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WATER RESOURCES MANAGEMENT FOR FOOD SECURITY IN NORTH AFRICA

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INTRODUCTION

Water is a precious resource. In Africa, it can be a matter of life and death, but also of economic survival. It can also be an instrument and a limiting factor in poverty alleviation and economic recovery, lifting people out of the degradation of having to live without access to safe water and sanitation, while at the same time bringing prosperity to the continent. In addition, water is the major limiting factor constraining agricultural production and food security all over Africa. Thus, everybody in Africa should be concerned and involved in the conservation and protection of water and in discovering new ways of managing Africa's water resources to improve its efficient, equitable and sustainable use, to the benefit of all.

Now it is noticeable that in some African regions, several rivers, particularly swamps, streams, wetland and lakes have dried up. In urban zones, providing sufficient drinking water, as well as water for sanitation and industry, has become a major challenge for the authorities. In most countries of the Sahel and North Africa for example, water resources have become a rare resource that necessitates particular attention of governments, local populations and the international community. The question is then how to preserve and use wisely the existing stock of water (surface water, ground water, rainfall water, sea water and so on).

This paper is concerned with the North African region, namely: Algeria, Egypt, Libya, Morocco and Tunisia.

RENEWABLE WATER RESOURCES

Due to the prevailing climatic conditions of the region, both surface and underground water are significantly very important. Based on water exchange characteristics, two concepts are often used in hydrology and water management to assess the water resources in the region, including the renewable ones, and the static storage component. The latter conventionally includes freshwater undergoing a period of complete renewal which takes place over many years as in the case of large lakes, groundwater (fossil water), etc. Intensive use of this component unavoidably results in depleting the storage and produces unfavourable consequences. It also disturbs the natural equilibrium established over centuries. Renewable water resources include water replenished yearly in the process of water turnover on the earth, and mainly runoff from rivers and groundwater recharge.

NON-RENEWABLE GROUNDWATER

Some countries, having few renewable water resources, overlie important non-renewable (fossil) groundwater basins, partly shared with neighbouring countries. In a country like Libya, fossil water is by far the largest part of its total water withdrawal. However, although groundwater reservoirs may allow the storage of huge quantities of water accumulated during the pluvial periods of quaternary, its development cannot be considered sustainable in the long term, as the lack of present recharge would result in the slow depletion of the aquifers. Moreover, the increase in the cost of pumping, as well as the deterioration of the water quality in some areas may also make the abstraction of fossil water less attractive with time.

NON-CONVENTIONAL WATER RESOURCES

Non-conventional water resources include water from desalination and treated wastewater. The total use of desalinated water in North Africa is estimated at 202.8 million m^3/year and Libya produces 50% of this amount. Re-used wastewater is estimated at about 441 million m^3/year, of which Egypt produces two-third and Libya the remaining one-third.

WATER WITHDRAWALS

The three major sectors of water use are the following: agriculture (irrigation and livestock), communities (domestic water supply) and industries. In Morocco, more than 90% of the water withdrawal is directed to agriculture. Algeria withdrawal is only 16% of its Annual Renewable Resources (ARR), Egypt 97%, which means they overexploited their fossil water, Morocco 37% and Tunisia 68%.

RAINFALL IN THE NORTH AFRICAN REGION

The region is almost arid and the desert spans in all its countries. However, rainfall occurs and varies from few millimetres to more than 1800 mm. Most of the countries in the region experience a wide range of tropical climates or the Mediterranean climate, marked by a single rainy season with variable periods.

Rainfall is mainly influenced by the seasonable relative movement of the sun and the associated wind movements. Various types of winds prevail and include: south-west winds blowing across the Atlantic ocean, south-east winds blowing across the Pacific ocean, and Northern, North-east, and North-west winds.

DROUGHT CHARACTERISTICS AND IMPACT ON THE REGION

Drought, in varying degrees of frequency and severity, is a common phenomenon in North Africa. Besides the human toll, the economic and socio-economic drought-related costs are usually very high in terms of lost production, misused inputs and diversion of development resources. As such, the need to understand the characteristics and occurrence of droughts is very important for the national development, especially in water resources management and development. However, the causes of the below-normal rainfall which in turn causes drought are not exactly known yet.

Since the last four decades rainfall has started to decline in almost all the countries of the region. This could be attributed, besides the weather changes, to changes in land use over vast stretches of the region; such changes include deforestation and over grazing of farmland.

Unreliability or inadequate amount of seasonal rainfall and prolonged dry seasons are manifestations of drought. The persistent drought that has been witnessed in the last few decades, caused food shortages, and demographic changes took place as inhabitants deserted their agricultural and grazing lands and moved into cities.

WATER POLLUTION

Problems related to water pollution in North Africa are recent. They emerged as by-products of the relatively highly accelerated urban, industrial and agricultural development, mainly due to the disposal of urban, industrial and agricultural wastewater into natural water resources. Moreover, programmes for water quality conservation were unable to match the rapid development of the water resources of the region. Water pollution is also a consequence of the recent drought episodes occurred in the region, which led to a serious decrease in the amounts of surface and groundwater with an adverse impact on water quality.

Although the effects on groundwater are under certain conditions more important than those on soil, farmers don't pay sufficient attention to this situation. Pollution of groundwater with constituents

present in wastewater is very common. However, some management aspects need to be followed by farmers in order to reduce such an impact.

INSTITUTIONAL CONSTRAINTS

Water Management to combat drought, water pollution and wastewater is a crucial issue in North Africa and needs to be addressed more seriously.

In almost all the countries of the region there is a large number of public institutions responsible for water management, but in many cases coordination between them is weak or may not exist. Their responsibilities are not clearly defined, thus some functions are performed by more than one institution, while others may not be fulfilled by any of them. For example, while several institutions may be involved in irrigation water distribution and use, no institution may be responsible for water quality monitoring or environmental protection.

In view of the above constraints, Governments in North Africa could take action to remedy the situation as follows:

- Create awareness regarding the use of treated wastewater in agriculture;
- Provide education and training to improve human capacities in water resource management;
- Promote and strengthen hydraulic and hydro-meteorological information exchanges;
- Capacity building in integrated water resources management; and
- Enhance community participation.

PRACTICES TO PREVENT AND COMBAT DROUGHT

There exist many practices for drought combat and/or prevention. Such practices include among others: water harvesting techniques; supplementary irrigation in rain-fed areas; reforestation; crop managing factors, particularly using drought resistant cultivars; development of water resources (supply management); expansion of the irrigated areas; improvement of the productivity and use of saline water for irrigation.

STRATEGIES TO PREVENT AND MITIGATE THE EFFECTS OF DROUGHT

The objectives of the strategies are as follows:

- Manage and control drought as well as other onset disasters through efficient allocation, redistribution, transfer, storage and efficient use of water resources, rainfall harvesting, and development of non-conventional water resources.
- Develop long term water balances/drought models with different scenarios including interventions like inter-basin water transfer.
- Promote coordinated planning to combat drought through long-term water allocation and conservation measures and also rehabilitative actions on catchment management.

The key strategy principles for drought combat and/or mitigation in North Africa are the following:

- Encourage the use of water harvesting techniques and the construction of dams to harness the floodwater.
- Increase the efficiency of water use in agriculture.
- Develop non-conventional water resources.
- Develop measures for catchment areas management.
- Promote community participation and raise public awareness.
- Establish data-base and update information on water resources.
- Enhance the cooperation between the countries of the region.
- Create a favourable environment for the private sector to invest in water development, particularly in agriculture.
- Encourage research directed to the development of low cost water harvesting techniques and other measures to combat drought.
- Develop appropriate institutions and/or make reforms for the existing ones, since they are fundamental requirements for sustainable water resources.

PRESENT SITUATION FOR WASTEWATER PRODUCTION AND RE-UTILIZATION

In the North African region, water related issues are more prominent than ever before. The region's freshwater resources have been in a precarious situation since the end of the 20th century. Many people are suffering from chronic water shortages and many are living under the frequent threat of flood and drought, while several water resources are in some way threatened by pollution.

The socio-economic development of the region has historically been associated with its water resources. Population distribution is closely determined after the distribution of the water resources along water courses and in relatively high-rainfall areas. Traditionally, agriculture is by far the main consumer of water, but due to the rapid urbanisation witnessed in the recent decades, domestic water consumption is increasing rapidly. So is the consumption for industry and hydropower generation.

Domestic water consumption of city dwellers in North Africa is increasing at unprecedented rates due to the explosive growth in urban population which resulted in tremendous amounts of wastewater. International trends show that wastewater reclamation and re-use have become significant elements in water resources management, rather than wastewater disposal options.

Wastewater reclamation and re-use have emerged not only as realistic options for new sources of water to relieve the shortage and meet increasing water needs in North African countries, but also to comply with wastewater disposal regulations aimed at protecting the environment and public health. In addition, from an environmental point of view, the reclamation and re-use of treated municipal wastewater for irrigation could be, besides being an effective means to manage scarce water resources, probably the most safe, easy and useful disposal approach.

Henceforth, the present situation and prospects for wastewater production and reutilization in the countries of the North African region could be summarized as follows:

1. In Algeria, the percentage of the population being served through a sewage network has increased from 52.4% to 63.7% during the years 1987-1995. Daily drinking and industrial water consumption is estimated at 356 thousand which is equivalent to 1.3 billion m^3/year. Normally 80% of the used water is disposed of, hence an amount of 600 million m^3/year could be obtained as wastewater. This amount can irrigate an area of 70 thousand hectares.
   There are 51 sewage wastewater treatment plants, but many of these are not working. As a result, the treated water of the total wastewater hardly exceeds 4%. There are also 453 decantation pools in 404 municipalities distributed over 31 cities in the country.
   In a study carried out by Taibi Rasheed (1999), the expected wastewater volume by the year 2020 in Northern Algeria will be estimated at 0.978 billion m^3/year. This amount could be stored in dams and could be used directly to irrigate small or medium plots.

2. In Egypt, sewage wastewater was estimated at 2.5 billion m^3/year and is expected to reach 5.5 billion m^3 by the year 2025. The latter quantity represents 10% of Egypt's annual share from the Nile Agreement between Egypt and the Sudan. Egypt has already started establishing treatment plants so as to re-use the treated water directly for agriculture, or discharge it on water courses without causing a harmful impact on the environment. Because of the growing water scarcity in the country, the Egyptian Government endorsed a strategy which includes the increase of water use efficiency through a set of different measures: improve the main irrigation network; increase the on-farm efficiency; obtain the maximum benefit from any drop of water, and re-use wastewater in a safe environment.

   One of the very important existing projects for wastewater treatment is in Great Cairo. There is a plant in Zaneen area (capacity 330 thousand m^3/day), Abu Rawash (1.5 billion m^3/day) and Gabal El-Asfar village. The quantity of re-used wastewater was estimated at 1.7 billion m^3/year, and expected to reach 2.4 billion in m^3/year by the year 2010.

3. In Libya, the techniques for wastewater treatment have been used since the early sixties, with the setting up of the first plant in Tubruk in 1963, followed by the construction of an appreciable number of plants in order to achieve two main purposes, namely:
   a. Protect the environment and eliminate or minimize the negative impact of polluted water on public health and natural resources.

b. Provide a water source (non-conventional) which suffices part of the water required for agricultural purposes as well as provide support to the available water resources, which is subjected to overexploitation.

During the last three decades, Libya has witnessed an increase in its population and in their income as well. This required the building of an intensive infrastructure that included: water supply system for the provision of drinking water as well as systems for collecting and treating wastewater, which are spreading over more than 50 cities and villages. The capacity of the wastewater treatment plants has increased from about 31 thousand m^3/day in 1970 to about 446 thousand in m^3/day.

4. In Morocco, during the last two decades, the increase in the annual demographic growth rate has led to a considerable increase in water consumption per capita. Studies have shown that between 1990 and 2020, the available water per capita will be reduced by 51%, that is from 833 in m3/h/year in 1990 to 441 in m3/h/year in 2020. Also the irrigated areas will be reduced from 33.8 hectare/1000 persons in 1990 to 29.3 hectare/1000 persons in 2020. Thus, water resources will be the most important factor that will hinder the future agricultural production.

   Wastewater re-use for agricultural purposes has been practiced in Morocco for decades. The quantity of wastewater has increased from 48 million m^3 in 1960 to some 370 million m^3 in 1990. This quantity is expected to reach about 900 million m^3 by the year 2020. The main factors that led to the increase of the wastewater could be summarized as follows:
   An increase in the urban growth by 4.4% per annum.
   An increase in the domestic water supply per capita from 58 to 116 litre/day during the period 1972-1992.
   An increase in water supply coverage from 53% to 79% during the period 1972-1992.

   It is worth mentioning that in Morocco untreated wastewater has been used in agriculture since a long time ago. In 1992, about 60 million m^3 of untreated wastewater was used to irrigate about seven thousand hectares in areas adjacent to some cities.

5. In Tunisia, treated wastewater is estimated at 130 million m3/year. There are about 54 plants for the treatment of wastewater. In the year 2001, treated wastewater was about 152 million m3/year and the plants for the treatment of wastewater increased in 2006 from 75 to 83 plants and the expected treated wastewater will be around 180 million m3/year. More than 50% of the wastewater is produced in the capital Tunis.

RE-USE OF WASTEWATER IN NORTH AFRICA FOR AGRICULTURAL PRODUCTION

To conclude this overview, it is worth noting that the re-use of municipal wastewater is not a new concept. With the increase in water demand, due to population growth and the rise in the living standards, wastewater re-use in the North African countries plays an increasing role in the planning and development of additional water supplies. This is particularly important for North African countries, characterized by low rainfall, mostly seasonal and with erratic distribution. The use of wastewater for beneficial purposes such as irrigation has been practiced although without control in some countries of the region.

In Algeria, the use of wastewater for irrigation has been practiced since 1980, but because of the malfunctioning of the wastewater treatment plants, the areas irrigated with the produced wastewater are comparatively small. In Karma and Wahran, only an area of five hectares was irrigated using wastewater simply treated in lagoons. In Marais, west of the capital Alger, an area of 10 hectares of pulses was irrigated, while in Constantine, an area of 2500 hectares was irrigated using wastewater,because of water scarcity in this city.

In Egypt, sewage water has been used to cultivate orchards in a sandy soil area at El Gabal El-Asfar village, near Cairo. The area gradually increased to about 2500 hectares. The effluent was refined to get rid of suspended matter before use in order to prevent infection as much as possible.

It could be stated that water which could be saved either for rehabilitation programmes or from reusing agricultural drainage water or sewage treated wastewater could help Egypt satisfy a considerable part of its future medium-range water needs. However, caution should be taken when setting up programmes for wastewater re-use . The short and long term effects of such programmes on soil properties and crop production should be carefully assessed.

In Libya, treated wastewater has been used for the production of fodders and the sludge has been used as a natural fertilizer. Treated wastewater is also used to irrigate public parks as well as in some cases for the purpose of road construction. The potential of treated wastewater in Libya can irrigate an area of 30 to 40 thousands hectares.

In Morocco, some research on using treated wastewater for agricultural production in Rabat, Ouarzzazate and Agadir was carried out. The results of these researches could be summarized as follows:

- An increase in tomato production in Rabat. Such production was 75 tons/ha when using treated wastewater, while only 53.4 tons/h when using normal irrigation water.
- An increase in the productivity of some crops (Sorghum, Wheat, Tomato, and Beans) by 70% in Ouarzzazate.
- Treated wastewater provided 40 to 90% of Nitrogen and 55 to 100% of phosphorus for the crops nutrients' needs.

Agriculture in Tunisia faces acute problems of water quantity and quality caused by limited conventional water resources and projected future needs. Using wastewater is now an essential component of any policy of integrated water resource management. Such policy allows optimal water use and savings on organic and mineral fertilizers, while preserving or improving soil fertility, preventing surface or ground water pollution and protecting the environment.

The authorities in Tunisia have decided to systemize the re-use of wastewater after being treated. However, the present wastewater treatment plants provide only secondary treatments, with an evident lack of disinfecting equipment. Thus, the agricultural re-uses allowed are only restrictive irrigations (fodder crops, olive, trees and cotton). More attractive irrigations (Public parks, sports fields, green spaces and vegetable crops, etc.) will not be allowed until efficient, reliable and cost effective disinfectant techniques are available. The irrigated area using treated wastewater was estimated at 6600 hectares.

CONCLUSION

This paper does not claim to be a masterpiece in water resources. It is a simple, descriptive study, related as a narrative story, highlighting the present situation of water problems in North Africa, including drought, food security, pollution, mismanagement and shortage of skilled and technical personnel.

The paper has shown that many North African countries are reaching the limit of their available water supplies. Also the Region is very vulnerable to high variation and unreliable rainfall, which leads sometimes to food gaps. Droughts are frequent and severe, and the mitigation of their pervasive effects will be a crucial element in food security, sustainable economic recovery and future development. As population increases, more people are at risk and the progressive exploitation and degradation may endanger the natural resources base, particularly by exerting more pressures on water resources.

International indicators show that water scarcity can prevail in countries where water use exceeds 40% of the available water resources. Causes leading to this scarcity differ from real scarcity to hidden scarcity, that is (i) all economically feasible water resources are exploited, and what remains is either technically or economically impossible to exploit; (ii) knowledge concerning the development of water resources is limited or absent; and (iii) water resources are available, but do not meet requirements (e.g. polluted). Other indicators of water scarcity are the water scarcity indices, which show the levels of water stress.

Four levels of water stresses could be identified:

1. Low water stress: countries using less than 10% of their available water resources do not experience pressures on their water resources.
2. Moderate water stress: countries using between 10-20% of their available resources, where water is becoming a factor which is limiting development.
3. Medium to high water stress: countries using between 20-40% of their available water resources.Here a careful management is needed to ensure the sustainability of water use. Competition between sectors have to be solved.
4. High water stress: countries using more than 40% of their available water resources. Here alternative sources of water have to be developed, and attention must be given to the management and demand supplies.

The paper showed that all the countries of the region except Algeria have far exceeded 40% of their available water resources being used for various purposes. Under these conditions, alternative sources have to be developed, and urgent attention must be given to the intensive management of the resources and the demands made on it.

The paper also showed that North Africa is very vulnerable to high variation and unreliable rain, and agricultural drought occurs as water supply is insufficient to meet crop or livestock requirements. Some strategies were proposed and they included: encourage the use of water harvesting techniques; increase the efficiency of water use in agriculture; develop non-conventional water resources and measures for catchment areas management; establish a network of data-base and update information on water resources; enhance cooperation between the countries of the region; create a favourable environment for the private sector to invest in water development; encourage research, and develop appropriate institutions and/or initiate reforms for the existing ones.

Finally, the paper dealt with the present and future re-utilization of wastewater from which the following remarks could be concluded:

- A marked indicative potential of wastewater production exists in the North African countries. The magnitudes of these productions vary from country to country. However, these productions, whether the existing ones or the potential ones, are not precisely quantified and characterized.
- Information regarding the existing network of wastewater treatment is hardly available.
- Several constraints facing the re-use of wastewater exist. These could be categorized as human, institutional, technical know-how, social, economic and environmental constraints.
- Wastewater has been re-used for irrigation in the region for sometime.
- However, the effects of re-use on public health and the environment, as well as its socio-economic analysis have not been sufficiently monitored.
- Standards and codes of practice for using treated effluent for irrigation have to be developed and established in each country.
- There is need for skills training in operation and maintenance of wastewater treatment plants, and training of farmers on the re-use of wastewater for irrigation.
- Laws and regulations, and institutions on water management need to be developed or amended to cope with the re-use of treated effluent.
- Public awareness campaigns and the promotion of health and education components should be included in water re-use projects.

In conclusion, the development of a North Africa Water Vision 2025 could be proposed. Its main objectives could be: (i) to enhance water use and management for the sustainability of food production; and (ii) to build capacities on Integrated Water Resources Management for the social and economic good as provided by the Dublin-Rio principles:

1. Fresh water as a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management to be based on a participatory approach, involving users, planners and policy-makers at all levels.
3. Women to play a central role in providing, managing and safeguarding water.
4. Water has an economic value in all its competing uses, which should therefore be recognized as an economic good.

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