ROSENBERG INTERNATIONAL FORUM ON WATER POLICY

TO BE HELD IN BANFF, CANADA

TITLE:

UPLAND WATERSHED MANAGEMENT IN DEVELOPING WORLD

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May 15th, 2006

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ABTRACT

Managing upland watersheds in developing countries is still a complex process dealing with soil conservation and natural resource preservation, water management policies, land use planning, legal and institutional frameworks, regional economic development, and improvement of living conditions of rural communities. A detailed review of Tunisia soil and water conservation policies over the last three decades is presented to show the considerable potential needed by developing countries to balance conservation and preservation of landscapes, food security, and rural development objectives. In the last few years onservation priorities took a new form in Tunisia based on an integrated agriculture development approach. Other relevant issues and challenges facing developing countries are also addressed in order to highlight certain constraints and underline the need to focus on local social and environmental issues.

1. INTRODUCTION

The seventh millennium development goals is dedicated to reduce hunger by half by 2015 and increase the global food production by 60% to close the gap in meeting nutrition requirements, cope with population growth and accommodate changes in diets over the next three decades (United Nations; 2005).

In fact, water scarcity, coping with uneven seasonal and annual water distribution, and impaired water quality pose serious challenges to economic development (Vorosmarty et al. 2000). For instance, India gets 90% of its rainfall during the summer monsoon season which makes its efficient management difficult. Because of the seasonal nature of rainfall many developing countries can use no more than 20% of their potentially available freshwater resources. A small country like Tunisia receives on average 36 billions cubic meters per year (cbm/year). This volume is limited to 11 billions cbm / year during a drought year and can reach 90 billions cbm during a wet year. Nevertheless, the potentially available surface water is only 2.7 billions cbm/ year, representing only 8% of the country rainfall.

Further, the world's available freshwater supply is not distributed evenly around the globe, within the continents and even within the countries. The world's population does not necessarily live in the areas receiving most of the world's annual rainfall. For instance, the Congo River and its tributaries account for about 30% of the entire African continent's annual runoff, while the watershed contains only 10% of Africa's population.

In response to these and other concerns, watershed protection and management has become a policy imperative in many developing countries and more specifically for the most of the densely populated regions (Doolette and Mcgrath, 1990). Watershed management policies necessarily focus on upper catchments because of its dynamic land-water interactions, its human settlements of poor rural communities, its lacks of infrastructures and its remaining forest and natural resources.

Thus, the fulfillment of the international commitment stated by the millennium development goals at the local level ought to be coupled with efforts to effective upland water

management, the real asset of the rural population, based on ensuring profitability, enhancing the living environment and also considering the sustainable use of natural resources.

Given the importance of upland natural resources, a wealth of literature pertaining to the review of upland watershed management dealing with approaches, tools, performances and evaluations has ensued in developed countries. On the other hand, there is not much published concerning developing countries with the exception of evaluation reports issued by of the international donor organizations (World Bank and the European Communities Commission). Further, most of the publications concerning developing countries relate to South East Asia, Eastern Europe and to a lesser extend Latin America and North Africa.

This paper has three main sections. In section 2, a brief review for the status for upland watershed for developing countries is provided. Section 3 presents a detailed historical review for the Tunisian water and soil conservation approach in dealing with scare resources, the injected social and environmental measures as well as the new developed methodology to ensure a sustainable development and improve the well being of the rural population. A number of the pertaining constraints and need in developing countries are discussed further in section 4.

2. UPLAND WATER MANAGEMENT STATUS

Upland watersheds are the principal source areas for freshwater supplies through streams, water storages, irrigation systems and groundwater aquifer recharges upon which agricultural development and many downstream communities depends. These uplands provide a source of food, natural resources and energy for a growing number of rural inhabitants (Brooks, K.N and al.; 2003). Even though, this might be true for both developed and developing countries,

the impact of degraded upland watersheds is more substantial for the poorest and most disadvantaged population in the developing countries.

Mountain watersheds provide 30 to 60 percent of the freshwater flowing downstream in humid regions while in semi-arid and arid areas they provide 70 to 95 percent (FAO, 2004). High rates of hill erosion and downstream sedimentation are among the most important issues in the developing world due to tree removal, harvesting of fuel wood, excessive livestock grazing and intensive cultivation of marginal lands or inadequate agriculture practices (World Bank, 1992). For instance, the reported soil loss for Philippines is between 74 and 81 million tones annually, affecting between 63 and 77% of the country's total land area (Shively and al. 2004). These challenges are particularly acute in China's southwest, where major and minor rivers, diverse mountain landscapes, and chronic poverty are intertwined.

Negative effects include the silting of streams and consequently increases the risk of flash floods (UNESCO, 1982); the accumulation of silt in coastal habitats that could be located hundreds of kilometers downstream and the reduction of aquatic ecosystems productivity (OECD, 1993), and accumulation of sediment in reservoirs reducing hydroelectric power generation capacity and the expected life of the structure. In addition, it impacts the water quality for water consumption. These problems are more intense in arid and semi arid regions where land degradation can induce desertification, wind erosion, saline water and pour structure and nutriment content of soils.

Further, the negatives impacts are observed on site in terms of erosion, channel degradation, and loss of biomass, as well as offsite effects such as siltation of lower dams and loss of river routing capacity and loss of yields in lower flat lands.

Maintaining healthy upland watersheds in developing countries is crucial not only to sustainable land management and protection of soil and water resources but also to ensure provision of basic needs and develop decent living conditions for the population.

3. THE STRUGGLE OF TUNISIA WITH UPLAND MANAGEMENT AND EROSION

Located in Northern Africa at the eastern extremity of the Maghreb, the water and soil of Tunisia are very favorable to degradation due to its physical, geomorphogical, hydroclimatical and socio-economic conditions. In fact, about 3 million ha, out of 9 million ha useful for agriculture and grazing, are threatened by erosion with 1.5 million ha critically affected (Tunisian Ministry of Agriculture, 1993).

Faced with these problems, the Tunisian government has made considerable efforts through physical, institutional and legislative measures in matters of soil and water conservation for the last three decades. The Ministry of Agriculture elaborated a National Strategy for soil and water conservation for the decade (1991-2000) based on slope land management, the transfer of surface water aiming at sustainable agriculture development. Nevertheless, the problems of erosion and water degradation and their consequences continue to be up-to-date challenges.

In this section, we will discuss the major problems, the achievements, as well as the challenges and the persisting problems.

Several historical sites in Tunisia testify that the local population was seldom indifferent to erosion problems. The origin of this upland erosion can be attributes to its geographical

situation, the succession of several civilizations [Roman (146 BC), Arab, Ottoman, French], its climatic conditions, and to the rural population style of life. Even though land erosion is not a new phenomenon, its intensity has worsened. In fact, the land used for agriculture went from 1.2 million hectares early in the previous century to over 5 million hectares nowadays. At the same time the Tunisian population is multiplied by five. The rural population density became more important especially in areas with excessive erosion and low productivity. This demographic increase induced a considerable clearing of the natural vegetation, lands were put under cultivation, and uplands become over grazed which accelerated its degradation.

The mountains areas of Tunisia are made up the final section of the two Atlas ranges that extend for about 2,400 km (1,500 miles) through Morocco, Algeria, and Tunisia; where most of the forest and endemic plants are located. The Tunisian mountains are diverse in geology and landscape; from the Mediterranean cliffs to the dyrs in the high plateau of Tunisia, to the southern sand-dunes and the Sahara Desert.

The Khroumirie-Mogod mountain chains which run along the north are the wettest part of the country containing the forests of cork oak, zen oak, and the rare Quercus afares. They are characterized by brown-dark soils developed on sandstone and on non-calcareous clays. The Khroumirie-Mogod chain has steep and irregular slopes.

The High Tell or the Tunisian Dorsal Mountain, in the center, which is the continuation of the Saharian Atlas is home for Pinus halipensi and Quercus ilex forests and and Stipa tenacissima (alfa). At the base of the large mountains there are calci-magnesic soils, which are crusted, limestone, brown and degraded on hardpan.

Mountains in the high steppes of central Tunisia and the Douirat mountains of southern Tunisia are mainly dominated by Juniperus.

In the last decade, the Tunisian Ministry of Environment and Sustainable Development initiated a program to protect what is left from the forests and the natural resources by the foundation of four national parks and seven natural reserves situated in mountainous areas.

The mountains of Tunisia are important sources of water providing about 80% of the nation's water through dams and water transfer, agricultural land, and forests exceptionally rich in biodiversity and home to rare and diverse ecosystems.

The mountain forests are degraded by cattle and human activity, a phenomenon that is in particular serious in the Dorsal Mountain, and in the Kroumirie-Mogod forests. In addition, these areas are fragile with soft rocks such as argillite and marl alternating with limestone and sandstone.

The climatic conditions in Tunisian play an important factor for the erosion problems in the north and the center of the country. Characterized by hot dry summers and cool moist winters; precipitation is very irregular and the rainfall varies considerably from the North to South and from year to year. Rainfall is torrential and event based and can reach 70 mm per hour on the mountains. High intensities up to 200 mm/hr were measured in some exceptional years.

From the 1960's to the 1980's, significant efforts were deployed resulting in several physical, institutional, legal achievements. Over one million hectares was treated by measurements of

soil and water conservation techniques that varied from the North to the centre depending on the suitable techniques: benches, cords, biological fixing and agro-pastoral management.

However, this work was established based on targeting specific areas in need for urgent intervention for specific land use or for a degraded upland area. They were also designed to keep the rural population in the interior regions of the country, often through costly development projects, usually without considering the economic aspects. The evaluation of two decades of considerable efforts showed that the engineering approach was not successful in winning the struggle against erosion. Further, the infrastructure implemented by the technicians was rarely maintained or protected by the farmers which represents a part of the failure to this approach (Bachta; 1994).

In the early 1990's, new orientations were taken founded on an integrated watershed management approach. A national water and soil conservation strategy was put in place with key objectives to meet on the long run by the year 2000 based on a progressive implication of the rural population to take in charge the conservation structures, capacity building of both the administrative stuff and the farmers through technical training, and by promoting private companies for services and encouraging the formation of new cooperative institutions.

The main strategy set up the following goals:

- Reduction of arable land loss;
- Improvement of soil fertility in order to avoid the decline of the outputs of production;
- Mobilization of an additional volume of 500 Million m^3 of water by conservation measures;
- Protecting the lifespan of dams,

- Attenuation of flood damages caused downstream,
- and enhancement of groundwater recharge

A program plan was then initiated aiming at the construction of 1000 hill dams, 4000 structures for flood control and groundwater recharge, protection of 600.000 hectares by implementing conservation measures and 400.000 hectares with cereal vocation by soft conservation techniques along with the maintenance of a million of hectares already treated. The implementation these actions was coupled with regional planning covering a number of governorates.

At the institutional level, an administrative unit under the authority of the hydraulics and rural equipments department was established in 1960. It was in charge of planning, execution and control of the soil and water conservation activities. This unit became a sub directory sub-directorate under the Forest Management department in the 80's and it was transformed lately to a national directorate of Land Conservation and Management with the following missions:

- elaboration of plans and orientations to safeguard the natural resources (soils, vegetation, and water)
- Promotion of technical measures in order to ensure a better use of the natural resources
- Evaluation of soils resources vocation and follow up soil behavior under the various modes of exploitation
- Monitoring soil and water though analyses
- Planning and elaboration of needed uphill catchment's studies, adjustment of anti-erosive work and follow up of projects implementation launched by the soil and water conservation programs

On the legal level, the soil and water conservation was governed by several texts, the most important of which are the declaration that water and soil conservation structures are public utilities and the law for water and soil conservation instituted in 1995.

It was noted that the observed failures were not due to the used techniques but mainly due to the approach. In fact the most modern technology in the world can be useless if it is not understood, accepted and implemented by the local population. A number of socio-economic studies in different parts of the world showed clearly that each area has its individual set of interrelationships between people and the land they are living on.

Other constraints were due to the social and economic characteristics of the affected areas. In fact, these areas are the most populated areas within the watershed. Consequently, the land status is cut into small to medium parcels which make anti-erosive actions sometime impossible to carry out.

Few years were taken to work on the methodology needed to apply the water and soil conservation strategy. Initiated in 1997, the new approach called Integrated Agriculture Development projects (PDARI) based on the realization of production and revenue potential of small agricultural holdings as well as improving basic infrastructure available to poor populations. The major project components addresses soil and water conservation, forestry and pasture development (pasture plantings on private and collective land and agro-forestry activities), agricultural development for smallholdings (promotion of fruit tree cultivation in some areas and rehabilitation of irrigated perimeters), upgrading of basic water drinking infrastructure and support for women's and community-based development by targeting smallholders and medium landholders practicing rain fed or irrigated agriculture, forest users'

communities; and rural women and youth. Thus, the project activities related soil and water conservation will affect as well smallholders living and exploiting the resources.

The participatory approach proposed for these projects is not based on the integrated development approach by micro-basin, as is the case in other countries. It is designed to achieve several interest groups not necessarily located at the basin.

Accordingly, programming instruments were set to promote greater involvement by populations in the planning process for development actions through consultative councils for at the “imada” (village) and “delegation” (several villages) level, which were to play a central role in mobilizing populations and in programming and monitoring results. The land occupation intervention unit is used for undertaking for forestry and pasture development actions, soil and water conservation works, and productivity improvements for agriculture. The authorized user associations brings together landholders to manage and maintain small hydraulic structures and assets with the assistance from the government in providing water, and agriculture-related finances, equipments, land training, and market information.

In some locations of the country, the NGOs can provide small loans in the context of local savings and loan committees within a village-type credit system put in place. Women’s issues are provided for through specific mechanisms (financial and training) to promote the economic and social role of women in rural areas.

The full impact of PDARI activities can be seen only in few years from now. However, some of the observable impacts in areas threatened by erosion were the improvement in the producing potential of smallholders and the reduction of silting in small dams and hill

reservoirs. In terms of the farmers' assets, land values will increase as land becomes better protected and covered with valuable tree plantings. In terms of community based development, the agricultural training as well as the art and craft training have given rise to hundreds of micro-projects and several marketable products (rabbits, honey through beekeeping, carpets and rugs, pottery and decoration).

4. ISSUES AND CHALLENGES

In order to address the upland watershed management in developing countries, a wide spectrum of issues related to social, cultural, environmental and economic development need to be underscored. This is not the intension of this section that aims to simply highlight some of the needs for upland watershed management in developing countries and underline the needs to focus on local social and environmental issues.

In some parts of the world, the development of large scale water and soil conservation projects does not necessarily have direct benefits to the small landholder who must survive within the constraints of his environment. Lebanon, Morocco, Syria and Tunisia were engaged in a program of construction small uphill dams as water harvesting systems by providing water storage facilities containing few hundreds of cubic meters. These structures are used for irrigation, livestock watering, domestic uses and sometimes for aquaculture. They protect the downstream villages against flooding and erosion and contribute to groundwater recharge.

In Tunisia, this experience had twofold: it was useful for improving the livelihood of the rural people and it played a major part in the protection of the large downstream dams from siltation (Albergel and al. 2004). Case examples of water harvesting systems are also found in

Mexico, India, Iran, and Pakistan (Ahmed, 2000; Christopher and al., 2000; Agarwal and al, 1997).

Thus, a useful step would be the documentation of alternative models used in developing countries to putting principles of water management and soil conservation into action. Several countries are in the process of reforming their water management policies and could benefit from other countries' success and failures in water policies, plans and programs in the context of their economic feasibility, environmental sustainability and equity and gender impacts.

It seems that there is a general acceptance of the need for considering social and environmental objectives in water planning in general and more specifically for upland watersheds. However, continued work is needed within several fronts to meet this challenge.

Technical Issues

Some technical aspects in upland watershed management require further study and research on leading topics relating to the following issues:

- Innovations in harvesting, storage, and management of water runoff in drought-prone areas to improved production of crops, trees and rangeland species. This allows stakeholders to build on local capacity for adequate planning, systematic design and sustainable implementation of water harvesting systems. The application of appropriate techniques for water yield improvement and recharge enhancement are still up to date issues (ISCO, 2006).
- Quantifying erosion extent and impacts through simple measurement and monitoring techniques at a small scale watershed under arid and semi arid conditions and low vegetation cover. It should be noted that although some sophisticated approaches to

modeling hydrological processes and erosion are available, there is a shortage of appropriate hydrological data for watersheds in general and specifically for upland areas which precludes a more complex assessment of erosion–sediment relationships in modeling. Adequate databases with extensive measurements and data collection programs will help to conduct accurate and further assessments on both the scope and the impact of the problems and on the effectiveness of the potential solutions.

- Choice of native and exotic species (trees, plants, etc) best suited for eroded sites can make a significant contribution to creating micro-zones that can lead the way in economic and social change. Examples in the Maghreb region shows that the transformation of landscape by tree plantation (olive, peach) through government investments have strengthened the producing potential and created micro-zones for intensification of agricultural production and a local dynamic for agricultural development to bring in real socio-economic change.
- Enhancing soil conservation, soil fertility and farm income through changes in land use activities that may result from combination of crops and inter-crop activities into crop rotations, different crop management techniques (irrigation and crop protection) and animal production.
- Quantifying relevant inputs and outputs of land use activities (i.e., balance of soil organic matter and nutrients, environmental impact of pesticides, labor and machinery requirements, and economic performance) using different quantitative methods. Special attention should be given in improving the current farming systems by intensifying their production systems putting more pressure on already deteriorated soils and inducing further problems for river water quality.

Planners and decision makers

Upland watershed management issues are complex and large amounts of technical, social, and environmental information at multiple scales are often required to assist the process. Thus, planners and policymakers need better tools for understanding landscape level effects of planning and policy. Sound scientific information is an essential ingredient to sound decisions (Santelmann; 2005).

Thus, modern tools for decision support purposes and spatial analysis, risk assessment, evaluating effects of changes in water and land practices including land suitability and land productivity assessment are of substantial use for developing countries. They contribute to better understand the biophysical themes ranging from specific soil constraints and climatic parameters to land degradation status and population characteristics at national and sub-national levels. Undoubtedly, there will be problems such as data creation, training of users etc. On the other hand, these tools present promises for enhancing information services for planners and engineers giving greater insights, more objective analysis, more ease in data sharing among administrations and more comprehensive studies.

From another perspective, it is noted that developing countries rush into drawing down national water management programs with a set of generic principals or goals. This is certainly not sufficient for upland watershed management. The methodology should allow for flexibility in planning, in designing the management process, development and review and evaluation processes, and should be adapted to the specific context and situation. Some of the important variables in a successful upland watershed conservation plans are the contextual characteristics in relation to conflicts, agreement on facts, culture, social conditions.

Rural population involvement

The involvement and participation of local landholders should be integrated as a major component in the design and development of relevant programs for upland watershed management. The case study presented earlier testifies for such need. However, it seems that there no is single way to institute such procedure for rural areas. It depends on cultural, social, institutional and political factors. The promotion of a participative action for water and soil conservation activities, suppose the existence of a tradition of public participation in the administrative decision making process on the institutional level which is not necessarily the case in developing countries. Further, rural population represents the lower-income group (poverty, illiteracy...). They are resistant to new techniques and may show a lack of confidence in the local administrations and poor civic mobilization for local issues. Hence, participative actions need to be built progressively and may require educational steps and training for both technicians and the rural population to define new tradition for making agreements, negotiating and managing conflicts.

Social and economical aspects

Even if the ultimate objective is upland watershed protection, the designed projects should operate within the framework of a rural development approach that can reconcile the imperative of conserving natural resources with creating conditions for diversifying local monetary revenues (off-farm activities, promoting proximity services, etc). This framework could be participatory local development. Means of investments involving socio-economic infrastructure, support for community-based organizations and the rapid development of certain revenue-generating activities have a positive impact on the dynamics of local economies which can improved the quality of life for the rural population and enable

populations to remain in their villages. Attention is to be paid in the context of growing off-farm employment opportunities that could results in low levels of labor and capital allocation.

Supported activities to create and strengthen management skills among women, and particularly girls, can also generated new revenue sources and provide an important means to ensure family solidarity.

5. CONCLUSIONS

This paper focused only on local upland watershed management in developing countries. Other important issues related to upstream-downstream planning and implementation that are in need for a better understanding ; trans-boundary upland watersheds and inter-government conflicts, adequate institutional and organizational arrangements, appropriate legislative framework to support watershed management policies would need a particular attention.

Overall, there has been general acceptance among developing countries of the need for considering social and environmental objectives in water resources management. However, continued work is needed to assure effective planning processes that balance local social issues, environmental concerns and economic development.

Strengthening the organizational skills of rural populations and their ability to take charge of infrastructure upon completion can enhance soil and water conservation and forest development activities. Public awareness is a must for people to cooperate in facing water and soil conservation challenges.

With a context of a development vision, further research in the in the field of hydrology, soil and water conservation, and upland watershed management is needed to consolidate the currently available information.

In addition, there is a need for comprehensive monitoring programs, evaluation systems; and processes to capitalize on local instruments and approaches from past experiences

ACKNOWLEDGEMENTS

The author would like to thank Professor Henry Vaux, Jr. of the University of California - Division of Agriculture and Natural Resources for his invitation to the Rosenberg International Forum on Water Policy.

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