RELEVANT WATER MANAGEMENT AND IRRIGATION ISSUES IN NORTH AFRICA

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I. Introduction

1. Water management and irrigation issues in North Africa are many and are linked to the scarcity. Some of them are linked to human behaviour and culture. For example incessant expansion of irrigated area, little awareness of the finite limits of water, increasing water wastage, salinity and pollution as well as watersheds degradation. Others are related to climatic hazards. For example drought, floods and desertification. Still another issue results from a mixture of human and climatic causes. For example the exhaustion of underground waters, caused by excessive water pumping and recurrent droughts.

2. A policy that can mitigate such stress is based on water sustainability. The attainment of this goal needs a deep change in attitude and approach of the policy makers. In addition, the wisdom and commitment of users towards its sound utilization is a prerequisite. In this context, concerted efforts must start at local and national level. Regional co-ordination is also required to improve national planning and programming. In North Africa, water sustainability can have far-reaching impact specially on irrigated agriculture and therefore on food security.

3. Essential for good water management is water planning. Rational utilization is equally necessary. This is an aspect in which consumers may play an important role. They need to understand that water supply has precise limits. If exceeded, water has to be obtained from non conventional sources e.g. recycled, desalinated and even from underground non renewable. But, these solutions are all expensive. This suggests that one has to invest first in projects based on water economies, as they can have a great impact on water supply. Large hydraulic projects and linked infrastructures are expensive and their construction justified if they have high socio-economic returns. Irrigated agriculture is one sector in which important water savings can be made in the sub-region.

II. Objectives

4. The main objective of this document is to identify and analyse priority water management and irrigation issues common in North Africa countries. Another consists in the analysis of the main challenges that water management and irrigation are facing in the North Africa, specially beyond the year 2000, when the population is expected to reach 178 million inhabitants. The third consists in the identification of strategies that may ensure long term water sustainability and irrigation in North Africa.

III. Water management and irrigation issues

Little surface water generation

5. This is a phenomenon that features in all countries in the sub-region. The combined result of low annual rainfall (170 mm mean in the sub-region) and high evaporation favors low surface water generation in the sub-region. In fact only 85.2 km^3 out of 1,504 km^3 of the total annual rainfall are transformed into surface water. The remaining water is evaporated or goes to underground reservoirs. The highest rates of surface water generation are registered in Morocco (20%) followed by Tunisia (10.3%). This is mainly due to the dam construction policy put into practice by both countries some decades ago. In Sudan the percentage is only 2.7%. Low rates are bottlenecks, specially for those countries heavily dependent on external water, like Mauritania and the Sudan.

6. The following table shows the rate of internal surface water generation in North Africa.

Table 1

Precipitation and Internal Annual Renewable Water Generation in North Africa in 1995

Mean annual rainfall (mm)	Annual Average Precipitation (cubic km per year)	Internal Annual Renewable Water (cubic km per year)	Precipitation as Internal Annual Renewable (%)
169.6	1, 504.00	85.2	5.7

Source: Irrigation in Africa in Figure: Water Reports No. 7, FAO Rome 1995.

7. The most efficient manner for increasing surface water generation is through the construction of new dams and water reservoirs to store the maximum water runoff possible and in particular that from exceptional rainy years. Many countries, and in particular Morocco and Libya, have since decades, followed this policy. In the first country, it is estimated that dam's capacity exceeds 15 cubic kilometers, the highest figure in the sub-region, after Egypt. In Libya, although there is disproportion between the average runoff and dam's storage capacity, the policy tries to capture the maximum of water from wet periods. In Algeria, dam capacity is estimated at about 5.0 km^3 whereas in the Sudan it is estimated at 3.2 km^3.

8. Another way to foster surface water generation is by enlarging the area covered by natural vegetation. Actually it is very tiny. For example forest cover, with the exception of Sudan, (country that possesses more than 43 million ha), in the other six countries hardly averages 5 percent. It is clear that forests, shrubs, annual and permanent grasslands, like those of *grass steppe with alpha*, that cover several million ha in the sub-region, facilitate water infiltration into deeper layers, mitigate water and wind erosion and reduces water surface run-off. Moreover, lack of vegetation in watersheds increases siltation in downstream dams, diminish their water capacity as well as that of small reservoirs and the water flow through canals. For example, in Sudan it is estimated that dam siltation may have reduced water storage capacity over 2.5 km^3 .

9. Experiences show the important role that forests and woody vegetation have on water infiltration into underground layers. That is highest in soils covered by forests and bush formations than in agricultural ones. The infiltration speed in both type of soils is shown in the following table:

Table 2
Water infiltration Speed into Ground Layers (cm/hour)

Type of soil	Surface Horizon	Deep Horizon
Forestry soil	150	30
Agriculture soil	80	5

Source: Watershed Rehabilitation, TRAGSATEC, Mundi-Prensa, Madrid (Spain), 1994

Challenges to improve surface water generation

10. Among them are:

- **increasing dam/reservoirs capacity to store the maximum volume of water from rainfall or snowmelt;**
- **broaden the area of natural vegetation, giving great importance to the conservation of shrubs and grasslands;**
- **fostering afforestation and reforestation programmes, specially with drought and nitrogen fixing species;**
- **rehabilitating of degraded watersheds, by mechanical and biological means.**

Increasing water demands

11. At the origin of such increasing water demand is irrigated agriculture. Currently, it consumes 87% of total water in North Africa. It is followed by the industry, public services and domestic uses which share the remaining 13 %. But, this structure has to shift to give way to meet the new water demands. It is no longer socio-economic and environmentally sound to continue to lose big volumes of water, for example by irrigating by gravity, when drinking water is not available in many rural areas and partially in the urban ones. Insufficient water storage, treatment and distribution facilities are preventing full water supply. This problem coupled with the increasing needs of a society that everyday demands more water and of quality, is widening the annual per capita water consumption gap in the sub-region.(12.5 m^3/ person in the sub-region between 1995-2000).

12. Using 1000 cubic metres per year as a volume consistent with normal use, then the whole sub-region can be classified as *of chronic water shortages*. In fact, serious shortages of water took place in 1995 in Algeria, Morocco and Tunisia, which were aggravated by the strong drought that affected most of the North Africa countries that year.

13. Moreover, from the table below it is estimated that an extra 2.2 km^3 of fresh water would be necessary the sub-region, to keep the same per capita water consumption of 1995 (601.2 cubic metres/year) in the year 2000. The estimated figure might be 2.9 km^3 per year in 2015. This suggests that the main effort to cope with water supply will have to be done by those countries having the lowest volume of renewable water resources and in those in which consumption is near that figure. In the group are Egypt, Libya and Tunisia. The following table depicts the estimated evolution of water consumption per capita between 1995 and 2000.

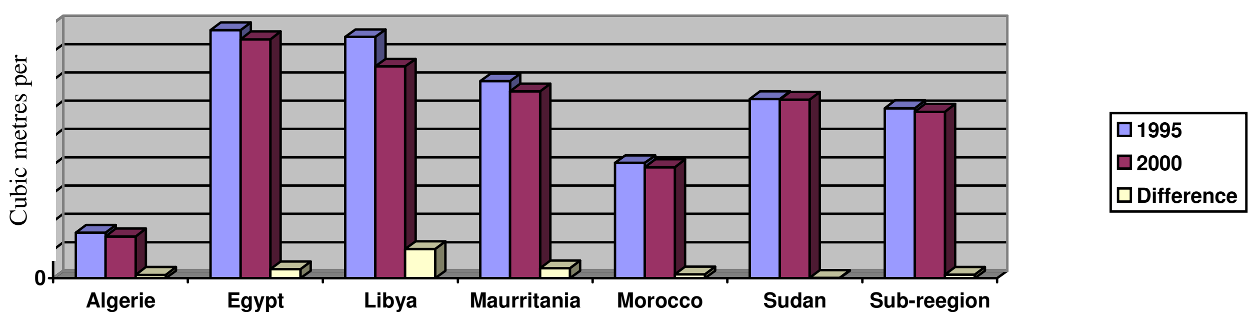
Table 3

Evolution of per Capita Water Consumption in North Africa (1995/2000)

Country	Algeria	Egypt	Libya	Mauritania	Morocco	Sudan	Tunisia	North Africa
Total renewable km^3/year	14.3	58.3	0.6	11.4	30.0	88.5	4.12	207.2
Consumption km^3 /year	4.5	55.1	4.6	1.6	11.0	17.8	3.1	97.7
Per capita consumption, m^3 (1995)	161.0	876.0	852.0	696.0	407.0	633.0	348.0	601.2
Per capita consumption, m^3 (2000) *	148.5	843.9	747.9	660.2	393.2	630.6	324.1	588.5
Difference	12.5	32.1	104.1	35.8	13.8	2.4	23.9	12.5

* 5% has been added to the volume of water consumed in 1995 in each country .

Sources: FAO Irrigation in Africa in Figures, Rome 1995 and Water Situation in North Africa: issues and challenges in 21st Century, NA-SRDC, Six Annual Meeting of the



Interagency Group for Water in Africa(IGWA), Rabat, Morocco, May 1998.

Challenges and approaches to increase water supply

14. Apart from the measures proposed in paragraph ten to increase surface water generation, the following can be of help:

- **diversifying water storage means and their efficiency;**
- **reducing water losses during distribution and utilization;**
- **setting up a reward scheme for water savings policy;**
- **promoting water recycling and re-utilization.**
- **fostering extension and training programmes and activities on water economies.**

High dependence on external surface water

15. The degree on external surface water dependence is high in the sub-region. That dependence may alter water delivery, specially when drought affects watersheds far from the receiving country. Floods can be the other face of the coin. The main advantage of such dependence consists in utilising a resource originated out of the national borders at low cost. Among the inconveniences are the consequent pollution and salinity of the water.

Table 4
Surface Water Dependency Rates in North Africa in 1995

Country	Algeria	Egypt	Libya	Mauritania	Morocco	Sudan	Tunisia
External dependence %	2.8	95.7	0	96.5	0	73.7	10.3

Source: ibid

16. From the above table it is seen that Egypt, Mauritania and Sudan receive the greatest volume of water from outside, that is 72.5 km^3 or over 75% of the total water utilized in the sub-region. After the construction of the High Dam Lake, and based on the Nile's average water flow during 1900-1959, Egypt can withdraw up to 55.5 km^3 per year and the Sudan up to 18.5 km^3. The Egyptian figure, represents 80.2 % of the total water withdrawal in the sub-region. Low dependency is registered in Algeria and Tunisia which account for 2.8 % and 10.3% respectively of external water. The situation is optimal in Morocco and Libya, which do not use any water originating from sources outside their national boundaries. In the case of Libya this dependence is at the price of large scale exploitation of its fossil reserves, a source that accounts for 85% of national consumption.

Challenges to lessen external water dependence

17. In those countries largely dependant on external water flows challenges might consist in :

- **fostering surface and underground water harvesting;**
- **setting up of water security banks specially for drinking and irrigation;**
- **rationalising water consumption and utilization, specially in those sectors having highest specific consumption;**
- **rehabilitating priority watersheds and water distribution schemes and**
- **promoting a co-ordinated policy for wastewater recycling, desalination, treatment, storage and reutilization.**

Increasing utilization of underground and fossil waters

18. These (renewable and fossil) are alternative-strategic resources that need a critical management. Increasing water consumption is leading the North African countries to rely more on them. For example in Egypt there are plans for increasing utilization of renewable underground water from 2.6 to 4.9 km^3 in the next coming 25 years. It is estimated that underground water accounts for 23 km^3 or about 25% of the water withdrawn in the sub-region each year. But, this volume might be higher. High exploitation costs are limiting its utilization. These are particularly high for drilling and water pumping below 50 metres depth. High investment is also needed for storing and water distribution.

19. Using data on known renewable underground water of 1990, it is estimated that if no new resources are added, there might be a reduction of 22 m^3 on underground water per head in the sub-region between 1992 and 2000. If the same pattern is kept, the gap may be 50 m^3 per head by the year 2015. Hence, the need for exploring and assessing new underground reservoirs.

Table 5
Estimated Volume of Underground Water per Capita in North Africa

Countries	Algeria	Egypt	Libya	Morocco	Mauritania	Sudan	Tunisia	Total
Km^3	6.66	3.42	4.32	5.00	0.30	1.30	1.73	22.73
Inhabitants (1992), millions	26.1	59.0	4.9	25.4	2.1	25.9	8.4	151.8
M^3 / inhabitant/ 1992	255	58	882	197	143	50	206	150
$M^{3/}$ Inhabitant/ 2000 *	210	50	673	171	122	44	175	128

* 177.9 millions of inhabitants estimated by 2000 in North Africa
Sources: (1) UN ECA, 10th IGE Meeting of the North Africa MULPOC, April 1991 and NA-SRDC.

20. Likewise, fossil water is a strategic resource, with stocks scattered throughout the sub-region. It is estimated that Algeria's Sahara region may produce 2 to 5 km^3 of that water annually. Others important stocks are: (1) the Nubian aquifer, which stretches from Egypt to Libya and Sudan, (2) the stocks South of 29th parallel in Libya , and (3) others available in Tunisia. In Libya the Great Manmade River Project is expected to transport 2 km^3 each year to the major cities in the coastal areas.

Challenges to sustainable groundwater utilization

21. Among the actions to ensure underground water sustainability are:

- **ensuring continuous recharge of reservoirs;**
- **monitoring storage water capacity evolution and**
- **keeping water quality standards, by preventing polluted effluents infiltrating into underground water reservoirs.**

Water quality downgrading

22. Water quality is falling in most of North Africa countries , due to multiple uses and poor handling. Although water pollution varies from one country and from one region to another, it is mainly caused by the impact of intensive agriculture, and increasing household and industrial uses. Drainage waters generally do not contain much organic matter, but dissolved salts, added as fertilisers and as other chemicals. Contrarily, organic matter and chemicals are abundant in water effluents from urban/rural areas. Industrial discharges contain chemical pollutants characteristic of each process. Tannery and dying are among the most pollutant activities in North Africa.

Water salinity and irrigated agriculture

23. Decreasing productivity of agricultural soils is often associated to the use of high salts concentration in water for irrigation. High water salinity may: (1) increase soil salinity; (2) lower soil permeability and (3) cause crops and plants toxicity. Water salinity affects not only the plant's growth but the soil long term stability, structure and micro-fauna growth. The increasing utilization of chemical fertilisers and other agrochemicals is one of its causes. The intrusion of saline water into aquifers near the sea (Nile delta and the Libyan coast) is another form of increasing underground water's salinity. The third is linked to water dissolving salt capacity during runoff. Water quality decreases during drought times.

24. According to data, water and soil salinity are increasing in the sub-region. For example, data from Tunisia indicate that 26% of surface water, 90% of pumped water from water tables and 80% from deep aquifers contain more than 1.5 gr./l have of salt. Morocco, due to extensive irrigation is facing similar problems. A practical way to avoid salinity in agriculture is to use water containing less than 1 gr./litre of dissolved salts. Soil permeability must be good to avoid waterlogging. Finally, toxic substances like, chlorides and sodium must be avoided in water. The following table shows some conventional water salinity indexes in the control of sprinkler and surface irrigation, as well as those for measuring iron content and water hardness.

Table 6

Water Quality Irrigation Indexes

Quality index	EC mho/cm *	Salts (gr./l)	SER(meq/l) **	SAR(meq/l) ***	Iron	Hardness
Good	1,000	0.75	60	4	0.5	Up to 22
Average	1,000-3,000	0.75-2	60-70	4-8	0.5-1	22-54
Not recommended	>3,000	>2	>70	>8	2	>54

*EC (electrical conductivity), microhm/cm = micro Siemens/cm; SER= sodium exchange rate; SAR= sodium adsortion rate.

Source: Pre-feasibility study on extension of small scale irrigation schemes in the North Africa Sub-region. 13th I.C.E, Tangier, April 1997.

25. The control of water salinity and sodium levels is of capital importance in agriculture. For example, high levels of sodium ion, (SAR higher than 3), in irrigation waters may affect root water absorption. Both soil structure and soil drainage capacity can be altered. Likewise, root absorption problems can appear when chloride is between 4-10 meq/l. Severe problems occur on plants root when the concentration on boron is greater than 2 ppm. The use of appropriate doses of fertilisers and other chemicals is of paramount importance to avoid not only soil salinity but to reduce crops toxicity. The utilisation of the two mentioned (SER) and (SAR) is recommended to evaluate sodium content and its potential impact on soil alkalinity.

Challenges towards water quality for irrigation

- **utilising water of appropriate quality for both crops and plants (there is high risk of soil salinity when EC is higher than 3, 000 mhos/cm);**

- **monitoring sodium content of water(e.g.. sodium concentration in water is recommended not to exceed 0.3 gr./litre, otherwise it can increase plant's toxicity and perhaps degrade soil texture);**

- **avoiding permeability problems, as they can develop crusting and surface waterlogging ;**

- **using fertilizer, compatible with the quality of water for irrigation (good water allows higher concentration of fertilizer, although it is better to add the fertilizer in several stages);**

- **avoiding concentrations of boron higher than 2 mg./l., chloride lower than 10 mg./l and Sodium Adsorption Rate (SAR) greater than 9.0. and**

- **using water of high quality for recharging ground aquifers.**

Wastewater production and re-utilization

26. The potential of wastewater recycling is enormous (about 8.0 km^3 in only 9 towns in North Africa by 2015), in spite of high costs. Urban effluents are expensive to treat due to their high Biological Demand of Oxygen (DBO_5), Chemical Demand of Oxygen (DQO) and varied microbiological composition. In particular DQO is high due to the discharges of chemicals specially soaps, detergents, and bleaching products from households and industries which send them directly into the sewage network. In spite of these difficulties, wastewater recycling can be a feasible technical and environmental activity in all North African countries. So far, Egypt reuses annually over 0.2 km^3 of the treated wastewater. The country treats over 0.6 km^3 of wastewater each year. In Tunisia, there were 28 treatment plans in 1992 and 57 new plants are expected to be built by the year 2000. Plans are to irrigate 20,000 ha with this water. In the other North African countries the effort for treating more wastewater is high.

27. The following table depicts how nine urban agglomerations of North Africa could generate about 7.6 km^3 of wastewater in the year 2015.

Table 7
Estimated Wastewater Generation in Nine Urban Nucleus in North Africa in 2015

Town	Algiers	Alexandria	Cairo	Casablanca	Khartoum	Rabat	Shubra el Kema	Tripoli	Tunis	Total
Inhabi-Tants (millions)	6.4	5.4	14.4	4.8	4.7	2.1	2.4	3.1	3.5	45.8
Waste water (km^3/ Year)	1.1	0.9	2.4	0.8	0.8	0.3	0.4	0.5	0.4	7.6

Sources: United Nations, Urban Agglomerations, New York 1996, Population Division 1997 and NA-SRDC.

28. Although short term 100% wastewater recycling is unrealistic, setting up of a long term policy target (e.g. ensuring primary, secondary and tertiary treatments perhaps in 5, 10 and 15 years span) to recycle the same volume as new water consumed annually, might be feasible in the short term for many North Africa countries. Moreover, as wastewater recycling and treatment costs are highest for water generated in big agglomerations, a low cost/effective approach might consist in starting by recycling water originated in rural and small urban centres. Poor people pollute less and this reduces costs of water reutilization. Another advantage might be the possibility of in-situ immediate utilization.

Challenges to foster wastewater re-utilization

29. The following might be of interest:

- **fostering political and popular awareness on water pollution;**
- **promoting efficient solid wastes sorting policy in households and industries (e.g. glass, metals, plastic and waste paper and board);**
- **incorporating into water price the costs for water treatment and re-utilization ;**
- **setting up economic, legal and fiscal measures to encourage mechanical, biological chemical recycling and re-utilization and**
- **diffusing among farmers the use of wastewater utilization in agriculture and forestry.**

Efficiency of the irrigation systems

30. The traditional surface irrigation systems are low water efficient. This is why farmers are shifting to new and higher water efficient irrigation systems. Sprinkler irrigation was the most popular irrigation systems in the 60s. Later, it gave way to drip irrigation and this to micro-irrigation. For example, in 1974 in Morocco there were only 5 ha micro-irrigated in greenhouse in 1974, whereas the today's figure is around 40,000 ha. In the sub-region the figure exceeds 130,000 ha, with Egypt sharing almost 64%. In Tunisia micro-irrigation schemes represent 3% of its total irrigated area, whereas that of sprinkler is 20%. In Libya sprinkler irrigation boomed in the 70's.

31. But, in spite of such a progress, surface irrigation is still dominant. The question is how long the system will last, as its water efficiency is low, (30-60%), and water price rising. It will largely depend on farmers' capacity to adopt the new irrigation techniques and technologies.

32. Before their adoption, farmers need to know the advantages and inconvenients of the new irrigation systems. They specially need information on suitable systems and irrigation technologies appropriate for their soils, water, climate and their crops. The selection of appropriate fertilizers, and the possibility to use fertigation and chemigation is also important. A third issue is how to maintain the water quality. They will also need to know the cost/efficiency of the new systems. Maintenance costs, including that of energy, have to be carefully assessed by farmers before any engagement or shifting to another irrigation system is taken.

33. For example the main advantages of *sprinkler irrigation* are:

- High water application efficiency (60-85%) and no need for soil leveling;
- Adaptability to any type of soils, specially sandy soils;

- Permits mechanization of some works;
- Facilitates chemigation and fertigation and
- Easy installation, maintenance and handling.

34. The main advantage of *drip irrigation* is its high water efficiency (75-90%). This means that the plant consumes almost the totality of water supply. The system is very elastic as it can supply up to 20 liters/hour. Another advantage is the reduction of transportation and distribution losses (the latter less than 5%). Moreover, these are practically nil as there is no evaporation. Apart from the equipment cost (specially high for greenhouse irrigation), one of the problem is the insufficiency of skilled manpower to deal with the many problems inherent to its management e.g. greenhouse ventilation, heating, , salinity, fungi and diseases control. This calls for the intensification of technical, vocational training and extension throughout the sub-region.

Challenges towards new irrigation systems

- **selecting those having an optimum cost/water efficiency;**
- **avoiding those excessively automated or difficult to install, and maintain;**
- **selecting those based on a minimum energy consumption and working at medium pressure ;**
- **adopting those designed for allowing fertigation and chemigation and**
- **choosing the most appropriate for the type of water, soils and crops.**

IV. Strategies for water sustainability and irrigation enhancing in North Africa

35. The following can improve water sustainability and irrigation in North Africa: (1) development of a more global and interactive water management policy; (2) adoption of new water and irrigation technologies and (3) offering prizes for individual and community effort towards water sustainability. In order to attain the main objective of water sustainability, greatest synergy among individuals and institutions seems essential.

36. Diagram in Annex I shows the required interaction among the three strategic directions. It is not sufficient to focus on the tree mains policy directions but one must also ensure their co-ordination with the main policy instruments and means to get their maximum impact.

a. Development of a more global and interactive water management policy

37. The main objective of such a new policy should consist in putting water in the global development agenda of each country. To put into practice such a policy ensuring better co-ordination among high level policy planners is a requisite. Secondly, the need to improve dialogue and action among policy programmers and water consumers, at sector level. And thirdly, the input, expertise and commitment of the local and regional authorities towards water sustainability, specially in agriculture. Availability of sub-regional information and data can contribute to the consolidation of the main objective.

38. In order to step forward in this direction it essential design appropriate policy water and irrigation laws, programmes and other tools to:

- create awareness on water scarcity, rewarding surface water generation and water saving actions;

- support integrated water sustainability programmes and projects to maintain the long term water multi-functions (sanitary, aesthetic, productive, cultural and environmental and development);
- share water management and distribution costs among water users;
- ensure long term water quality supply, from harvesting areas to consumer places and
- facilitate discussions for integrated and community water planning and utilization.

Recommended mechanisms and options

39. Apart from drafting and improving existing water laws, and regulations the dissemination of *Water Codes of Practice* among water users is seen as a low cost/efficient instrument for improving water sustainability in the sub-region. Other policy mechanisms and means are identified in matrix B, Annex II:

b. Diffusion of new water management and irrigation technologies

40. The areas in which science and technology can contribute the most to water sustainability and self-sufficiency are mainly the following three: (1) water resources assessment and monitoring, (2) water economies, specially on irrigation and (3) water recycling, treatment and re-utilization.

41. Apart from stimulating a policy for reducing water losses and using water efficiently a policy effort is needed for fostering wastewater re-utilization. In addition to the primary and secondary wastewater treatments, the North African countries should stimulate the utilization of the low cost biological ones (including those using aquatic plants) which is a practical tertiary way. Treated wastewater can be used for: (1) aquifers recharging, (2) for irrigated agriculture and (3) municipal reuse (non potable). In all cases the control of the microbiological quality is essential. The World Health Organization recommends water retention in stabilization ponds for 8-10 days to get its microbiological quality before it is used to irrigate cereals, cash crops, fodder, pastures and even trees.

42. In areas prone to acute water scarcity and high salinity, distillation processes may be a solution to increase water supply. For example poor farmers can use solar stills for purifying small amounts of water at low cost and using simple technology. Solar energy can be used for evaporating water and condensed vapour collected by plastic roofs or slanting glass. Reverse osmosis still remains as an expensive alternative.

43. Matrix C in Annex III, shows a set of specific technologies for water management and conservation in North Africa. It identifies those that can tackle the problems of water resources assessment, storage, distribution and consumption, including irrigation. Desalination and wastewater technologies are also possible options.

c. Supporting individual and community activities towards water sustainability

44. Within the new integrated water management policy framework, governments, the international community and NGOs should support efforts of private and community groups to ensure water sustainability and irrigation in the sub-region, at least in the three following areas: (1) training on water economies, (2) extension of new techniques and practices to keep

water quality protected and (3) diffusion of the legal, economical, fiscal and other mechanisms and means towards such a end. Matrix D in Annex III identifies some of them .

V. Conclusion

45. The first conclusion is that there is considerable *water scarcity* in the sub-region. It has a great impact on water supply (only 600 m^3 per head in 1995, 1000 m^3 being an acceptable standard, per year). Insufficiency often implies heavy reuse, and therefore *high pollution* by untreated sewage, industrial and agricultural waters. Unless countries join efforts to reach the above threshold of thousand cubic metres per capita the stress will not only persist but will likely increase, following the population pressure (229 million inhabitants in the year 2015).

46. A second conclusion is that for meeting such an objective, the strengthening of water policy and programme coherence and co-ordination is necessary in countries and in the sub-region as well. The Common Country Assessment (CCA) and the UN Development Assistance Framework (UNDAF) are two effective tools to this end. Water policy planning and programming need to be better co-ordinated at local, regional, national and sub-regional level. The UN System-wide Special Initiative for Africa is an international framework for better water sub-regional planning. Equally essential is popular participation. Apart from setting national programs for eliminating water leakage points, countries should strengthen their legislation, programmes and means to increase *surface water generation and storage.*

47. The construction of *multi-purpose and inter-linked new dams* (for drinking, irrigation and energy generation) can strengthen water and food security in the sub-region. Ideally, big dams should be constructed in areas with low evaporation and with low risk of siltation. For both purposes, a policy for watersheds re-vegetation, preferably with fast growing species, appears as an efficient tool . Moreover, dam location near the consumption centres would help to reduce water distribution and treatment costs. A policy to stimulate farmers to build mini-dams, mini-reservoirs and house-water storage can strengthen water security.

48. In most of countries *vulnerability to drought and to external water supply* can be lessened by designing programmes and mechanisms to optimize the use of the local and received water. For doing so, governments should stimulate efficient irrigation, industrial and low cost water recycling technologies and systems. For example new irrigation technologies, ecologically sound and cheap wastewater treatment methods, specially green filters should be encouraged.

49. From the industrial point of view, prizes should be given to entrepreneurs needing less and recycling more water. Moreover, to cope with cyclic drought, the setting up of a national *critical water security stock* appears as a basic tool to reduce such vulnerability. It could be composed of water from: (1) the above mentioned inter-linked surface water stock network; (2) underground, fossil and renewable stocks and (3) mini-dams, ponds, wells and other reservoirs made by farmers. Its financing could be made with savings from stemming water losses.

50. Another conclusion is the need for designing a *national water quality plan*, with sub-regional and international support. A first priority is the necessity to stimulate water users, through fiscal, economic, technical and legal measures and means to preserve the quality of

water, specially in water scarce areas. Drainage and wastewater re-utilization plans are also vital to ensure a harmonic development of the irrigated agriculture, grasslands, forests and other activities. Moreover, as surface water pollution is spreading across all North African countries they should design plans to prevent and control underground pollution.

51. Finally, as change is driven by people, and most of them are still rural in North Africa, the local, national and international institutions should encourage their *training and support logistically and technically* for the achievement of the two main objectives of a sound water policy, namely: (1) to make an optimal use of all water resources and (2) ensure by all means its long term quality and sustainability.

VI Specific conclusion

52. Due to the increasing water consumption and the difficulty to get new freshwater resources in the short term, it is suggested that one should carry out a sub-regional study on : *The present status of wastewater production, treatment and prospects for its reutilization in agriculture in the sub-region, beyond the 2000.* This could be the starting point for launching a long term sub-regional programme on wastewater re-utilization (SPWR) which might be composed of the three following sub-programmes: (1) data and information updating ; (2) technology and research dissemination and (3) fellowships for upgrading the scientific and economic knowledge on wastewater recycling for agriculture. The NA-SRDC could contribute with its intellectual and organizational capacities towards this end.

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ANNEX I

ANNEX II

MATRIX B

Policy Mechanisms for a new Water Management Policy in North Africa

Policy Mechanisms	Objectives
❖ Local, sub-regional and regional commissions, boards and committees for common water resources planning and management;	*Regular meetings, preparation of priority studies, programmes and projects, field visits to common watersheds, storage and distribution facilities.*
❖ Regional fund for common water resources assessment, monitoring and water quality;	*Creation of a regional fund to update data and information on water availability and consumption using Geographical Information Systems (GIS)*;
❖ National programmes for integrated Water management and distribution (e.g. drinking, irrigation, industrial and watershed management);	*Strengthening co-ordination on water management/utilization programmes, projects and activities through watershed units.*
❖ Fiscal, financial and technical support to water saving projects;	*Setting up fiscal and economic advantages for projects and activities saving 5,10,20% of water per year in their current activities and for the new ones.*
❖ Financial and import facilities to farmers adopting new agricultural irrigation systems and practices	*Improving access of farmers to credit for renewing irrigation equipment; premium for shifting from gravity to new irrigation techniques, advantages for the construction of water storage facilities and to services (e.g. irrigation, fertigation, chemigation, desalination and drainage) and*
❖ Institutional support to imports And research of equipment and know how aiming at water recycling and re-utilization.	*Reduction of local taxes to imports of agricultural and industrial equipment, systems, technologies and know how for wastewater re-utilization, specially for biological wastewater treatments and desalination (e.g. solar stills)..*

Source: NA-SRDC, Tangier, Morocco, September 1999.

ANNEX III

MATRIX C

Technologies for water management

Generic Systems	Specific Technology
Water resources assessment	• Satellite remote sensing and interpretation of imagery • Hardware and software for airborne digital and remote sensing techniques • Field equipment for hydrological and climatic control • Isotope techniques for ground water control and • Geographical Information System (GIS)
Harvesting	• Small dams and mini ponds • Household roof collection • Pumps , windmills and shadoofs • Reforestation in watersheds behind dams • Recharge of aquifers
Distribution	• Leakage and maintenance • Lining of irrigation canals • Cleaning up of canals and drainage
Domestic Water	• Leakage in taps and piping • Low flush toilets • Flow restrictors • Kitchen water wastes
Irrigation	• Drip and micro-irrigation • Improvement of drainage • Traditional forms of water distribution
Waste water treatment	• Biological ponds (methods MPIP and RZM) • Low-cost plants
Desalination	• Household units • Brackish water plants

Source: NA-SRDC Water Situation in North Africa: Issues and Challenges in the 21st Century, Six Annual Meeting of the Interagency Group for Water in Africa (IGWA), Rabat, Morocco, 26-28 May 1998.

ANNEX IV

MATRIX D
Support to Individual and Community Effort towards Water sustainability in North Africa

General activity	Water Supply	Water Consumption
Training in water economies	Upgrading the knowledge for the design, construction and maintenance of efficient water reservoirs and low-cost treatment plants; reduction of water leakage and on costs/benefits analysis (CBA) of water management projects.	Reduction of water consumption, pollution and wastage at home, industry and in agriculture (e.g. installation of water meters, drainage, water recycling and on new irrigation systems including automation).
Extension of techniques and equipment to keep the best water quality standards	Equipment, know how and manuals for monitoring water's quality standards of potable, treated wastewater for irrigation and underground.	Tools and systems to ensure water quality for drinking, agriculture and industry (e.g. filtration, flocculation, chlorinating and biological purification).
Diffusion of legal, economical, fiscal and other mechanisms towards water sustainability in North Africa.	Local, national and international norms, mechanisms, regulations and means to increase water supply in North Africa.	Community, local, regional meetings and other activities to disseminate information on water sustainability.

Source: NA-SRDC, Tangier, Morocco, September 1999