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in

Lamaddalena N. (ed.), Bogliotti C. (ed.), Todorovic M. (ed.), Scardigno A. (ed.).
Water saving in Mediterranean agriculture and future research needs [Vol. 2]

Bari : CIHEAM
Options Méditerranéennes : Série B. Etudes et Recherches; n. 56 Vol.II

2007
pages 33-43

USE OF NON CONVENTIONAL WATER RESOURCES IN IRRIGATED AGRICULTURE

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SUMMARY Food security coupled with water scarcity is a cause of serious concern in almost all developing countries. The present over-use and degradation of water resources and growing competition of non-agricultural water users are expected to influence the cost and availability of water for food production. This situation is the root cause to spur special interest in non-conventional water use as an additional water source, particularly in the irrigated agriculture. However, the use of non-conventional water has a multidisciplinary nature with inter-linkage with environment, health, industry, agriculture, and water resource policy. In this regard, significant challenges still remain in the areas of technological, managerial and policy innovation and adaptation, human resources development, information transfer and social and environmental considerations. Sustainability and success of non conventional water uses depends on sound implementation and management. During the planning and management phases, the ecological, social and economic aspects should be considered in order to assure social and economic viability of any reuse activities. Further research is necessary to develop general guide lines, setting up a universal strategy and use systemic indicators for assessing, monitoring and evaluating the sustainability of nonconventional water reuse in the Mediterranean region. For sustainable and safe use of non conventional water, it is needed to provide the decision maker and the users with a concrete and very clear answer on how agriculture can make use of non conventional water resources in a way that is technically sound, economically viable and environmentally non- degrading.

Key Words: Non conventional water, Drainage water , Water Scarcity , Waste water **.**

INTRODUCTION

Food security coupled with water security of many of the developing nations is a cause of serious concern. The natural resources base of land and fresh water per capita has been decreasing with the fast rate of rise of population. The increased demand of fresh water resources is a global concern, but for the Mediterranean region and particularly the arid and semi arid region, it becomes a serious challenge. Accelerated urbanization and industrialization in the Mediterranean are now opposing extreme pressure on the existing limited and vulnerable water resources. Meanwhile, agriculture activities are also geared to feed the ever-increasing population. These ambitious development activities tend to siphon off more and more water. Thus, water demand often exceeds reliable and exploitable water resources. Such existing imbalance between the limited water supply and the steadily increasing demand leads to serious conflicts over water and to the degradation of water quality in most of the countries of the region. Traditionally, the response to water shortage in the region has been addressed through developing more supplies. However, such traditional approach will be no longer adequate in the future.

In the developing countries of the region agriculture sector is receiving the lion share of available water resources, about 80 percent. But the water use efficiency on the farm level is about 50 percent with losses around 50 percent. Such situation clearly emphasizes the central importance of demand management, particularly in the agriculture sector. Improving water use efficiency and increasing water productivity in the irrigation field means greater potentiality for water saving, this being the central issue to producing more food, fighting poverty, reducing competition for water and ensuring that there is enough water for the nature. Indeed, there is a high potentiality for water saving in the agricultural sector in the region. But, this will not be enough to overcome the prevailing water scarcity and to provide the increasing population with their food and fibre demands.

In the region, it is now a must to look for additional water resources that could be sustainable used in the agriculture sector. It is out of question that water availability for irrigation could be enhanced through the scientifically based use of non-conventional water.

The uses of various types of non-conventional waters (urban waste waters, industrial waste waters, brackish waters / saline waters, and drainage waters) have been intensified in most countries in the region. However, even though its re-use and recycling can appear like a simple and appropriate technology, in reality it is a complex one. The use of non-conventional water has a multidisciplinary nature with inter-linkage with environment, health, industry, agriculture, and water resource policy.

To attain full utilization of this vital water source, one has to find sound solutions to several obstacles still hampering the sustainable and safe use and recycle. In this regard, significant challenges still remain in the areas of technological, managerial and policy innovation and adaptation, human resources development, information transfer and social and environmental considerations. Achieving the goals needs the using of tools available today from the scientific, technological, legal, political and economic framework. This required concerted efforts supported by national institutions and both regional and international organizations

TECHNICAL- TECHNOLOGICAL DEVELOPMENTS OF NON-CONVENTIONAL WATER USE

Human use of fresh water has increased more than 35 times over the past three centuries. The experts predict a severe shortage of fresh water in the 21st century. More than 230 million people living in some 26 countries, 11 of them in Africa and 9 in the near east will suffer from water scarcity (less than 1000 m^3 per person per year).

In the Mediterranean region, particularly the southern and eastern countries, it is quite apparent that some of those countries are now already under severe water stress, and within the next twenty years, it is expected that most of the countries of the region will be under absolute water stress. The available water per capita per year will amount to few hundreds cubic meters (Fig. 1).

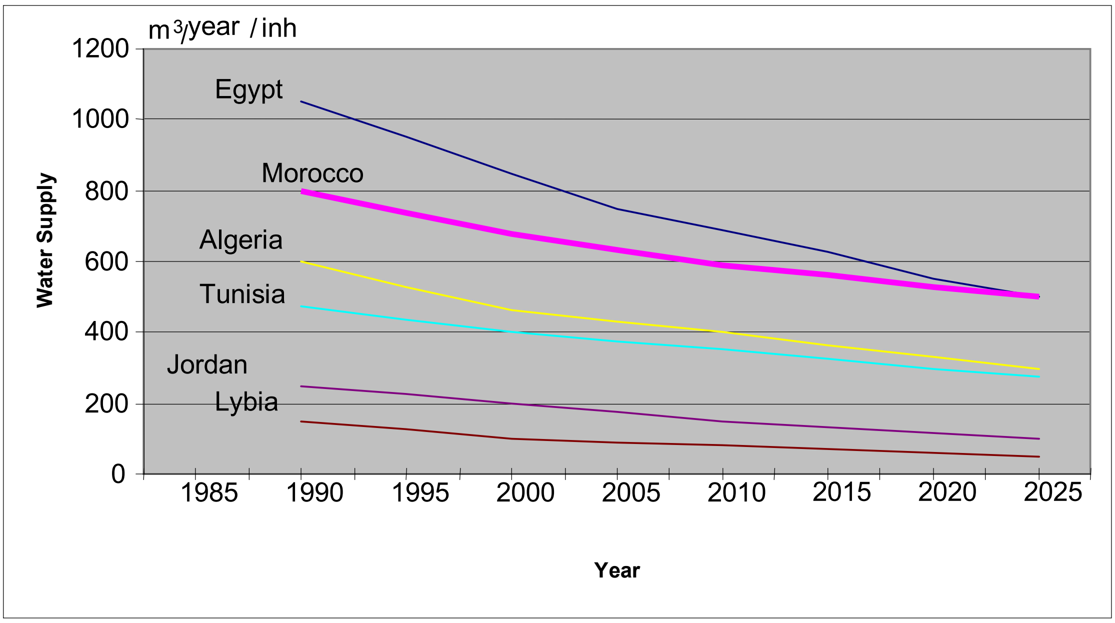

Fig. 1. Available Fresh Water Per Capita per Year for some Arab countries

For the Mediterranean countries, the non conventional water resources of varying quality including saline water, drainage water and waste water with varying qualities could play an effective role in mitigating water scarcity, particularly in the irrigation sectors. This is not only due to the opportunity they could provide to increase the irrigated area and food production, but, also to the fact that they are a renewable resource and are subjected to continuous increments with time, besides being present in relatively big quantities as high as nearly 10 percent of the whole available freshwater in the region. However, the full use of this source for irrigation requires that certain measures be carefully considered to guarantee its save and sustainable use. The complex interaction of water, soil and crop in relation to water quality must be well understood. The technology and concepts of using and managing the non-conventional water in irrigation must be available and well developed for sustainable production on permanent economic basis. It requires the development of new scientific practices, new guidelines for use that cope with the prevailing local conditions and new strategies that facilitate its use on a relatively large scale. Aware of these complex inter-linkages, the sustainable use and achievements of maximum benefits of non conventional water resources, as a freshwater saving practice still require further development including planning, investigation, monitoring and management.

Over the last five decades and more, many research scientists, organizations, institutions and authorities have advocated the concept of using saline water for irrigation to increase food production. Considerable amounts of such water are available in various countries of the regions, but, they are still marginally practiced in irrigation, although they could be successfully used to grow crops without long term hazardous consequences to crops or soils by applying improved management practice.

Globally, there are around 43 countries, mostly from arid and semi arid regions, are using saline water for irrigation. The southern Mediterranean countries are practicing saline water in irrigation purely by necessity rather than by choice. There are successful examples in using non-conventional water in Irrigation in the Mediterranean regions:

In Egypt, about 5 thousand millions m^3 of saline drainage water is used for irrigating about 405,000 ha of land, *Table 1*. About 75 percent of the drainage water discharged into the sea has a salinity of less than 3,000 mg/l. The policy of the Government of Egypt is to use drainage water directly for irrigation if its salinity is less than 700 mg/l; to mix it 1:1 with Nile water (180 to 250 mg/l) if the concentration is 700 to 1500 mg/l; or 1:2 or 1:3 with Nile water if its concentration is 1,500 to 3,000 mg/l; and to avoid reuse if the salinity of the drainage water exceeds 3,000 mg/l. The annual average volume of available drainage water is about 14 thousand million m^3. The policy of the ministry of water resources and irrigation is to make full use of each drop of drainage water by the year 2017, *Table 2*. Some large scales projects are currently executed depending on the drainage water as the main source for irrigation.

Table 1. Reuse of Drainage Water in the Nile Delta during 1995/2003

Year	***Eastern Delta***		***Middle Delta***		***Western Delta***		***Total Reuse***	
	Q	***EC***	***Q***	***EC***	***Q***	***EC***	***Q***	***EC***
1995_96	1745.9	1.89	1814.6	1.79	705.9	1.42	4266.3	1.77
1996_97	1843.2	1.94	1947.9	1.85	642.5	1.31	4433.6	1.81
1997_98	1736.3	1.66	1801.3	1.77	632.4	1.35	4170.1	1.66
1998_99	2126.9	1.48	2168.3	1.52	738.3	1.07	5033.5	1.43
1999_00	1661.8	1.64	1891.4	1.64	1183.6	1.97	4736.8	1.72
2000_01	1830.2	1.57	1958.8	1.76	1058.3	1.92	4847.3	1.72
2001_02	2026.5	1.74	2199.8	1.67	1062.8	1.76	5289.1	1.71
2002_03	2329.3	2.00	2082.4	1.90	875.6	1.76	5287.4	1.92

Q: Drainage water Discharge (million m^3 / month)

EC: Drainage water salinity (ds / m)

Table 2. Maximum Possible drainage water reuse in Nile Delta (million m^3)

Region	Available Drainage Water	Currently Reused	Possible to be reused
Eastern Delta	4083.65	2049.89	1519.02
Middle Delta	5849.14	2007.73	2881.06
Western Delta	3819.15	1123.56	2384.33
Total	13751.94	5181.18	6784.41

The techniques and technologies used in drainage practices are under continuous development on a well established research base. The development and verification of design drainage criteria for local conditions are always a concern with the progress of drainage projects to cover new areas. Pilot areas are designed and implemented for meeting specific changes in the hydrological, soil or cropping conditions. A dynamic monitoring programme to validate the accuracy of the used criteria is essential. A modern computerized data base was established to store all relevant collected data and information. The introduction of an integrated water management approach is the most reliable procedure for water resources management. Much research work has been and still being carried out to improve drainage implementation including testing and evaluation of new materials and machinery and the adoption of new techniques to cope with the local conditions. Equally, emphasis is given to determine the effects of the re-use of drainage water in irrigation on soils and their productivity for a range of crops. The environmental impacts are carefully monitored and investigated. Health and ecological measures are of concern. Social aspects, particularly those related to women as important users of water are progressively coming to the centre of attention.

Egypt has a policy to use brackish and saline ground water with EC up to 4.5 ds/m and reuse of drainage ground water with EC 6ds/m with SAR values of 10 to 15 in blending or cyclic mode with good quality water. The reuse of treated waste water in Egypt started in 1915 in the eastern desert north east of Cairo. An area of 2500 acres is still under irrigation with waste water, which receives only primary treatment. With the scarcity of water resources, it is planned to irrigate 150 thousands acres with treated waste water. All urban waste water projects include facilities for treatment up to the tertiary level and allow reuse for irrigation. It is estimated that present amount of waste water from major cities and urban area is about 5 billions m^3/year. Currently, detailed criteria for waste water reuse in agriculture are under review and preparation. Several pilot programs have started and under continuous monitoring for some refinements.

In Morocco, there are approximately 7.7 millions hectare of arable lands, of which one million hectare is actually irrigated and the rest is under rain fed agriculture. However, poor soils physical conditions, soil salinity, water quality and water stress are considered major limitation for agriculture development. Rational use of irrigation water, by adopting adequate drip irrigation for high value cash crops and the use of supplemental irrigation is widely recommended to stabilize and to improve crop yield. However, with the scarcity of high quality water resources, the use of non- conventional water is not only a necessity, but also an inevitable option to alleviate the water crisis. The potential of waste water is shown in Fig.2.

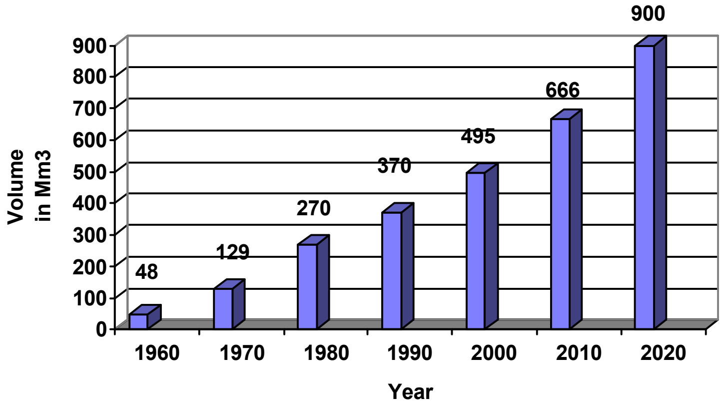

Fig. 2. The potential of waste water in Morocco

In Agadir region, sand infiltration system is used to treat its waste water to be reused in agriculture and landscaping. This technology generates high nitrate concentration in the effluent. To face the salinity problem and to diminish its hazards negative effect on both soil productivity and crop production, an ample research programme was conducted to establish an appropriate land, water and crop management under saline irrigation practices. The contribution of the farmers in facing the salinity problem, through improving the local technologies, cannot be denied.

The knowledge and the experience gained from the research work indicated that the cultivars, the growing media, the climatic conditions and the salt level of irrigation all affect the final yield. The experience of Morocco on the use of saline water as an irrigation source clearly indicates the high potentiality in its use if proper management is developed for specific crops under specific climatic and soil conditions.

The learned lessons of this experience is that salinity problems could be faced and sustainable solution could be attained by improving the local technologies the farmers are using by introducing simple techniques such as stage of planting, selection of cultivars, application of organic manure, modified soil media. Such simple techniques can have a greater impact on the marketable yield and quality of the product.

In Algeria, the possibilities of using drainage water with a relatively high salt concentration level (9 ds/m), SAR value (15.7) and PH of 8 were experimented for the development of salt lands in Biskard area, southeast of Algeria. The drainage water is an important source for the irrigation of palm trees due to its presence in relatively high quantities exceeding 3 millions m^3/ year. The experience demonstrated the successful use of drainage water in irrigation through an appropriate irrigation and leaching scheduling, the addition of soil amendments to avoid soil sodicity, the selection of the palm trees varieties as well as the irrigation method. The availability of substantial quantities of drainage water offers the best guarantee for increasing the irrigated area in south of Algeria.

In Tunisia, the water resources is about 4.5 billion m^3, of which 2.7 billion m^3 of surface water and 1.8 billion m^3 of ground water. It is expected that by year 2020, the domestic and industrial demand will increase and the available water for agriculture will decrease. In order to overcome this problem and provide the different sectors with their needs, management, conservation of existing water resources and development of non-conventional water source have been developed in the field of water planning and management.

Water and soil salinity is a major constraint for Tunisian agriculture development. Salinity problems and saline irrigation practices and management have been intensively investigated since 1970. The experience gained helped in improving the agricultural productivity under saline environment and setting up the needed guide lines and management techniques to be practiced for save and sustainable use of saline water in irrigation. The saline Medjerda river water (annual average EC of 3.0 ds/m) has been used to irrigate date palm, sorghum, barley, alfalfa, rye grass and artichoke. The soils are calcareous (up to 35% $CaCO3$) heavy clays, which crack when dry.

Waste water reuse is now an essential component of the Tunisian national water resources strategies and an integral part of overall environmental pollution control and water management strategy. The waste water reuse policy was launched at the beginning of the 1980. Of the 237 million m^3 of waste water discharged annually, 123 million m^3 are treated in 52 treatment plants. Within the next ten years, this amount is expected to increase by 50%. The policy aims at extending waste water treatment to all urban areas. The reclaimed waste water is used for irrigation, tourist areas, to irrigate golf fields and hotel parks. Also, it is used in groundwater recharge and industry.

In Greece, water resources are limited temporally and spatially. The total water consumption, in 1990, was 5500 millions m^3 / year. It increases by more than 3 % annually. The major water use is irrigation with a percentage of 85 %, while domestic use is 11 % and industrial use is about 4 %. The continued increase of domestic and irrigation water demand can only be met through an integrated water management scheme that includes the use of all sources including non-conventional waters. Imbalance of water demand and water supply is often experienced, especially in the coastal and south eastern regions, due to temporal and spatial variations of the precipitation, the increased water demand during the summer months, and the difficulty of transporting water due to the mountainous terrain.

Today, there is 350 municipal waste treatment plants can serve about 65 % of the country population. By reusing the effluent of the existing plants, the reused water, particularly for irrigation of agricultural land, can be increased by 3.2% of the current total use of freshwater. Thus, the freshwater that is currently used for irrigation can be saved. This percentage will be substantially increased as the number of municipal waste treatment plants increase.

In Cyprus, the water scarcity together with the high cost associated with collecting and using the limited surface rain water for irrigation, has become real constraints. Therefore, alternative water resources, innovation approaches and new technologies are sought to help solving the problem. Development of more efficient irrigation methods to save water by better utilization, irrigation with saline water and reclamation and use of treated municipal waste water, are promising alternative and innovative approaches. By irrigating with modern irrigation systems, crops are grown successfully and higher yield is obtained with more saline waters. Experimental data and experience gained suggested that with proper irrigation and fertilization management, some problems associated with salinity can be alleviated and occasionally overcome by recurring to crops that are semi- tolerant or tolerant to salinity. The municipal treated effluent is considered as integrated part of the water resources. It is assumed that 6% of the cultivated land could be irrigated with municipal treated effluent.

In Jordan, irrigated agriculture consumes 70% of the water available, competing with the rapid growth of urban and industrial demand. Therefore, saline water is a highly valuable source of water for irrigation. A major challenge to agriculture is the optimal utilization of brackish water and treated waste water without causing adverse effects to the environment and at the same time reducing the amount of fresh water consumption for food production. It is expected that within the next twenty years, the proportion of non- conventional water will be more than 30% of the total available water resources. The amount of waste water reused in agriculture in the Jordan valley increased from 20 million m^3 in 1990 to 42 million m^3 in 2002. It was projected that the reuse of treated waste water will reach 60 million m^3 in 2002. Research findings regarding crop production indicated that for sweet corn, irrigation with saline water of less than 3.5 ds/m has not caused significant reduction in yield. The tolerance threshold of soil salinity for relative yield of union varies from 2.43 to 3.6 ds/m. The drainage water is used for irrigating garlic and onion with careful management.

Brackish water with salinities ranging between 3-11 ds/m is used in the southern Jordan valley. The experience gained indicated that yield production will differ from to another according to crop salt tolerance degree. A limiting factor for using brackish water in irrigation is the salt accumulation in the soil. Therefore, available fresh water for leaching is required. Another solution is the alternation irrigation, fresh water is used during the sensitive germination and emergence stages until the crop stand is established, then, irrigation is practiced with saline water.

In Syria, non-conventional water resources are restricted to wastewater (drainage water, wastewater). Agricultural sector is the largest consumer of conventional and non-conventional water resources. Wastewater amount is about1.2 billion m^3/year and drainage water is about 1.536 billion m^3/year. About 29.2% of wastewater is treated, 34.6% is used without treatment, and 36.2% is lost by discharge to water bodies and valleys. There is a need for establishing treatment plants at small community level with population (5000 – 10000) to make use of water randomly lost and contaminating the environment.

There is a lack of crucial local criteria for wastewater use in agriculture. The existing criteria are merely indicators and preliminary guidelines that can be developed through research activities. There is a number of environmental, health and economic problems as a result of improper and irrational use of wastewater are already exist. The essential pre-requisites for the development of safe non-conventional water use lie in the development of institutional and legislative aspects together with training, information and others.

There is a need to implement some pilot projects for the optimal utilization of conventional water and giving top priority to the most critical and urgent issues. Also, Supporting scientific and research centers and institutions for conducting integrated and applied water research and studies is required, since these centers and institutions are an integral part of the institutional structures responsible for water resource development and utilization. Training of technical and scientific staff and giving special consideration to skill upgrading, performance promotion and capacity improvement.

In Lebanon, the total available water resources is about 2000 millions m^3. The total need, in 2020, is estimated as 2450 millions m^3. This imbalance will force the country to search for new non-conventional water resources. Waste water is the only suitable source for additional water due to economic constraint. A master plan for secondary waste water treatment is already elaborated for all Lebanon and Funded at 70.47 % of total Cost. Between 2005 and 2007, constructed plants are previewed to serve, until 2015, 88% of the total Lebanese population. The possible collected waste water for treatment, in 2020 is about 250 millions m^3.

In Turkey, The total available water resources are about 108.66 billion m^3, (surface water is about 95 billion m^3 and ground water potential is about 13.66 billion m3). The irrigable area is about 4.3 millions hectare (16.6 % of the total irrigable land). It is estimated that, only 8.5 millions hectare can be irrigated with the present water resources. When all irrigable lands are opened to irrigation, roughly 200 km3 more water is going to be required. Therefore, the solution was to apply the deficit irrigation programmes including supplemental irrigation and to manage the irrigation systems according to deficit irrigation approach and to find the new water resources. Unconventional water such as brackish water (treated waste water, drainage water), shallow ground water and saline water must be used in near future.

The estimated waste water, urban and industrial in 2001, is about 6.7 billions m^3. The collected water looks like to complete the little part of the deficiency of water resources. The diluted sea water seems to be the only way in future. Some experiments have been carried out using saline water for irrigation. The results from experiments showed that saline water decreases the yield and quality of all the plants. However, the data and information regarding the use of unconventional water in irrigation, for a lot of crops grown in the different region of Turkey, were obtained and the studies are being continued.

SOCIOECONOMIC, ENVIRONMENTAL, INSTITUTIONAL AND POLITICAL ASPECTS FOR NON-CONVENTIONAL WATER USE

In most of the Mediterranean countries, the highest portion of the water resources is allocated to the agriculture, mainly being for irrigation. Non conventional water could relieve as a substitute for freshwater in irrigation. However, implementation of non-conventional water in irrigation is still a big challenge due to the complexity of the systems. Planning and management of agricultural reuse operations need to take into account the socio-economic, institutional, organizational, legal, regulatory, environmental and technical aspects.

Reusing agricultural drainage water implies an increase of global irrigation efficiency, but also entails the degradation of the water quality, which affects the soil properties, reduces crop yield and pollutes the flows returned to the hydrological ecosystem. Also, Reuse of treated and untreated waste water in irrigation has a high positive potential to environmental relief and social and economic development. But, reusing waste water without good planning can cause soil quality problems in the long run, due to building up salinity and heavy metals. It also results in health risk due to the exposure of farmers, consumers and neighbouring communities to infectious diseases. Therefore, the various factors of risk must be converted into actions of attenuation and regulations associated to good practices. The code of good practices of reuse, all as standards of quality, must be developed and adapted to take into account the specific local conditions.

Agriculture use of non conventional water is more easily accepted and implemented in water-short areas where irrigation is already practiced. However, skills development, appropriate institutions and strong extension services are required. Participatory bottom up approach is a cornerstone issue governing success and/or failure in any reuse irrigation project. Water user associations should be involved and associated in the planning and management process to ensure the success of the project. The farmers usually succeed in developing appropriate strategies to make the best use of the available water in order to maximize the agriculture production.

Finally, sustainability and success of non conventional water uses depends on sound implementation and management. Poor planning and management might bring high health and environmental risks, and undesired economic and social results. During the planning and management phases, the ecological, social and economic aspects should be considered in order to assure social and economic viability of any reuse activities.

GAPS AND ACHIEVEMENTS

Non conventional water is well recognized, in the Mediterranean region, as an alternative source of irrigation water. Many researchers and scientific institutions have intensively investigated the use of non conventional water in irrigation and the way to practice and manage it. The information, the experiences globally gained and the findings of research, all resulted in a notable development on the use of non conventional water for irrigation and demonstrated its high potentiality for use.

In Italy, Bari institute and many other research institutes and universities are giving the non conventional water resources practices and management the priority in their research programmes. Bari institute has intensive research programme on the use of saline water for irrigation. The experience gained demonstrates that saline water can be used effectively for the production of selected crops under the right conditions.

In Egypt, intensive research programme together with field experiments have been carried out for reusing agriculture drainage water. Monitoring and evaluation program are under continuous developments on a well- established research base. Guidelines for optimal use of drainage water and setting up strategies for reuse, under the Egyptian conditions have been delivered.

In Morocco and Tunisia, intensive research programme for the use of treated waste water in irrigation. The finding of the program demonstrates the suitability of reuse of treated waste water in irrigation when appropriate practices are adopted.

In fact, Important and useful research on the potentials and limitations and hazards of the use of non conventional water in irrigation were undertaken in relative isolation and no mechanism existed for coordinating the research work and to utilize effectively the research findings. There is no universal approach to achieve salinity control in irrigated agriculture; it varies from country to another. It depends on economic, climatic, social and hydro-geological conditions.

The further research will have to give more attention in the following areas:

Defining policy and strategy on the use of non conventional water in irrigation. To arrive at these policy and strategy, monitoring programs are required on both water quantities and qualities, as well as on soils properties;

Integrated management of water of different qualities at farm level, irrigation system and drainage basins with the explicit goals of increasing agriculture productivity, achieving optimal efficiency of water use, preventing on- site and off- site degradation and pollution, and sustaining long term production potential of land and water resources;

Developing and use of mathematical models to relate crop yield to irrigation management under saline conditions so that empirical models can be reliably applied under a wide variety of field conditions;

The trade-off between provision of full drainage and drainage volume reduction;

The incorporation of salinity into groundwater flow models to predict the development of not only water logging but also of soil water salinity. Regional agro-hydro-salinity models should be of immense value in planning appropriate water management strategies;

Activating the role of policies and institutions in creating demand for technology to ensure the sustainability of irrigated agriculture in saline environment;

Conducting a comprehensive and coordinated research on potentials and hazards of the use of non conventional water for irrigation;

Establishing working relationship on national, regional and international institutions dealing with the reuse of non conventional water through the formulation of networks;

Conducting and fostering a comprehensive multi-disciplinary basic and applied research programme in coordinating fashion on the sustainable use of non conventional water in irrigation and related problems and obstacles;

Providing facilities for research workers and improving the Institutional Capacity Building;

Incorporation of environmental, Institutional, political and social and economic concerns.

Further research is necessary to develop general guide lines, setting up a universal strategy and use systemic indicators for assessing, monitoring and evaluating the sustainability of nonconventional water reuse in the Mediterranean region.

IDENTIFIED PRIORITIES

Non conventional water is a potential source for additional water to be used in irrigation. But, in the long run, it could seriously affect the crop production; deteriorate the soil productivity and creating serious environmental problems and health risks. Therefore, during the reuse practices a monitoring program has to be apply, to identify areas with environmental and health risk as a result of low water quality. It is the first step towards identifying priority actions that will reduce the health risks. In some areas short term action may be required to change the practices mechanism, but always the longer term actions that will reduce the pollution and enhance the reuse potential are still required. The short term actions can be separated into pollution control actions and protection actions. Pollution control actions are measures to reduce the non conventional water in areas that are already polluted. Protection measures are measures to prevent vulnerable areas to be polluted in the future.

In general, to enhance the reuse potential the various factors of risk must be converted to actions of attention in the following fields:

Planning

- Strengthen the participation of the beneficiaries
- Monitoring the quality of non conventional water and reinforce existing regulation

Economic Aspects

- Establish cost-beneficiate analysis
- Insure that reuse policy is profitable to the farmers

Organizational Aspects

- Encourage cooperation between different institutions
- Establish services contacts between the manufacturing institution and local expertise institution

Regulation Aspects

- Establish norms and standards for the reuse of non conventional water
- Limit the parameters to be monitored

Technical and agronomical Aspects

- Encourage the drip irrigation system
- Optimize the recycling of the nutrient elements included in the water
- Develop a strategy for the storage of wastewater

Sanitary Aspects

- Develop analytical methods for monitoring persistent contaminants
- Improve research techniques for parasites and virus
- Develop a methodology and monitoring evaluation system of the impact of the reuse on the soil, crops and ground water.

Awareness arising

- Establish awareness and education programs for farmers, engineers and technicians
- Develop handouts on different aspects of the reuse of non conventional water.

RECOMMENDATIONS

The continued increase of domestic and irrigation water demand can only be met through an integrated water management scheme that includes the use of all sources of water including non-conventional waters.

Non conventional water such as (brackish water, treated waste water, drainage water, shallow ground water and saline water) is a potential source in several countries and there is a wide experience in the Mediterranean region for using it in irrigation as fresh water saving practices.

The complex interaction of water, soil, plant, and climate condition, in relation to water quality should be considered when using non conventional water in irrigation.

Water management strategies should establish when using non conventional water to minimize the negative impact on environment and soil productivities. The management strategy should include efficient use of water (not excessive), sustainable and save use of water, suitable irrigation system and suitable crop (salt tolerant level matches the salinity level). Efficient water use would minimize drainage volume and rising water tables which is an environmental problem

Monitoring and evaluation programme should be carried out for water quantities and qualities, as well as soil's salinity.

Socio- economic, institutional, political, ecological, health and environmental aspects are to be taken into consideration by decision- makers when considering using non conventional water resources for irrigation.

Cost recovery is an essential requisite to ensure the economic sustainability of the use of non-conventional resource.

Supporting scientific and research centres and institutions for conducting integrated and applied water research and studies since these centres and institutions are an integral part of the institutional structures responsible for water resource development and utilization

Encouraging the establishment of networks between scientific and research centres on using non conventional water.

Farmer's participation in the planning and management is a key for the safe use of non conventional water in irrigation. Involvement of the farmers in the exercise will close the knowledge gap between farmers and researchers.

Further research is needed on integrated water, crop and land resources management to safely and sustainable use of non conventional water. Use of mathematical Models should be encouraged to predict long term salinity impact on soil, plants and the environment.

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