water potential. Therefore, it is important to examine why iinvestments in irrigation have been low in the last decades and understand where irrigation have performed well and why others continue to fail. This should enable policy makers to avoid mistakes involving investments in irrigation and to ensure that the benefits of irrigation are equitable and sustainable. .

Africa could irrigate 42.5 million hectares, based on available land and water resources and by far the greatest potential is found in Nigeria, which accounts for more than 2.5 million hectares. Countries such as Cameroon, Chad, Ethiopia, Mali, Niger, South Africa, Sudan, Tanzania, Togo, and Uganda each have at least 100,000 hectares of potential (FAO Aqua stat, 2005).
It is also has an average of 0.27 ha of cultivated area per inhabitant in Africa (0.24 ha for average in the world) and 1.02 ha per economic active person engaged in agriculture (1.16 ha for the average in the world). These numbers should be compared and analyzed by taking into account the population growth and the economically active population engaged in agriculture. In Africa, population growth is relatively high (2.2 percent per year) when the average in the world is only 1.2 percent per year. It means that the pressure on agriculture and irrigation sector is higher in Africa today and in the future, to ensure food security and nutrition to more people. The same remark is valid if we consider that 56 percent of the economically active population is engaged in agriculture against 21 percent as an average in the world. It is also an opportunity for agricultural transformation if decisions on investments in irrigation are made wisely to optimize production and generate employment for the active agricultural population.

In the early 1960s, there were 7.4 million ha of irrigated area under cultivation in Africa (Future Agricultures; WP119, June 2015). Although this area has nearly doubled to 13.6 million ha after almost 50 years, in 2006 African countries irrigated just 5.4 percent of their cultivated land, compared with a global average of around 20 percent and almost 40 percent in Asia (FAO Aquastat 2010). Hence the irrigation sector’s contribution to agricultural output is relatively small. Geographical coverage is also skewed since a large proportion of irrigated land is concentrated in five countries, namely South Africa, Egypt, Madagascar, Morocco and Sudan (Frenken, FAO Aquastat 2005).

Given this low level of irrigation development and investment in Africa, there is a need for understanding the factors behind it, and to find ways to address them.

## 4. Why irrigation investments in Africa have been low?

In other parts of the world (South Europe, Asia, and USA) and in the second half of the twentieth century, big parts of agricultural budget were diverted to irrigation projects (Rosegrant and Svendsen, 1993), and deployed with new seed varieties and fertilizers to boost yields, and with mechanization and new irrigation technologies and management approaches. The result today is that other developing regions meet the challenge of feeding their growing populations through irrigation and intensification of agricultural production, and what is called Green Revolution in Asia was in a large part boosted by what irrigation gave to agricultural output. The growth that occurred in the developing world did not have the same pathway in Africa, expressed by low investments in irrigation sector (equipped irrigation area only doubled in almost 50 years, from 7.4 million ha in 1961 to 13.6 million ha in 2006, corresponding to a progress from 4.4 to 5.4 percent of cultivated area (FAO Aquastat 2011)). Major reasons for this low investment in irrigation during the last decades in

Africa are described in many papers and from many data; in particular the following reasons are underlined.

- Irrigation for agriculture has not been prioritized by African governments or their development partners. Urban Water and Sanitation were prioritized under the MDGs, but not irrigation for agriculture.

- High irrigation investment costs. Average total cost for irrigated scheme for one hectare in Sub Saharan Africa is US$ 8,374 in 2000 prices. When irrigation schemes are linked to new construction with land opening, infrastructures (e.g. dams), the average unit cost per ha is US$14,455 in Sub Saharan (A. Inocencio and al, IWMI, 2005). If a country would plan for a large investment project (50,000 ha), it would be in millions of US$ and usually governments make use of banks for big loans (e.g. In Nigeria, the National Fadama Development Project is intended to irrigate 50,000ha for a budget of US$ 104 Million and loan from WB of US$ 67,5 Million, in 2000).

- Irrigation requires big amounts of water resources (water requirements to irrigate 1000 ha in peak period is almost equivalent to more than drinking water requirements for 2 or 3 million people depending on their daily consumption). Water resources development for irrigation needs to build big size and costly infrastructures (multi-purposes dams, deep wells and infrastructures for water conveyance and pumping stations) and needs skills for operation and maintenance.

- High irrigation investment costs combined with lower prices for food at international markets and the failure of some past irrigation projects (low profitability in the field, economic internal rates of return lower than 10 percent due in some cases to technical failures: e.g. in Mozambique's Limpopo scheme, Biswas, 1986) are among the most reasons for the reluctance of governments to prioritize irrigation among a set of urgent and visible projects like drinking water and sanitation and reluctance of donors to invest substantially in irrigation. It is important to scrutinize and study deeply at national and local level which factors are behind the high cost of irrigation projects and identify cost-reducing options in order to make irrigation investments more attractive and profitable at macro level and on farm level.

- Weak capacities of specialized institutions to undertake initiatives for multi-purpose water infrastructures and irrigation schemes, which also require studies and evidence (social, economic, environmental…) to make a convincing case on the potential benefits of the huge investments proposed.

- Poor performance of irrigation investments made, in particular at large scale, from public funds. Poor performance is partially due to errors in the design, institutional inefficiency, unreliable water supply, difficulties to access and afford inputs like spare parts and fertilizers (African farmers use less than 10 per cent of the amount of fertilizer used in Southeast Asia (: AU/DREA, 2014) and high cost of energy.

- Difficulties accessing profitable and close markets. The state of rural infrastructure is so poor that road density in Africa is 2.5 times less than in Latin America and 6 times less than in Asia. The average transport cost per km for the Douala-N'Djamena (Cameroun-Chad) distance is almost 3 times that of the USA, and 2 times that of Western Europe, which clearly undermines intra-African trade and competitiveness. Africa trades more with the rest of the world than within itself; Intra-African trade has been between 7-10 per cent against 40 per cent in Europe and 60 per cent in North America, in 2010 (AU/DREA Report, January 2014). This is influencing cropping pattern to grow more cash crops responding to foreign markets and their norms and standards of quality of agricultural products.

- The political decision makers did not see relevant return from irrigation high investment with intervention of the public sector (e.g. a review of six Kenyan irrigation schemes found that only one was delivering a net profit. Biswas, 1986). Politicians are more convinced by the short term and visible results due to social pressure, and macro level benefits, but also by the need to properly address the challenges to increase productivity for national strategic crops (e.g. cereals, rice, and maize) like the real success stories in Asia, South Europe and within Africa. The fact is that yield levels are currently low and there are opportunities to make productivity gains (this term is understood here as yield increasing). For example, if cereal yields were to be doubled to two tons/ha on average - still less than half of the average in the developing world, which is an achievable target in the short term – African countries would grow an extra 100 million tons of food per year. This would shift Africa to a major food surplus region and help eradicate hunger and poverty on the continent (AU/DREA report, January 2014).

- In some cases, irrigated crops were unable to compete with subsidized foreign exports. It is the case for cereals. From the side of the government, cereals are strategic crops and irrigation has to contribute to the effort of self-sufficiency at macro-level. From the side of the farmer, cropping cereals is not profitable. In between, mechanisms and incentives have to be deployed by governments to approach farmers' objective of maximizing the net profit. Decision makers need to be convinced that irrigation is contributing to social welfare and food security, perhaps less than some other economic sectors (like tourism or industry in some countries), but the lesson of history is there: Developing countries start with agriculture and irrigation was the key for their development. Till today, European Union is supporting small farmers and protecting several sectors of agricultural production. In addition to irrigation investments, Africa needs mechanisms to protect small farmers against subsidized foreign products (mechanisms and subsidies for irrigation maintenance, spare parts and energy, quality seeds and guaranteed minimum price of products). It needs a clear and medium term political commitment based on evidences and successes in agricultural and irrigation policy of developed countries between 1960s and 2000 (Europe, Asia…etc.).

- In 2005, the Commission for Africa Report called for doubling irrigation area by 2015 (Ling Zhi You, WB 2008). We do not have data for 2015 but despite donors and governments commitments, levels of public investment have remained low and overseas assistance to irrigation sector declined in 2010 (FAO 2011, citing OECD 2010). Spending needs are estimated by Foster and Briceno-Garmendia in 2010 (WB, 2010) at US$ 3.4 billion annually when the average spent in 2001-2006 period was US$ 0.9billion. There is a notable gap in mobilizing resources and the public sector remains the main source of finance for large-scale irrigation.

- Policy makers should be informed by experiences in irrigation in different contexts:
  African countries have different historical legacies that can shape the irrigation sector today: large scale irrigation systems developed from the colonization period for export products

(cotton, cereals), irrigation management transfer (starting in 1980s with water use associations and today with PPP) and market policies (liberalization).

The example of "Office du Niger" in Mali (initiated by the French in 1932) is one of the oldest and largest irrigation schemes in Sub-Saharan Africa. The irrigation scheme was originally developed to grow cotton for the French textile industry. In addition to government commitment, the project's success is attributed to comprehensive reforms and rehabilitation: technical, institutional, and economic factors. Technical factors include water management through physical rehabilitation of irrigation and drainage networks, a comprehensive package of improved technologies available at farm level and involving the private sector, and appropriate agricultural mechanization. Institutional and economic factors include liberalized paddy marketing and processing, land-tenure security, infrastructure improvements (roads), and stronger partnerships with farmers (water use associations) tripled average paddy yields to 5 tons per hectare, increased the area under cultivation to about 80,000 hectares, boosted settler population by over 220 percent, and increased paddy production per capita from 0.9 ton to 1.6 tons, reducing poverty and increasing food security (Ref: Africa's Infrastructure: A time for Transformation, 2008 (http://www.infrastructureafrica.org/).

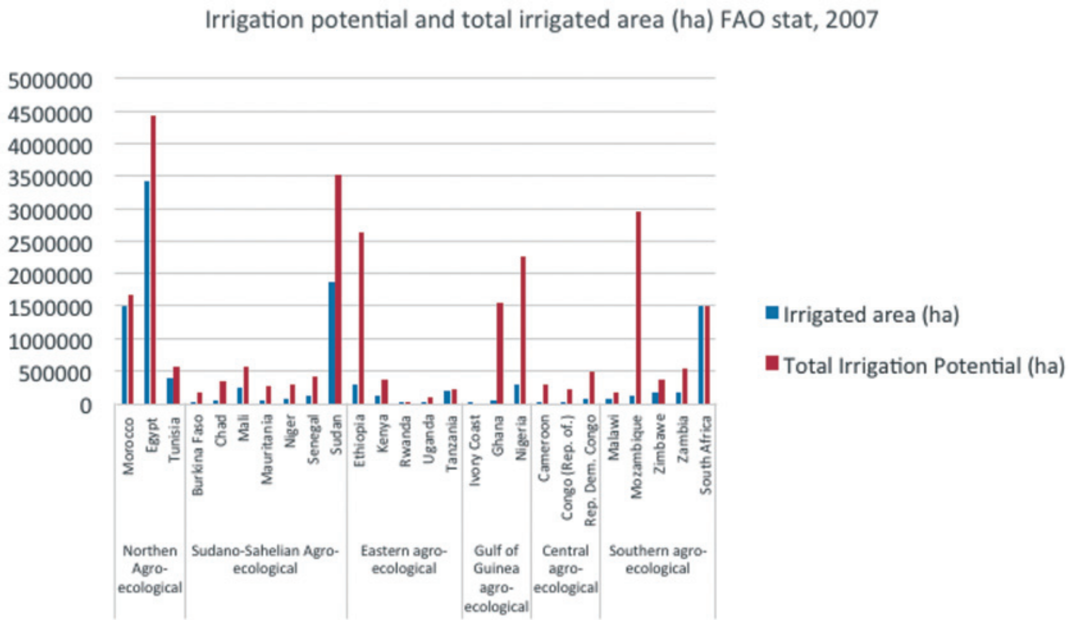
- Political stability had an influence on developing institutions devoted to irrigation, and poor coordination of national or sub-regional agencies in charge of irrigation did not help to advocate irrigation sector (e.g. in many countries, irrigation sector is managed between two Ministries: Water resources and Agriculture, which need harmonization and coordination in the field). Today, the political stability and will in many African countries is conducive for long-term irrigation development, resource mobilization and capacity building. Countries that have succeeded to make the most progress in developing the major part of their irrigation potential are politically stable with a commitment to irrigation sector development, coming from the governments and from the donors (e.g. South Africa and Mozambique developed big part of their irrigation potential).

An example is the Sahel region where despite water scarcity and the issues of shared transboundary water resources of the Senegal River, the riparian countries have succeeded politically to create at basin level, a regional office for the management of water resources and shared benefits including from hydropower and irrigation. Water resource management is multi-objective and multi-users and irrigation is part of a cooperative water management solution, under water scarcity conditions in general. The success of Senegal River Basin Office to advocate and mobilize resources for irrigation investment, taking into account different objectives and users (hydropower, transport on the river and market access, fisheries, health) is evidence of a successful cooperative water management and irrigation sector promotion.

- Referring to the irrigation potential and total irrigated area estimated by WB in 2011 (Graph 1), Morocco, Egypt, Sudan and South Africa have developed most of their potential in irrigation. In other countries, the opportunity for substantial development of irrigation sector remains - in Eastern Africa (e.g. Ethiopia, Kenya, Uganda, South Sudan), in Sahel Region (Chad, Senegal, Niger, Mauritania and Mali), in Nigeria and in Southern Africa (Mozambique, Malawi, Zimbabwe and Zambia). In these countries, the prevalence of small size farms raises the importance of small scale irrigation systems for both social and economic benefits: an example is Ethiopia, which has established a specific program for small scale irrigation that is under the Agency for Agricultural transformation.

Currently given the low irrigation development and existing arable land potential, the first constraint for the majority of smallholders is access to commercial bank loans (issue of land tenure and registration) and to technological support at farm level. Indeed, the connection between land tenure and irrigation is strong and constitutes a constraint for irrigation development because land tenure's link with social and cultural rules. Technical design and management of irrigation systems need to respect these rules to ensure communities and individual commitment and accountability for maintenance, optimal operation and sustainability of irrigation schemes and water resources.

**Graph 1**. Irrigation Potential and total irrigated area (Ha) FAO Stat, 2007




## 5. Climate and agro-ecological zones (typology)

Africa has several climate and agro-ecological zones and Table 1 below describes the FAO categorization of seven main agro-ecological zones in Africa (FAO 2005, IFPRI 2009). The link between the analysis and actions proposed by this study and Table1 is irrigation relevance and kind of water resources development (inland and trans boundary) needed to contribute to agricultural transformation. Below and where necessary, the description, data and analysis refer to agro-ecological zones. Some of the content is common to all agro-ecological zones where irrigation has high relevance.

**Table 1**. Agro-ecological Zones in Africa (FAO 2005, IFPRI 2009)

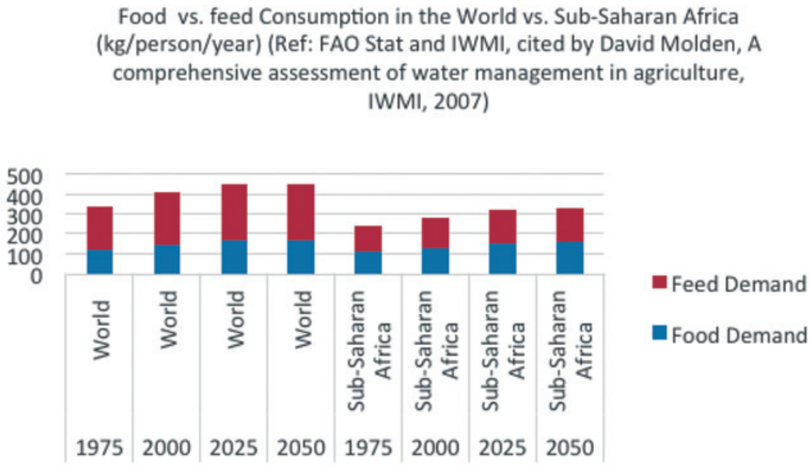
| Region | Countries in zone | Main Characteristics | Relevance of Irrigation/Inland and Trans boundary |
|---|---|---|---|
| Northern | Algeria, Egypt, Libya, Morocco, Tunisia | Arid and Semi-arid, erratic rainfall and water scarcity; 47% of total irrigated areas in Africa | High/ Mainly Inland for surface water and trans boundary for groundwater |
| Sudano-Sahelian | Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, The Gambia, Mali, Mauritania, Niger, Senegal, Somalia, Sudan | Mainly arid. Recurrent droughts. | High/ Inland and trans boundary |
| Eastern | Burundi, Ethiopia, Kenya, Tanzania, Rwanda, Uganda | Mainly Arid and Semi-arid lands, erratic rainfall and water scarcity. Recurrent droughts. Exception, humid southern part of Uganda, Burundi, Rwanda, and Tanzania | High/ Inland and trans boundary |
| Gulf of Guinea | Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo | Humid to tropical in the South and dry in the North. | High/ Inland and trans boundary |
| Central | Angola, Cameroon, Central African, RDC, Congo Brazzaville, Equatorial Guinea, Gabon, Sao Tome and Principe | The region is well endowed with rainfall and water resources. | High in semi-arid local parts/ Mainly rain fed. |
| Southern | Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe | Climates vary from arid to subtropical and tropical humid conditions. | High/ Inland and Trans boundary |
| Indian Ocean Islands | Comoros, Madagascar, Mauritius, Seychelles | Mainly arid in some parts and tropical humid in other parts. | High in the arid parts |

## 6. Increasing imbalance between food production and demand

The major livelihood zones in Africa related to production and to water as a limiting and potential factor for irrigation development, are mainly: agro-pastoral zones, cereals in all Africa zones (wheat, barley, maize, millet, rice and sorghum), root crops, tree crops and commercial crops (e.g. cotton in Egypt, Sudan and Senegal and sugar cane in Senegal, Egypt and South Africa). Currently, production of the above crops is mainly rain fed and although production on irrigated land is expanding, it still insufficient to eradicate hunger, to secure food and improve nutrition. Indeed, Africa is making progress but still experiencing worst nutrition situation (Regional Overview of food insecurity Africa, FAO 2015). This situation of vulnerability has continued despite the declined prevalence of undernourishment in Sub-Saharan Africa in terms of percentage (from 33 percent to 23 percent between 1990-92 and 2014-2015; FAO 2015) but increased undernourishment in terms of people (229 million in 2014 compared to 175.7 million in 1990).

Demand for food is increasing in volume due mainly to population growth. Graph (2) shows positive trend on increased food and feed consumption per capita in Africa, and increase of the volume of demand for food resulting from high population growth (Africa's population is expected to more than double, rising from 1.1 billion today to at least 2.4 billion by 2050. Nearly all of that growth will be in the 51 countries of sub-Saharan Africa ( Ref: Population Reference Bureau, 2013). It calls for more agricultural production per capita per year by 2025 to mitigate the imbalance between agricultural production and demand, and expansion of the agricultural land under irrigation will be an important way to meet this challenge.

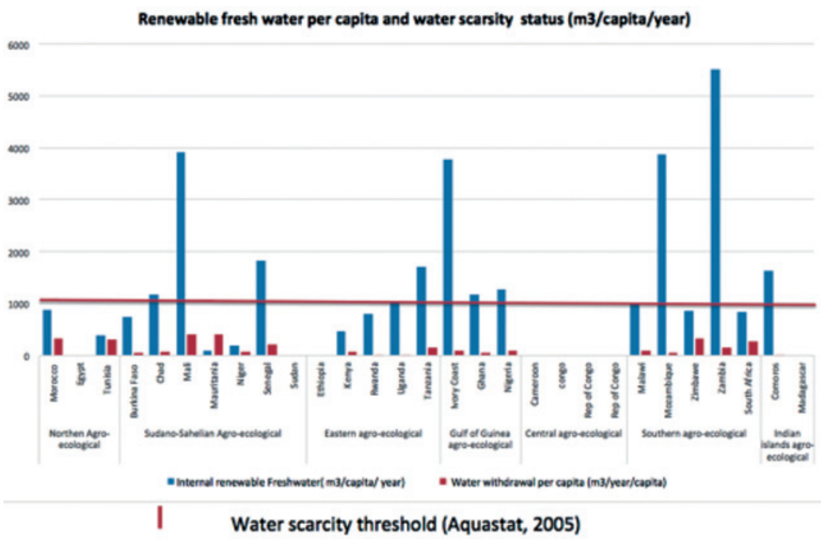
**Graph 2**. Food and feed consumption in Africa




## 7. Water Supply for irrigation

Expanded irrigation development and improved water management are keys to increasing production, under water scarcity conditions. In Africa, water scarcity has three dimensions: scarcity of water quantity and quality, scarcity of water infrastructures and scarcity of services and capacities. Indeed, countries like Morocco and Tunisia in the North, Kenya and Rwanda in the Eastern Africa, and South Africa, have their potential of renewable freshwater per capita under the water scarcity threshold (Graph3: 1000m3/year/capita, FAO 2005,) and some are under water shortage threshold (500 m3/year/capita). Under these conditions, some countries (e.g. North Africa and South Africa) have developed water infrastructures, services and capacities to address irrigation challenges facing scarcity in quantity or quality.

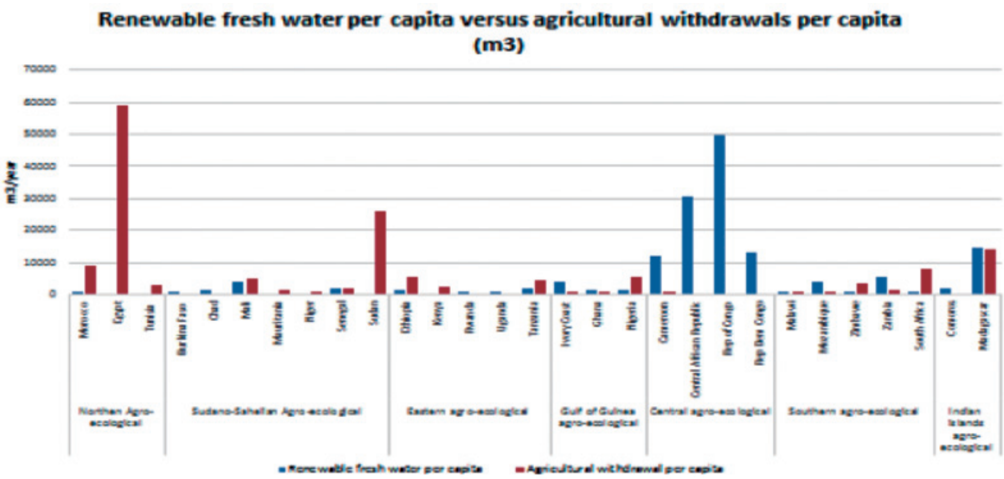
**Graph 3**. Water scarcity status (FAO Aquastat 2005)



The present situation shows that water withdrawal per capita is still low (Graph 3) and water withdrawal for agriculture is also low (Graph 4), despite the fact that many countries in Africa are endowed with high levels of water per capita. The potential of the total internal renewable freshwater resources in Sub-Saharan Africa in 2013 were estimated to 3,857 billion m3, and water withdrawals are only around 189 billion m3, which is 18 percent of internal resources (WB 2015, Development indicators).

Agricultural water use accounts for 31 percent of total water withdrawals and less than 2 percent of the potential resources. In East Asia where agriculture is developed, the potential is less than in Sub Saharan Africa (1,982 billion m3), water withdrawal is 51 percent, and agriculture is the largest user (91 percent of the water withdrawal) (Ref: “Small Scale Irrigation: Is This The Future?”,  (Facon and Mukherji, FAO and IWMI, 2010). Thus, in the absence of significant water supply infrastructure networks, the impacts of water scarcity and drought are huge (e.g. food insecurity threats are expected in some parts of Ethiopia and Somalia for 2016). In the Horn of Africa, initiatives have been launched to improve resilience to drought (IGAD in Eastern Africa) and a water platform has been set up to improve multi-purpose water resources infrastructures development for hydropower and irrigation, including groundwater resources.

**Graph 4**. Renewable freshwater per capita and agricultural water withdrawal (Aquastat updated 2015)




In view of the present situation, Africa’s water supply strategy for the future (except North Africa and South Africa which have already mobilized most of their freshwater resources) is to develop multi-purpose water supply from the existing potential of water resources (i.e. for domestic use and irrigation, in addition to hydropower, industry and ecosystem services). The experience from North Africa is the elaboration of decennial plans for agricultural water management between 1980-2000, which have water infrastructures development as the main pillar (big and small dams, shallow and deep wells, and geographical water transfer network, etc.). Today, these countries benefit from the development of their water supply systems to develop and transform their agriculture and are focusing on production and quality of products and markets. One interesting example of the water supply strategy is Tunisia’s management of virtual water through cash crops exportation: Tunisia, a water scarce country, exports many irrigated cash crop products (e.g. vegetables, fruits, dates and olives and olive oil) off-season to European markets while importing agricultural products such as fodder, and cereals. The balance is that 1m3 exported through products is equivalent in terms of economic value to 7m3 imported through products (Lebdi, Ciheam 2009). Water scarcity could be addressed partly by smart market orientation and exchange of agricultural products once the water supply constraint is already lifted. Since trans boundary water resources require agreements at different levels, water supply plans from inland water resources (none shared surface water resources and aquifers) could be strengthened for domestic demand as well as for irrigation.

Overall, in Sub-Saharan Africa available water resources are not fully used even though there is severe local water scarcity and recurrent droughts exacerbated by climate change effects. Therefore, temporal and spatial distributions of rainfall and water resources potential are the main challenges to address for water supply development. Future water supply strategies need to consider, in addition to an inter-annual multi-purposes water storage infrastructures, the geographical water transfer to fill the gap of temporal and spatial water distribution and to cover local needs, which means agreements for allocation between users (at water basin level, in the same country and between countries) in considering equity and sustainability of resources and the nexus between water and energy (geographical water transfer requires energy and pumping in absence of gravity).

Currently, two main situations of water supply and irrigation infrastructures are prevalent: (a) irrigation at large scale and dam-based schemes, and (b) small scale schemes based on deep or shallow groundwater resources, small reservoirs, river diversion and water harvesting systems. Because big dams have high cost and are complex to operate or to manage, the trend is they are no longer built for just one purpose and irrigation is one objective among others, in particular hydropower. This context suggests basin scale water resources management, which is successful in West Africa (e.g. Senegal River).

In general and it is the case also that in Africa, irrigation systems are mostly large scale downstream dams. On middle and highlands, where the majority of smallholders are living, major benefits can be derived by focusing on the development of water harvesting and soil conservation strategies and on watershed level management. Supplementary and deficit irrigation and soil moisture management techniques can also be applied.

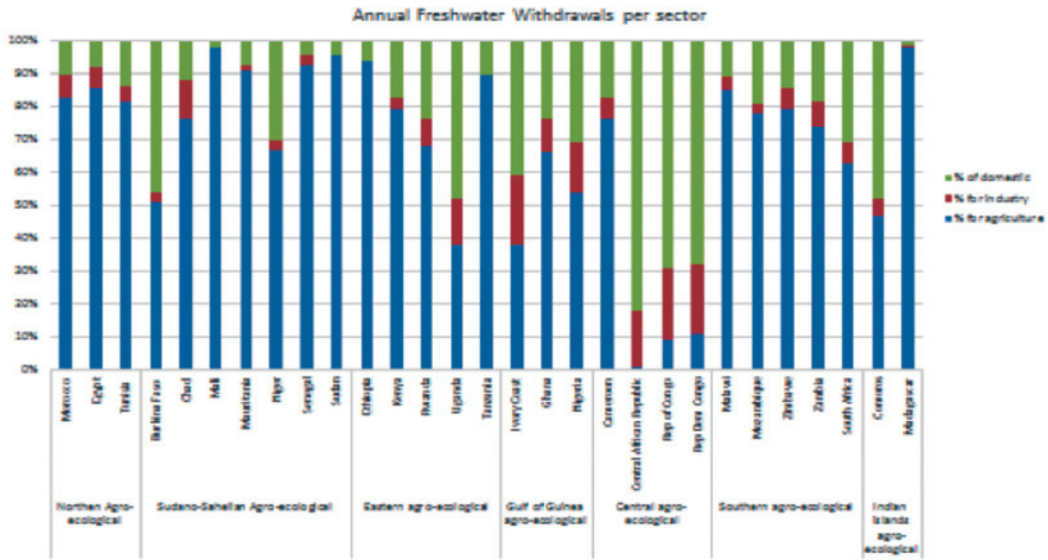
## 8. Impact of water use competition in irrigation sector development in Africa

Water scarcity in its three dimensions cited above combined with existing multi-users and multi-objectives water resources management lead to competition around water resources. In fact, Africa's population is expected to double by 2050 and water consumption is expected to increase by 70 percent (UNDESA, 2015). As shown in Graph 5, the agriculture sector will continue to be the major water consumer and irrigation would be needed most in ASALs (Arid and Semi-arid Lands), which are hard-pressed to raise crop production and livestock. However, the demand for hydropower, domestic and industry sectors will increase and competition for water accessibility will increase in a context of local water scarcity. Priority is for drinking water and animal watering and because irrigation development is still low, the competition between sectors for water use is currently low. In the future, and this is today the case in North Africa, when irrigation is well developed and becomes the main consumer under water scarcity conditions (e.g. in North Africa, irrigation consumes around 80 percent of available water resources), irrigation often considered the main water waster (global irrigation efficiency is not exceeding 60-70 percent) will have to be more efficient (water application at farm level and in the water transport systems and irrigation schemes). In addition to water supply strategy, it will be necessary to promote and to strengthen water demand management strategy, today and in the future.

It is obvious that because agriculture is still the main employer in Africa and the development of irrigation oriented to markets and services is a serious option to sustain employment and to stop rural migration (to cross Sahara and seas to Europe or to move to urban zones), the competition between irrigation and other water uses will need to take into account social and economic effects and will require massive investments for irrigation. For example, China is now attempting to balance food security objectives, economic growth objectives, rural/urban income disparity and rural exodus objectives (Facon, FAO 2010).

Accordingly, total water allocation for irrigation to strengthen agriculture may continue to increase, but it is likely to lag behind production needs, which is increasing faster. This means there has to be increases in water use efficiency (water transport and water application in the field), and productivity (considering here the crop yield in tons/ha) and intensification (number of cropping growth per year on the same field).

**Graph 5**. Annual Freshwater Withdrawal per sector
Ref: World Bank Development Indicators, 2015.




## 9. Productivity

Productivity is expressed in quantity of output or value of output (which is relative to the market) per unit of input consumed: the yield of products harvested is an indicator of productivity of land, expressed in Tons/ha; water productivity is the production per m3 consumed including losses and wastage and inform on the performance of the irrigation system and monitoring. In the African context of climatic uncertainties and of local water scarcity and competition for use, there is a need to extend irrigated land to increase the volume of production but also, for the same land, a need to improve productivity and stabilize productions between seasons and years. What is the potential for that improvement judged from successful experiences in Africa and abroad?

The objective of intensive agriculture is to cultivate year-round and to stabilize production subject to erratic rainfall, climatic and hydrologic uncertainties and recurrent droughts. In Africa, cereals (as an example) are a strategic and staple food whose production in rain-fed areas follows spatial and temporal variability of rainfall, which weighs heavily on profitability. Research experience (Table 2, Experiences in ICARDA Centre 1999, in Aleppo/Syria and applied in North Africa-Middle East) show that supplementary irrigation can stabilize yields around 5-6 tons per hectare instead of 0.7 to 2.3 tons/ha, and improve water productivity around 1.46 kg/m3 to 1.92 kg/m3. Appropriate irrigation techniques are accompanied by smart agricultural measures (soil fertilization, crop rotation).

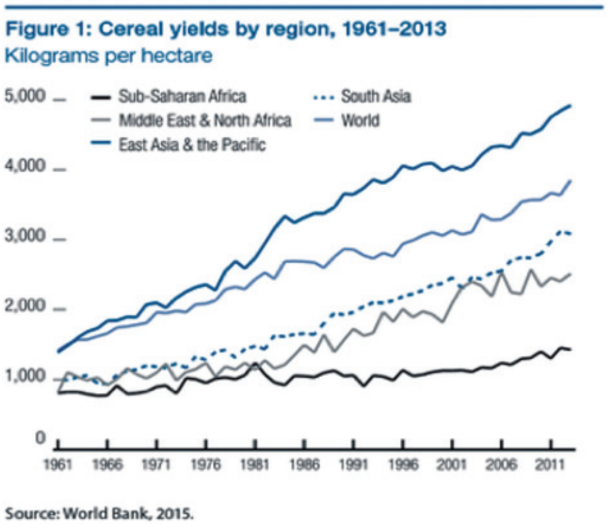
**Table 2**. Yield and Irrigation water productivity for **wheat grains** under rain-fed and supplemental irrigation in ICARDA Research Centre in Aleppo/Syria (ICARDA, Oweis, 1999).

| **Season (rainfall mm)** | **Dry (234mm)** | **Average (316mm)** | **Wet (504mm)** |
|---|---|---|---|
| Rain fed Yield (Ton/ha) | 0.74 | 2.30 | 5.00 |
| Water Productivity under Rainfall (kg/m3) | 0.32 | 0.73 | 0.99 |
| Irrigation application (mm) | 212 | 150 | 75 |
| Total Yield (rainfall plus Irrigation: Ton/ha) | 3.84 | **5.60** | **6.44** |
| Yield increase due to irrigation (Ton/ha) | 3.10 | 3.30 | 1.44 |
| Water Productivity increase (kg/m3) | 1.46 | 2.20 | 1.92 |

Considering its arable land and water resources, Africa has a lot of potential to transform its agriculture (Graph 6; Ref: Transforming Africa's Agriculture to Improve Competitiveness. WB, 2015), and raising productivity is a major factor to achieve this objective. Physically, improvement of productivity in rainfed and irrigated areas require availability of a technological package at farm level (e.g. fertilizers, water on time according to climate conditions and crop growth stages, made possible by irrigation).

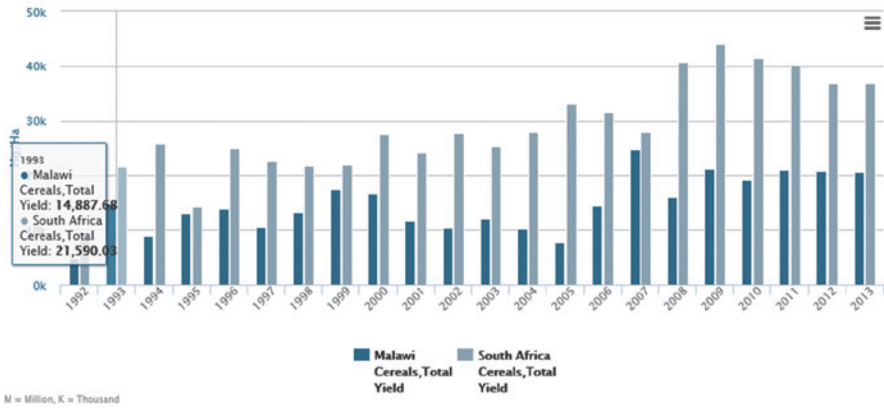
The fact is that average cereals yield is almost five times higher in South Asia than Sub-Saharan Africa (Graph6) and the yield growth in Africa for the last fifty years is really slow if not stagnant. Productivity of most crops is low in Africa, which is an issue today but an opportunity for a large improvement for the future.

**Graph 6**. (Drawn from: Cereal yields by region, 1961-2013 (World Bank Indicators, 2015)).




As can be seen in the Graph 7, comparing average cereal yields for the period 1992-2013 between Malawi and South Africa (Ref: FAO Aquastat 2015), since 2001 Malawi cereal yields have been less than half of those of South Africa.

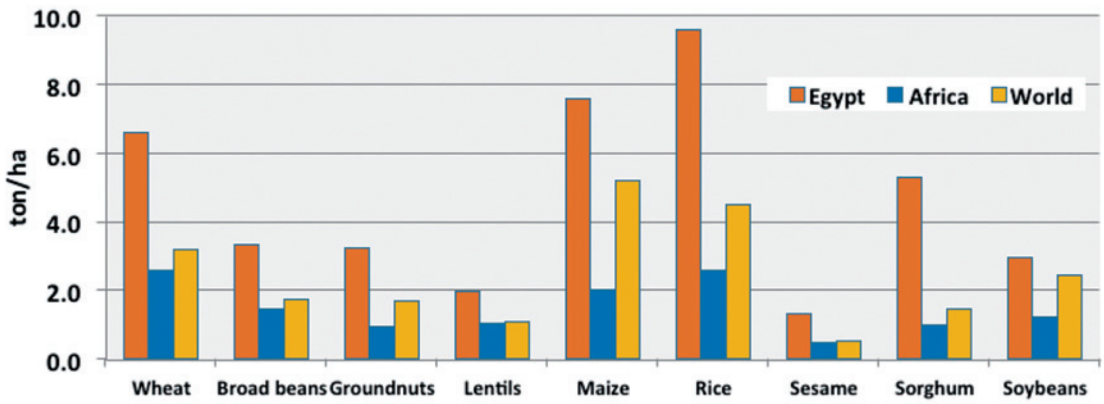
**Graph 7**. Yield Gap in Cereals between Malawi and South Africa (1992/2013, Ref: FAO stat 2014)




The overarching development issue facing many African countries like Malawi in agriculture is the low productivity and profitability of smallholder agriculture, which has been characterized by low and stagnant yields, particularly in maize production. The low and stagnant yields have been influenced by a dependence on rain-fed farming and low level of irrigation development, poor varietal selection, declining soil fertility, and overall poor agricultural practices. The productivity of most agricultural crops similarly has not substantially improved to reach the optimal yields observed in other regions like South Africa and Egypt (Graph 8). The gap between potential and actual yields given the available technologies ranges from 38 percent to 53 percent for cereals and 40-75 percent for vegetables (Ref: Agricultural Sector Wide Approach (ASWAp), Ministry of Agriculture Irrigation and Water Development, Malawi, 2009).

Graph 8 shows that the average land productivity (yields) for some crops in Egypt, where irrigation is well developed for centuries, because it is the only option for important agricultural production in arid and semi-arid country, is higher than the average productivity in Africa.

**Graph 8**. Average yields for some field crops among Egypt, Africa and the world in 2011-2013
(Ref: Ministry of Agriculture and Land Reclamation (MALR), Bulletin of Agricultural Statistics 1990-2013. Egypt)




The following are the main factors behind the success in crop productivity in Egypt, and they explain partially the gaps observed in some countries in Africa, to reach the optimal production (Ref: Ministry of Agriculture and Land Reclamation (MALR), Bulletin of Agricultural Statistics 1990-2013 Egypt, and FAO Stat 2015).

- Irrigated crop production in Egypt achieved tangible progress, particularly during the past two decades, hence reflecting the success of agricultural horizontal expansion (extension of irrigated land) and vertical expansion (increase of yields). At farm level, the country is paying greater attention to improved agricultural practices enhanced by closer extension system to the farmers and applied research adapted to the local context.

- Efforts are made to introduce high yielding early maturing wheat varieties as well as high yielding maize hybrids. According to (MALR, 2014), the average yield of wheat increased by about 29 percent from around 5.12 ton/ha in 1991-1993 to about 6.43 ton/ha in 2001-2003 to about 6.61 ton/ha in 2011-2013. However, the average yields for rice, cotton, sugarcane and maize increased by about 26, 53, 10 and 26 percent respectively during the period 1991-2013 (MALR, 2014).

- Involvement of the private sector closely to the farmer, in particular through supply of irrigation equipment and food processing. The private sector has played a big role in the extension, availability of technological package, awareness campaign and building skills at farm level, in particular water saving and irrigation monitoring from appropriate irrigation technology and suitable cropping pattern applied in each agro-ecological zone.

- The Government facilitates access to bank loans and secured land tenure, access to markets and regulation of the prices of products ensuring a minimal income for the farmer. The public sector supports maintenance and operation, rehabilitation and modernization of irrigation systems for better and reliable water service at farm level.

- ➢ Options to overcoming productivity-related challenges can continue to be learned from the experiences of countries with successful irrigation systems. In general, the Governments are in charge of heavy collective water infrastructures (water storage, hydraulic networks, and pumping stations) and heavy maintenance to facilitate access to water. At small scale levels (e.g. Morocco) a special agency is created for advisory and extension in agriculture and in particular in irrigation, focusing on productivity. The private sector is involved and private technical advisors are trained and subsidized for providing advisory and extension services across irrigated areas in the country. In North Africa, in addition to the commitment of the Governments to heavy investments, modern irrigation equipment (drip and sprinkler) are subsidized at the farm level and for the first installation, between 60 and 100 percent of their cost, in particular for smallholders. Financial and technical empowerment of farmers is a challenge and condition to improve productivity at farm and consequently at national level, achieving agricultural transformation objective from bottom to top (i.e. for large and small farmers), through improving productivity, ownership of operation and maintenance and cost recovery of irrigation investments and services.

Largest gains in productivity are achieved where its level is low and today this is the reality in Africa: actual yields are low and potential to increase productivity is large. Table 2 on yield and water productivity and the research results in Middle East –North Africa, confirm that conjunctive use between rainwater and supplementary irrigation has major impact on productivity. For example, experience shows that 1m3 of water applied as supplemental irrigation, with appropriate time, duration and frequency might produce more than 2kg/m3 of wheat grain over relying only on rainfall.

Investing in full irrigation or in water harvesting, upgrading rain-fed areas and managing supplementary or deficit irrigation can multiply productivity (as shown in Table 2, Graph 7 and Graph 8) in drought-prone regions like Eastern, Sahel or other African sub-regions. The most advantage can be gained by incorporating rain-fed areas in a program of productivity improvement through supplementary irrigation, which is lower cost than full irrigated areas and also improves equity. Indeed, investment in agricultural water management in rainfed areas may focus on a large number of farmers, bigger cumulative surface (in North Africa, full irrigated potential is between 7 and 10 percent of arable land) and can achieve big production increase in terms of volume with acceptable productivity as analyzed above.

Besides the objective of agricultural production stabilization and productivity improvement to secure foods, countries and AU/Regional Economic Communities (RECs: IGAD, Ecowas, EAC, SADC) and UN agencies (FAO, UNICEF, and WFP) are calling for **nutrition improvements**. Unless significant food diversification is realized in wet seasons, countries cannot achieve this objective without developing irrigation in dry seasons. Three current major trends are underlined: (i) Producing food, meat and milk require a range of crops, more land and water and different irrigation regimes than that required for large rainfed areas planted with one or two cereals; (ii) Favourable markets will foster these shifts in agriculture and irrigation, pushing farmers to invest on their own to be market responsive; (iii) Small farms clustering and organization of users will be required to enable easy water allocation and operation and maintenance (participatory management, water use association, community-based management) in order to realize economies of scale of irrigation systems.

### 9.1 Irrigation systems analysis and benchmarking in Africa- Lessons from experiences

For irrigation to contribute efficiently to agricultural transformation, there is need to analyze the current performance of irrigation systems and the main issues and constraints to be addressed, in order to identify appropriate actions. We discuss this with reference to the agro-ecological zones (Tab 1.).

In that respect, the main indicators that permit a comprehensive coverage of important aspects of the irrigation systems and their performance are mainly (Svendsen, IFPRI 2009):

- Water resources availability and utilization
- Land Irrigated
- Agricultural productivity
- Irrigation systems and technology
- Policy and institutional

Most of the measurement of the indicators is drawn from FAO Aquastat, updated in 2005 and for some countries, updated in 2015; and from World Bank, IFPRI and IWMI reports. Some data are qualitative, in particular for policy and institutional aspects of the irrigation sector.

#### i. Sources of water for irrigation in Africa

Considering inland and transboundary water resources, water resources used in irrigation are: (i) Conventional water resources, constituting the main resource for irrigation: Surface freshwater (lakes and rivers), deep and shallow groundwater and rainwater harvesting; (ii) **Unconventional water resources** with local and small scale use in irrigation: brackish water and treated waste water. In Africa, more than 78 percent of irrigation land is irrigated from surface water and almost 20 percent from groundwater (Table 3).

Table 3. Water Resources use for irrigation. FAO, AquaStat updated, 2015

| Region | Surface Water | | Groundwater | | Other Sources | | | | Total Area |
|---|---|---|---|---|---|---|---|---|---|
| | Area | % of total | Area | % of total | Mix of surface and Groundwater | | Treated Wastewater | | |
| | (ha) | (%) | (ha) | (%) | (ha) | (%) | (ha) | (%) | (ha) |
| Northern | 4 138 685 | 66.4 | 1 839 494 | 29.5 | 25 000 | 0.4 | 227 527 | 3.7 | 6 230 706 |
| Sudano-Sahelian | 1 986 450 | 94.7 | 111 788 | 5.3 | 0 | 0.0 | 0 | 0.0 | 2 098 238 |
| Gulf of guinea | 230 432 | 64.0 | 122 285 | 34.0 | 7 371 | 2.0 | 0 | 0.0 | 360 088 |
| Central | 125 652 | 100.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 125 652 |
| Eastern | 446 920 | 75.4 | 146 183 | 24.6 | 0 | 0.0 | 0 | 0.0 | 593 103 |
| Southern | 1 715 995 | 87.4 | 246 849 | 12.6 | 58 | 0.0 | 0 | 0.0 | 1 962 902 |
| India Ocean Islands | 1 102 528 | 99.5 | 5 375 | 0.5 | 0 | 0.0 | 0 | 0.0 | 1 107 903 |
| Total | 9 746 662 | 78.1 | 2 471 974 | 19.8 | 32 429 | 0.3 | 227 527 | 1.8 | 12 478 592 |

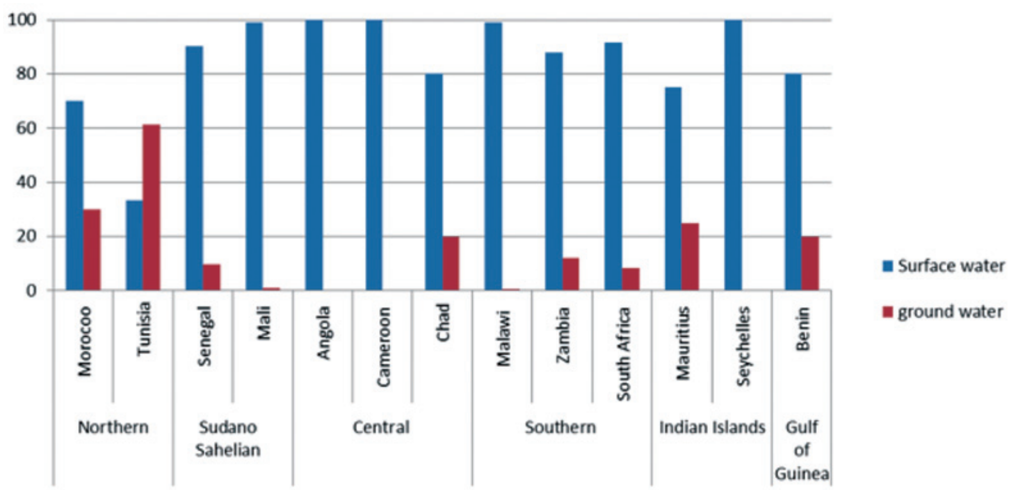
If we refer to Graph 9 below, on the percentage of irrigated land using surface or groundwater resource (AquaStat, 2015), three main issues are relevant for each agro-ecological zone (Tab 1.):

(i) Weak knowledge of groundwater resources potential and its use: small use of groundwater resources in irrigation is observed in particular in Sub-Saharan. The main issue is weak knowledge of groundwater resources potential, both renewable and fossil and their location (shallow, deep water tables) and the way to develop them. Energy is a constraint (access and affordability) to assess to and use these resources profitably for irrigation (at national level and at farm level). To improve knowledge and use of groundwater, countries need to develop deep studies on the location and the potential of groundwater resources and in order to sustain the use of these resources, a policy and legal rules have to be developed at national level and for each aquifer.

(ii) Complex political context: weak political will, policy, institutional and technical capacities to develop transboundary surface and groundwater resources, at basin level; and

(iii) Low development of conjunctive use of surface and groundwater, to address hydrological droughts. Surface water has been the primary source in the majority of irrigation systems in Africa, and development of groundwater use, in parallel with surface water, can provide an alternative source when surface water availability is low, particularly during periods of drought. The reliability of supply from groundwater is less affected by seasonal or annual erratic rainfall than are surface water systems, and may provide buffering against droughts. The development of groundwater resources for irrigation and its sustainable management to avoid water depletion, is one major option for resilience to drought (e.g. IGAD region is developing this scenario with OSS ("Obervatoire du Sahara et du Sahel", IGAD 2015).

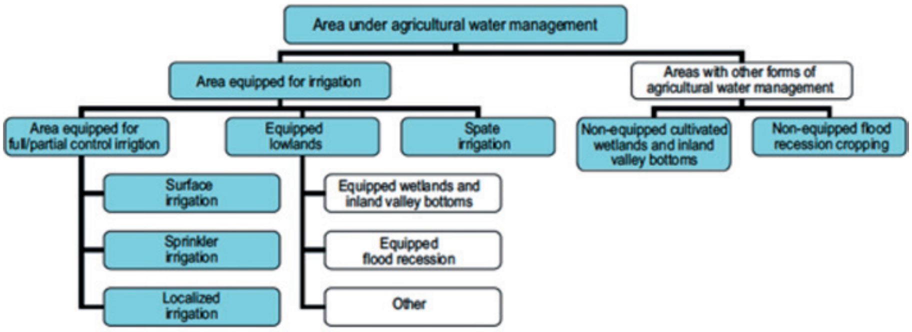
**Graph 9**. Percentage of irrigated land using surface or groundwater resource (AquaStat, 2015)



**ii. Performance of irrigation systems**

FAO (Graph 10: Aquastat, 2005) identified several systems of agricultural water management, including two pillars: area equipped for irrigation and area non-equipped for irrigation but cultivated under flood recession or on wetlands and valley bottom. Part of the modern irrigation developments in Africa are under the first pillar: equipped irrigation areas. And three main irrigation systems, under large or small scale, are prevalent: (i) full/partial control irrigation with three main irrigation techniques: surface, sprinkler and drip irrigation; (ii) equipped lowlands (cultivated wetland and inland valley equipped with water control structures for irrigation and drainage, intake, canals, etc.) and areas along rivers making use of water from receding floods); (iii) spate irrigation (referred to floodwater harvesting).

**Graph 10**. Agricultural water management and irrigation systems (FAO Aquastat, 2005)




The Full or partial control irrigation schemes can be large or small scale. In Africa, the diversity of land tenure situations has led to different definitions of large scale schemes, which vary from one country to another. While certain countries consider a scheme of 25 ha as large, other countries use a minimum area of 500 ha. Large scale irrigation schemes more than 1000 ha is usual in Africa but truly large schemes in Africa exist in Sudan (Gezira-Managil irrigated with water form blue Nile and Sennar Dam) and in Egypt (more than 100,000 ha). Schemes of more than 50,000 ha are also found in North Africa (Tunisia, Morocco, and Algeria), Senegal and in Mali.

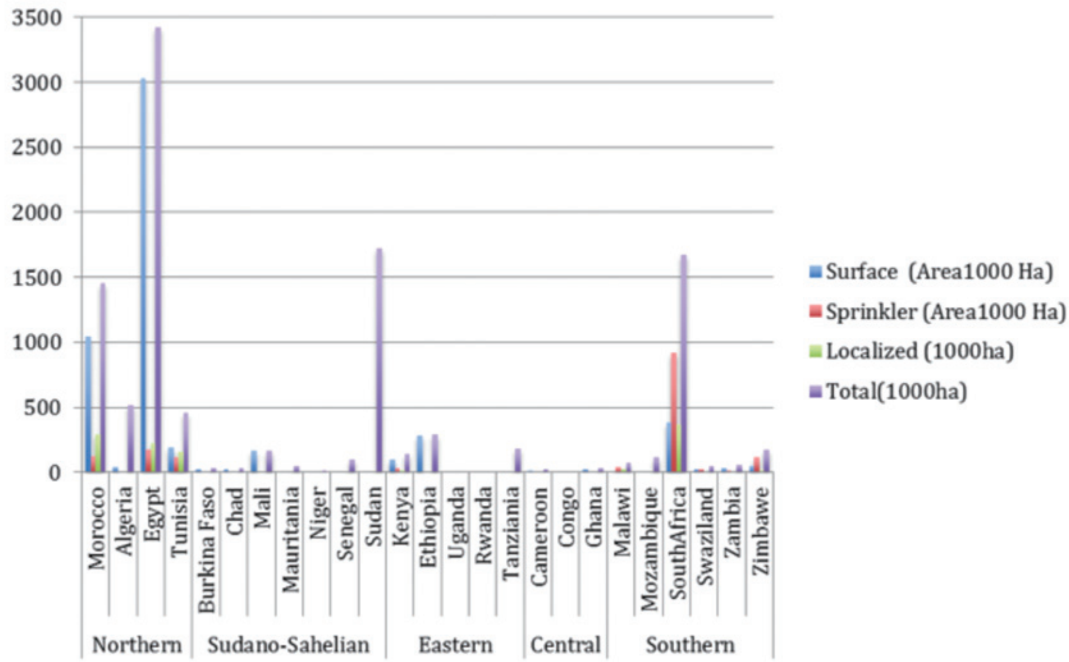
As an example of diversity of definitions of large, middle and small scale in Africa, in Ethiopia: Small scale is intended less than 200 ha, medium scale is between 200 and 3,000 ha and large scale is more than 3,000 ha; In Burkina Faso: small scale is less than 50 ha, medium scale is between 50 and 300 ha and large scale is more than 300 ha. In the Senegal River Valley, the large-scale irrigation schemes are called GA ("Grand Aménagement") and the total area is above 1000 hectares. Small-scale irrigation schemes are called PIV ("Périmètre Irrigué Villageois") since they are managed by villagers, but they can include Private irrigation schemes (Ref: SAED. 2011).

In all countries, small holders are the majority and can be clustered under large scale irrigation scheme. Considering all kinds of irrigation scales, only South Africa, Egypt, Madagascar, Morocco and Sudan have at country level, total irrigated area of more than 1 million ha. In terms of land and water potential and in terms of investment as a realistic percentage of GDP (percentage of GDP in irrigation investment needs in Sub Saharan Africa is presented by Liang Zhi You, WB, June 2008), achievement of 1 million ha of irrigated areas is a feasible objective for long term, at sub regional level sharing transboundary water resources (e.g. the Sahel Initiative for six countries, 2015) and for some countries having big size of potential like Angola, Ethiopia, Ghana, Madagascar, Mozambique, Nigeria and Tanzania (Ref: FAO Aquastat 2015), which would really transform agriculture and socio-economic situation of countries and Africa.

In Africa, large scale irrigation refers to large irrigation systems with collective hydraulic networks and a formal management institution (it is in general dam-based). Small scale and individual irrigation generally refer to traditional irrigation systems, based on community management or individual irrigation systems using technologies for exploiting shallow groundwater (treadle pumps, cheap pumps from China and India and other countries, sometimes using solar energy, as in Egypt), or surface water (river diversion).

The most used irrigation technique both for large or small scale is still surface water irrigation (Graph11), except where the irrigation sector is developed and water scarcity is high (Tunisia, Morocco, South Africa, and Egypt) where drip and sprinkler irrigation techniques are applied. Sprinkler and drip irrigation have higher water use efficiency (70 to 90 percent) than surface techniques (40 to 60%), but require higher levels of initial capital investment. This poses a challenge, given the limited financial capacity of farmers and their difficulties in accessing bank loans. In order to promote water saving by modern irrigation techniques with higher water use efficiencies, Governments in Tunisia and Morocco have initiated programmes towards on-farm irrigation systems modernization, and public support and subsidies to farmers to enable them afford drip irrigation equipment for first-time installation.

**Graph 11**. Area equipped for full control irrigation (1000Ha), AquaStat 2015

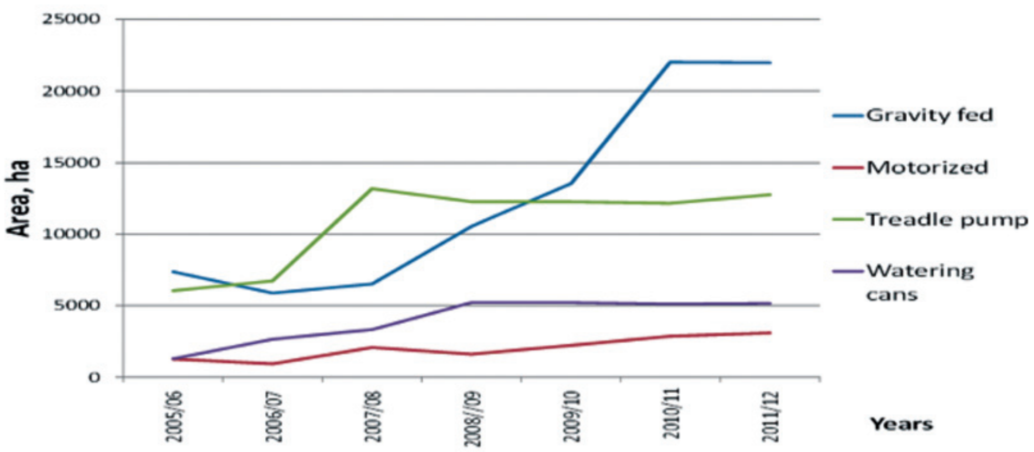



For large scale and small scale irrigation systems, the main issue following initial investment is how to transfer operation and maintenance, recover the cost for irrigation services and promote ownership by the beneficiaries, regardless the irrigation technique installed on the field (surface, sprinkler or drip).

Drip irrigation is used at small scale irrigation systems and on individual farms and sprinkler irrigation systems are mostly used for large scale irrigation growing crops like sugar cane and cereals. Both drip and sprinkler irrigation systems require energy for pressurized water delivery, thus added charges in operation and maintenance. In particular large scale irrigation faces the high cost of pumping energy (in the absence of gravity), which is a challenge everywhere in Africa, from North to South, despite the subsidies given to cover part of the bill of energy used in agricultural activities in some countries (North Africa).

The result is that pressurized and motorized irrigation have not expanded for individual and small scale systems because operation and maintenance complexity, absence of skills and spare parts in nearby markets, and the cost of energy. Irrigation by gravity (surface irrigation) and treadle pump are the techniques mostly adopted by end users and smallholders (Graph 12).

**Graph 12**. Trends in Irrigation Development by Technology,
(Ref: Malawi Department of Water and Irrigation Annual Report, 2013)




Therefore, the balance between the costs of inputs (energy, seeds, fertilizers, workforce, transport… etc.) and income (market prices and benefits) is an issue for most smallholders. For social, economic and macro-economic reasons, subsidies to sustain and improve irrigation management and crop production are the practice everywhere in the world (European Union, USA …etc.). At the macroeconomic level, the link between production (rainfed and irrigated), value chain and markets, investments in related activities outside the irrigation sector (e.g. at farm ecological tourism) could be one way to breakout of the constraint of having to base financial viability of irrigation systems only on the profitability of farm production.

In Africa, particularly at small scale, irrigation techniques need adaptations for success, with the following criteria.

**Operational simplicity**: Surface irrigation, if it is well monitored (water use efficiency around 60-70%), is the most simple, but needs workforce and time. Drip irrigation is well adopted by farmers and by governments, disseminated largely at farm level in African countries for vegetables and fruit trees crops and subsided by some countries that are facing water scarcity for its high water use efficiency. Drip irrigation can integrate well with fertilization and has high productivity for fruit trees and vegetables in extensive areas or in greenhouses (e.g. in Kenya where drip irrigation is developed for the irrigation systems, growing fruits, vegetables and flowers. Kenya is now the second largest horticultural exporter in Sub-Saharan, after South Africa and the largest exporter of vegetables to EU, after Morocco. Ref: FAO Report 31).

**Standardization and certification of irrigation equipment to support operation and maintenance:**

Sprinkler irrigation techniques require pressure and energy for pumping. The smaller is the size of the pumping station, the simpler is the operation (water rotation, water service delivery) and the lower is the maintenance requirements. At community level or for a large scale irrigation system, operation and maintenance require common and participatory organization of farmers. One main issue is the timely availability of spare parts in the local market, maintenance skills and equipment with international standards and norms (drippers, pumps, sprinklers, pipes,). Currently, there is a need to promote sub-regional centers of irrigation equipment certification: In France, the center of irrigation equipment certification is established to regulate the market and to ensure the performance of equipment and spare parts so as to protect end users. The same system can be found in Morocco.

**Limited capital for initial investment in irrigation systems**: For individual surface water irrigation systems, this many not be a big problem, but for other under pressure irrigation systems public intervention is needed to finance the initial capital investments.

**Appropriate implementation of irrigation techniques**: requires capacity building, availability of irrigation technological package at farm level and extension and advisory services for end users. In addition and in order to cope with climate change, the technical package may integrate Climate Smart Agriculture (CSA) promoted by FAO (Ref: Climate-Smart Agriculture Sourcebook, FAO 2013) as agricultural practices based upon integrated management at farm level (sustainably increase productivity and system resilience through crop husbandry, soil fertility and efficient water use).

## 10. Investments in Irrigation in Africa

With reference to the IWMI report 109 (Costs and performance of irrigation projects, Inocencio and al, 2007) and to the WB report (Irrigation investment needs in Sub Saharan, Liang Zhi You, 2008), Table 4 below shows the average unit cost of irrigation projects in Sub-Saharan Africa and other regions, from a survey of 314 irrigation projects that were implemented in 50 countries worldwide between 1967 and 2003. Of these irrigation projects, 45 were from 19 Sub-Saharan Countries. Unit cost is defined as the total irrigation related projects costs divided by the size of the irrigated area. The unit cost is an average for all projects (both new construction and rehabilitation/modernization), but also defined for new projects with construction and then for projects of irrigation systems focusing on rehabilitation and modernization.

**Table 4**. Average Unit Cost of irrigation projects in US$/ha (Ref: IWMI 109, Inocencio and al, 2007)

| Region | All sample projects | | New construction | | Rehabilitation / Modernization | |
|---|---|---|---|---|---|---|
| | Unit total cost | Unit cost of Hardware | Unit total cost | Unit cost of Hardware | Unit total cost | Unit cost of Hardware |
| SSA | 11,828 | 8,188 | 14,455 | 10,473 | 8,233 | 5,059 |
| Non-SSA | 3,882 | 3,183 | 6,590 | 5,481 | 2,280 | 1,824 |
| North Africa | 6,311 | 5,251 | 8,780 | 7,542 | 4,582 | 3,648 |
| East Asia | 5,105 | 4,317 | 8,221 | 6,900 | 1,990 | 1,735 |

The average unit total cost is US$ 5,000 for the entire sample of projects studied by IWMI, for Sub Saharan, it is US$ 11,800 and it is US$ 3,900 for non-Sub Saharan countries (Tab 4). The average unit cost in Sub-Saharan Africa for new projects with construction is US$ 14,500/ha and for rehabilitation, it is US$ 8,200. Another result from this study (Tab 4) of irrigation projects in Sub-Saharan Africa is that 56 percent of projects are considered as successful according to the economic internal rate of return above 10 percent (it is between 72 and 84 percent success in other non-Sub Saharan regions, IWMI Report 109, 2007).

WB report (Liang Zhi You, Irrigation Investment needs in Sub Saharan Africa, WB, 2008) shows that the unit cost/ha of new irrigation projects in Sub-Saharan Africa is between US$600 and US$2,000, if we do not consider the cost of water storage infrastructures like dams.

The factors behind this cost and performance are in particular linked to: (a) projects are relatively more expensive because of their small size; (b) the share of storage infrastructures (dams, reservoirs, roads) is large; (c) the degree of participation of farmers to the project has positive impacts if it is applied from the beginning (design); (d) the lack of end user accountability (ownership of the management scheme by farmers, cost recovery to ensure reliable irrigation service) has negative impacts on the cost of maintenance and accelerate the need for the rehabilitation; (e) multi-purpose irrigation and hydropower projects have better cost and success than irrigation solely; (f) lack of capacity building and water accounting lead to high cost of operation and maintenance and low agricultural performance at farm level, and finally (g) low capacity of some companies involved in irrigation sector, to design and implement with high quality and on time without overrun cost.

In fact, the cost difference between Sub-Saharan Africa and other regions (e.g. East Asia) is also because rainfall is lower in Sub-Saharan Africa, crop water requirements are higher, and required time for irrigation per year is longer--6 to 8 months in some areas with bimodal hydrology like Ethiopia and in many other countries (3 rainy months and 9 dry months), which necessitate high reservoir storage capacity, big size of irrigation schemes, more total energy for pumping and long-time irrigation in the year. This is exacerbated by few conjunctive uses of surface water and ground water.

The cost is very sensitive to new construction (e.g. dam) and the WB study (Liang Zhi You, WB, 2008) shows that when water storage infrastructures costs are excluded and the size of irrigated area is big (thousands of hectares), the unit cost per hectare is between US$600 and US$2,000 instead of US$11,800 to US$14,500 (Tab 4). Since African governments would consider multi-purpose water reservoirs (hydropower and irrigation) and contributions from hydropower revenues and other sectors benefiting from irrigation (food processing, equipment), the cost of US$600 to 2,000 correspond to the incremental investment costs of developing irrigation areas.

In the field, the impact studies of irrigation projects in Sub Saharan (A.Inocencio and al. Costs and performances of irrigation projects. IWMI, Report 109, 2007) revealed that some farmers' returns increased at least by 65 percent depending on crop grown, irrigation techniques and varieties. The re-estimated Economic rate of Return of 40 percent exceeded the appraisal estimate of 24 percent.

**Investments required implementing Irrigation plans**

The potential needs in increased irrigated area, according to agro-ecological zones in Sub Saharan Africa (Tab 1), is estimated by the WB (Liang Zhi You. 2008), as shown in the table 5, covering large scale and small scale irrigation schemes.

**Table 5**. Potential increase needs for large scale and small scale irrigation (in Million hectares)
Ref: Liang Zhi You. 2008. "Irrigation Investment Needs in Sub-Saharan Africa. Africa Infrastructure Country Diagnostic, WB.

| Region | Large Scale Irrigation | Small Scale Irrigation |
|---|---|---|
| Sudano-Sahelian | 0.26 | 1.26 |
| Eastern | 0.25 | 1.08 |
| Gulf of Guinea | 0.61 | 2.61 |
| Central | 0.00 | 0.30 |
| Southern | 0.23 | 0.19 |
| Indian Oceans Islands | 0.00 | 0.00 |
| **Total** | **1.35** | **5.44** |

The portfolio to develop the above irrigation increase is estimated by WB in 2009 (Liang Zhi You. 2008. "Irrigation Investment Needs in Sub-Saharan Africa. Africa Infrastructure Country Diagnostic, WB) and shows from the Table 6 that Internal average Rate of Return (IRR)of irrigation projects is high (relatively to 10 percent) for all Sub Saharan Africa (from 22 to 33 percent) for Sudano-Sahelian (33%), Eastern Africa and Central (28%/29(%) and Gulf of Guinea (22%). The assumptions for irrigation investment study conducted by WB (Tab 6) are that large scale systems are dam-based, assumed 50 years investment horizon and average unit cost is: US$ 3,000 /ha for on farm development and $ 0.25/m3 for water delivery and conveyance and $ 10/ha for operation and maintenance, which means the cost of the dam is not taken in account. For small scale, the assumptions are the unit cost for small scale is USD$ 2,000/ha for on farm investment and $80 for operation and maintenance, and assumed a five-year cycle of investment. Small scale irrigation systems are based on small reservoirs, farm ponds, treadle pumps and surface water harvesting structures.

**Table 6**. Investment cost and average Economic Internal Rate of Return,for large scale and small scale irrigation (in Million hectares)

| Region | Large Scale Irrigation | | Small Scale Irrigation | |
|---|---|---|---|---|
| | Investment cost (US$ Million) | Average IRR (%) | Investment cost (US$ Million) | Average IRR (%) |
| Sudano-Sahelian | 508 | 14 | 4,391 | 33 |
| Eastern | 482 | 18 | 3,873 | 28 |
| Gulf of Guinea | 1,188 | 18 | 8,233 | 22 |
| Central | 4 | 12 | 881 | 29 |
| Southern | 458 | 16 | 413 | 13 |
| **Total** | **2,640** | **17** | **17,790** | **26** |

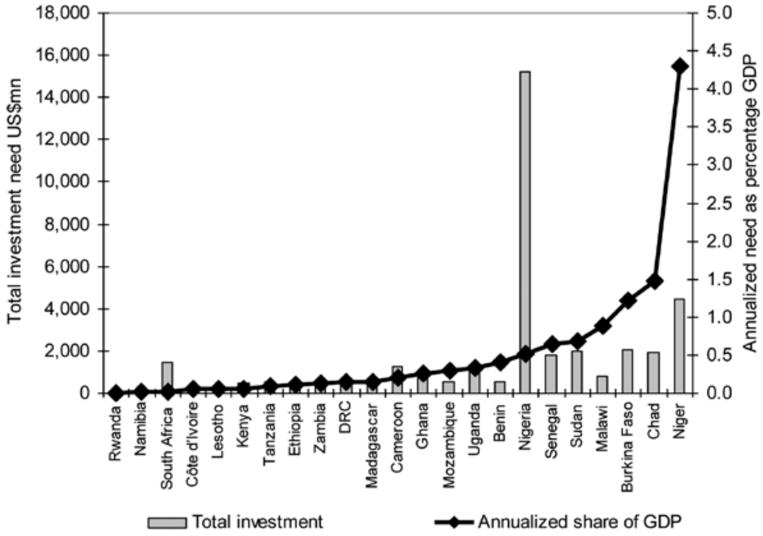
Ref: Liang Zhi You. 2008. "Irrigation Investment Needs in Sub-Saharan Africa. Africa Infrastructure Country Diagnostic, WB.

The total cost of large scale irrigation (excluding the cost of dams) is lower than small scale investment cost, and the same for the Internal Rate (still higher than 10 percent). When it is possible to build big dam (physically feasible: suitable river inflows and geological site) to promote large scale irrigation systems coupled to hydropower production, irrigation may benefit from the hydropower revenues of the dam (e.g. Manantali Dam, within Senegal River Project). Otherwise, Small scale irrigation area is bigger and the Internal Rate of Return is higher than large scale area and may benefit a majority of farmers (they are 80 percent in Sub Saharan) despite some major constraints inhibiting the development of small projects in Africa, in particular land tenure issues.

This leitmotiv cited above requires heavy investments and based on area that are economically viable for irrigation, World Bank report ("Irrigation Investment Needs in Sub-Saharan Africa", Liang Zhi You, 2008) forecasts that the current potential investment increase (based on assumptions of unit costs/ha of WB, 2009) is around US$ 20 Billion. The total irrigation investment need in Africa comes to more US$ 40 Billion (large and small scale plus rehabilitation of existing systems). It varies between countries (Graph 13) with 15 US$ Billion for Nigeria alone. Eastern Africa and Western Africa are among the countries with the largest investment needs. Graph 13 shows irrigation investment needs as a percent of national GDPs.

Like in East Asia (1970s and 1980s) and North Africa (1970s and 2000s), if up to 50 percent of agricultural expenditures are diverted to agricultural water management, Sub-Saharan Africa's full irrigation potential could be realized over a 50-year time horizon, with two-thirds of the total expected to be achieved in 20 to 30 years, depending of the countries and Graph 13 shows that based on AU 2063 agenda (http://agenda2063.au.int/en/vision) and focusing on the next 50 years, this pace of irrigation investment trend could be affordable by countries, which as a percentage of GDP is below 0.4 percent of GDP in most African countries. The impacts of this investment trend could help transform agriculture in particular water scarce agro-ecological zones (Tab.1).

**Graph 13**. Irrigation investment needs required to realize irrigation potential In Sub-Saharan Africa, by country




## 11. Lessons from experience

The green revolution resulted in steady increase in staple food production, which made food affordable. For Africa to benefit from a similar experience will require the following.

- **Is Productivity growth sustainable?** The Green Revolution relied on soil, water and intensive use of manufactured inputs such as mechanization, fertilizers and chemicals. But some of these inputs have negative externalities such as lakes or aquifers pollution.

- **Are small-scale or large scale irrigation systems the future in Africa?** To answer this question, let's explore East Asian experience in identifying both the scenarios and advantages of small scale and large scale irrigation systems. In particular, due to the high investments in irrigation (big size of water infrastructures, equipment and energy) and in view of huge investments required for the sector, which option should be supported in Africa, based on Asian experience? The following is analyzed within African context (Tab 7), from results of a study by FAO and IWMI in Eastern Asia (Facon and Mukherji, FAO and IWMI 2010).

- Cheap pumping technologies (essentially from China and India) is leading to an explosion of unregulated market, expansion of pressurized irrigation techniques and over exploitation of underground water tables in Africa. Regulation (technical and legal) of irrigation equipment market is required.

- **Small scale and individual irrigation systems** are built from shallow groundwater, using tube wells and low cost pumps, which have significant impact on the dissemination of this kind of irrigation systems in East Asia. The risk of unregulated large dissemination of cheap pumps is ground water depletion, in particular in the absence of farmer accountability and laws dedicated to the protection of aquifers and its sustainable management. If in Africa, this kind of irrigation systems will be developed without legal, institutional and technical precautions (laws and accountability of users, organization of users, authorization for use of groundwater, follow up and water accounting, auditing of aquifers), the dissemination of low cost pumps from China or India and their affordability by farmers will threaten the sustainability of underground water resources. Of particular concern is the low performance of pumps and irrigation equipment available in the market without norms and standards, unregulated water exploitation, unsustainability of underground water resources, and unsustainability of surface water resources because misuse of non-standard pesticides and pollution;

In that respect and to enable irrigation sector to contribute to African agricultural transformation, like in Asia, structural and policy refinements are required to help decision-making for a clear vision on future investment in irrigation and their benefits. The refinement of agricultural water policy and water code and the elaboration of irrigation master plans at basin level is a prerequisite for reform of institutions (at central and basin level) and programs. The challenge remains enforcement of the rules adopted.

Because large scale design needs good initial estimation of irrigated area and estimation of its potential and constraints, the involvement of stakeholders at basin level is required from the design stage. In particular, overestimation of available, accessible and affordable land and water potential and capacities for implementation are a source of inefficiency as observed in East Asia (T.Facon and A. Mukherji, FAO/IWMI, ADB conference, October 2010), due to: (i) development of informal irrigation systems upstream and around the irrigated area; (ii) unplanned extensions of the initial irrigated area, due to social and political pressure; and (iii) absence of capacities for implementation and management.

With regards to transboundary water basin management and promotion of irrigation sector, The Senegal River management is a successful experience that can inspire other transboundary basin managements in Africa to develop the irrigation sector. The Senegal River Agreement between countries (Senegal, Mali, Mauritania and later Guinea) was adopted since 2002 and fixed the modalities of water repartition and main sectors of use, including irrigation, and created institutionally the Inter-Governmental Agency in charge of the implementation and management ("Office de mise en valeur du fleuve Senegal: OMVS"). The multi-purpose dam of Manantali is shared between countries (capacity of 11 km3) and has a potential to irrigate 375,000 hectares with cost recovery policy, and producing hydropower. Currently (http://www.portail-omvs.org/, 2015) around 137,000 hectares are implemented and irrigated, including cereals, rice, maize, sorghum and around 11,000 hectares sugar cane. L'OMVS offers an example of planning and implementation of projects, having the sub-regional level and transboundary water resources as operational base. And because conflicts linked to water access appear time to time between communities or between usages (hydropower for industry and irrigation), OMVS established an institutional framework for pro-active arbitration of conflicts, communication and coordination policy at sub-regional level, national and local levels. Technically, OMVS is supporting irrigation areas development from transboundary water resources and supporting national institutions to improve agricultural intensification and productivity, within an Integrated Water Resources Management framework, linking irrigation, fisheries and livestock in terms of water access and allocation.

## 12. Options of investment in irrigation systems in Africa: benchmarking between large scale, individual and small scale

To investigate which options of investment should be supported in Africa, we should focus on factors affecting the selection between large scale irrigation systems and individual and small scale systems according to the African context and learning from the experience from Africa and Eastern Asia.

The main indicators selected to benchmark between small scale, individual irrigation systems and large scale systems, are: (i) water productivity gain; (ii) economic costs (data are qualitative) and benefits; (iii) poverty reduction and equity. The Table 9 presents the main results from the analysis drawn from Eastern Asian experience in investing in irrigation to contribute to the transformation of agriculture and the context of Africa (analyzed above).

**Table 7**. Benchmarking between small and large scale irrigation systems in African context

| | **Productivity Gain** | **Economic costs And benefits** | **Poverty Reduction Equity** |
|---|---|---|---|
| **Small Scale (community sharing one source of water) And Individual irrigation system** | • Significant contribution to productivity by allowing cultivation year-round and crop diversification.<br>•<br>• Private systems are preponderant and they invest to improve intensification of land use and productivity. | • Lower investment cost/ha but higher operation cost (pumping); The development of treadle pump, drip kits, solar energy for low pressure irrigation systems) contribute to decrease operation charges and it is an opportunity for mechanization at farm level. Energy requirement in operations is an important consideration in irrigation design.<br>• Reliable water service delivery when groundwater is the main source.<br>• Less reliable water supply in case of river diversion and run-off schemes.<br>• The larger the irrigation system, the higher the EIRR. A cluster of small scale systems or individual systems has more benefits. Institutional organization of users is important and required in large scale systems and small scale where water source is shared between a few number of farmers (shared deep well, small surface reservoir), but not in individual systems, which is an advantage for reliable service and accountability. | • Small scale and individual irrigation systems have much larger impacts on poverty reduction;<br>• Strong way to break out the poverty cycle in Africa and secure minimal income with small investments;<br>• It has significant impact on nutrition<br>• **Issue of equity**:<br>➢ Water allocation downstream to communities;<br>➢ Arbitration for water rights between users (pastoralists upstream and farmers downstream);<br>➢ Access to land for irrigation activities, coupled with gender mainstreaming. |

| | | | |
|---|---|---|---|
| **Large Scale irrigation system** | • Improved irrigation techniques are used (sprinkler or drip irrigation) but productivity could be improved through better water service delivery. | • Initial investment is high (water storage infrastructures, water supply infrastructures, institutions for operation and management).<br>• Large scale design needs good estimation of irrigated area, through stakeholders' involvement from the design stage. Overestimation is a source of inefficiency, due in particular to: (i) development of informal irrigation systems upstream and around the planned irrigated area; (ii) unplanned extension of the initial irrigated area, due to social and political pressure.<br>• Many large scale irrigation systems have poor cost recovery record. | • Significant role to guarantee production of part of the national strategic food requirements (cereals, rice, maize) and contribute to resilience of the agriculture sector to droughts (in North Africa, the irrigation sector contributes up to 40-50 percent of the national production during dry years)<br>• **Issue of equity**: only part of rural farmers access and benefit directly from the large scale investment |
| **Remark** | mprovement of productivity is relevant in both small scale, individual and large scale irrigation systems.<br>However, this improvement should focus also on areas where rural people are vulnerable and productivity is low and where high returns (social, economic and financial) from little extra water use can make a difference (hence the importance of soil conservation and water harvesting programs at watershed level). | • Initial investment is high (water storage infrastructures, water supply infrastructures, institutions for operation and management).<br>• Large scale design needs good estimation of irrigated area, through stakeholders' involvement from the design stage. Overestimation is a source of inefficiency, due in particular to: (i) development of informal irrigation systems upstream and around the planned irrigated area; (ii) unplanned extension of the initial irrigated area, due to social and political pressure.<br>• Many large scale irrigation systems have poor cost recovery record. | • Small scale and individual systems have large impacts on poverty reduction and nutrition;<br>• Large scale systems have large impacts on national resilience to drought and production of strategic crops and crops for exportation (virtual water); low impacts on braking out of the cycle of poverty at individual level;<br>• Inequitable access to water for large scale; conflicts on water allocation between upstream and downstream for small scale irrigation systems |

In particular, according to physical (water and land resources) and social African context, large scale is lucrative at macro-economic and micro-economic scale but location-bound; small scale is ubiquitous but relatively remunerative for smallholders. Considering keeping investment cost low to improve feasibility and viability and keeping irrigation system simple for operation and maintenance affordability, the leitmotiv for irrigation schemes in the future in Africa is: creation, rehabilitation and modernization of irrigation large scale systems and small scale systems, focusing on small farmers in both. In addition to that, focus on irrigation (deficit irrigation, supplementary irrigation) mixed to water harvesting infrastructures development in rainfed areas is important and will touch major part of arable land and major part of farmers. Around that, mechanisms for operation, maintenance and management are established according to the balance between macro-level benefits and micro-level benefits. In this regard and in many cases, the sum of farmers' interest may be different from national interest as perceived by governments who want to secure strategic food and cash crops (usually through subsidies at large scale irrigation systems) while farmers and local water users will behave according to the market.

## 13. Multilateral and Bilateral Support for Irrigation in Africa

In general, both multilateral and bilateral institutions provide support for irrigation in Africa. This is especially the case with capacity building and technical assistance in the establishment and management of small and large irrigational systems. The support includes the water and sanitation program called WASH.

Among bilateral institutions, JICA is involved in supporting irrigation systems, especially as they relate to the promotion of green revolution in the production of rice. Specific examples include JICA's projects in Egypt to promote the efficient and equitable uses of irrigation water from the Nile River. Through these projects, JICA facilitates the upgrading and modernization of major irrigation systems, improvements in local canal systems in reducing waste through evaporation, establishments of water users' associations such as farmers (to enhance participatory decision making processes in the utilization of water resources) and training of Egyptian officials in the management of water resources. In this regard, JICA provides water resource- related experts as well as equipment (such as vehicles and computers) in order to achieve its objective of efficient and equitable utilization of water from the Nile River. JICA has irrigation related projects in Ethiopia, Kenya, Malawi, Somalia, and the Sudan (e.g. the Gezira scheme). JICA's projects in Ethiopia are designed to enhance the resiliency of farm communities in times of draught through the use of irrigation.

## 14. Private sector support to irrigation investment in Africa

The role of water demand management to stimulate private sector involvement and enhance cost recovery. Lessons learnt from experience in Africa.

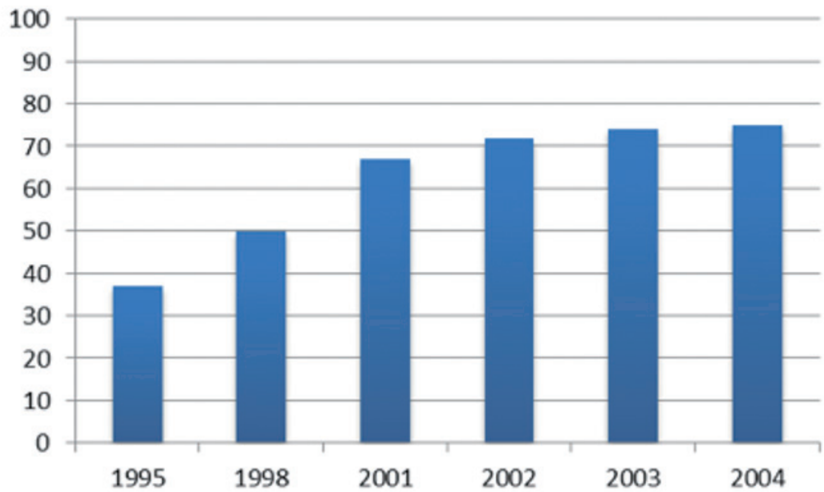
The heavy investment in irrigation requires involvement of potential stakeholders and **partnerships with the private sector**. Currently, the largest part of investment in large scale Irrigation systems comes from public sector. For small scale, it is essentially individual or community level financing with public subsidies for main infrastructures and heavy maintenance (water storage reservoirs, deep wells, main water supply scheme). The sustainability of current irrigation systems needs to be strengthened through strong Public, Private and People Partnerships (**PPPP**).

In Africa, many irrigated areas are managed without cost recovery mechanisms. In the context of water scarcity, water use competition and low water use efficiency, irrigation sector needs to realize better performance in terms of water management, water use efficiency and irrigation monitoring at on farm level. Actually and despite absence of national water pricing strategy in most irrigated areas in Africa, many countries recognize the need for water pricing, partially to recover costs as well to encourage to water savings and to environmental protection.

The lesson learnt from water demand management experience, private sector stimulation and cost recovery action in Tunisia (Hamdane, A. Water Demand Management: progress and policies, MAP 168, 2007) would inform on the way to address strategically the challenges of efficient water management. The main components of these deep reforms on irrigation sector, having big impacts on transforming agricultural sector, concern: (i) refinement of the policy by introduction of water saving strategy, volumetric water accounting, water pricing, water use associations, and an environmental component to monitor and control water resources quality, strengthening decentralization, institutional autonomy and the partnership with private sector; (ii) refinement of the legal framework to implement the policy directives; (iii) implement a water saving strategy for 10 years: adopt an integrated approach then technical only (organization of water use association and their empowerment, capacity building including extension agents, involve research sector in the field, involve private sector in particular companies for irrigation equipment , organize markets, enforcement of the legal framework,…etc.), subsidize modern irrigation systems (60 percent of the cost of drip and sprinkler systems), create water use associations and support, initiate a progressive and step by step water pricing to recover the delays for cost recovery (increase from 1990 to 2000 water tariffs by 9 percent per year), and involve for all the steps end users through water use associations.

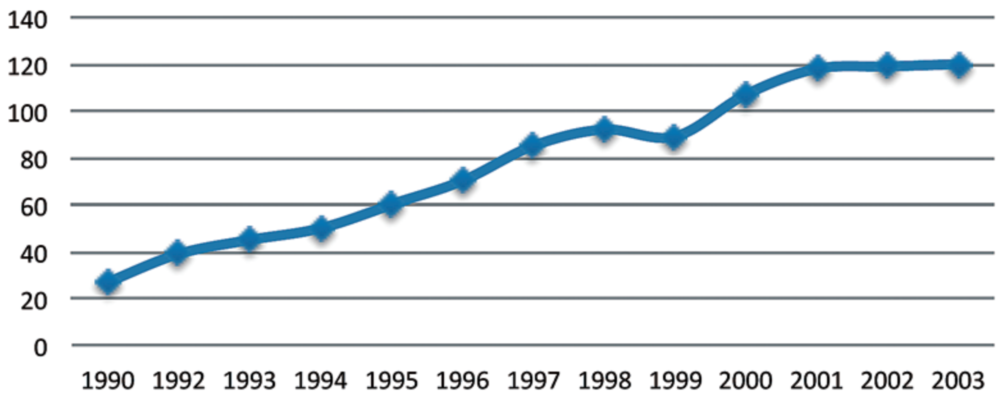
The results of this reform appear through the timely correlation between the evolution of water pricing rate (Graph 14), the development of water use associations and capacity building and information and the increase in water saving equipment rate at farm level (graph 16), more than 70 percent of irrigated areas are equipped with sprinkler and drip irrigation techniques and surface irrigation is upgraded (waterproofing channels). The contribution and the impacts of the private sector are critical at this step and its synergy with farmers is great: guarantee of international norms of equipment, availability for supporting maintenance and operation, advisory on better practices in irrigation monitoring. The impacts are mainly: transformation in cropping and increases of productivity, in particular with drip irrigation and fertilization, transformation in on-farm water management towards water savings, diversification in crop production for better nutrition and new markets and integration in value chain process and smallholders orientation to markets.

**Graph 14**. Tunisian Irrigation Water Tariffs Yearly Progress
(Vertical axis: tariff of 1 m3 provided to the farmer in "0.001 Tunisian Dinar"))




Source: Water Demand Management: progress and policies, MAP 168, 2007

**Graph 15**. Progress of water saving irrigation equipment
(Vertical axis: % of irrigated land equipped by drip, sprinkler and improved surface irrigation systems)




Source: Water Demand Management: progress and policies, MAP 168, 2007

## 15. Institutional situation analysis in irrigation in Africa and perspectives

The heavy investment in irrigation requires strong institutions, legal framework and consistent policy. Strong institutions develop and enforce effective policy and legal frameworks, which in turn, provide the political and legal support for the institutions.

The mapping of **institutions** in many countries in Africa (several sources from the Net: IWMI, IFPRI, FAO), identifying actors and their organizational mandates and functions related to irrigation, shows that irrigation activities are largely in the hands of public state institutions, some missions are decentralized and others not yet (Ethiopia has a Federal Ministry of Agriculture to coordinate and harmonize between Regional Ministries and national level). At national level, many countries have two Ministries related to irrigation: Ministry of Agriculture where development of small scale irrigation systems and improvement of agricultural production in irrigated areas (also rainfed areas) is the main mandate; and the Ministry of water resources and energy where water infrastructures and large scale irrigation systems are in their mandate (Tanzania, South Africa or Morocco: Aquastat 2015). Recently, some countries are merging all irrigation activities within the same Ministry of Agriculture (Malawi, Ethiopia). Two remarks on this organization:

- Institutions involved in irrigation and related activities have limited operational linkages (e.g. coordination between hydropower water release and irrigation water demand), in particular in absence of one coordination system;

- Water resources providers are asking for better water use practices, in particular for irrigation sector in a context of water scarcity, multi-users and arbitration for water allocation. One common coordination system will be judge and jury in case of arbitration, monitoring and evaluation.

In between, and even with one Ministry or two Ministries related to water resources and irrigation (which depends on national context), the essential point is related to the harmonization of implementation in the field of programmes or projects. Currently, the most common form is inter-departmental coordination through working groups, inter-sectorial committees or steering committees. Effective coordination could be obtained through joint sharing and implementation of activities, particularly at grass roots level (e.g. "Agricultural Development Offices in Morocco" in charge of all functions of water resources and irrigation in the field, following the main national principles and directives and focusing on local action from planning, design, to implementation and management. In Turkey, Regional Water Authorities have responsibility for the same decentralized functions (to operate regionally) and Ethiopia is promoting Regional Water Authorities.

Institutions in charge of irrigation in Africa need to be supported to address common challenges. We underline the following points as short term challenges: (i) Political will to ensure that public institutions in charge of irrigation perform according to their mandates and expectations, which requires a monitoring and evaluation process; (ii) most institutions and departments still need human, financial and technical resources to implement their mandates and programmes. Many countries in Africa need financial and technical support from development partners. This challenge is even more pronounced at local level; (iii) control of corruption and financial mismanagement in the use of public resources, since irrigation requires heavy investments and several actors' involvement; (iv) non-state actors and institutions involvement in irrigation to synergize with public institutions, like national water board, local water committees and civil society organizations, gender mainstreaming associations or associations focusing on environment; and (v) initiatives for communication and training on water resources management and irrigation towards **journalists and judges**, who can give support in strategic decision making and arbitration, and in an independent contribution to the evaluation of expected impacts of programmes and projects and lessons learnt for future investments.

## 16. Appropriate policy: current situation and perspectives

The above institutional actions are effective if they are backed by appropriate policy. In general and except some countries (e.g. Malawi irrigation policy, since 2000), irrigation has not its own national policy but it is integrated in many policies which is most common for African countries because national and international commitments (e.g. MDGs Goals, CAADP): Water policy, environmental policy, food security policy or nutrition policy, climate change policy, crop and livestock policy and land policy, education and research policy. This large number of policies needs harmonization of irrigation action to avoid policy incoherence and poor service delivery when it comes to implement in the same area and with the same actors. Irrigation sector policy requires multi-sector support and it is not achievable without a clear Irrigation Strategy and Irrigation Master Plan. Currently, many countries (e.g. Kenya and Rwanda) have or on the way to draft their irrigation master plans that fix achievable targets in irrigation and milestones and allow for ex-post evaluation of the chapter on irrigation in each policy.

The irrigation master plan is important to help demonstrate and quantify how irrigation investments will benefit the national economy. Current investments are still low in this sector because multi-purpose dams require high financial investments and the focus on small dams will limit scope to domestic and industrial water use. The gap of investment will be exacerbated by absence of clear policy, strategy and master plans, and quantifiable benefits to national economy to help politicians to make appropriate decisions. For instance, Master plans could integrate value chain development opportunities and clearly indicate the benefits to all actors along the value chain.

## 17. Dealing with irrigation externalities/impacts

Irrigation can play a crucial role in enhancing food security and reducing hunger; however irrigation, planning, design, implementation and realization on the ground are the results of many socio-economic, political and environmental factors. Every water infrastructure and irrigation system once realized has some positive and negative consequences. In this section, the following irrigation externalities are presented followed by an evidence-based experience.

In Table 8 below are presented the major environmental impacts and their possible solutions derived from experiences, through main externalities cited by FAO in 1995[1].

| Problem | Mitigation measure | Example |
|---|---|---|
| **1. Degradation of irrigated lands:** | Improve Irrigation and drainage operation to match demand both 'how much and when'. This underlines the importance of irrigation design and monitoring at field level, according to the water and soil quality and physical and chemical characteristics. | The Bura Irrigation Scheme in Kenya was built between 1977 and 1984 with initial investment costs estimated at USD 98 million and a projected command area of 6 000 ha (Rosegrant and Perez, 1997). It was, however, later on discovered that most of the land contained soils with high salinity and low (sub-soil) permeability. The actual area that could be irrigated was only 3,900 ha and the investment costs shot up to USD 128 million. |
| **2. Salinization** | Provide **drainage** including disposal of water to evaporation ponds or the sea if quality of river flow adversely affected by drainage water. | **India**[2] : To develop strategies to implement **subsurface drainage** in farmers' fields to reduce salinity. |
| **3. Alkalization** | Maintain channels to prevent seepage, and reduce inefficiencies resulting from siltation and weeds. Allow for access to channels for maintenance in design. | **China**[3] : adaptation measures such as maintenance of channels and clean them from possible weeds. |
| **4. Water-logging and drainage** | Provide water for leaching as a specific operation. | **India-Punjab**[4] : Diversification of low water requirement crops, salt tolerant crops and policy initiative were applied by the Punjab national government.<br>**Nigeria**[5] : lack of information for farmers and on crop water requirements; capacity building initiatives |
| **5. Soil acidification** | Set-up or adjust irrigation management infrastructure to ensure sufficient income to maintain both the irrigation and drainage systems.<br>Analyse soils and monitor changes so that potential problems can be managed. | **Rajastha, India**[6] : Drainage with eucalyptus species was attempted along small stretches of the canals. The experiences were good only along certain patches where the plants survived but failed due to continuous water stagnation. |

1 Environmental impact assessment of irrigation and drainage projects.1995. T.C. D. A.W. Hall.HR Wallingford. United Kingdom.53 FAO IRRIGATION AND DRAINAGE PAPER

2 Acharya N.G. Ranga Agricultural University, Bapatla, Andhra Pradesh, India Agricultural Water Management (Impact Factor: 2.29). 03/2008; 95(3):179-189. D

3 Final Report 0188 PRC ADB Grant Project: Climate Change Adaptation Through Groundwater Management of Shanxi Province, People's Republic of China (English)

4 http://planningcommission.nic.in/reports/genrep/rep_waterpunjab2702.pdf

5 https://cgspace.cgiar.org/rest/bitstreams/29162/retrieve

6 http://publications.iwmi.org/pdf/H042689.pdf

| | | |
|---|---|---|
| **6. Increased incidence of water related disease** | Educate about causes of disease.<br>Repair leaking canals and bunds; drain or fill seepage pools, burrow pits near agricultural fields; redesign hydraulic structures into free-draining ones; use alternative irrigation techniques (sprinkler, drip). | **Egypt**[7] : With Schistosomiasis or Bilharzia (a potentially disabling disease) endemic in the area, Egypt developed and tested improved hand-tools, enabling labourers to work from the channel banks without needing to enter the water. Thus, the risk of infection was substantially decreased. |
| **7. Increased inequity** | Improve health facilities | **Ghana**[8] : The extra income earned through irrigation was used to improve health facilities. |
| **8. Reduction in irrigation water quality supply** | Control industrial development | **Ireland**[9] : Grouping of Small Scale Private Water Supplies to Create Critical Mass for Programme of Investment to Improve Water Quality in Rural Ireland. |
| **9. Water quality problems for downstream users caused by irrigation return flow quality (ecological degradation)** | Designate land for saline water disposal; build separate disposal channels.<br><br>Educate for pesticide or sewage contamination dangers.<br><br>Monitor irrigation water quality<br>Define ecological requirements | **Vietnam**[10] : Assessment and management of slow-onset hazards, especially under climate change and sea level rise contexts. |
| **10. Reduced big-diversity in project area** | Operate dams to suit downstream requirements and encourage wildlife around reservoir | **South-East Asia**[11] : Sharing of expertise and resources among the affected countries to prevent peat land fires and manage peat lands wisely |
| **11. Damage to downstream ecosystems due to reduced water quantity and quality** | Designate land (in law and supported by protection institutions) for flood plains; wetlands; watersheds; drainage water disposal; river corridors. | **Malawi**[11] : in Malawi attempts to integrate multiple benefits and costs.<br>**South Africa**[11] : The South African National Water Act of 1998 protects the water requirements for ecosystems and supports them through an ongoing scientific effort |
| **3.6 Ground water depletion:** | Define and enforce abstraction regulations. | **India**: Community self-regulation of groundwater resources: |
| **Saline intrusion at coasts** | Adjust abstraction charges. | **United States and South East Asia**[12] **:**<br><br>An effective early warning communication and response system |

7 Schistosomiasis is a water-borne disease and is caused by trematode worms. As part of the life cycle, these worms invade snails living in streams and ditches and, after metamorphosis, produce stages that invade vertebrates venturing into the water. Humans are ready victims of schistosomiasis that, like river blindness, is a chronic disabling disease. There are many other waterborne diseases, with potentially disabling consequences

8 McCartney, M. P.; Boelee, E.; Cofie, O.; Mutero, C. M. 2007. Minimizing the negative environmental and health impacts of agricultural water resources development in sub-Saharan Africa. Colombo, Sri Lanka: International Water Management Institute. 41 pp. (Working Paper 117)

9 UNEP, 2010

10 Vulnerability And Adaptation To Salinity Intrusion In The Mekong Delta Of Vietnam, 2015

11 http://www.iwmi.cgiar.org/assessment/Water%20for%20Food%20Water%20for%20Life/Chapters/Chapter%206%20Ecosystems.pdf

12 https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter6.pdf

## Conclusion

Africa has large gaps and large opportunities to overcome the current challenges of ending hunger and secure food. The main building blocks resulting from the analysis above are the following, taking in account long term African Agenda 2063 and mid-term African water vision and national and sub-regional context of countries:

- ➢ Road Map for water supply strategy as a part of national development plans, including in particular multi-purposes big water infrastructures for inter-annual management; at inland and transboundary levels;
- ➢ Single out an irrigation sector appropriate policy for the Agenda 2063, refined to answer the agricultural transformation objectives and elaborate Irrigation Master Plans focusing on the next 2025 milestone (African water vision), aligned to National Investment Plans;
- ➢ National and Sub-regional Capacity building Programmes focusing on irrigation institutions (public and non-public) to enable policy implementation; create or reorient at sub-regional level a centre of irrigation experiments and equipment certification, linked to research and experimentation institutions;
- ➢ Creation, rehabilitation and modernization of irrigation systems (large scale and small scale) constitute the main components for irrigation investment strategy, including mechanisms for participatory irrigation management, transfer of maintenance and operation and partnership with private sector;
- ➢ Promote a programme of water demand management and water saving and accounting, to stimulate private sector involvement, enhance step-by-step cost recovery, and integrate environmental component and gender mainstreaming.

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