Mediterranean Climate Changes: Water-Related Disasters and Needed Measures

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Abstract

For most Mediterranean countries, a few water policies and decision-making frameworks have fully considered the implications of climate change. This is particularly true in the developing countries, which face the greatest potential financial, human and ecological impacts from climate change but have the weakest capacity to cope with its effects, besides being the ones of highly water stressed conditions.

The countries of the mediterranean region, and the developing ones in particular, should be encouraged and supported to set feasible and quantifiable targets for reducing water-related risks. This will require appropriate legislative and financial support to conduct vulnerability assessments on water-related disasters as a pre-step to establish strategies for implementing preventive disaster management measures.

Résumé

Dans la plupart des pays méditerranéens, les politiques et les cadres décisionnels qui ont pleinement pris en compte les implications du changement climatique sont peu nombreux. Ceci est vrai surtout dans les pays en voie de développement qui sont sujets aux plus forts impacts financiers, humains et écologiques potentiels du changement climatique mais qui sont quand même ceux qui ont la moindre capacité d'y faire face et, à la fois, les plus exposés aux conditions de déficit hydrique.

Les pays du pourtour méditerranéen, et les pays en développement en particulier, ont besoin d'encouragement et d'aide pour la mise au point d'objectifs réalisables et quantifiables permettant de réduire les risques liés à l'eau, ce qui demandera un appui législatif et financier pour faire des évaluations de vulnérabilité vis-à-vis des désastres hydriques en tant que phase préliminaire pour mettre au point des stratégies visant à des mesures préventives de gestion des désastres.

1. Introduction

The climate change is increasing the frequency and intensity of hydro-meteorological hazards resulting from internal dynamics in the Earth's natural system and the adverse effects of human activities (such as emission of greenhouse gases) on this system. For more than one decade, the climate change, its causes and consequences have been playing an increasingly important role in the world-environmental agenda, thus becoming one of the major issues covered by the scientific and political communities.

The climate change resulting from human impacts is expected to have additional effects on human lives, societies and the environment in the future, through changes in pattern, frequency and intensity of rainfall, an increase in temperature and a rise in sea level due to iceberg melt in the polar regions. According to the intergovernmental panel on climate change (IPCC, 2001), between 1990 and 2100, average surface temperature will increase by 1.4 – 4.8 degrees Celsius, the average sea level will rise by 9 – 88 centimeters, and the average annual number of people flooded by coastal storm surges will increase several folds by the year 2080.

Global warming and associated climate change along with uncontrolled urbanisation, deforestation and environmental degradation will further increase the frequency and intensity of water-related disasters (floods, droughts, tropical storms); those are, nowadays, a huge challenge for sustainable development of our society not only at local and regional but also at global scale.

The international community has recognised the climate change as a serious problem at global scale already by the end of the eighties which resulted in the United Nations Framework Convention on Climate Change signed by 154 states at Rio de Janeiro in 1992. This Convention entered into force on 21 March 1994 and represents the foundation of the global forces to combat the main causes of climate change and mitigate its adverse effects on human society.

Nowadays, at the beginning of the new Century, the management of water-related risks is receiving much more coverage and the attention of many international and regional organisations. This was clearly demonstrated at the 2nd World Water Forum in The Hague, March 2000, where the Ministerial conference declared "managing risks to be one of the key challenges". One year after (2001), the International Conference of Freshwater in Bonn, identified managing risks to cope with variability and climate change. Focusing on this subject, the World Summit on Sustainable Development, took place in Johannesburg, 2002, where a plan of implementation was adopted. The summit recognised that "an integrated, multi-hazard, inclusive approach to address the vulnerability, risk assessment and disaster management is an essential element of a safer world in the

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21st Century" (United Nations, 2002). This trend has continued also in 2003 when the Dialogue on Water and Climate was one of the major topics treated during the Third World Water Forum, held in Kyoto.

2. Drought, floods and flash floods

Regarding drought, there is no universal definition that precisely characterizes such a phenomena.

In general terms, it could be regarded as a deficiency of rainfall with respect to the normal, related to seasons or longer periods, insufficient to meet human and environment demand (activities and ecosystem functions).

However, although being a normal recurring feature of climate, occurring in virtually all-climatic regimes, drought could be severely affected by temperature, high winds and low relative humidity, thereby differing in terms of intensity, duration, locations and spatial extent (National Drought Mitigation Center, http://drought. unl. edu).

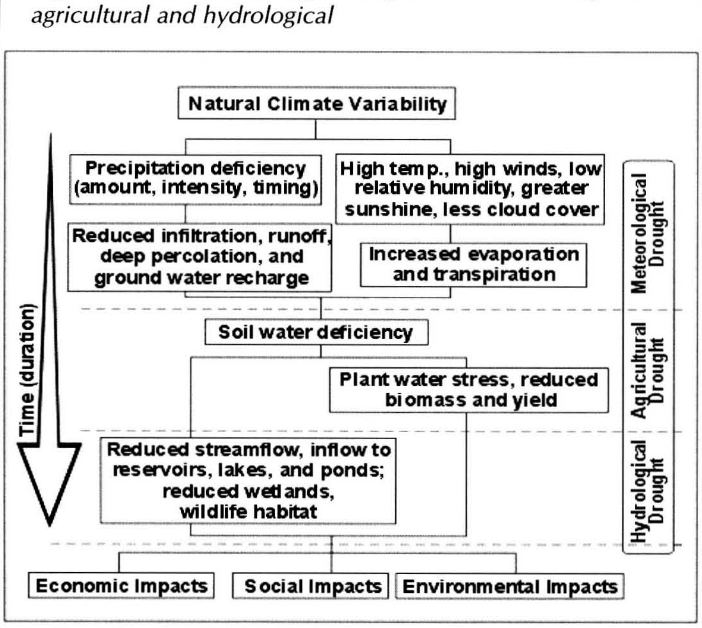
Operational definitions of drought categories taking into account the kinds of impacts on human activities and environment, categorise the drought as meteorological, agricultural and hydrological (Fig. 1).

The meteorological drought, specific to any region depending on atmospheric conditions, is defined on the basis of physical parameters (precipitation, wind, temperature, etc.).

The agricultural drought is defined on the basis of the crop water demand, therefore related to all the inherent factors of the targeted agricultural activity.

The hydrological drought, generally defined at the basin level, analyses the surface and underground flows and storages in terms of impacts on human activities and ecosystem functioning.

Fig. 1. *Definitions of drought categories as meteorological, agricultural and hydrological*



Source: www.drought.unl.edu/whatis/concept.htm

Though such definitions may be useful for practical purposes and for sake of simplicity, in real terms a clear-cut separation between each of them is not possible since they are strictly interrelated.

The three categories should be viewed in an integrated approach.

As a matter of fact, drought mitigation is an extremely complex issue. Drought is more than a simple physical phenomenon. Furthermore, its severity depends not only on the duration, intensity and spatial extension, but also on the human activities. That's why several monitoring drought indices have been proposed, differing in number and kind of the involved variables, structures, time and space scale (Palmer drought severity index, deciles, crop moisture index, surface water supply index, standardised precipitation index, etc.). The challenge is to make the most appropriate choice depending on the objective of the analysis and taking into consideration the input data availability and reliability.

As for floods, besides the occurrence of the "traditional" ones (significant rise of water level in a surface water body causing a general or temporary condition of partial or complete inundation of normally dry land areas), more frequent are becoming the so-called "flash floods".

They are floods of short duration with a relatively high peak discharge, usually as a result of intense rainfall localised over a relatively small area and occurring suddenly - usually within 6 hours from the rain event - with little lead time for warning, fast moving and generally violent, generally small in scale of area of impact (www.weather.com, 2002; Montz and Gruntfest, 2002).

Flash floods occur nearly anywhere, at any time and, depending on the global conditions and characteristics of the watershed, are often associated with other instability events, such as landslides and mudslides.

Their occurrence is expected to escalate in the future because of the combined action of both climate change and increasing human activities in flooding-prone areas.

The severity of the impacts of such floods is a matter of basin characteristics and land use.

3. Climate change analysis in the Mediterranean region

As a matter of fact, the analysis of droughts, floods and flash floods goes beyond the hydro-meteorological aspects, involving hydrology, topography, geo-lithology and morphology, land use, the ecosystem functioning (habitats and ecosystems being fully water-related), and many other aspects.

In the Mediterranean area, characterised by annual average rainfall ranging between <200 and 800 mm/year, the direct impacts of climate change consist in a raise of air temperature, a decreased level of precipitation, a modification of rainfall pattern in terms of intensity, timing and spatial distribution and a consequent increase of flooding disasters and periods of droughts.

It should be emphasised that alternate moist/humid and drought periods, already natural in the region, as in the case of Apulia region (southern Italy) (Fig. 2), could be aggravated in the future.

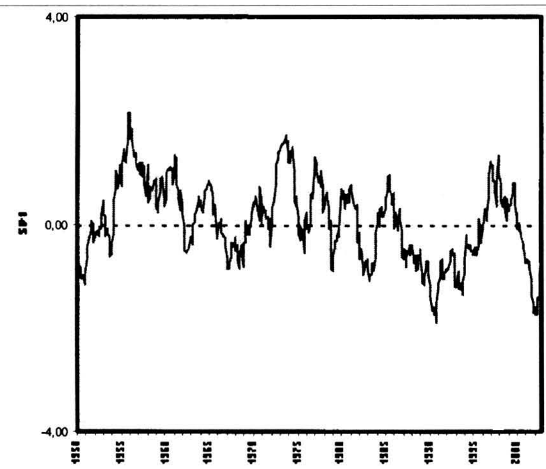
Furthermore, highly sporadic compact forms of rainfall (e.g. a few km^2), already so frequent, could worsen, with both huge quantities accumulated in much shorter time (e.g. 1-day or minus), and larger inter-annual variability.

Recently, Todorovic' and Steduto (2001) have analyzed the trend of the mean temporal and spatial variation of weather variables in the Apulia Region (Southern Italy) and compared the climatic water balance (difference between precipitation and evapotranspiration) throughout four decades, from 1951-1960 to 1981-1990. The results have demonstrated a significant decrease of precipitation, in the range of 22.5%, and a slight decrease of evapotranspiration, equivalent to 5.4% with respect to the period 1951-1960. The overall results have shown that water deficit in the region has increased, on annual basis, on average by 110 mm, which could produce a serious impact not only on water supply and demand in the region but also on water quality and overall watershed conditions increasing the risks of erosion and desertification processes.

A similar situation was observed also in the other areas of the Mediterranean region which on average receives less precipitation than in the past and suffers frequently from low rainfall: in Cyprus, the precipitation has decreased during the twentieth century by about 100 mm while the average air temperature has increased on average by 1°C; long dry periods have occurred in the Eastern Mediterranean basin in 1989-1990; Tunisia suffered severe drought from 1987 to 1989; Western Iberian basins and Morocco faced the worst drought in 1991-1995; etc. (Demuth amd Stahl, 2001).

In the same period, many places of the Mediterranean were subjected to flooding disasters not only in the Northern Mediterranean countries (Spain, France and Italy) but also in the Southern ones (as it was the case of Algeria in 2001). The tremendous impact of those disasters resulted in the thousands of people died and huge economic damages amounting to several hundreds of millions of Euro every year.

Fig. 2. *Example of drought and moist periods from 1950 to 2000 in Apulia region (19 stations; SPI index mean values / _t=24 months). Values below zero indicate drought periods.*



4. Disasters and Trends

The effects of water-related hazards are social, economic and environmental; social effects are direct, for example, human deaths or the destruction of infrastructures.

Economic effects include damage to property and other assets and adverse effects on stock market prices in and around the affected areas because of damage to agriculture and industry.

Environmental effects are relatively direct and sometimes have a long-term negative impact lasting for decades or even centuries. This is well demonstrated in the case of accidental or deliberate water pollution by heavy metals or organic chemicals. Those pollutants are not only causing serious long-term damage to all kinds of water bodies and the ecosystems, but also, if they are trapped in sediments such as in riverbeds or seaports, the remedy is technically difficult and economically costly.

Recent surveys indicate that the world has experienced 2400 hydro-meteorological disasters during 1992 - 2001, 39 percent of them were caused by floods and 10 percent by drought. Such natural disasters vary from one region to the other. In Asia and Central America, floods and landslides are the main concerns; while in the Mediterranean, Middle East and North Africa, droughts are frequent.

Concerning the natural disasters, people affected by floods are nearly three times greater than those affected by droughts. Floods accounted for 63 percent of the people affected by all natural disasters, and droughts for nearly 22 percent.

However, floods were less deadly; they caused 18 percent of deaths from all natural disasters, compared to 52 percent from droughts. This was more pronounced in the developing countries where some 98 percent of deaths occurred.

In addition to such enormous social impacts, during the past ten years (1992 – 2001), at the global scale, hydro-meteorological disasters caused an estimated $446 billion economic loss. The economic impact was much stronger on the developing countries than the industrial ones due to their greater vulnerability and lower capability to cope with. An example is the recent flooding disaster in Algeria (on November 2001) when uncontrolled deforestation, rapid urbanization and poor or non-existent infrastructures accompanied by high intensity precipitation have caused the death of about 900 persons and have provoked the material damage and loss of property of about US$ 300 million.

This disaster emphasises in particular the vulnerability of the less-developed societies and poor population because of considerable social, financial and economic losses. In fact, in developing countries, the impact of hydro-meteorological disasters on livelihoods cannot be reflected simply in terms of dollars. Losses of just few hundred dollars may reflect a lifetime of work and saving for a family. Therefore, in developing countries, serious disasters can set back the economic development intensively.

5. Water disaster impacts: the need for adaptation measures

Climate change and its uncertainty that have so far filled our thoughts, are nowadays well felt and clearly appearing. The world faces a period of high climate variability and change with the sequences of higher temperatures, extreme rainfall or shortages and a rise in sea level. Such prospects points to big challenges that require urgent adaptation measures.

Unfortunately, most of the measures needed are not well developed for appropriate implementation to mitigate the expected disasters. This holds true for both developed and developing countries.

In the Mediterranean region, changes in climate will have serious implications for people, for the places they live and for the environment. Rising temperature could further reduce river flows as well as the rate at which underground aquifers recharge, worsening the water stress in most of arid and sem-iarid countries of the region, those already suffering acute water shortages.

This will result in serious negative impacts concerning not only food production, but also development in those countries where economic growth is fundamentally centred on agriculture. In addition, any reduction in the available water resources will be reflected on the sectorial water uses, thus accentuating the existing emerging conflicts.

Furthermore, climate change could adversely affect human health in many ways. Through changes in temperature and precipitation, water-related health problems could be exacerbated.

In addition, such effects will be much more severe on the rainfed agriculture in the region, which provides nearly 60% of the cereal production, and wheat in particular.

Many of the coastal areas in the Mediterranean will be subjected to some damage. The climate change, including the combined effects of more frequent and more intense rainfall and the rise in the sea level, will mean greater flooding and erosion as well as the intrusion of saltwater into freshwater sources.

To mitigate such damages, it is required to have appropriate measures, precaution strategies and actions ready to face the event before its occurrence and not at the time the event is already hitting.

6. Management: needed Measures

Water-related hazards are not completely controllable, and they are leading to large socio-economic losses. Humanity has found no means of controlling these extremes and instead seeks to manage arising risks as best it can. Disaster management needs to emphasise risk management initiatives that are far more economic and humanitarian than emergency relief and post-disaster recovery. Management needs to be integrated into socio-economic development and poverty alleviation strategies, promoting stronger coordination and solidarity among all concerned.

In the Mediterranean, but worldwide as well, there is a shortage of adequate disaster prevention, preparedness and mitigation measures. This shortage stems from several factors, some of them being:

- risk reduction is not always treated as an integral part of water resources management;
- the political will to take adequate risk reduction measures is lacking;
- risk reduction is perceived as a technical problem ignoring both the social and economic factors; and
- inadequate policy and institutional capacity and resources.

The acceptable design level for water-related disaster mitigation measures could vary from one country to the other in the region, due to the variation in the socio-economic structure of the country, its population density, economic development, land and urban development as well as the resources available.

Regarding floods, mitigation measures include structural ones such as dikes, levees and flood control dams, etc., and other non-structural ones including land use and hydraulic planning, flood forecasting and emergency response plans.

Through the new available technologies, it is now becoming increasingly possible to predict floods in real time. But, despite the progress made in terms of science and technology of monitoring and warning systems, as well as in terms of hydro-meteorological models, the damage in terms of loss of lives and properties is continuing and uncertainty prevails, due to the very weak capacity building in implementing and disseminating these new technologies.

Equally so, forecasts, warning and preparedness must all be addressed in a framework of planning tools including the control of land use not only in those areas prone to flash floods, but also in the pertinent watershed area, which is in its totality responsible for the runoff responses to precipitations.

Compared to other water-related disasters, drought is generally slow but the associated human and socio-economic losses are significant.

To mitigate droughts, a range of short-term measures are available including relief programmes, crop insurance schemes, changes in land use practices, conjunctive water use of both surface and underground water, as well as the use of non-conventional water resources as additional water source for irrigation. Long-term measures include changing crops, building storage reservoirs, initiating effective water harvesting programmes and decreasing risk rates for communities.

However, the success and/or failure in implementing such measures are fundamentally a matter of the institutional capacity in finding the reasonable solutions to overcome the major constraints impeding an effective drought water management.

7. Measures to mitigate drought in agriculture

Some of the abovementioned measures to manage or prevent disasters in the agriculture sector as well as others could be outlined in the following.

7.1. Estimating water requirements and agricultural drought risk

For irrigation purposes, rain distribution is at least as important as its total amount.

Ideally, rains should match crop needs throughout the year to avoid stresses depending on water excess or insufficiency. Short of that, efficient modern agriculture should act to correct both extremes through drainage and irrigation. A sound, economically effective planning, however, must be based on the knowledge of the inherent risk as well as an accurate estimation of crop reaction to climatic vagaries and resulting stress. Combining the evaluation of risk and related losses in yield and/or soil fertility, one may obtain a platform for the estimation of the "threshold cost" (namely of maximum acceptable cost) of protective structures and practices, according to the desired safety degree (Haan and Bunn, 1971).

Drought, in particular, has been the object of a number of studies addressing its characteristics, probability of occurrence and strategies to combat it.

Agricultural drought, which occurs whenever available water in the soil is insufficient to satisfy plant needs, is defined according to S (severity), M (magnitude) and duration (D); being magnitude the average water deficit, and severity the cumulative deficit, we can define S = M x D. However, it must be noted that it is not only the drought itself to imperil crop production, but also the more or less sensitive phenophase of the crop during the drought period, as clearly stated by Hiler and Clark (1971) as early as over three decades ago. Thus, in order to correctly estimate the “threshold cost”, it is necessary that a reliable estimation of the risk of a relatively severe drought spell during a more or less sensitive crop phenophase be available, along with a sufficiently reliable provision of concomitant reference evapotranspiration: only such a set of information can enable the operators to work out a valid trade-off between expected crop losses and the costs of protective structures such as those for water procurement and distribution.

7.2. Reducing crop water requirements

Many adaptive strategies can be adopted, including the selection of less water-demanding varieties and the change - as far as possible - of planting dates.

The adoption of new varieties with a shorter life cycle can help to better adapt crops to harsh environmental conditions by permitting them to escape the periods of more probable or severe drought events.

Some considerable potential support in reducing plant water requirements or tolerance to water stress is expected from biotechnology, although “firm evidence on tillage and water effects must await further research and development of new transgenic varieties” (Henry, 2000).

A reduction in water consumption can be obtained by improving the efficiency of water conveyance systems as well as the application efficiency of irrigation systems, since combined water losses in such segments can exceed the value of fifty per cent (Hamdy and Lacirignola, 1999; Hamdy, 2001). An accurate irrigation management can help to considerably reduce water consumption per unit of yield by enhancing water crop productivity: for this reason the “demand management” is of paramount importance (Hamdy, 2001).

7.3. Water Harvesting

Water harvesting is a practice midway between water requirement reduction and water availability increase. The term "water harvesting" was coined by Geddes (1963) to indicate "the collection and storage of any farm waters, either runoff or creek flow, for irrigation use". Structures for water harvesting range from big artificial reservoirs damming creeks to store flowing water, down to microbasins with the capacity of 100 litres or less (Oweis, 2001).

Water harvesting structures are of special interest to face the forecast climate changes: in fact, they are useful to combat both the impact of more intense precipitation and that of longer drought periods.

In Mediterranean climate, micro-basins (otherwise called "diked furrows" or "tied ridges"), are particularly suitable for application in tree crops (olive, grapevines, fruit and stone crops) since they can be implemented soon after harvesting, before the rain season at fall and can be cancelled, if required, at springtime. Furthermore, such “microbasins” technique not only permits to capture all the incoming precipitations and enrich the soil and the aquifer with water, but has also the parallel advantage of eliminating or drastically reducing runoff and soil erosion. One further technique for water harvesting is the injection of artificial seepage into suitable aquifers of excess surface water to be recovered when needed. This solution can be attractive under specific conditions but in all cases it requires additional energy costs for lifting when re-used. Interventions on a smaller scale include land shaping to obtain farmed strips where water flows and is “harvested” from collecting areas.

7.4. Non-conventional water resources

The ever more acute scarcity of freshwater availability has encouraged investigation on new forms of water supply.

Seawater desalination has been the object of intense research, which has succeeded in considerably reducing treatment costs, resulting in an appreciable diffusion of such a technique and enriched know-how; however, seawater desalination is still too expensive in economic and energetic terms to be proposed as a large-scale solution for agriculture. Actually, its cost in excess of USD 0.50 /m^3 confines its use to high value crops. Towing icebergs or using large tankers to procure freshwater are solutions that have been proposed and experienced on a limited scale, but have enjoyed no wide acceptance.

Basically, only two non-conventional water resources can be proposed at present, namely, brackish waters and urban wastewaters, both of them entailing some degree of risk and in need of further research.

7.5. Brackish Water

Using brackish waters is risky for the crop, and in a more or less long term, also for soil fertility, unless provisions are made for adequate salt leaching; also the aquifer can be damaged if an appreciable amount of salts pollutes it.

The problem is that the existing guidelines, which were worked out in a period of unlimited freshwater resources, are very conservative and therefore in need of being profoundly revised. They do not take into account the complex relationships in the soil-plant-atmosphere continuum nor place sufficient emphasis to the type of management, which has a considerable impact on plant response. In addition, ranking plant response to salinity according to a generic "yield reduction" has been criticized as a non-scientific approach and the adoption of more soundly based approaches has been suggested (Behboudian et al., 1979; Everard et al., 1994; Steduto et al., 2000).

When operating with saline waters, irrigation scheduling must take into account leaching requirements and the different response of plants to a given water quality. In particular, it is debated if it is useful to reduce the interval, since, contrary to what maintained among others by Goldberg and Gornat (1971) and Bernstein and Francois (1973), Hamdy (1996) concludes that "the bulk of evidence does not support shortening irrigation intervals when saline water is used". Of course, also the irrigation method and management can affect plant response, not only with saline water scorching plant leaves when sprinkled, but also with the different plant response to day or night sprinkling, and depending on water and salt distribution in the soil.

The use of brackish waters obliges to adopt appropriate practices for leaching the salts that accumulate in the soil. Leaching management raises problems regarding leaching fraction amounts and intervals. Early equations proposed to determine leaching requirements (USDA, 1954; Ayers, 1976) were based on rather nebulous principles. Hamdy (1996) suggests simply to leach residual salts, when needed, increasing by 20-30 % water volumes required for full irrigation after carefully controlling soil salinity build-up.

The management of multi-source water can basically be reduced to blending or alternating freshwater with saline water: the second option is generally recommended, with the water selection to be done according to plant phenophases and expected precipitations (Hamdy, 1999).

7.6. Urban Wastewater

Urban wastewaters are a very promising non-conventional resource, deserving full consideration for at least three good reasons:

- their use permits to free freshwater resources to satisfy more pressing uses (domestic, industrial);
- they are presently a costly burden for their treatment;
- they are rich in organic matter and fertilizers (which can be a blessing to the crops but pollute the environment if released without control).

On the other side, the uncontrolled use of urban wastewaters implies risks to the health of irrigators and consumers and is potentially harmful to the soils, the aquifers and the water bodies due to the heavy metals, the parasites and the pathogens they could carry. As a consequence, an a priori evaluation of the level of treatment needed for a safe use, and the total maximum daily load (TMDL), namely the permissible amount of pollutants for any particular environment, are necessary. The ever-shrinking freshwater availability encourages the reuse of wastewaters for irrigation: for instance, Tunisia is planning to irrigate 30.000 hectares with them, while Egypt has a programme to treat nearly 3 billion m^3 by the year 2010 (Hamdy, 2002).

However, a major problem with the reuse of wastewaters for irrigation is the determination of the treatment level in order to make them safe; worldwide, the trend has been to follow the stringent guidelines set initially by the Environmental Protection Agency (EPA) in California, making them ever more stringent, in the assumption that "more stringent means more advanced". The trouble is that these guidelines were elaborated in an age of abundant freshwater resources and that the underlying philosophy is "better safe than sorry". Having realized that the full acceptance of such guidelines leads to absurdly limiting consequences, the World Bank and the World Health Organization proposed some more lenient standards, which received only a limited acceptance by the responsible authorities.

This is actually a major problem, seriously impacting the diffusion and the safe reuse of wastewaters; it will be necessary to collect and elaborate the results of the ongoing research to obtain those data which are required to revise and update the existing standards and, parallel to this, it is necessary that the responsible authorities abandon their exceedingly conservative approach trading the principle that "more stringent is more advanced" in favour of "more advanced is as lenient as possible". Indeed, the sad consequence of the present unreasonably stringent standards is that quite often farmers simply ignore them, irrigating with untreated wastewaters.

In perspective, it would be advantageous to the farmers and the society at large if simple, natural, inexpensive treatment procedures such as bio-depuration of wastewaters and vegetative filter strips for the protection of water bodies become widely accepted, due to their ability to combine low-cost solutions and reasonably efficient level. Also the infiltration of wastewaters through soils after a primary treatment (Soil Aquifer Treatment, SAT), under appropriate conditions (e.g. no karstic conditions, no shallow water table) is a simple and inexpensive solution that deserves full consideration; some research works are in progress to fully explore the potentiality of this solution under various soils and daily load conditions.

8. Water related Disasters: Priorities to be addressed

To mitigate both extreme events, floods and droughts, beside the technical measures, effective adaptation measures are needed by strengthening the resilience of societies and natural ecosystems. However, this will require an accurate prediction of climate change and scenarios building and greater cooperation and dialogue between water managers and the climate community.

As a matter of fact, funding of work related to climate change has been underway since 1990s. The United Nations framework convention on climate change (UNFCCC) established a special fund to aid the developing countries in preparing and implementing national programmes of action for adapting the climate change. However, the fund has given priority to mitigation strategies for reducing greenhouse gas emission. Activities to adopt water management strategies under climate change have received little attention and often do not meet the funding criteria.

Concerning the developed Northern countries of the Mediterranean, most of them have recognized the urgent need to review or establish disaster management policies after having experienced disasters. Some countries have made apparent progress, but many governments still act only after the disaster has struck. Actions must be taken before disasters occur and, therefore, efforts need to be accelerated and more resources need to be applied.

Inadequate institutions in the majority of the Mediterranean countries are one of the major constraints to manage effectively water-related disasters. Few countries have established consistent coordinated programmes that involve governments, institutions, the private sector and the communities in disasters management.

In the region, a range of actions relating to the challenge of managing water-related disasters is urgently needed. These actions should cover several themes focusing on specific objectives and directions.

Beside these actions, several priorities need to be addressed at local, national and regional levels, some of them being:

- integrating disaster prevention, preparedness and mitigation into socio-economic development;
- establishing comprehensive policies and strategies, an appropriate legal framework, and relevant institutions to ensure effective disaster management;
- improving the capacity building in water-related disaster management. Education and training addressed to all levels are the fundamental key elements;
- promoting regional cooperation sharing knowledge and information and working on shared challenges between the Northern and Southern countries of the Mediterranean;
- abundant information is available locally, nationally, regionally and globally. The question is how to make the best use of it and to ensure that it gets to those who need it most at the time and in the form they need it;
- creating networks and partnerships aids disaster preparedness by providing platforms for exchanging data, know how, experiences and sharing lessons and best practices;
- enhancing advanced research introducing recent technological innovations (satellite monitoring, geographical information systems, computer and communication technologies).

A crucial priority is to increase the direct involvement and participation of local communities and NGO's in planning, decision-making and implementations of disasters management strategies; community-based approaches are effective for several reasons:

- communities define their problems more accurately than outsiders and thereby identify appropriate measures to overcome them;
- communities draw local skills and experts living with the disasters;
- communities deploy low-cost appropriate technologies effectively, and the technologies are likely to be sustainable because they are owned by the community and build local capacity.

Finally, the Mediterranean countries, and the developing ones in particular, are facing big challenges. Climate change mitigation and water-related disasters cannot be faced without providing the needed technical and financial support. This is the important role for international organizations. The United Nations agencies, bilateral and multilateral aid agencies, industrialized countries and other international organizations can provide important support to national disasters management by developing research and study programmes, introducing the new advanced technologies in this field as well as sharing professional knowledge and practice.

Strengthened coordination and solidarity is needed not only among those affected by hazards but also among donor agencies and other organizations concerned to ensure effective and efficient use of the limited resources. Sound sustainable financing mechanisms need to be developed for risk management and climate change adaptation, drawing on national, bilateral, multilateral and private investments.

The costs of prevention and mitigation are usually far less than those for disaster relief and recovery.

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