LAND USE CLASSIFICATION FOR INTEGRATED WATERSHED MANAGEMENT

Report of the APO Seminar on Land Use Classification for Integrated Watershed Management held in Seoul, the Republic of Korea, 23-27 April 2001 (SEM-24-01)

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SEMINAR HIGHLIGHTS

INTRODUCTION

The Seminar on Land Use Classification for Integrated Watershed Management was held in Seoul from 23rd to 27th April, 2001. The seminar was organized by the Asian Productivity Organization (APO) and hosted by the Government of the Republic of Korea. The Korea Productivity Center (KPC) implemented the program. Twelve participants from 10 member countries and four resource speakers from International Water Management Institute (IWMI) and the Republic of Korea attended the seminar.

The objectives of the seminar were: 1) to discuss issues and constraints in integrated watershed management in member countries; and 2) to examine the adoption of integrated watershed management approaches and land use classification methods for the protection and sustainable development of watersheds.

The seminar consisted of a presentation and discussion of resource papers, presentation of country papers, syndicate discussion and a conduct of field visits to the Rural Research Institute of Korea Agricultural and Rural Infrastructure Corporation (KARICO) and Stream Restoration Research Area of the Korea Institute of Construction Technology. The topics covered by the resource papers were: 1) Participatory Management Systems for Sustainable Watershed Development; 2) Sustainable Watershed Management System and Water Quality Control in Korea; 3) Scientific Basis for Integrated Watershed Management - A Landscape Ecological Approach; 4) Participatory Research on Catchment Management: The IBSRAM Experience in Asia; and 5) Run-off Characteristics by the Moving Storm in the Watersheds. The country papers focused on the status of land use classification for integrated watershed management in the respective countries of the participants. In the syndicate discussion, the participants also identified the major issues and problems in land use classification for integrated watershed management, and suggested strategies to address current issues.

The highlights of the seminar are as follows:

RESOURCE PAPERS

Participatory Management Systems for Sustainable Watershed Development (Frits Penning de Vries)

Much of Asia's surface consists of sloping land, and due to the population pressure, much of the land that is not totally mountainous is used for cropping or grazing. Profitable land use on sloping lands is more difficult to develop than on flat land. Add to this the fact that the people are generally resource poor. As a consequence, land degradation is a serious threat to the sustainability of many rural areas. Sustainable use and restoration of currently marginal land require explicit knowledge of site- and situation-specific conditions. Farmers' knowledge of local conditions, opportunities, and bottlenecks for innovations can be gathered in a rapid and cost

effective manner. Strengthening the capacity of national organizations to deal with research and extension for the management of land is an indirect way to improve natural resource management and an important role for international organizations. Distinguished here are two categories of interactions for achieving sustainable land management:

a. Participatory adaptive research with farmers (women and men) and other land users, to learn from them and to accelerate identification of better technologies. Success stories are presented.
b. Participatory research and research management to expand the capacity of national research and extension centers to deal with natural resource management. Impact is reported.

This paper confirms that end-user participation for achieving sustainable land management is crucial, particularly if resource-poor farmers are targeted. Farmer participatory research is no panacea, and has inherent and practical limitations. National research and extension services need to adopt it as one of their basic approaches. It is argued that it is a major challenge to scientists to define a minimum data set for on-farm trials that permit extrapolation of insights to other locations and situations.

Participatory approaches are an essential component of developing with and delivering to farmers appropriate land management information. They can use this, together with government development plans (as developed through SysNet-LUPAS or other means) and knowledge about their site and situation, to make their own operational and strategic choices.

Sustainable Watershed Management System and Water Quality Control in the Rep. of Korea (Sang Eun Lee)

The Republic of Korea has limited water resources. The average annual precipitation exceeds the world average, however, the per capita annual precipitation is only one-ninth of the world average due to very high population density. In addition, since about two-thirds of the annual precipitation is concentrated in only four months, numerous and large dams have been constructed to provide storage reservoirs and for flood control. However, due to long hydraulic retention times of these artificial lakes and large watershed area, deterioration of water quality and eutrophication of the water supply reservoirs have become of major concern. Since controversies between the residents in upstream and downstream of river basin are often encountered due to the different views for the beneficial uses of the water, sustainable management of major watersheds is of great importance.

Under the River Act, rivers in the country are divided into three classes: Class A rivers are directly administered by the Ministry of Construction and Transportation (MOCT) while Class B rivers are administered by local governments. Class C rivers are also administered by local governments but are indirectly governed by the Water Act. While there are more than 400 major lakes out of 19,000 lakes in the country, the most major ones are artificial lakes. However, most artificial lakes are prone to become eutrophic due to their long hydraulic retention times.

In terms of water quality, there are five grades (I, II, III, IV and V) for river and lake waters and three grades for sea waters mainly based on the use of water of

which Grade I denotes the best quality water which can be used for drinking with minor treatment. All waterways in the country are divided into 194 reaches and each reach has different target of water quality based on the beneficial uses of the water. In 1999 the number of reaches which have achieved the target was 29.9 percent whereas it was only 12.8 percent in 1991.

The government had executed a 5-year plan (1993-1997) to supply safe and clean water called National Clean Water Supply Plan. Eight ministers were involved in this plan with the Ministry of Environment playing a key role. In 1996, the National Commission on Water Management was installed in the Office of the Prime Minister to coordinate the various policies of water management which were operated by different ministries. Since then, all major policies for water management have been finalized by the Committee for Coordination of Water Management Policy headed by the Prime Minister through the report from the National Commission on Water Management (NCWM).

The NCWM established a 15-year plan (1997-2011) called the Comprehensive Water Management Plan in 1996. Again, all water-related agencies participated in the plan which consisted of water quantity provision plan and water quality management plan. To improve the water quality of rivers and lakes through successful implementation of the Comprehensive Plan, the water quality management strategies for four major river basins called the Special Water Management Program for Four Major River Basins were initiated.

The special program to protect watershed areas of four major rivers includes five strategic plans such as measures for pollution prevention, measures for pollution load reduction, strengthening water friendliness of the relevant policies, proper measures to support upstream region of drinking water supply sources and consolidation of financial and institutional systems. The plans include an investment of 11.57 trillion Wons (approx. 10 billion US dollars) to water quality improvement by the year 2005 and 4.67 trillion Wons to water supply and water resources development by the year 2008. This amount does not include the investment required for residents support, land purchase and O&M cost of water pollution control facilities. The plan also includes the formation of committees for watershed management with the relevant ministries, including the Minister of Environment, Governors and/or the Mayors of relevant Provinces for each the four major river basins as the decision-making body for all issues related with watershed management.

Scientific Basis for Integrated Watershed Management - A Landscape Ecological Approach (Hojeong Kang)

Proper water management is an extremely urgent and important matter to most of the countries in the world. To cope with this problem, a large amount of investment has been made, but water quality is not improving as expected in the Republic of Korea (ROK). One of the most important, but a missing point, is control of non-point source pollution. Due to the characteristics of non-point source pollutants, the Integrated Watershed Management (IWM) has been widely accepted because it incorporates another layer (social and political issues) on top of the traditional watershed management with the considerations of hydrology, land-use patterns and geomorphology.

A landscape ecological approach would be a valuable method for a successful implementation of the IWM scheme. Landscape ecology is a new branch of ecology, originated from European scholars and developed by American researchers. Key tools include remotely sensed imagery, GIS, spatially explicit models and landscape indices. The main components for landscape ecological analysis are a matrix, patches and corridors. Not only the attributes of each patch (e.g., shape, size, edge), but also the landscape composition (e.g., richness and diversity) and configuration of patches are considered in the analysis. By using this approach, several studies have shown that spatial variations of water quality can be explained by land cover types and their patterns. Further, predictions of effects on water quality by future land use changes could be made.

In summary, a landscape ecological approach has a lot of potential as a tool for IWM because: 1) water quality management requires a large scale approach; 2) landscape analysis is less expensive than traditional ground-based survey; 3) such analysis is not only practical with current technologies, but is also improving very rapidly; and 4) the foci of landscape ecology (e.g., land-use patterns, habitat loss) are on the critical factors of IWM.

Participatory Research on Catchment Management: The IBSRAM Experience in Asia (Frits Penning de Vries)

Land degradation brought about by soil erosion has been a serious threat to increasing food production in Asia where more than 50 percent of the area is hilly and mountainous. Farming practices employed in these marginal uplands have become environmentally unsustainable, resulting in decreasing agricultural production in the area and affecting the economic activities downstream.

Quite a few research studies on soil erosion have already been undertaken, but results of such studies have not yielded significant impact on the adoption of alternative land management systems that are sustainable and which could provide reasonable returns without further degrading the environment. This concern was the primary reason for the establishment by IBSRAM of the Management of Soil Erosion Consortium (MSEC). The MSEC is one of the four consortia established through the soil, water, and nutrient management (SWNM) initiative of the Consultative Group on International Agricultural Research (CGIAR).

The MSEC uses an integrated, interdisciplinary, participatory and community-based approach to research that involves all land users and stakeholders on a catchment scale. It focuses on the on- and off-site impacts of soil erosion, emphasizes community involvement and provides scientific information for a rational decision making. The MSEC draws on the comparative advantages offered by the NARES, IARCs, and ARIs which conduct research at different scales, ranging from individual plot and farm to the catchment, regional and national scales in order to develop principles of global relevance. With the Asian Development Bank (ADB) as a major donor, the framework of the project is now operational in six countries, namely; Indonesia, Laos, Nepal, Philippines, Thailand and Vietnam. Representative catchments in these countries have been selected, characterized and instrumented for soil erosion and hydrological measurements and research and capacity building

have been initiated. At this early phase of the consortium, benefits of the broad, eco-regional approach are already evident. These include increased awareness on the part of decision-makers and research leaders, increased cooperation across disciplines, choice of more relevant research topics and across-sites application of findings.

Run-off Characteristics by Moving Storm in Watersheds (Gye Woon Choi)

Although it is widely recognized that temporal and spatial variability of precipitation can affect run-off, the ability to model these influences with existing models is limited. Most existing models can accommodate temporal variability but assume spatial uniformity over the watershed. Spatial variability can be approximated in existing models by the subdivision of watershed into smaller sub-watersheds and plane units. However, this approximation still assumes spatial uniformity over each sub-unit of the watershed and, therefore, is not a true representation of the physical system.

If moving storms which can be frequently identified with the typhoons, cyclones and hurricanes as are shown in watersheds, the spatial and temporal variability of several hydraulic and geometric data in the watershed affects the run-off pattern and the peak discharge. If the variability of the temporal and spatial data is not well considered, then the run-off obtained through simulating the models may not well agree with the observed data. Recently it was known that when moving storms are indicated in the watershed, they can be effectively simulated using the GIS techniques.

In this paper, the run-off characteristics by the moving storm are investigated using the GIS techniques and the isohyetal maps using the data observed from 16:00 to 23:00 on August 2, 1999 in the Chun Yang rain gauging station are produced to show the temporal variability of the rainfall. Isohyetal maps are applied in the experimental watershed known as Bokha watershed.

The rainfall distribution by the storm moving to the NW direction in the Bokha watershed is studied as time goes by. Also, the run-off by the moving storm having different moving velocities is compared with others and shows a big difference with the bigger discharge in the slowly moving storm.

As shown in the comparisons, through the simulation using the GIS technique in the watershed, the advantages of easy preparation of the data and the short computational time can be obtained with good agreement with the observed data.

COUNTRY PAPERS

Republic of China (Lien Chang Chan)

The Republic of China (ROC) is a geologically fragile island with steep topography and plentiful but unevenly distributed rainfall. In addition to improper land use and the great earthquake in 2000, massive soil movement and debris flow often occurs with prolonged rainstorms. Great amount of sediment is delivered to reservoirs that substantially reduces their effective storage capacities and longevity. Pollution derived from residential and agricultural sources also degrades the quality of the water supply.

The quantity hazard and quality risk of water resources in ROC have long been recognized. Great efforts have been devoted in integrated treatment of reservoir watersheds. Many meaningful experiences have been gathered. However, due to different objectives of water use, land use characteristics and environmental background, different treatment tools should be used for various reservoir watersheds. The experience in integrated treatment at the Tehchi Reservoir Watershed among the 44 existing reservoirs in ROC is reported as follows:

The integrated treatment approach includes forest management, soil and water conservation on farms and roads, sediment control engineering works, reservoir riparian zone, promotion and extension of fertilizer and pesticide application reduction in farm land, water quality monitoring and control, promotion of ecological preservation, land use monitoring and control. This approach has achieved significant results. To deal with anticipated new problems, studies have been initiated to treat domestic sewer and solid waste, to develop rules and regulations for streamflow area planning and to optimize management schemes for the watershed.

Current land use information database is established using the Geographic Information Systems (GIS) technique. With the aid of remote sensing and satellite imagery, instantaneous and fast retrieval land use change information may provide evidence for prosecuting illegal land use.

The critical problems that need immediate solutions and appropriate remedies include the reclamation of illegally cultivated farmland for reforestation, water pollution along the riverbed of Yeouhsing Stream due to vegetable farming, aboriginals return land campaign, farmers replacing fruit trees with vegetable crops resulting in increase in soil erosion and water pollution, the involvement of cooperation between many government agencies for integrated treatment of the watershed, and the increasing pressure derived from reservoir sedimentation, water quality degradation and ecological preservation.

India (Saurabh Garg)

Natural resource management has traditionally occupied prime status in the Indian society. However, the conventional institutions progressively was diluted over time and it is only during the last 50 years that water management has started occupying center stage in rural development.

While participatory watershed programs were giving a separate focus from 1974 onwards, over the last decade people's participation and people's management have been emphasized in the various government sponsored integrated watershed development programs. All these programs now follow a common approach in order to make watershed management more holistic.

The main concepts are convergence of different programs of rural development and poverty alleviation, utilizing the concept of the micro-watershed (500-1000 ha) as the unit of development, utilizing the land according to its capability, integrating remote sensing techniques for better planning and prioritization, conserving maximum possible rain water at the place where it falls, focus on training of the field level implementing agency, emphasis on capacity building and community mobilization to make watershed development a people's movement, developing an institutional

structure for post-project sustainability, participation of the people right from the selection and planning stage through implementation and post-project maintenance, and interventions for the resource poor, landless and the under-privileged, including women.

The objectives of watershed management are now moving towards a livelihood perspective and a watershed plus approach which includes the concept of developing sustainable livelihoods to secure better equity. With 60 percent of the population making its living from agriculture, optimal land use is critical for achieving better livelihoods. Land use classification and strategy for optional land use are also discussed in the succeeding sections.

The impact that a successful watersheds based intervention will have on land use and livelihoods is now engaging the policy makers and planners in developing strategies to ensure that the substantial investments being projected will give the intended benefits of drought-proofing the rainfed areas in the country.

India (Rajeshwar Singh)

Rajasthan is the largest State in India and much of the State area is rainfed. Many watershed programs are being implemented in the State with the ultimate goal of developing natural resource base, sustain their productivity and improve the standard of living of millions of poor farmers and landless people. This is being done both through centrally-sponsored schemes of the government, externally-aided projects and private initiatives of local communities and NGOs. All these projects and programs lay emphasis on mobilizing people's active participation. Affordability, replicability and sustainability are the main built-in elements of these projects. The projects are being implemented through community-based organizations. Indigenous know-how coupled with improved technical guidance of subject specialists is used in the management of land, water and vegetation. Various practices like contour bunds, *khadin*, *tanka*, shelter belt plantation, agro-forestry, horticulture, mixed cropping, earthen check dams, v-ditches, pasture development, afforestation on wasteland, loose stone check dams, *gabions*, dug out ponds, *anicuts* adopted for conservation and production of arable and non-arable lands and for treatment of drainage lines. Besides this, in order to supplement the income of farmers, to provide some source of income to the landless and to empower women, other income generating activities are also being taken up in the project areas.

Impact evaluation studies of watersheds have unequivocally shown improvement in ground water recharge, enhancement of cropping intensity, changes in cropping pattern, high yields of crops and reduction in soil loss. While there have been major visible grains, the problem of sustainability and replicability by the community continues to plague the watershed development projects as evidenced by the unwillingness of local communities to operate and maintain completed structures and plantations on community property. This is due to inadequate capacity-building in communities. Other constraints in rainfed agriculture development are microscopic coverage in the area, convergence of various rural development schemes, infrastructural constraints like input supply and output market points and technological constraints due to vast diversity in socio-economic conditions and agro-ecology.

Islamic Republic of Iran (Reza Roshani Kalkhoran)

Iran has a total geographical area of about 1,650,000 square kilometers. The country lies between 25 and 40 degrees North latitude and 44 and 64 degrees East longitude. The Iranian territory is composed, to a large extent, of mountains surrounding the saline, sandy, and rocky deserts of the central plateau and forming a closed basin containing many kinds of accumulations. Phytogeographical and ecological regions of all the countries in the near and Middle East are characterized by the lack of rainfall during the hot season. Iran has by far the greatest variety of regional climates, and consequently, of soil and vegetation. It has wet forests like those in central Europe, central Asian-like steppes, deserts of the Saharasind type, and subtropical mangroves.

The basic aim of watershed management is to implement a comprehensive, coordinated and incorporated management on all resources of a watershed basin in order to achieve a suitable, logical and optimum use of human, agricultural and natural resources of land. At the same time, the water wastage and soil erosion should be reduced.

Production capacities of agricultural lands and other natural resources in Iran are deteriorating because of lack of attention paid to the principles and programs of watershed management. Every year a huge volume of productive soil and water get wasted, and day by day production capacity of such natural resources is decreasing. Thus, the main objectives of watershed management activities are: 1) to stop these damages and to protect the precious natural resources for providing different wood and agricultural products; and 2) to minimize the danger of human and natural catastrophes (flood and landslide).

Mongolia (Amarzaya Tserenchimed)

Mongolia is located in the center of Asia and covers an area of 1,566,500 km^2 as a mountainous country. Basically, its topography consists of mountains, hummocks and high denudation plains, forming three major regions. Mountains are found mainly in the northern and western regions and denudation plains in the Southeast. Surface and ground water in Mongolia is substantial. There are some 4,000 rivers in the country with a total length of 67,000 km and 16 large lakes, each of more than 100 km^2 in area. The Northern part of the country is well watered by lakes and rivers. Minor rivers join the Orhon River which is one main tributary of the Selenge River, that pours into the Baikal Lake. The Hentii Mountains are the part of the world's watershed between the Arctic and Pacific Ocean basins and closed drainage of Central Asia.

The watershed area of Mongolia remains under government control as common property lands, and the Ministry of Nature and Environment has the responsibility for investigating, monitoring, conserving and protecting the natural and social environment. The Natural Resource Policy Department section of water is the main organization responsible for such activities in every single settled place.

The main issues in the integrated watershed management are as follows: 1) how to improve the water supply capacity and quality, particularly, to provide water source in the Gobi desert area, build and renovate the construction for watersheds to improve the quality of water, hence health of the people; 2) how to organize and

provide comfortable condition of water usage and increase cleaning standard of sewage system; and 3) how to investigate and disseminate new modern technology, know-how and traditional way of water use concerns on needs and requirement of socio-economic development.

In Mongolia, land use is classified into 6 main categories, i.e., agriculture land, city-village and settled place, highway and engineering network area, forest, watershed and reserved land. The watershed area consists of rivers, streams, lakes, ponds, marsh, ice and eternal snow, including intake wells, pumping stations, reservoirs, etc. Such things have then own sanitary and protection zones 1,2,3 under the water law and related regulations.

The Mongolian government's main role is to invest and formulate legal condition of watershed management and to keep and investigate water resource, to provide the integrated watershed management, and to implement international projects and programs effectively to benefit the people.

Nepal (Laxman Sharma)

Nepal is one of the richest countries in terms of freshwater resources with an average surface water availability of about 11,200 m^3/capita. Agriculture is the main occupation of about 80 percent of the population. The socio-economic importance of watersheds are immense in Nepal in terms of agricultural and forest produce, including herbs and medicinal plants, pasture lands and the quality and quantity of water bodies required for irrigation, hydropower and drinking supplies.

The fragile and unstable nature of mountain areas coupled with extreme hydrometeorological conditions are the major causes of land degradation ushering in land use changes in Nepal. Natural phenomena and anthropogenic disturbances leading to landslides, debris flows and wide spread erosion along with other socio-economic reasons have caused the rural people to further exploit and foray into marginal lands expanding cultivation to steeper slopes, continuing deforestation and land degradation.

The southern hills (Siwaliks) and the middle mountains are more susceptible to watershed deterioration. The main areas of problem in Nepal in the watershed management are soil erosion and soil loss, scarcity of water at required places and time in desired quantity and quality, biological degradation, increased sand mining, siltation of reservoirs, siltation of riverbeds in the plains and economic problems. The cumulative effects of watershed deterioration are decline in farm and forest products, high sediment in water bodies and reduced efficiencies of infrastructures. There is a need to regulate land use through land zoning and to improve watersheds. There are issues related to watershed management at the operational and strategic levels such as coordinated efforts, policy and legal lacuna, technical, management and participation aspects.

A bottoms-up approach with public participation is in place in Nepal. The government, mainly through the Department of Soil Conservation and Watershed Management, carries out the activities of land productivity improvement, erosion and hazard prevention, protection of physical infrastructures, soil conservation, community forestry and extension programs as well as encouraging NGOs, INGOs and the international community.

Pakistan (Rashid Ali)

Pakistan is situated in a semi-arid climatic zone in South Asia where normal temperatures are subtropical (exceeding 45°C) and annual rainfall is uneven and low (not more than 150 mm). The country has an agricultural economy that is heavily dependent on artificial irrigation.

Pakistan being a densely populated country, is highly dependent on its natural resources. Land holdings are commonly small due to which farmers tend to use every piece of land for agriculture without considering its suitability. Watershed management thus assumes a very important role in the preservation of land fertility which plays a pivotal role in enhancing the socio-economic condition of the local inhabitants as well as of the people of the downstream area.

A number of Provincial and Federal Government agencies are responsible for watershed management in Pakistan. Besides, a number of NGOs are also active in the watershed areas. However, their activities are at local level but carry a lot of significance in motivating the communities to participate in the watershed management activities and also to shoulder the post project responsibilities.

The Tarbela and Mangla Watershed Management Projects have adopted the concept of better land use planning for implementation of integrated watershed management activities according to land use classification system. Based on this classification, 0.57 million ha have been earmarked for cultivation, 0.33 million ha for range management, and 0.60 million ha for afforestation. Some 0.18 million ha have been categorized as unproductive land.

Watershed research is also being conducted by the concerned national institutes. There is a need to investigate large scale land-use change effects and test models on watershed recovery.

Implementation of various watershed programs over the past 50 years in the country at micro- and macro-levels has resulted in increased awareness in farming community about the integrated watershed management. The farmers are in the process of learning better methods of cultivation, improvement of pastures and afforestation of wastelands by raising nurseries on self-help basis.

For successful implementation of a watershed management program, it is important that various activities in forestry, soil conservation, infrastructure, range management, environmental degradation training and public motivation should be planned and executed in an integrated manner keeping in view land use and land capability classification of the watershed area. Involvement of local communities and NGOs in the planning process and implementation of the program is very essential. Besides, regular monitoring should be an integral part of all watershed management programs.

Philippines (Wilfredo E. Cabezon)

The Philippines has 125 proclaimed watershed forest reserves covering a total of 1,499,334 hectares. These watersheds provide a wide range of benefits to the socio-economic development of the country. However, all these watersheds today are in varying state of degradation due to natural hazards (high rainfall, warm tropical climate), direct causes (deforestation, inappropriate agricultural practices and industrial

activities), and indirect causes (population growth, poverty, limited institutional support, etc.). As such, the government is pursuing management approaches characterized by: holistic, integrated and multiple use management; multi-sectoral and interdisciplinary planning; and participatory sustainable watershed management.

At present, there is no land use classification system specifically adopted to watershed areas in the Philippines. The general classification of land for multiple use has been adopted from the Bureau of Soils and Water Management as a way of classifying watersheds. It employs an integration of environmental dimensions and management practices to identify and map pedo-ecological zones which represent broad environmental management units. There is also a proposed guideline for evaluating and classifying watersheds based on factors such as vegetative cover, soil and water degradation, biodiversity and conservation effectiveness of existing land use.

The role of government with regards to the sustainable watershed development of the country can be grouped into the following aspects: enactment of appropriate policies and legislation; promotion of research and extension programs; making available environment-friendly technologies and application of decision support systems like development of databases. The NGOs, on the contrary, are focused on helping the government in terms of program design and implementation.

Aware of the critical role of the watersheds in the socio-economic development of the country, the government is continuously looking for ways on how to conserve and manage watersheds of the country. To this end, various policies and laws are being promulgated that will hopefully ensure the sustainable, productive and economic use of the watersheds.

Sri Lanka (Wijedheera J.K.V. Ranjith and Lalith Kannangara)

Watershed areas have immense importance for the socio-economic development of Sri Lanka as a resource for agricultural production, and as a supplier of water for hydropower generation, irrigation of agricultural lands and drinking. Many institutions deal directly or indirectly with the activities of watershed management at the national level which makes it difficult to focus on and undertake interdisciplinary efforts on a specific watershed management goal. The decisions on watershed management are made at the national, provincial, division and district levels. However, integrated watershed management (IWSM) still does not get much attention of the policy makers and planners.

The major issues in IWSM include absence of single national organization for IWSM, unawareness about IWSM among the policy makers, planning and implementation of programs without considering the real problems of the stakeholders, lack of financial resources for IWSM, mismatching of management boundaries and watershed boundaries and too many organizations involved in watershed management.

The suitability of land for major uses in Sri Lanka has been assessed using generalized geographic information system. Data on soils, climate and topography have been analyzed to arrive at overall land suitability estimates for the entire country, regardless of present use.

The government's duty is to help people to use watershed in sustainable manner. The private sector should work according to the guidelines laid by the

government for any given activity in the watershed area. The objectives of the National Forestry Policy are: to conserve forests for posterity, with particular regard to biodiversity, soils, water and historical, cultural, religious and aesthetic values. The national forest policy emphasizes the need for safeguarding the remaining natural forests in order to conserve biodiversity, soil and water resources.

At present there is no explicit and accepted National Land Use Policy for the country. However, the National Land Use Policy formulation has received the highest priority of the Land Use Policy Planning Division (LUPPD) under the Ministry of Agriculture, Lands and Forestry.

The Land Commission Report (1985) states that present forest cover should be retained, river basin watersheds should be used as regional boundaries, and emphasis should be given on the integrated watershed management.

Thailand (Kosit Lorsirirat)

Watershed areas play an important role in the socio-economic development of Thailand. However, such areas are deteriorating due to increasing human interventions in the watershed lands because of increasing population pressure. Watershed lands are subjected to soil erosion as a result of increase in arable farming and deforestation.

The major issues in integrated watershed management include, among others, top-down planning, absence of a single national organization for watershed development and thus involvement of many agencies with diverse interests, lack of people's participation, ineffective implementation of the projects, scattered know-how and information, siltation of downstream water reservoirs and river systems, and quality of water.

In view of the above situation and under initiatives of the Royal Forest Department, in 1982 the cabinet approved the Office of Environmental Policy and Planning (OEPP) to be the lead agency to carry out a "watershed classification project" with technical assistance form Kasetsart University and financial support from IUCN. The results of watershed classification study were endorsed by the cabinet in 1995. In 1996, the OEPP was commissioned to conduct a study on the critical watershed of Thailand.

Though Thailand has made some progress in the classification of watershed lands, formulation of legal framework (act) on watershed management, adoption of bottom-up approach and active participation of all the stakeholders, the same is true for the establishment of a single national decision-making and executing organization for watershed management, provision of adequate financial resources, capacity building and creation of awareness among the people about the significance of watershed management. All of this are imperative for a sustainable integrated watershed management through proper land use planning.

Vietnam (Thai Dai Hoang)

Vietnam, located entirely in the tropical zone of northern hemisphere, has an area of 331,689 km^2. Three-fourths of its area is covered by mountains and hills. Vietnam is an agricultural country with approximately 80 percent of its population living in the countryside of which 70 percent is engaged in agricultural production.

The country has dense network of rivers and springs with plentiful water resources. But the overall amount of flow is distributed unevenly even as there are 2,360 rivers greater than 10 km in length in Vietnam. However, the number of relatively closed catchments is 106, the areas of which range from 11 km^2 to 810 thousand km^2. Rivers in Vietnam are mainly small, except the nine river systems with a basin area of greater than 10 thousand km^2. The annual average volume of surface water is about 835,000 million m^3 of which 315,000 million m^3 service Vietnam's territory.

The natural and social conditions of Vietnam make problems of watershed management very important. Water resource management and land use are problems closely related. Water resource management has been carried out on different scales, i.e., whole territory, watershed, or administrative unit. The paper discusses the achievements of water resource management in relation to land use classification, especially in the Red River delta and Mekong River delta. These deltas have been and continue to be essential ingredients in agricultural production.

FIELD STUDIES

The participants visited the following relevant facilities in the host country:

Headquarters of the Korea Agricultural and Rural Infrastructure Corporation (KARICO)

In the afternoon of 24th April, the participants visited the headquarters of the Korea Agricultural and Rural Infrastructure Corporation (KARICO) in Gyeonggi-do some 40 km from Seoul. On their arrival, the participants were received by the officials of the KARICO and were briefed on the history and present activities of the corporation, including a video about the KARICO experience.

The KARICO was established on 1st January 2000 through a merger of the Farmland Improvement Associations, Federation of Farmland Improvement Association and the Rural Development Corporation. It is a state-run enterprise that contributes to the economic and social development of rural areas. The objective of the KARICO is to accomplish a successful implementation of rural development projects, comprehensive management of agricultural infrastructures, construction of more environment-friendly infrastructures and the promotion of farm improvement. It looks forward to leading a sustainable agriculture and rural development. Its certified technical licenses include ISO certification (ISO1991, ISO14001) and 24 government-certified technical licenses.

The KARICO Rural Research Institute

After visiting the KARICO headquarters, the participants were shown the Rural Research Institute (RRI) nearby where they were greeted by Dr. Byeong-Ho Cheong, Deputy Director General of the Institute. A briefing on the activities and accomplishments and objectives of the Institute was made by Mr. Daesu, Executive Officer. They were also shown a video.

The RRI is dedicated to the establishment of prosperous rural communities in the country. Its staff is composed of 125 persons who are in charge of rural infrastructure

development, high-technology agricultural facilities, consolidation of marginal farmland, underground storage, improvement of rural environment, and management of irrigation facilities.

The participants observed the Integrated Water Management System with TM/TAC System in the research area of Water Management Research Group of the RRI. This facility serves as a model for training on Automatic Water Management System and services 10 different locations in the country.

The participants also visited the demonstration area of the Integrated Tideland Reclamation Project—a reclaimed area from the sea shore. Necessarily, the area went through desalinization process in order to become a wet land. Part of the area has been filled by one-meter layer of soil brought from the neighboring mountains. For some 10 years now, the area has since been used as a farm land, including the introduction of fauna and other flora. As a demonstration area, the KARICO expects to generate useful observations that may benefit other areas with potentials for tideland reclamation projects.

Stream Restoration Research Area

Another field trip on 26th April saw the participants visiting the Stream Restoration Research Area (A Case Study of Yangjae Stream) of the Korean Institute of Construction Technology (KICT). Dr. Daeyoung Yu, Senior Researcher of the Institute, received the participants and briefed them on the project activities and accomplishments.

The national and regional (Class 1) rivers (major streams in ROK) have a total length of 4,100 km. At present, almost all the reaches of the rivers are completely channelized by straightening them, constructing levees, and removing all obstacles in the channels such as sandbars, flood debris, including live trees and bushes, which may hinder water flow.

It was learned that in the 1980s, the necessity of restoring those heavily channelized streams was felt. Emphasis was put on channelizing urban streams with concrete canals and levees. Consequently, a series of channel restoration research projects were initiated. One of those research projects is about adapting "close-to-nature river (or stream) improvement techniques" to the highly channelized streams in the country. The research was initiated in 1996 by the KICT and the Ministry of Environment. For the study, the Yangjae-cheon (stream) was selected as urban stream with a drainage area of 58.6 km^2 and that flows in the southside of Seoul.

The first test reached 200 m long upstream of the channel and the second test reached 300 m long in the mid-stream portion of the Yangjae Stream.

The participants visited both research areas of the above channel restoration project. They observed various types of close-to-nature river improvement techniques applied to the low-flow channel and instream region, stream corridors and levees. Such techniques have been quite successful in restoring the physical habitat of the stream. But the cost of close-to-nature river approach for maintaining the natural habitat and scenery of the stream is almost three times higher than that of the modern approach of straightening the streams and constructing levees along the straightened streams.

SYNDICATE DISCUSSION OUTPUT

A syndicate discussion among participants was organized on 27th April and identified below major issues and problems in land use classification for integrated watershed management, suggesting strategies to address such issues. The discussion was led by the chairperson, Dr. Wilfredo Cabezon and rapporteur, Mr. Laxman Sharma.

The output of the syndicate discussion is given below:

Issues	Strategies
1. Policy - Poorly defined objectives, goals and strategies of the government; - Inadequate legislation and acts; - Socio-economic viability and sustainability; and - Poor financing and management of watershed management programs.	1. Design programs to serve interests of stakeholders; 2. Enact comprehensive and appropriate legislation/acts; 3. Formulation of well-defined water and land use policies; 4. Appropriate participatory approach; 5. Establish one coordination body/authority for watershed management activities; 6. Broaden the resource base through participation of the private sector, and through managing loans from both local and foreign funding agencies; and 7. Ridge-to-valley approach for treatment.
2. Capability - Capabilities of the government line agencies to implement programs; - Lack of awareness and capabilities on the part of the public; - Involvement of the NGOs; - Training and education; - Research work; and - Less use of modern information systems.	1. Strengthen local institutions through linkages with concerned agencies; 2. Disseminate knowledge through mass media such as print, radio, TV, etc.; 3. Develop appropriate infrastructure (credit facilities, banking, roads, drainage & irrigation, etc.); 4. Educate agency personnel and public; 5. Use of indigenous knowledge in management and development of watersheds; 6. Training of all stakeholders of a watershed; 7. Use of information technology, remote sensing, GIS, etc.; 8. Focus on uplands/highlands; 9. More focused research on integrated watershed management; and 10. Broaden the applicability of manuals from different countries.
3. Implementation - Huge areas under watershed deterioration; - Top-down traditional approach in watershed management; - Excessive exploitation of land, water and forest resources; - Multiplicity and lack of coordination of different agencies; - Inequity of benefits accruing from previous attempts; - Delay in program funding and execution; and - Lack of post-project sustainability.	1. Prioritization of watersheds (atlas preparation); 2. Public consultation and encouragement of people's participation; 3. Promote the use of appropriate and low cost soil, water and forest conservation practices; 4. Encourage the convergence of state activities/NGOs; 5. Protect rights of resource poor, women and children; 6. Timely provision of funds to avoid delays in program implementation; and 7. Initiate backward and forward linkages with concerned agencies and sectors in watershed management.

4. Assessment - Absence of evaluation mechanisms; - Lack of adequate monitoring of soil and water qualities; - Inadequate investigation and research; - Lack of feedback mechanisms at all levels; and - Poor regional networking.	1. Development of criteria for evaluation; 2. Periodic monitoring of changes in soil and water qualities; 3. Timely review and monitoring; 4. Social auditing; 5. Independent impact evaluation of programs implemented; 6. Encouragement of research and innovations; 7. Develop and strengthen feedback mechanisms at all levels; and 8. Establish/strengthen regional networking.

CONCLUSION

All APO member countries represented in the seminar are aware of the significance of integrated watershed management and of land use planning in socio-economic development. The participants expressed willingness to sustain the development of watersheds through people's participation. The concerted efforts of policy makers, planners and administrators based on multi-disciplinary and participatory approach would be needed in proper land use planning for sustainable development of watersheds. However, financial, technical know-how and cooperation at the national, regional and international levels would be necessary to promote proper land use planning for integrated watershed development, particularly, in resource-poor countries.

The seminar was, in general, successful in accomplishing its objectives with many lessons and insights learned. Follow up activities would be required for further promoting awareness on the significance and strategies for sustainable development of watersheds on the part of member countries. In this regard, the participants felt that another seminar on status of watershed degradation in the member countries or multi-country study mission from less developed countries to more advanced ones could be considered.

1. PARTICIPATORY MANAGEMENT SYSTEMS FOR SUSTAINABLE WATERSHED DEVELOPMENT *

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INTRODUCTION

The Asian Development Bank (1997) reports that already 1-4 percent of the national GDP is lost in Asia due to degradation of the environment. Further degradation threatens to reduce the basis for self-sufficiency in agricultural products in Asia (Penning de Vries, 1998). More than 50 percent of Asia's land surface is sloping (by more than 8 percent) and in some countries there is even a significantly larger fraction (Magrath and Doolette, 1990). Hence there is an urgent and major need for sustainable use and management of sloping land, and for practical knowledge on how to achieve this.

Resource-poor farmers in marginal areas need technologies that are highly effective, so that crucial inputs are required at maximum efficiency. Natural resources in areas with marginal agricultural opportunities are generally heterogeneous spatially: with uneven topography, variable soil quality, and irregular water supply, etc., particularly on sloping lands. To allow these areas to reach a high yet sustainable level of productivity, site- and situation-specific management (SSSM) is needed. Site-specific because uniform application of inputs to heterogeneous land is inefficient, or even harmful. Situation-specific because the socio-economic conditions, such as land tenure, markets and labor prices, determine to a large extent the success of interventions among resource-poor farmers. Therefore, the development of currently marginal lands requires explicit attention to SSSM. Different methods contribute to achieving sustainable land management (SLM):

- Using farmers' knowledge of local conditions, opportunities, and bottlenecks for innovations (including 'indigenous knowledge') is a rapid and cost effective way to obtain information for effective SSSM (Gandah *et al.*, 1998). This is called 'participatory research' .
- Using 'intelligent' tractors with appropriate sensors that determine the optimum rate of fertilization for every part of a farmer's field, and subsequently, apply those rates (Bouma, 1997). This is called 'precision agriculture'.
- Remote sensing by satellites to obtain site-specific information about land, vegetation and water conditions. This is helpful for coarse information from remote areas.

* Paper based on ***Penning de Vries, F.W.T., Chalinee Niamskul, Hans Dieter Bechstedt, Amado Maglinao,*** and ***Adisak Sajjapongse***. 2000. Participatory approaches for sustainable use of sloping lands in Asia. Pp.203-215 in: R. Roetter *et al.* (eds.), Systems research for optimizing future land use in South and Southeast Asia. *SysNet Research Paper* 2. International Rice Research Institute, Los Baños, Philippines.

SLM is achieved when: (1) the use of the land is productive and (2) stable across years; (3) the soil is maintained or improved; (4) the practices are economically viable to the farmers and other stakeholders; and (5) the technology is also sociologically and culturally acceptable (Greenland *et al.*, 1994). The need for farmers' insights and knowledge is particularly great for SLM, because fine tuning is needed between the specific choices for components of a technology and the site (soil, climate) and situation (socio-economic conditions), information that is specific to the farm. The participatory approaches are tools to identify more effectively the specifics of a site and situation, and to add indigenous knowledge to scientific knowledge. Indigenous knowledge sometimes reveals constraints to the development of new systems that scientists overlook, e.g., the importance of seasonal fires. On other occasions, it indicates the relative weight of a known phenomenon at a specific location, such as the frequency of damaging hail storms. Often, several SLM variables cannot be measured (either because methods do not exist, or because time, staff, and funds are not available), so that stakeholder participation helps to amass local input and complements SLM analysis based on scientific methods.

IBSRAM leads and carries out research on sustainable land management with National Agricultural Research and Extension institutes (NARES) in developing countries through collaborative networks. Our focus is on agriculturally marginal lands and sloping lands in Asia, Africa, and the Pacific Islands. Theoretical and practical experiences show that development of appropriate techniques (i.e., techniques that are adopted widely) proceeds much faster by using indigenous knowledge, and their dissemination is faster with the involvement of farmers. Hence, our networks use participatory approaches extensively. Figure 1 shows how they are part of the uptake path of IBSRAM's products in the supply of knowledge (through farmer participatory research), and in its dissemination (through NARES):

- Participatory research and research management with NARES, to expand their capacity to deal with Natural Resource Management (NRM) research and extension; and
- Participatory adaptive research with farmers, to learn from them and to accelerate the identification of better technologies.

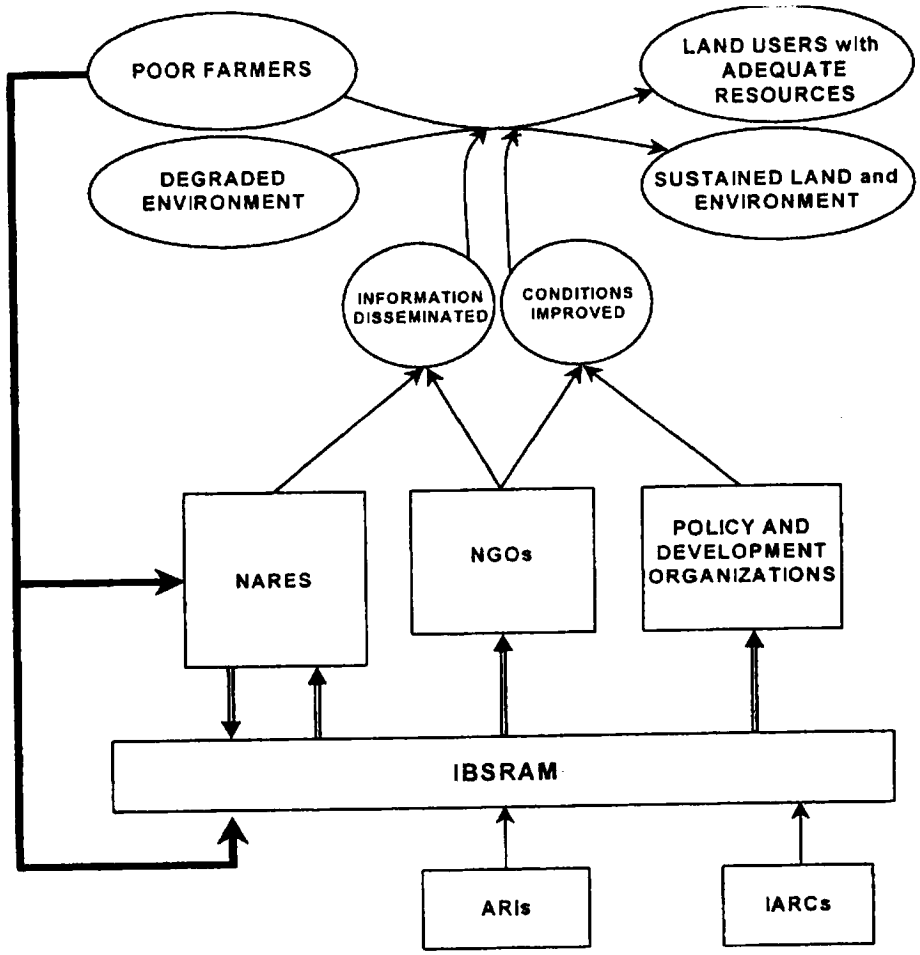
This paper analyzes briefly the nature of these categories in participatory approaches, to consider our experiences, and to draw conclusions for the future. The relation of this paper to the SysNet-LUPAS methodology is outlined at the end.

PRINCIPLES AND EXPERIENCES WITH PARTICIPATORY METHODS

The term 'participatory approach' (PA) is used for many activities. We like to distinguish two groups of PA: participatory activities with farmers (PAF) in order to produce better research results, and participatory activities with research and extension officers (PARE) to build their capacity to deal with natural resource management.

Farmers Help Scientists

PAF means inviting farmers or their representatives to help reviewing constraints in land use and bottlenecks for SLM, and to help the design and testing of



- The uptake paths through which IBSRAM supplies practical land management information to different users in developing countries, and the flows of scientific and indigenous knowledge that it brings together.
- The bold arrows indicate information flow due to farmer participatory activities (PAF). The open arrows indicate interaction in a participatory manner with national organizations (PARE).
- ARIs are advanced research institutes participating in international agricultural research.
- IARC are international agricultural research centers, largely CG-centers.

Figure 1

improved technologies and practices. Farmers are invited in the process mainly because they are better 'sensors' of problems, they often know the sites in more detail, and are better 'integrators' of signals than scientists or instruments. The involvement of farmers (we prefer: 'stakeholders in land use') is represented in Figure 1 (the line between resource-poor farmers and IBSRAM). PAF helps to avoid technologies that scientists consider to be 'good' not being accepted in practice because: (1) farming household needs were not sufficiently taken into account; or (2) the advice to farmers was inadequately site- and situation-specific. (Farming households are also not uniform. PAF should be sensitive to the categories of farming households needing different solutions.)

The participation of end users in the design of products has become quite common in the equipment and service industry (consumer surveys), and its value to land management is no surprise. Yet, involving farmers as serious partners for finding

solutions is still relatively recent and not practised commonly. This approach also matches the requirements for FESLM and SSSM:

- Sustainable land management requires attention to five dimensions: productivity, stability, conservation, economic viability and social acceptability (Greenland *et al.*, 1994); and
- Site- and situation-specific farming emphasizes that resource-use efficiency is maximized ecologically and is economical when inputs are adjusted to the very local (m^2, ha) situations on fields and farms.

A major expansion of PAF use in agricultural R&D has emerged with on-farm trials (as opposed to on-station trials). Trials designed with and managed by the farmers tend to be more relevant. Yet, because of difficulties with interpreting results (see below), their use spreads slowly. Comparing notes and expectations between farmers and scientists is thus a natural interaction. In our Asialand sloping lands (ASL/SL) network, for instance, alley width was adjusted on farmer's recommendation and hedgerow species were replaced in the Pacific (PFL) network on the suggestion of farmer-scientists, and in both cases we noticed the more rapid spread of the newer system. In our latest network, the Management of Soil Erosion Consortium (MSEC), we involved land users right from the project design stage when indigenous knowledge on catchment management and insights in their constraints was elicited (Pongsapichs and Leslie, 1997; Maglinao and Leslie, 1999). We expect that as land management in many catchments operated by MSEC improves, the use of indigenous knowledge will have helped the process significantly, as indigenous knowledge and scientific knowledge complement each other in the development of technologies.

A clear example of the need for farmer's participation is the case of erosion prevention and controlling soil and nutrient loss. Two networks [in Asia (ASL/SL) and in the Pacific (PFL)] address land management to control erosion. They developed effective methods to stop erosion (hillside ditches, contour grass strips, alley cropping, etc.). Target farmers generally recognize the loss of soil through erosion, and appreciate the loss of future capacity to yield crops, but erosion control in itself is not a top priority as the negative effects of erosion take many years to accumulate. Moreover, farmers often cannot justify the extra labor, cost, and inconveniences incurred when future advantages are still many years away. Indeed, we found that concerns about the annual income, relative costs and labor requirements are always pressing and must be addressed with the highest priority from the beginning. Typically, farmers' priorities and bottlenecks include one or more of the following (IBSRAM, 1999b; Penning de Vries *et al.*, 1998):

- Need for erosion controlling crops that also bring cash (at the right time of the year), with labor requirements that fit the household capacity;
- Need for methods that are still cheaper and less labor demanding;
- Need for tree seedlings and seeds of improved varieties;
- Need for information about a broader range of opportunities (e.g., on fertilizer advice, economic potential of other varieties, market expectations); and
- Need for funds at crucial stages (revolving funds, credit).

Our network responses include: more practical alley dimensions (compatible with other cultivation activities), contour crops that also contribute income and fit

better the farm labor calendar, more flexible trial designs (plus the knowledge transferred to farmers to use the flexibility to their advantage), advice on the use of fertilizer; better identification of target groups (including female-headed households), etc. (Many of these responses are well-known from farming activities elsewhere, but can be new and innovative in a particular situation; this goes somewhat against the common trend of demanding 'revolutions').

Three examples help to illustrate the benefits of PAF as follows:

1. In 1997 in the Thai province of Loei, farmers started to use land conservation technologies developed in the ASL/SL network after a training workshop on modern methods in conservation farming. They modified the recommended choice of hedgerow species, and tried the technology on parts of their land; this appeared to achieve both conservation and production. No subsidy of any type was involved. Now, the Loei farmers demonstrate to others what to try and how to do it. The ASL/SL network has learned that varieties to be recommended should be more carefully selected. [The course was developed by the Department of Agricultural Extension (DOAE), with expert input from IBSRAM (on conservation technologies) and Khon Kaen University (KKU, on farming systems research). The success in Loei encouraged the DOAE to extend the workshop to many more provinces and districts in 1998. IBSRAM, KKU and the Department of Agriculture are now preparing a project to extend conservation farming to several more provinces and to reaching millions of farmers.]
2. Small cooperatives of farmers in Malaysia, associated with the ASL/SL network, created a revolving fund. '... the idea of having a revolving fund for the continued use of soil conservation technologies is now a workable arrangement. This has brought a stronger sense of responsibility to the farmers in managing the alleys between the rubber rows considering that the alley crops of pineapple and bananas, being medium-term crops, need a longer time and care before they bear fruit and provide income. The idea of ploughing back a portion of the expected income from the sales of the intercrops into a central pool resulted from a series of discussions in the field. The idea is to have a contingency fund to support any form of input to maintain the crops.' (Maglinao, 1998).
3. Small farming communities in Indonesia participated in ASL/SL on-farm trials. 'Realizing that without fertilizers, the corn would grow poorly, every attempt was made to obtain fertilizers. The group decided that the farmers should get fertilizers through their own efforts and a cooperative system was considered a good solution. All project farmers agreed and they collected membership fees for the Kemitraan Simpaan Pinjam that was formed as a savings and loans cooperative system. Because the accumulated fund was not adequate, the project provided loans to cover the difference so the farmers could buy the fertilizers under the condition that they would repay their loan after the harvest. By the end of December 1996, all their loans had been repaid and the cooperative's funds had doubled from the original amount.' (Maglinao, 1998; IBSRAM, 1999b). IBSRAM is currently advocating this form of farmer cooperation as a means to overcome lack of credit.

Why does PAF need to be promoted more in developing countries than it was in Western agriculture? In our view, this is in relationship to the high rate of land degradation, the small size of NARES, and our desire to reduce rural poverty faster. Farmer's participation accelerates technology development, but is not inherently better than research-driven technology development. PAF can be skipped when a sufficiently large basket of relevant options has already been presented to farmers, and if they possess the information needed for selection. In other words, PAF is not needed when ample and effective research, development, and extension have occurred. This has been the case in the Western countries with much R&D, but not in countries with much smaller budgets and numbers of staff. Greater efficacy with smaller R&D support can be achieved through participatory approaches that help to focus faster and better on, and solve, the real bottlenecks. Yet this realization is relatively new. Only a decade ago, farmers were almost always at the end of the technology development process, and were receivers of research results.

Limits to Participatory Research with Farmers

While PAF has unique advantages and should be promoted, we must remain aware of its inherent limitations. Rhoades (1998), while, in general, a strong supporter of participatory methods, warns that we should not expect too much. There are different limitations:

1. Participatory research is a partial and subjective method, as sampling of ideas and a few persons is always imperfect, socio-cultural conditions may change rapidly (rendering results volatile), and analyses can be strongly biased. Analyzing results from PAF requires a good scientific mind and a large dose of common sense.
2. Using results from PAF through common scientific techniques is frequently very difficult or even impossible. For the biophysical aspects of trials, some important difficulties are:
   - There are few repetitions, if any;
   - Processes are very difficult to monitor and commonly only once a year;
   - It is difficult to install and maintain equipment;
   - Management of trials are difficult to control or even to monitor; and
   - Farmers often do not see the value of a 'control treatment', and change treatments intuitively.

It is, therefore, necessary to carry out the participatory research with a sound scientific background so that one-time observations can be processed in scientific minds and results still have value in later years, in other places and in different economic conditions. Otherwise insights obtained are of local value only, without any generic merit. It is a major challenge to science to define a minimum data set from on-farm trials for extrapolation of SLM technologies. For socio-economic variables, this is even more difficult as methods to measure and observe cannot give precise answers, and theories are not always well-developed. The socio-economic aspects of any farming households may not be representative and variable, while community level indicators of bottlenecks or (potential) impacts have received little attention.

In summary, there is a dichotomy between the need for rigor and the narrow

basis of data often available. This is already stretching scientific integrity to the limit. With the constant pressure to perform analyses faster and cheaper, there is a clear danger of participatory research degenerating into mere *ad hoc*, site-specific data collection without a broader value.

Participatory Approaches in Capacity Building in NARES

NARES and NGOs are responsible for approaching land users and policy-makers in their own countries. A role of IBSRAM, and other international agricultural research centers, is to enhance their capacity for research and research management, and to supply information to decision-makers and change socio-economic conditions (Figure 1). Enhancing this capacity requires a participatory approach to research and extension (PARE). IBSRAM has done this in networks since 1985, with 34 institutions and 187 national staff in 18 countries. This implies classroom and on-the-job training in on-station and on-farm research and research management, annual meetings with the collaborators to discuss progress and planning, and encouraging international exchange. IBSRAM does not have its own field or laboratory facilities, as all fieldwork occurs with and through NARES.

Networks exist ideally for around 10 years, and pass through the phases of development and training, production of results at the institutional and technology level, and preparation of dissemination via extension and NGOs. Each network has a Steering Committee (SC), typically consisting of one member per participating country, and has in its terms of reference to oversee the operational part of the network. Current networks of IBSRAM are: Asialand sloping lands network (ASL/SL, 7 countries), Pacific land network (PFL, 6 countries), Asialand Acid Soils network (ASL/AS, 4 countries), and the Management of Soil Erosion Consortium (MSEC, 9 countries) are described elsewhere (IBSRAM, 1998). The framework in which they operate is presented in the Medium Term Plan (IBSRAM, 1999a).

In a survey of the impact of IBSRAM's activities since 1985, the participatory network mode of operation appeared to be highly appreciated by our partners and their supervisors (IBSRAM, 1996). The outputs of the network mode of R&D, and more importantly their impact, were recently reviewed (Maglinao, 1998). Some of his conclusions are presented in Table 1. Since many organizations are active in NRM and involved with NARES, it is inevitable that impacts are the result of the outputs of many organizations, and cannot be attributed to any single organization. With respect to the impacts mentioned, the following concrete examples can be cited from this report:

> "... the Philippine collaboration with IBSRAM and SANREM projects on natural resources management has provided rich insights for infusing constructive improvements in the Philippine agriculture and resources research and development system through PCARRD (Philippine Centre for Agricultural Research and Rural Development, Los Baños) and its research network .... Among the impacts identified are the following: (1) rationalized review of R&D proposals; (2) balancing of commodity approach with the institutionalization of environmental concerns in research; (3) input to PCARRD's Medium Term Plan; (4) improved operationalization of the consortia approach; and (5) establishment of indicators of sustainability."

"IBSRAM's activities have provided the NARES with the confidence to question external SLM options (that may be deemed inappropriate by farmers for any number of reasons) and offer appropriate alternatives (usually offering short- and medium-term cash flows or providing food) under both research and on-farm environments. They also increase the awareness of the NARES on the need for flexibility when guiding farmers towards SLM, given an often dynamic and volatile on-farm environment."

"Probably because of gained experience and improved capability, a number of IBSRAM collaborators have been given greater responsibility and even the opportunity to provide inputs and give advice in national policy making."

"IBSRAM has opened the door for a wider and more active participation of the NARES in regional and global activities related to SLM. They now have better opportunities to attend regional and international meetings that provide additional exposure to new developments. The NARES have thus become more active partners in determining the direction of R&D on soil and water resources."

A recent survey of contacts of the national partners in one network (ASL/SL) to non-network institutes, a prerequisite for 'impact', indicated that on average 10 different national research, extension and policy organizations are now in regular contact with each national network partner.

Table 1. Impact of 12 years of participatory approaches with NARES on capacity building, the research community and on farmers (from Maglinao, 1998)

OUTPUTS	IMPACT
- Improved capacity of the NARES (upgraded research facilities, trained manpower, quality assurance); - Modern methodologies and diagnostic tools (participatory paradigm, consortium approach, DSS, GIS); - Relevant concepts and models (Framework Evaluation Sustainable Soil Management; Soil Water and Nutrient Management [CG-system wide initiative], Resource Management Domain); - Linkages and collaboration (with the NARES, IARCs, ARIs, and donors); - Appropriate technologies and practices (contour hedgerows, management of Vertisols, organic-matter management in acid soils, etc.); and - Publications and other information materials (annual reports, network documents, workshop proceedings, global data bases, etc.)	*Impact on the NARES* - Reorientation of research priorities and funding allocation; - Integration of SLM in national policies and guidelines; - Narrowing the gap between research, extension and farming community; and - More opportunities for participation in regional and global research. *Impact on the farmers* - Increased adoption by farmers of SLM technologies; and - Greater initiatives of farmers to sustain adoption of technologies.

Even though the dealing with NARES has been on a participatory basis from the beginning, their (and IBSRAM's) dealing with farmers was not participatory initially. Research occurred 'on station', and farmers were shown the results. Although they participated eagerly in field days, this did not lead to spontaneous adoption of improved soil management techniques. This observation, and the awareness (Greenland *et al.*, 1994) that SLM requires broader attention than soil management *per se* led us to implement PAF in our networks, beginning with ASL/SL. Training of NARES to involve PAF started in 1996, and already more than 17 countries in Asia, Africa, and the Pacific, participate. The course provided a basis for a training manual (Bechstedt, 1999). Most of the network research now occurs 'on-farm'. Although some NARES are now also capable of carrying out PAF, we continue to reinforce capacity in three ways:

- By reaching out to more countries: special effort will be devoted towards NARES and NGOs that are yet ineffective in reaching farmers.
- By research on how to overcome institutional and policy barriers to participatory approaches in some situations.
- By designing simple yet effective participatory approaches for small communities with different stakeholders, such as catchments with upland and downstream land users.

Participatory approaches imply that part of the responsibility for choosing directions and activities lies with NARES. We make this explicit by recognizing the role of the network steering committees as such. It should be noted, though, that donors of projects do not always fully appreciate the shared responsibility.

Limits to Participatory Approaches

It is worthwhile remembering that some problems are not solved by better communication alone, and participatory work may not be sufficient to achieve the adoption of improved methods. Land users may not be able to do what they want because economic, legal or institutional conditions may not be met due to the absence of markets and (micro) credit, prices that do not express the cost of maintaining a healthy environment to be expressed in the price of farm products, land tenure, or a conducive and enforced legal structure. Garrity *et al.* (1998) noted that extensive activities to promote sustainable land management in Mindanao, Philippines, were not rewarded with much success until the national government adopted a decentralized approach to environmental protection, and provided every village with some financial means. In the area described by Garrity, these funds were used to set up common tree nurseries, and SLM suddenly started spreading rapidly. The bottleneck then was shortage of communal funds, even though he believes that participatory activities laid a basis for effective use of the funds.

Governments should step up support to resource-poor farmers either directly (paying farmers for keeping their land in good condition and without polluting the environment, as done in Europe and the USA), or indirectly, through permitting farmers to include environmental concerns in the price of their products. Such actions do not necessarily mean subsidies, although these need not be ruled out when it is for the ultimate benefit of the environment (Rey *et al.*, 1999). Subsidies may be

considered for transition periods, particularly when the initial investments in land to achieve SLM may be high.

The activities of a large number of private companies play an indirect role in land management. Agrochemical factories in the first place, because of their supply of fertilizer and crop protection agents, that if overused or wrongly timed (quite common) lead to damage. The participation of the private sector in the process of reducing the pressure on the environment is, therefore, crucial, for instance, through the distribution of information on the proper use of the agrochemicals (through NARES, NGOs, their outlets and retail organizations), by promoting healthy materials and methods, and by supporting research on methods and materials that have a less detrimental effect on the environment.

RELATION BETWEEN PARTICIPATORY APPROACHES AND SYSNET-LUPAS METHODOLOGY

Farmers make decisions about land management that are of a short- to medium-term nature, while policy makers will also make medium- to long-term decisions. They do this also with different sets of information and different objectives. Medium- to long-term plans and targets selected by the local or national government (whether based on LUPAS [Roetter *el al.*, 2000; Hoanh *et al.*, 1998) scenario analyses or any other method aiming at regional scale analysis) have little direct impact on farmers. They will respond to how these plans are translated into better markets, better credit systems, improved information, etc. (Figure 2). When LUPAS is applied to whole provinces and states, land units are largely in the order of 1 to 10 km^2, meaning that there is still much variability in site- and situation-specific conditions. In addition, every farm household has a different set of resources in term of land, water, equipment and labor, capital and education. Farmers, therefore, still keep the challenge of making many right decisions. The better the government planning and the better the translation of this in improved socio-economic conditions, the faster farmers see returns for their investments. Participatory research is an effective component of developing for, and delivering to, farmers appropriate land management information under current conditions. In this manner, farmer participatory approaches complement and can support the implementation of development plans such as those based on LUPAS analyses for medium- to long-term agricultural planning at regional scale. This will be even more the case in the future, when SysNet-LUPAS methodology will be further advanced to solve conflicts between different decision levels (province, municipality, farm) and will take into account the development pathway from current to future sustainable land use and production systems (Roetter *et al.*, 2000).

Acknowledgment

Thanks are due to the many Asian farmers who contributed their wisdom, and showed how their knowledge and enthusiasm make 'farmers participatory research' effective.

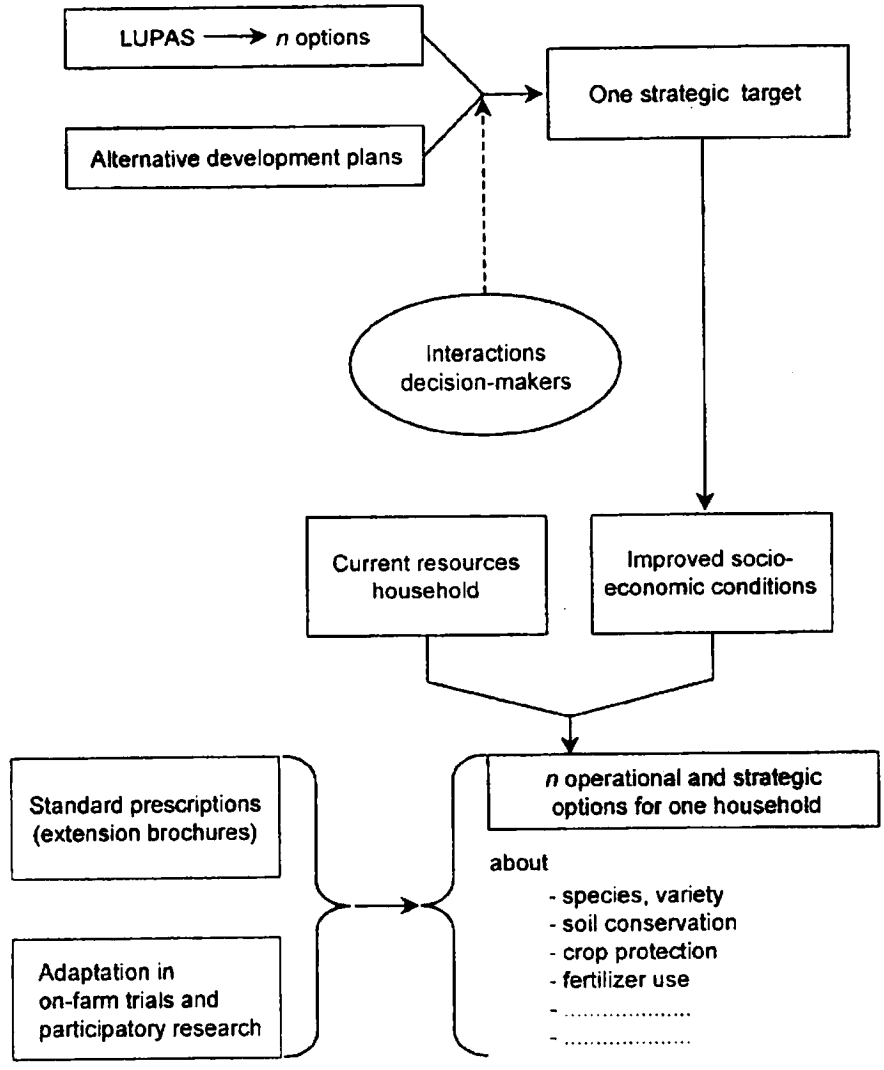


Figure 2. The source of information on which a particular farmer makes his/her choices. The diagram indicates how LUPAS and participatory approaches are complementary.

REFERENCES

Asian Development Bank, 1997. Emerging Asia changes and challenges. ADB, Manila, Philippines.

Bechstedt, H.D., 1999. Training manual on participatory research and technology development for sustainable land management. Global Tool Kit No. 3. IBSRAM, Bangkok, Thailand.

Bouma, J., 1997. Precision agriculture: Introduction to the spatial and temporal variability of environmental quality. In: Eds. G. Bock and J. Lahe, CIBA-EERO Symposium on Precision Agriculture. Ciba Foundation Symp. 210, pp. 5-17.

Gandah, M., J. Bouma, J. Brouwer, J. & N. Van Duivenbooden, 1998. Analysis of constraints to agricultural production in the Sudan Savanna zone of Nigeria using multi-scale characterization. Neth. J. Agric. Sci. 46(1), 39-51.

Garrity, D.P., A. Mercado and M. Stark, 1998. Building the smallholder into successful

natural resource management at the watershed scale. In: Soil Erosion at multiple scales: Principles and methods for assessing causes and impacts. CABI, UK and IBSRAM, Thailand, pp. 73-82.

Greenland, D.J., G. Bowen, H. Eswaran, R. Rhoades and C. Valentin, 1994. Soil, water, and nutrient management research - A new Agenda. IBSRAM, Bangkok, Thailand, 80 pp.

Hoanh, C.T., R. Roetter, D.M. Jansen, P.K. Aggarwal, F.P. Lansigan, N.X. Lai, I.A. Bakar and A. Tawang, 1998. Generalizing SysNet methodologies for land use planning at the sub-national level. In: Eds. R. Roetter, C.T. Hoanh, N.V. Luat, M.K. Van Ittersum and H.H. Van Laar, Exchange of methodologies in land use planning. International Rice Research Institute and National Agricultural Research Systems from India, Malaysia, Philippines, Vietnam, SysNet Research Paper Series No. 1., pp. 41-56.

IBSRAM, 1996. Response to IBSRAM stakeholder questionnaire. IBSRAM Newsletter 42: 2-3.

IBSRAM, 1998. IBSRAM Highlights 1998. Bangkok, Thailand, 64 pp.

IBSRAM, 1999a. Common ground: Implementing the IBSRAM Vision. IBSRAM, Bangkok, Thailand, 48 pp.

IBSRAM, 1999b. The management of sloping lands in Asia (IBSRAM/Asialand). Network Document no. 24, IBSRAM, Bangkok, Thailand, 240 pp.

Maglinao, A.R., 1998. IBSRAM's impact: Making the difference in sustainable land management research. Issues in Sustainable Land Management no. 4, IBSRAM, Bangkok, Thailand, 72 pp.

Maglinao, A.R. and R.N. Leslie, 1999. Site selection and characterization: Focus on biophysical and socioeconomic inventory. Issues in Sustainable Land Management no. 6, Bangkok, IBSRAM, Bangkok, Thailand

Magrath, J.B. and J. Doolette, 1990. In: Watershed development in Asia: Strategies and technologies. World Bank Technical Paper 127, World Bank, Washington DC, USA, pp. 36-70.

Penning de Vries, F.W.T., 1998. Land degradation reduces maximum food production in Asia. In: Proc. Int. Symp. World Food Security and Crop Production Technologies for Tomorrow, Kyoto University, Japan, pp. 17-24. (Abstract also published in Jpn. J. Crop Sci. 67(2) 1998.)

Penning de Vries, F.W.T., F. Agus and J. Kerr (Eds.), 1998. Soil erosion at multiple scales: Principles and methods for assessing causes and impacts. CAB International, UK and IBSRAM, Thailand, 390 pp.

Pongsapich, A. and R.N. Leslie (Eds.), 1997. Indigenous technical knowledge for land management in Asia. Issues in Sustainable Land Management no. 3, IBSRAM, Thailand, 50 pp.

Rey, Ch., I. Scoones and C. Toulmin, 1996. Sustaining the soil. Indigenous soil and water conservation in Africa. Earthscan Publications Ltd. London, UK, 260 pp.

Roetter, R., P.K. Aggarwal, A.B. Ismail, N.X. Lai. F.P. Lansigan and C.T. Hoanh, 2000. SysNet methodology development 1996-99. This volume.

Rhoades, R.E., 1998. Participatory watershed research and management: where the shadow falls. Gatekeeper Series no. 81. International Institute for Environment and Development, London, UK, 25 pp.

2. SUSTAINABLE WATERSHED MANAGEMENT SYSTEM AND WATER QUALITY CONTROL IN THE REP. OF KOREA

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INTRODUCTION

During the last four decades, through successful execution of several phases of the Economic and Social Development Plans, the Rep. of Korea (ROK) has enjoyed an unparalleled period of economic growth, industrialization and rising living standards. In early 1960s, the late President Park once said that he wanted to see the sky covered with smokes from industries after he visited several industrialized countries and he believed that the industrialization is the only way for ROK to become competitive in the world. With his confidence and strong leadership, remarkable industrialization and economic growth could have been possible. However, the rapid industrialization and urbanization have resulted in consistent increase in water demand and serious environmental problems.

Despite the increasing quantities of wastewater and pollutants from various sources, the implementation of various and more systematic water pollution control strategic plans has started only since the 1980s which was after the water quality of the major water-bodies already had seriously deteriorated. Although there has been remarkable expansion in various water pollution control facilities with very intensive investment made during last 10 years, many cities still have poor sewer systems and water qualities of most rivers and lakes are still poor.

The country has limited water resources. The average annual precipitation exceeds the world average, however, the per capita annual precipitation is only one-ninth of the world average due to very high population density. In addition, since about two-thirds of the annual precipitation is concentrated in only four months, from June to September, and the surface water run-off during this rainy season is discharged into the sea with flood, only 24 percent of total annual precipitation is being properly utilized.

To deal with this problem, numerous and large dams were constructed to provide storage reservoirs, flood control and for energy production. However, due to long hydraulic retention times of these artificial lakes and large watershed areas, deterioration of water quality and eutrophication of the water supply reservoirs have become major concern. In addition, controversies between the residents in upstream and downstream of river basin are often encountered due to the different views for the beneficial uses of the water and thus sustainable management of major watersheds is of great importance. Concerning these, this paper was prepared to introduce the

status of water pollution and past experiences and strategic plans for watershed management to improve water quality and also to ensure enough quantity of safe and clean water in the country.

RIVERS AND LAKES

Under the River Act, rivers in ROK are classified into three classes: Class A rivers are directly administered by the Ministry of Construction and Transportation (MOCT). Class B rivers are administered by local governments. Class C rivers are also administered by local governments but are indirectly governed by the Water Act.

The total number of rivers which are designated by the Act is 3,964 with total length of 30,416 km, including 62 Class A rivers, 55 Class B rivers and 3,847 Class C rivers (Table 1). There are also 34,958 tributaries and small rivers with a total length of 39,110 km which are not designated by the Act. Among the river basins listed in Table 1, Han River, Nakdong River, Keum River and Yongsan River are the four major river basins which cover most of the country. For the purpose of more efficient water quality management, the Ministry of Environment has divided all waterways in ROK into four large influenced regions based on the four major river basins since 1991.

Table 1. Distribution of Rivers in the Rep. of Korea, by River Basin

River Basin	Basin area (km^2)	Number and Length							
		Total		Class A		Class B		Class C	
		No.	km	No.	km	No.	km	No.	km
Total	88,747.5	3,964	30,416	62	2,858	55	1,320	3,847	26,238
Han	26,018.0	705	7,257	15	814	12	553	678	5,890
Nakdong	23,817.3	825	7,460	10	830	10	191	805	6,440
Keum	9,810.4	503	3,742	11	402	20	362	472	2,998
Yongsan	3,371.3	185	1,472	5	197	2	46	178	1,229
Sumjin	4,896.5	284	2,071	3	237	1	22	280	1,812
Others	20,834.0	1,462	8,414	18	379	10	146	1,434	789

Table 2. Characteristics of Major Lakes

Lake name	Inflow ($10^6m^3/yr$)	Total storage (10^6m^3)	Catchment area (km^2)	Av. depth (m)	HRT* (days)	Surface area (km^2)
Soyang	1,874.5	2,900	2,703	41.4	562	70.0
Paldang	16,505.2	244	23,800	6.7	5	36.5
Chungju	4,610.3	2,750	6,648	28.4	217	97.0
Andong	1,098.5	1,230	1,584	23.9	410	51.5
Namgang	1,584.6	136	2,285	5.8	31	23.7
Hapcheon	641.4	794	925	28.8	435	27.6
Imha	852.9	1,060	1,230	22.1	456	48.6
Seomjingang	592.1	466	763	17.6	287	26.5
Chuam	700.4	860	1,010	14.0	451	61.3
Daechung	2,864.8	1,490	4,134	20.5	190	72.8

* Hydraulic retention times.

Table 2 summarizes the relevant dimensions of the major lakes in the country. While there are more than 400 major lakes out of the total 19,000 lakes in ROK, the major ones are artificial lakes. If the lake has hydraulic retention time of longer than 3.6 days with enough concentrations of nitrogen and phosphorus, the lake is considered to readily become eutrophic lake. Accordingly, it can be said that most artificial lakes in the country are prone to become eutrophic since Table 2 indicates that hydraulic retention times of the major lakes are fairly long.

WATER RESOURCES AND WATER USE

The average annual precipitation in the country is about 1,274 mm which is 1.3 times the world average of 973 mm. However, the annual run-off per capita is 2,900 m^3 which is only one-ninth of the world average of 26,800 m^3. About 65 percent of the annual rainfall is concentrated in four months, June to September, and thus most rainfalls during this season are lost with flood.

Figure 1 shows the water balance in ROK. Of the total annual precipitation of 126.7 billion m^3, some 45 percent is lost through evaporation and/or infiltration, and the balance (69.7 billion m^3) become surface run-off. However, since 39.6 billion m^3 are directly discharged into the sea, mainly with flood, the available annual surface run-off becomes 30.1 billion m^3 which is only 24 percent of total annual precipitation.

It is now believed that there are at least 1.5 trillion m^3 of ground water in the country. However, technical and economic feasibility of groundwater development is fairly limited considering the soil and ground conditions. Water uses for various purposes are also shown in Figure 1 which indicates that agricultural use is still the major component while municipal use is 21 percent and industrial water use is 8 percent.

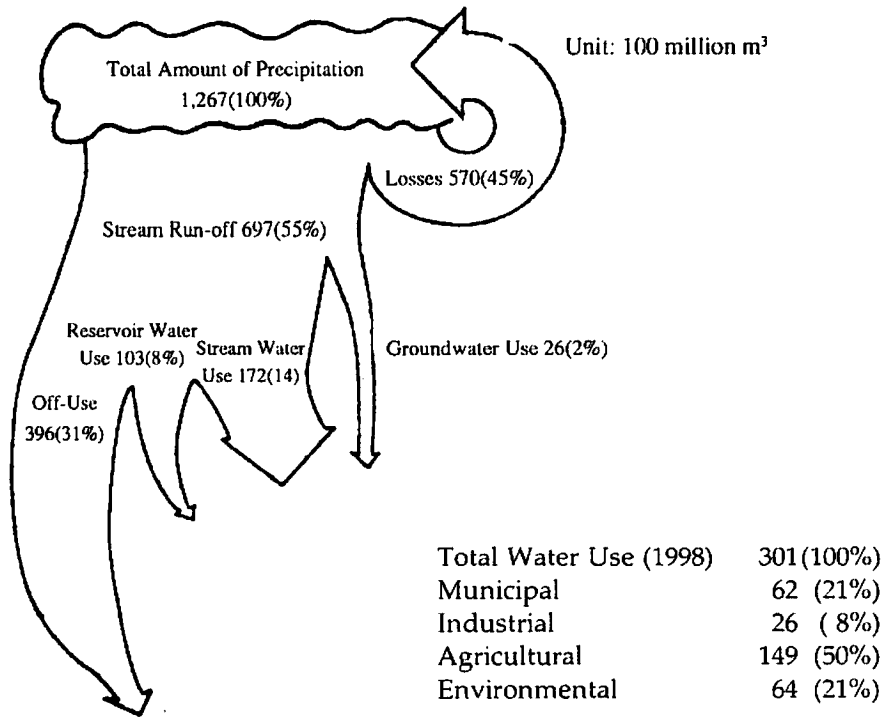

Figure 1. Water Supply and Use (1998)

POLLUTION OF RIVERS AND LAKES

Sources of Pollution

The major sources of water pollution are domestic sewage and industrial wastewater. As of the end of 1999, the total wastewater discharge was 20,541 x 10^3 m^3 per day, of which 85 percent was domestic sewage and 14 percent was industrial wastewater. Besides these major sources, various livestock farm wastes also make some contributions, although volumetric contribution was less than 1.0 percent. The contribution to BOD loading was 19.9 percent.

The number of industrial wastewater discharger increased from 23,310 in 1992 to 39,939 in 1997. The number was reduced to 37,621 in 1998 mainly due to the economic crisis during this period. The rate of livestock farm wastewater generation also increased as more meats are now being consumed than before. Although the number of cattle and pig farms decreased from 790 x 10^3 in 1990 to 570 x 10^3 in 1996, the total number of cattle and pigs increased from 6.65 million head to 9.91 million head during the same period. However, the most of these livestock farms are small scale and thus the sources of livestock wastes are so scattered that the control of these wastes is very difficult, hence much of the waste is discharged without proper treatment.

Water Pollution Levels

Table 3 summarizes the BOD levels of upstream, midstream and downstream of four major rivers, i.e., Han River, Nakdong River, Keum River and Youngsan River. Water qualities of upstream and midstream of Han River are fairly good, however, it becomes poor at downstream as it flows through Metropolitan Seoul and also as several heavily polluted tributaries are joined with Han River.

Table 3. Water Quality of Major Rivers

(unit: mg/L)

River name	Point	Target	1990	1997	1998
Han	upstream (I)	1.0	1.3	1.6	1.3
	upstream (II)	1.0	1.1	0.8	0.8
	midstream	1.0	1.0	1.5	1.5
	downstream	6.0	4.7	5.5	4.6
Nakdong	upstream	1.0	1.0	1.1	0.9
	midstream	3.0	3.2	4.7	3.2
	downstream	3.0	3.3	3.8	3.2
Keum	upstream	1.0	1.5	1.1	0.9
	midstream	1.0	3.1	3.6	2.3
	downstream	3.0	3.1	3.4	2.4
Yongsan	upstream	1.0	1.2	1.6	1.6
	midstream	3.0	6.7	7.2	5.9
	downstream	3.0	1.2	2.3	2.0

It should be noted that the water quality of midstream, the Paldang Reservoir, has deteriorated despite the tremendous efforts which have been concentrated to improve its water quality as it is the major source of public water supply for 20 million residents of Seoul and vicinity.

Water quality of upstream Nakdong River is also good showing 0.9 mg BOD/L, however, as the river receives Keumho River which is heavily polluted with wastewater from the City of Daegu and various industrial wastewaters, the water quality is deteriorated. The water quality is slightly improved at downstream mainly by self-purification of the river while there are no major pollution sources between midstream and downstream.

The water quality of Daechung Reservoir, which is located at upstream of Keum River and is the major source of public water supply for central Rep. of Korea, barely meet the Grade I water quality standard (BOD < 1 mg/L) while those of midstream and downstream became worse as sewage and industrial wastewater from various sources, including City of Daejeon and Cheongju City are discharged into the river.

The length of the Yongsan River is shortest among them and the river basin area is not very large. Because of several reservoirs for agricultural purposes are located at upstream, the average flow rate of the river becomes rather low and thus BOD at the junction of the river and Kwangju-chun is very high, i.e., about 5.9 mg/L, since Kwangju-chun is heavily polluted with sewage and industrial wastewater from the City of Kwangju. Table 3 shows that the water quality tended to improve at downstream.

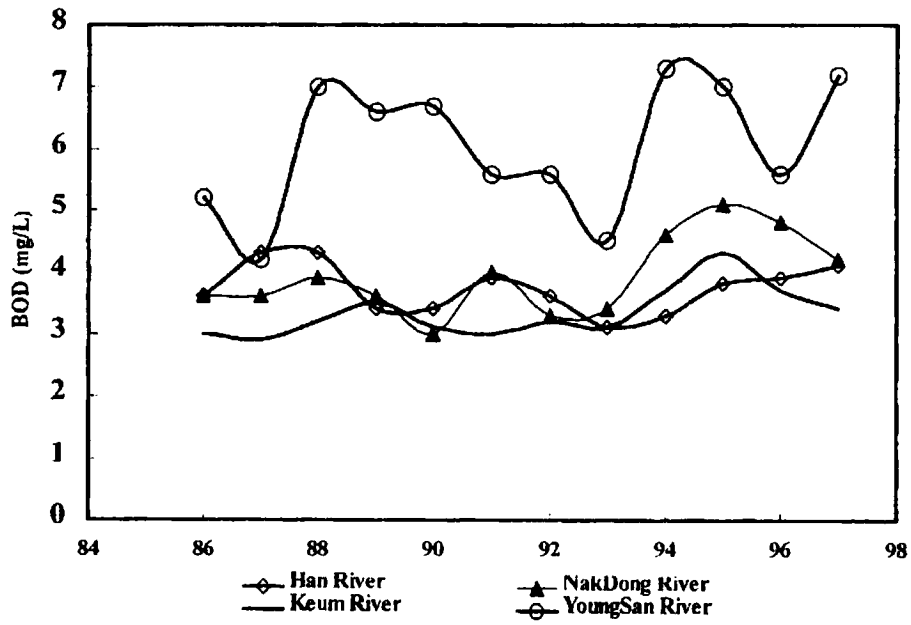

Figure 2. Water Quality of Four Major Rivers, 1986-97

The water resources in the country heavily depend on artificial lakes while the reservoirs are prone to become eutrophic as described earlier. Table 4 shows the concentration of total nitrogen and total phosphorus in two major reservoirs, i.e., Paldang and Daechung reservoirs. As shown in this table, T-N and T-P concentrations have increased in both reservoirs which have already been experiencing several eutrophication problems.

Table 4. Nutrient Levels in Two Major Reservoirs (Paldang and Daechung)

Year	T-N (mg/L)		T-P (mg/L)	
	Paldang	Daechung	Paldang	Daechung
1995. 3	2.377	1.215	0.030	0.020
1997. 3	2.542	1.974	0.026	0.029
1998. 3	2.522	2.174	0.069	0.039

Water Quality Standards

It is now almost impossible to maintain water quality in all the water bodies to the level of drinkable water and it is not economical even in advanced countries. Therefore, it is very important to maintain water quality clean enough to protect beneficial uses and ecosystems of the water bodies. This is why the water quality standard was established and revised in order to protect the environmental capacity of the water body.

In terms of water quality, there are five grades (I, II, III, IV and V) for river and lake waters and three grades for sea waters mainly based on the use of water of which Grade I denotes the best quality water which can be used for drinking with minor treatment. The standards for major conventional parameters such as BOD, SS, PH and Coliforms are defined for each grade and those for nine hazardous substances are also defined for public health purposes.

The standards for lake waters are similar with those for river water with few differences: COD instead of BOD is the parameter for organic pollution and more stringent SS standards are applied for lake waters than river waters. Since 1993, total nitrogen(T-N) and total phosphorus(T-P) have been included in the standards for lake waters concerning eutrophication. All waterways in ROK are divided into 194 reaches and each reach has different targets of water quality based on the beneficial uses of the water. In 1999, the number of reaches which have achieved the target was 29.9 percent while it was only 12.8 percent in 1991.

All regions of ROK are divided into four groups such as Clean area, A area, B area and Special area for the purpose of regulating industrial wastewater discharge. The Clean area represents the regions where the quality of water is maintained within Grade I water quality standard. The areas A and B stand for the regions where the water qualities should be maintained within the standards of Grades II or III and Grades IV or V, respectively. The areas with industrial complexes and agro-industrial zones are designated as special areas and different standards are applied based on the characteristics of the area and the volume of wastewater discharged. The standards of T-N and T-P are applied to areas which are designated as Special Protection Area by the Minister of Environment.

Water Pollution Control Facilities

As of the end of 1999, 150 sewage treatment plants were in operation treating approximately 17.7 x 10^6 m^3 of sewage per day which is equivalent to 68.4 percent of

total daily sewage generation in ROK. Construction of sewage treatment plants became active only after the '80s as priority was given to large cities and industrialized cities. Most treatment plants are quite large: 44 out of 150 sewage treatments have treatment capacity of more than 100 x 10^3 m^3/day each.

Conventional activated sludge system has been the major type of treatment process. Appropriate technology for small and medium sized cities and advanced treatment process for the cities located in special region have become major concern. Appropriate treatment process is being selected considering efficiency, economy and relative difficulty of operation and maintenance along with local conditions, and for most inland cities, nutrient removal capability has become very important.

There were 30 integrated industrial wastewater treatment plants in operation as of the end of 1999 with a total treatment capacity of 643 thousands m^3/day to treat wastewater generated in various industrial complexes. Plans are afoot to construct 51 integrated industrial wastewater treatment plants by 2005 to treat 90 percent of the total industrial wastewater generated. Some 89 small scale integrated wastewater treatment plants are also in operation with a total treatment capacity of 60.4 thousand m^3/day to treat wastewater generated in agro-industrial zones.

A large portion of nightsoils, approximately 27,000 m^3/day, is treated at nightsoil treatment plants in the urban area. About 3 percent of nightsoils is decomposed in tanks with long retention time, while the rest, 19 percent, is handled in some other means, such as composting or ocean dumping. Livestock farms which grow more than 1,000 pigs or more than 100 cattle or horses with the farm area larger than 1,400 m^2 or 1,200 m^2, respectively, should treat the wastewater to meet the effluent BOD and SS standards of 150 mg/L. Wastewater discharged from smaller farms with an area of 150~1,400 m^2 for pig farms and 350~1,200 m^2 for cattle or horse farms should meet the BOD standard of 1,500 mg/L. However, most livestock farms are rather small scale, only 30 percent of the livestock wastewater is regulated by the laws and thus wastewater generated form 70 percent of the livestock farms are not properly treated before disposal.

WATER QUALITY MANAGEMENT PLANS

Clean Water Supply and Comprehensive Water Management Plans

The Korean government had executed a 5-year (1993-97) plan to supply safe and clean water called the National Clean Water Supply Plan. Eight Ministries related with water management were involved in this plan while the Ministry of Environment had played a key role. In 1996, the National Commission on Water Management (NCWM) was installed in the Office of the Prime Minister to coordinate the various policies of water management which were operated by different Ministries. Since then, all major policies for water management have been finalized by the Committee for Coordination of Water Management Policy headed by the Prime Minister through the report from the National Commission on Water Management.

Also, in 1996, the NCWM promulgated a 15-year plan (1997-2011) called the Comprehensive Water Management Plan. Again, all water-related agencies, including the Ministry of Budget, participated in the plan which consist of water quantity provision

plan and water quality management plan. Although the various projects included in the water quality management plan will be completed by 2005, since quantity cannot be considered separately from quality, the quality management plan should last during entire period of the comprehensive plan. The details of this comprehensive plan are summarized in Table 5. To improve the water quality of rivers and lakes through successful implementation of the Comprehensive Plan, the water quality management strategies for the four major river basins called the Special Water Management Program for Four Major River Basins was established.

Table 5. Comprehensive Water Management Plan

Title	Content	Amount of Investment (Million $)	Period
Sewage and Wastewater Treatment	- Construction of 246 sewage treatment plants and sewage rehabilitation;	2,000	1997-2005
	- Construction of public livestock waste treatment plants;	625	1997-2005
	- Assist farmers to build individual livestock waste treatment facilities;	688	1997-2000
	- Modernization nightsoil treatment plants; and		
	- Expansion of integrated wastewater treatment plants in industrial complex areas.	675	1997-2005
Strengthening Standards and Enforcement	- Develop more stringent water quality standards; - Strengthen effluent standards on industries; and - Introduce a charging system based on pollutant emission.		
Information Management System	- Expansion of water quality monitoring networks; and - Computerize water quantity and quality information.		

SPECIAL WATER MANAGEMENT PROGRAMS FOR MAJOR RIVER BASINS

Firstly, a special program for water quality protection of Han River Basin was finalized in 1998. Since the Paldang Reservoir is a drinking water source for 20 million residents in City of Seoul and vicinity, this program emphasizes various measures to protect water of this reservoir and thus this program was named as Special Measures for Water Quality Management of Paldang Reservoir and other drinking sources in Han River Basin. For the successful execution of the program, a Special Act for Han River Basin was enacted in February 1999 and a Committee for Watershed Management of the Han River Basin became effective since April 1999.

A special program for the Nakdong River Basin was drawn up in December 1999 and the Special Act for Nakdong River Basin was submitted to the National Assembly in June 2000. The special programs for Keum River Basin and Yongsan River Basin were drafted in 2000 and the special acts to protect these two river basins were prepared and planned for submission to the National Assembly early this year.

The special program to protect watershed areas of four major rivers include five strategic plans such as measures for pollution prevention, measures for pollution load reduction, strengthening water friendliness of the relevant policies, establishing proper measures to support upstream region of drinking water supply sources and consolidation of financial and institutional systems. The details of these strategic plans are described as follows:

Measures for Pollution Prevention

The shores of major reservoirs, such as Paldang, Daechung, Chuam reservoirs and several water supply reservoirs in Nakdong River Basin, and the areas within certain distances of both banks of tributaries to these reservoirs have been designated as buffer zone. New development of restaurants, hotels, community housings, factories and livestock farms are not allowed in the designated zones.

The publicly-owned forests within five km of both banks of main upstream rivers of Paldang, Daechung, Chuam reservoirs and major tributaries to these reservoirs are designated as the preservation forests in order to maximize the water containment capacity of the watershed.

The implementation of total pollution load management systems to all watershed areas of four major rivers is voluntary for the watershed areas of the Han River, including Paldang reservoir area. However, it will become mandatory for Nakdong, Keum and Yongsan River Basins after year 2003.

The areas regulated by the most stringent effluent discharge permit need to be expanded.

Measures for Pollution Load Reduction

a) ***Domestic wastewater*** -- Construct 278 new sewage treatment plants in four major watershed areas (Han River Basin: 109, Nakdong: 100, Keum: 48, Yongsan: 21); construct 462 small community wastewater treatment plants (Han River: 79, Nakdong: 166, Keum: 88, Yongsan 129); improve sewage treatment rate to 72.6- 84.4 percent by year 2005 (Han River Basin: 81.6 percent, Nakdong: 84.4 percent, keum: 72.6 percent, Yongsan: 76.4 percent); and apply more stringent discharge limit to the sewage treatment plant by the year 2004 (BOD_5: 20→10 mg/L, T-N: 60→20 mg/L, and T-P: 8→2 mg/L).

b) ***Industrial wastewater*** -- Construct new integrated industrial wastewater treatment plants for 18 industrial complexes (Han River Basin: 6, Nakdong: 6, Keum: 5, Yongsan: 1); prohibit any hazardous waste discharger in the areas of water supply sources of Nakdong River Basin, upstream of Deachung Reservoir and watershed of Chuam Reservoir.

c) ***Livestock wastewater*** -- Construct 30 publicly-owned livestock wastewater treatment plants (Han River Basin: 6, Nakdong: 16, Keum: 3, Yongsan. 5); and promote

conversion of livestock waste to resources by supporting composting facilities of livestock waste and storage and solid/liquid separation facilities of livestock waste.

d) ***Non-point source control*** -- Provide more green areas and wetlands along the shores of rivers and lakes to function as the buffer zone to reduce the pollution load from non-point sources; and construct proper holding basins for irrigated water and for drainages and surface run-off waters from city areas.

e) ***Water quality management of lake water*** -- Implement appropriate measures to prevent eutrophication of Paldang, Daechung, Chuam Reservoirs and downstream reach of Nakdong River such as upgrading the nutrient removal capability of sewage treatment plant, livestock wastewater treatment facilities and nightsoil treatment plant; and improve on-site purification capacity of reservoirs and rivers by providing artificial marsh and installation of natural purification facilities.

Strengthening Water Friendliness of the Relevant Policies

a) Increase the dry flowrate of major rivers to ensure enough river maintenance flow;

b) Implement demand control policies for water saving, such as mandatory installation of wastewater reclamation facilities in new buildings, popularization of water saving devices and rehabilitation of old water supply pipes;

c) Conversion of river management strategy from the concept of better utilization and flood control to the concept of natural-type river improvement considering cleanness, ecological soundness and aesthetic characteristics; and

d) Prohibit and/or minimize riverbed cultivation or farming in the upper region of reservoirs for drinking water supply sources.

Support Residents in Upstream Regions of Drinking Water Supply Sources

a) Establish proper measures to ensure income increase, improvement of welfare and better educational works for residents in designated conservation areas for drinking water source and designated buffer zones. The details should be determined by the competent watershed management committee; and

b) Impose and collect proper rate of water usage charges from end users of the public water supply in the region. The revenue established by the water usage charge can be used to support local government to share their burden for the capital and O&M costs of water pollution control facilities.

Consolidation of Financing and Institutional Systems

a) Invest 11.57 trillion Wons (approx. 10 billion US dollars) to water quality improvement by year 2005 (Han River Basin: 2.64 trillion Wons, Nakdong: 4.25 trillion Wons, Keum: 2.72 trillion Wons and Yongsan: 1.96 trillion Wons) and 4.67 trillion Wons to water supply and water resources development by year 2008. This amount does not include the investment required for residents support, land purchase and O&M cost of water pollution control facilities; and

b) Establish the committees for watershed management with the ministers of the relevant ministries, including the Minister of Environment, Governors and/or the Mayors of relevant provinces and the president of the Korea Water Works Corporation

(KOWACO) for each four major river basins as decision-making body for all issues related with watershed management.

PROGRAMS OF EACH RIVER BASIN

Han River

Since the special water management program for the Han River Basin was established in 1998 as stated earlier, the systems for all necessary measures have been completed and they are now in implementation stage. The special program covers five sub-regions in Paldang region, North-Han River region, South-Han River region, Imjin River region and Chamsil region, of the Han River Great Region, in which five province-level local governments of Seoul City, Inchon City, Kyunggi-Do, Kangwon-Do and Chungchungbuk-Do are included.

The main target of the program is to improve the quality of Paldang Reservoir water to Grade I (BOD_5<1.0 mg/L) by 2005 through implementation of seven measures which are pollution prevention, pollution load reduction, supporting system for residents in regulated areas, ensuring enough water for river maintenance, environmental education and public information, surveillance and supervision of water pollution source and consolidation of proper water management system. As this is already the 3rd year since this program was initiated, many subjects have been accomplished and some of important accomplishments which have been made thus far as follows:

- The Special Law for Han River Watershed Management was enacted in 1999 and the Committee for Han River Watershed Management was organized also in 1999;
- In September 1999, total area of 423.8 km^2, which is approximately 2 percent of total basin area, were designated as buffer zone and 1.2 km^2 of private properties in this zone has been purchased by the government by March 2001;
- Water usage charge of 80 Wons per capita was started to be imposed per m^3 in 1999 and 2000 and the rate was increased to 110 Wons since 2001;
- With the introduction of mandatory pre-investigation system for environmental soundness in 2000, it has become possible to essentially prevent the disordered developments; and
- The relevant acts and/or policies have been revised also to limit further disordered development activities in this region.

Nakdong River

The special water management program for the Nakdong River Basin was finalized in 1999 and the program covers four sub-regions of Upstream region, Midstream region, Western region and Eastern region, of the Nakdong River Great Region, in which six province-level local governments, i.e., Busan City, Daegu City, Woolsan City, Kyungsangbuk-Do, Kyungsangnam-Do and Kangwon-Do are included.

The target of this program is to improve the water quality of drinking water sources in the region to Grade 11 (BOD_5<3 mg/L) by 2005 and to supply clean and safe water in adequate quantity to all regions by 2008 through the implementation of

the seven measures cited earlier. The concepts of those seven measures are similar to those for the Han River Basin. However, the subject entitled "ensuring enough water for river maintenance" is substituted by a subject entitled "protection of aquatic ecology of the rivers." The proper and sustainable watershed management is especially important in the Nakdong River Basin as about two-thirds of the total population in this region live in the midstream region of Nakdong River and many industrial complexes are also located in the midstream area and thus water usage in upstream and midstream regions are quite large and water quality of downstream is heavily affected by very active midstream development.

Therefore, the water quantity is still very serious issue in Nakdong River Great region while it is not easy to carry out any further water resources development projects. Accordingly, demand control is essential for sustainable watershed management and thus a special research team was organized to investigate the current situation of water usage and to propose proper water management strategy in this region. The team has operated for 13 months and submitted their final report in February, 2001. The detailed implementation plans are now in the preparation stage by the relevant agencies based on the content of this report. Total investment required to achieve the target is 8.46 trillion Wons by 2005, including the investment for water resources development. The Special Law for Nakdong River Watershed Management is now being reviewed by the National Assembly and the Committee for Nakdong River Watershed Management will start its function as soon as the law is enacted.

Keum River

The special water management program for Keum River Basin was finalized in 2000 and the program covers four regions in Mid-Keum River region, Lower-Keum River region, Daechung Reservoir region and Mankyung-Dongjin River region, of the Keum River Great region, in which six province-level local governments, i.e., Daejeon City, Chungchungbuk-Do, Chungchungnam-Do, Kyunggi-Do and Chullabuk-Do are included.

The target of this program is to improve the water quality to the appropriate levels (Daechung and Yongdam reservoirs: <2 mg COD/L, midstream of Keum River: <2.2 mg BOD_5/L and midstream of Mankyung River: <4.8 mg BOD_5/L) by 2005 and to supply clean and safe water in adequate quantity to all regions by 2011 through implementation of the seven measures. The concepts of those seven measures are similar to those for Han River Basin. However, the subject entitled "ensuring enough water for river maintenance" is substituted by a subject entitled "strengthening water friendliness of the relevant policies."

As the program was finalized late last year, the actual implementation of the detailed measures is now only in starting stage. However, the special program to protect the water quality of Daechung Reservoir has been implemented. As Daechung Reservoir is the major water supply source of central ROK, the area around this reservoir, along with the area around Paldang Reservoir, has been designated as the Special Measures Zone and thus any development works in these areas are limited, the wastewater discharge limits are strongly enforced and the

construction of water pollution control facilities, including sewage treatment plants in these areas, has the highest priority. It is planned to organize a Committee for Keum River Watershed Management in 2001 and Councils of Counter-measures for Water Management consisting of the mayors of the local governments will also be organized for each sub-region this year.

Yongsan River

The special water management program for the Yongsan River Basin was finalized in October 2000 and the program covers two sub-regions, the Yongsan River region and Sumjin River region, of the Yongsan River Great region, in which four province-level local governments, i.e., Kwangju City, Chullabuk-Do, Chullanam-Do and Kyungsangnam-Do are included.

The target of this program is to improve the water quality of the midstream of Yongsan River to Grade II (BOD < 3 mg/L) and that of Sumjin River to Grade I (BOD < 1 mg/L) by 2005 and to supply clean and safe water in adequate quantity to all regions by 2011 through implementation of the seven measures. The concepts of those seven measures are similar with those for Keum River Basin. As the program was finalized late last year, the actual implementation of the detailed measures is now only at the starting stage. However, it is planned to organize a Committee for Yongsan River Watershed Management in 2001 and Councils of Counter-measures for Water Management consisting of the mayors of the local governments will also be organized for each sub-region this year.

REFERENCES

Ministry of Environment, Korea, 2000. Environment White Paper '99. Seoul, Korea.

Ministry of Environment, Korea, 1998. Report on the result from Investigation of Wastewater Dischargers.

Ministry of Construction, and Transportation, Korea, 1999. The Fourth Comprehensive National Physical Planning.

Korea Environment Institute, 1997. Environmental Policies: International Issues, Case Studies and Strategies.

National Commission of Water Management, 2000. '00 Water Management and Policy.

Sang Eun Lee, 1999. Strategies for Water Pollution Control in Korea

Table 1. Water Quality Standards for River Waters

Grade	Purpose of Use	pH	BOD (mg/L)	SS (mg/L)	DO (mg/L)	E.coli (MPN/100mL)
I	• 1st class water supply • Natural environment preservation	6.5-8.5	≤1	≤25	≥7.5	≤50
II	• 2nd class water supply • 1st class fishery • Body contact recreation	6.5-8.5	≤3	≤25	≥5	≤1,000
III	• 3rd class water supply • 2nd class fishery • 1st class industrial water supply	6.5-8.5	≤6	≤25	≥5	≤5,000
IV	• 2nd class industrial water supply • Agricultural water	6.0-8.5	≤8	≤100	≥2	-
V	• 3rd class industrial water supply • Environment conservation	6.0-8.5	≤10	-	≥2	-
All rivers (hazardous substances)		Cd ≤ 0.01mg/L. As. Cr^{-6} ≤ 0.05mg/L. Pb ≤ 0.1mg/L. ABS ≤ 0.5mg/L. CN. Hg, Organic phosphorous. PCB ≤ detection limit				

Table 2. Water Quality Standards for Lake Waters

Grade	Purpose of Use	pH	BOD (mg/L)	SS (mg/L)	DO (mg/L)	E.coli (MPN/ 100mL)	TP (mg/L)	TN (mg/L)
I	• 1st class water supply • Natural environment preservation	6.5-8.5	≤1	≤1	≥7.5	≤50	≤0.010	≤0.200
II	• 2nd class water supply • 1st class fishery • Body contact recreation	6.5-8.5	≤3	≤5	≥5	≤1,000	≤0.030	≤0.400
III	• 3rd class water supply • 2nd class fishery • 1st class industrial water supply	6.5-8.5	≤6	≤15	≥5	≤5,000	≤0.050	≤0.600
IV	• 2nd class industrial water supply • Agricultural water	6.0-8.5	≤8	≤15	≥2	-	≤0.100	≤1.0
V	• 3rd class industrial water supply • Environment conservation	6.0-8.5	≤10	No floating materials	≥2	-	≤0.150	≤1.5
All rivers (hazardous substances)		Cd ≤ 0.01mg/L. As. Cr^{+6} ≤ 0.05mg/L. Pb ≤ 0.1mg/L. ABS ≤ 0.5mg/L. CN. Hg, Organic phosphorous. PCB ≤ detection limit						

Table 3. Water Quality Standards for Sea Waters

Grade	pH	COD (mg/L)	DO (saturation %)	SS (mg/L)	E.coli (MPN/ 100mL)	Normal Hexane extracts (mg/L)	TP (mg/L)	TN (mg/L)
I	7.8-8.3	≤1	≥95	≤10	≤200	ND	≤0.05	≤0.007
II	6.5-8.5	≤2	≥85	≤25	≤1,000	ND	≤0.1	≤0.015
III	6.5-8.5	≤4	≥80	-	-	-	≤0.2	≤0.03
All areas (hazardous substances)	Cd ≤ 0.01mg/L. As. Cr^{+6} ≤ 0.05mg/L. Zn, Pb ≤ 0.1, Cu ≤ 0.02 CN. Hg. Organic phosphorous. PCB < detection limit							

3. SCIENTIFIC BASIS FOR INTEGRATED WATERSHED MANAGEMENT – A LANDSCAPE ECOLOGICAL APPROACH

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INTRODUCTION

Water quality deterioration is one of the most serious environmental problems faced now by many countries. Globally, the number of countries with scarcity of arable land to feed their people increased from four in 1960 to nine in 1990, and is projected to increase at least to 26 in 2025 (Population Action International, http://www.populationaction.org). A recent study has further suggested that the impact of increased population on water resources is more serious than previously anticipated (Vörösmarty, 2000). Asian countries are not exceptions. In particular, the rapid growth of the economy in these areas and following consequences on water resources, e.g., rapid increase in water consumption, increases in sewage water and industrial outflow and wide spread of non-point sources have drawn attention from governments, public, NGOs and researchers. To cope with the aggravating environmental conditions related to water resources, many countries have invested astronomical amount of money on the construction of water treatment plants and other environmental facilities. Furthermore, each country has tightened its laws and regulations to control the water quality. For example, the Rep. of Korean (ROK) government invested 2 percent of its GDP to solve environmental problems, of which 51 percent was poured into water-related sectors in 1997. Eight of the total 21 laws related to the environment also focus on water quality management (Korea Ministry of Environment; http://www.me.go.kr). However, the water quality in ROK is not improving as expected. On the contrary, the quality and available quantity of water in some areas are actually worsening or decreasing in recent years.

This suggests that conventional management of water resources may be of limited value, and hence new approaches are warranted to handle these problems. Some scientists proposed that water pollution from non-point sources, which have rarely been dealt with in conventional management schemes and regulations, would be the missing link to accomplish a better management for water resource in ROK (Kwon, 1998). The same study further suggested that 10-20 percent of the total BOD, 50-70 percent of total nitrogen, 15-25 percent of total P loadings are originated from non-point sources in ROK. Considering the fact that most of the serious water pollution in ROK is closely related to eutrophication with high loadings of phosphorus or nitrogen, these studies indicate that a proper water quality management will never

be achieved without appropriate management of pollution originating from non-point sources.

Since the origins and fates of non-point pollution differ from those of point sources, the former needs to be handled in dissimilar ways. The characteristics of non-point pollutions are wide distribution of pollution sources, and low concentrations but high loading due to high quantity of water. It should also be noted that the non-point source pollution is closely associated with land-use patterns because urban areas, agricultural lands, construction sites and cattle farms are the main sources for such pollution. As such, instead of intensive treatments of polluted water at the outflow from point sources, water pollution from non-point sources should be treated at a larger scale with considerations on hydrology, land-use patterns and geomorphology. It has also been acknowledged that natural resource management related to water quality is shifted to a watershed focus, which is closely related to both food security and environmental issues, rather than administrative or political units.

Studies and regulations on land-use patterns require another layer on top of natural sciences or engineering oriented approaches because they are intertwined with economic activities, public goods and personal interests. Therefore, there has been an urgent request for watershed managers to incorporate multi-layered problems, and to integrate several different levels such as economics, ecology, hydrology, as well as social demands and development of urban areas, implementation of laws, and democratic political procedures. To meet those needs, the Integrated Watershed Management (IWM) has been introduced to overcome difficulties involved in the watershed management.

Social and political issues are often standing out when the concepts and implementation of IWM are addressed. However, conventional scientific basis for IWM may be so *hard-science-oriented* that the results of such studies cannot be easily understood to people involved in IWM, or fail to incorporate key points directly connected with non-point source pollution. The main purpose of this paper is to introduce a new approach of *landscape ecology* as an efficient tool for integrated watershed management. Basic concepts for IWM and landscape will be presented and how landscape ecological ideas can be incorporated into IWM schemes will be discussed.

Watershed and Watershed Management

Watershed is a basic hydrologic unit. Hydrologic and ecological processes govern the quality of soil and water resources within the watershed. Watershed is defined as a delineated area with a well-defined topographic boundary and water outlet, and interchangeable with a catchment and basin.

The importance of watershed management is closely related to the rapid deterioration of environment at a global scale such as decrease in arable land area per capita, resource degradation, deforestation and desertification, water quality deterioration and soil erosion. In particular, watershed management is of interest in relation to non-point source management. Such management schemes can be categorized into three phases based on the implementation steps. The first phase is direct management on pollution sources to reduce production of pollutants. The second phase is a control

process which prevents the already produced pollutants from flowing into the water body. The final phase is treatment of polluted water before it is discharged into lakes or rivers which often is not practical due to the characteristics of non-point pollution. Optimal management of watershed is extremely diverse and no single model can be applied over wide ranges of regions. In general, watershed management should be applied in accordance with land-use patterns. At the same time, land-use patterns are closely related with social issues of local people such as economic activities (e.g., agriculture, forestry) and urban development. Further, a single watershed is often divided into several different administrative units which makes it much harder to control or manage in a united way. In short, a watershed is an effective scientific unit for water resources management but other layers (economy, urban planning, administrative process, interests of local people) should be considered to achieve the water quality amelioration.

INTEGRATED WATERSHED MANAGEMENT

In order to cope with the difficulties mentioned above, Integrated Watershed Management (IWM) concept has recently been introduced and applied. The IWM deals with problems that cut across elements of the hydrological cycle that transcend the boundaries among water, land and environment, and that interrelates with water with broader policy questions associated with regional economic development and environmental management (Mitchell, 1990). This definition points out the interdependencies in nature and in the economic and social aspects. This approach also differs from the conventional ones in several ways (Cobourn, 1999). First, the IWM considers several questions (e.g., water supply, water quality amelioration, ecosystem conservation) and their interactions at a time. Second, the main aim of the IWM is a long-term sustainability. Third, the IWM is not a single gigantic scheme which has been finalized and would not be modified. Rather, it represents gradual and steady management policy. Fourth, the IWM is not a top-down approach with instructions from the central government but a bottom-up approach from local governments and people. Fifth, the IWM acknowledges the difficulties regarding overlaps of administrative units or jurisdictions, and hence requires collaboration among all levels of government and social organizations. Finally, the IWM incorporates a human dimension in such a way that an attempt should be made to educate all stakeholders to prevent non-point source pollution, to avoid wasteful water use, and to improve watershed management.

In general, the relationship between basic research and the IWM can be presented as follows: Basic research → Journal articles, books, reports, seminars, web pages, and other information → IWM (decision process, management decision or requirement) → Governmental funding → Basic research.

As such, the connection between basic scientific research and the IWM would be of great importance for a successful water quality management. In other words, the results of basic research should be relevant to and efficient for the scope of IWM, and the implementation of IWM should provide more funding for basic research.

LANDSCAPE ECOLOGY

Definition and History

Landscape ecology is a young branch of modern ecology that deals with the interrelationship between man and his open and built-up landscapes (Naveh and Lieberman, 1984). In Central Europe, the Netherlands and West Germany in particular, landscape ecology was initiated as part of ecology emerging from the combination of ecology, landscaping, land management and planning, and sociology based on a holistic approach. These regions exhibited a relatively bending topography and a large percentage of fragmented land compared to the New World. As such, the spatial distribution of vegetation was easily noticed and widely studied. Further, high density of population required an intensive and effective use or management of land. All these natural and social demands came up with the birth of landscape ecology.

However, the opening of modern landscape ecology was not possible until the wide usage of aerial photos which allowed scientists to overview wide areas from a distance. The term was introduced by a German geographer, Carl Troll, who viewed the birth of landscape ecology as a result of the marriage of geography (landscape) and biology (ecology). The main points in Europe stress that landscape ecology concerns not only natural systems, but also a landscape, including human beings. Furthermore, their central interests were focused on geographical approaches.

However, landscape ecology has been developed in a different way in the 1980s when the study was introduced and modified by ecologists in the US. They have expanded the basic concepts of landscape ecology to incorporate the functional aspects of systems. For example, primary productivity, transport of materials, including nutrients, movement of wild animals and the spread of vegetation were some of the examples in which landscape ecologists showed interest.

The current definition of landscape ecology can be described as the study of spatial variation in landscapes in a variety of scales. For example, they attempt to connect the flows or cycles of energy, nutrients, biomass, or information to the structure of a landscape. It includes the biophysical and societal causes and consequences of landscape heterogeneity (IALE web page: http://www.crle.uoguelph.ca/iale/). They place landscape as a higher level in the hierarchy of the composition of the nature, in such a way that landscape is made with several different ecosystem patches. Further, they made it clear that the main question in landscape ecology is to address the effects of spatial distribution of components of landscape on functional processes of such systems. As a consequence, landscape ecology focuses on the sizes, distributions, and patterns of ecosystems over a wide area and their changes over time. This characteristic allows landscape ecology to be connected with watershed management or the IWM.

Recent development of landscape ecology includes the adaptation of remote imagery, GIS (geographic information systems), indices based on information theory or fractal dimension (O'Neill *et al.*, 1997). Owing to these techniques, it may be possible to address the long-term trends of land-use changes and patterns at different scales over a wide area.

Contents of Landscape Ecology and Relevance to IWM

Some of the most important environmental changes occur at the spatial scale of landscape. Further, political decisions to manage natural resources are made at broad scales such as river basins, forest districts and large administrative units. As such, assessment and management of environmental problems should be considered and executed at the landscape level to address those problems. The main concerns of landscape ecology are structure, functions, and changes of a landscape. This landscape level approach has already proved to be effective in explaining and predicting biotic diversity, watershed integrity and landscape stability (Foreman and Gordon, 1986).

Analyzing landscape level data (e.g., aerial photos, satellite images, vegetation maps and digital elevation model), landscape ecology usually focuses on three different components, namely; a matrix, patches, and corridors. A matrix is a component with the largest area and the highest connectivity. A patch is an area with more or less homogeneous with respect to a measured variable. It could be understood as pieces of a land cover with a similar type surrounded by a matrix. Corridors are a linear component placed over matrix which often connect different patches. For example, in a marginally developed forest, the area with forest stand could be a matrix. Likewise, pieces of developed lands could be patches, while roads connecting them could be corridors. In contrast, pieces of forest lands could be patches while urban areas could be a matrix in an intensively developed urban area.

Once a matrix, patches and corridors are identified, several indices could be calculated. These indices or indicators have been proposed to explain the phenomena at the landscape scale which are mostly related to the shapes, distribution and connectivity of patches in the landscape. A single patch can be described by its size, perimeter (edge), or ratio of these two.

At the larger scale than a single patch, landscape patterns can be analyzed in two aspects. The first one is landscape composition, which refers to the number of patch types represented on a landscape, and their relative abundance. Indices to summarize the composition are derived from the indices used to summarize species diversity in community ecology and may suffer the same interpretative drawbacks. The composition of patches can be presented by richness or diversity of types represented on a landscape. The second type is landscape configuration. Typical indices of landscape configuration are as follows:

Size Distribution -- This is simply relative abundance or frequency of patches in different sizes categories.

Dispersion -- This connotes the tendency for patches to be regularly or contagiously distributed with respect to each other. Often this is summarized in terms of nearest-neighbor distances among patches of like type.

Contrast -- This refers to the relative difference among patch types (for example, oak-hickory forests adjacent to oak-pine forests have a lower-contrast edge than oak-hickory forests adjacent to open fields).

Shape Complexity -- Various measures of shape complexity are based on the relative amount of edge per unit area. Commonly, this is indexed in terms of edge-to-area ratios, or as fractal dimension. Shape complexity connotes the geometry of patches: whether they tend to be simple and compact, or irregular and convoluted.

Adjacency (Contagion) -- This refers to the tendency for elements (i.e., patches) of a given type to occur next to patches of another type (or in some cases, the same type). This can be expressed as a matrix of pairwise adjacencies between all patch types, where the elements of the matrix are the proportions of edges in each pairwise type. Sometimes this matrix is averaged to provide an overall index of contagion, i.e., the tendency for patches to occur in pure clumps as compared to highly interspersed mixtures. In other words, this represents the probability of higher clumpness of land cover than random expectation.

Connectedness -- This generally refers to functional joining or connections between patches. What constitutes a "functional connection" between patches clearly depends on the application or process of interest.

Application of Landscape Ecology To IWM

Landscape characteristics such as land-use or land-cover type have known to be closely related to water quality of streams and estuaries at the watershed scales. In particular, key findings and progress in landscape ecology have developed in connection with studies and analyses of land-use patterns. Landscape indices mentioned above have been known to explain various ecosystem structures and functions.

For example, Basnyat *et al.* (1999) have shown that water quality (e.g., nitrate, sediment) in streams can be explained by land-use/land-cover at different scales in southern USA. They found that nitrogen and sediment concentrations were closely related to land-use patterns at streambank (areas adjacent to streams) or contributing areas (areas surrounding the stream and contributing nutrients that end up in stream water). Regression analyses exhibited that water quality was the highest when passive land uses (i.e., forests and grasslands), while non-passive land uses (e.g., agriculture lands, urban/built-up areas) had negative impacts on water quality.

Another study conducted in the eastern part of USA also indicated that land-use patterns were associated with stream chemistry at the regional scale (Herlihy *et al.*, 1998). The study indicated that concentrations of Cl^-, nutrients, acid neutralizing capacity, and basic cations were strongly related to the land cover.

A general scheme of assessing landscape condition relative to water resources is often composed of the following steps (Jones *et al.*, 2000). The first step is quantifying relationship between landscape metrics and stream conditions in an initial set of biophysical settings. For this, remotely sensed data set and primary landscape data are collected and processed followed by calculation of landscape indicators. At the same time, stream chemistry and other field data are collected and constructed to database. Then quantitative relationships between landscape indicators and stream conditions are determined typically by multivariate models or other statistical analyses.

The second step is application of the model or relationships found in Step 1 to other biophysical settings. This step is to evaluate the relationships on a new set of areas, and hence to test the general applicability of the relationships determined in Step 1.

The third and final step is conducting the landscape assessment by which we could assess water quality using, for example, remotely sensed data only. Further, it

could be possible to predict consequences of any changes in land-use, and hence the information can be incorporated into the IWM to maximize social goods and services and to minimize possible impacts on water quality.

PERSPECTIVES IN THE APPLICATION OF LANDSCAPE ECOLOGY TO IWM IN ASIA

The applicability of theories of landscape ecology to Asia may have several difficulties. Most of the key concepts and ideas were introduced in the US or European countries which have different physical settings from Asian countries. For example, the Rep. of Korea has concentrations of rainfall over a short monsoon season (i.e., excessively high coefficient of river regime) and a large portion of mountainous areas. Other difficulties would be found in the unavailability of key information such as high resolution digitized elevation model, satellite imagery or vegetation maps. Finally, ideal IWM cannot be achieved without sound social processes even if landscape ecological approach may provide useful information for IWM. Social processes should be based on democratic and scientific foundations. This includes democratic governments, facilitation for exchanges of information among different groups (e.g., researchers, universities, governmental institutes, NGO, local people, politicians, mass media), investment for basic sciences related to watershed management.

In spite of those difficulties and research questions that remain, landscape ecological approaches will be a powerful and useful tool for the IWM in the future. The reasons are that: 1) water quality management will require a larger scale approach due to the scales of problems; 2) such approach is less expensive than approaches using only ground-based surveys in the long run; 3) the approach is practical with current technologies which is expected to advance further; and 4) the approach focuses directly on the habitat loss or land-use patterns that is a critical component of the IWM.

REFERENCES

Basnyat, P., Teeter, L. D., Flynn, K. M., Lockaby, B. G., 1999. Relationships between landscape characteristics and non-point source pollution inputs to coastal estuaries. *Environmental Management* 23:539-549.

Cobourn, J., 1999. Integrated watershed management on the Truckee River in Nevada. *Journal of the American Water Resources Association* 35:623-632.

Foreman, R. T. T., and Gordon, M. 1986. *Landscape Ecology*. New York, John Wiley & Sons.

Herlihy, A. T., Stoddard, J. L., and Johnson, C. B., 1998. The relationship between stream chemistry and watershed land cover data in the mid-Atlantic region, US. *Water, Air, and Soil Pollution* 105:377-386.

Jones, K. B., Heggem, D. T., Wade, T. G., Neale, A. C., Ebert, D. W., Nash, M. S., Mehaffey, M. H., Hermann, K. A., Selle, A. R., Augustine, S., Goodman, I. A., Pedersen, J., Bolgrien, D., Viger, J. M., Chiang, D., Lin. C. J., Zhong, Y., Baker J., and van Remortel, R. D., 2000. Assessing landscape condition rela-

tive to water resources in the western United States: A strategic approach. Environmental Monitoring and Assessment 64:227-245.

Kwon, S-K., 1998. Management improvement and perspective on non-point sources of water pollution in Korea. *Journal of Korean Society of Environmental Engineers* 20:1497-1510.

Mitchell, B., 1990. *Integrated Water Management: International Experiences and Perspectives*. Belhaven Press, London.

O'Neill, R. V., Hunsaker, C. T., Jones, K. B., Riitters, K. H., Wickham, J. D., Schwartz, P. M., Goodman, I. A., Jackson, B. L., and Baillargeon, W. S., 1997. Monitoring environmental quality at the landscape scale. *Bioscience* 47:513-519.

Vörösmarty, C. J., Green P., Salisbury, J., Lammers, R. B., 2000. Global water resources: vulnerability from climate change and population growth. *Science* 289:284-288.

4. PARTICIPATORY RESEARCH ON CATCHMENT MANAGEMENT: THE IBSRAM EXPERIENCE IN ASIA[1]

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INTRODUCTION

The global population is expected to increase by 2.3 billion people in the next 25 years. In Asia, the increase over this period will be about 1.6 billion, and a significant increase in food production will be needed to feed them. However, land degradation brought about by soil erosion is a serious threat to the region, where more than 50 percent of the area is hilly and mountainous. Farming practices employed in many areas of the region have become environmentally unsustainable, especially in the uplands where most of the rural poor live. This is further aggravated by the continued deforestation and urbanization, resulting in the reduction of the area of land suitable for cultivation and the deterioration of the quantity and quality of water available for rural, industrial and urban use.

Earlier researches on soil constraints to food production have focused on the biophysical problems and the technical solutions without considering the social and economic dimensions of the problems. They aimed at attaining maximum or optimum production without considering the farmers' constraints. Furthermore, research utilized small field plots without ample consideration of the possible geographical extension or scaling up of the results. Consequently, much of the knowledge gained by this research could not be used by farmers.

Recognition of this inadequacy led the International Board for Soil Research and Management (IBSRAM) to a re-examination of approaches to research on sustainable land management (Greenland *et al.*, 1994). This results in a new research paradigm which provides an organizational model that engages scientists and research institutions to handle a common goal through a participatory, interdisciplinary, and community- and catchment-based framework. This framework is now operationalized by IBSRAM through the Management of Soil Erosion Consortium (MSEC).

This paper describes the consortium model and the principal bases for the implementation of its project. It provides information on MSEC's early experiences, emphasizing on the participatory process that it has employed at several stages of project implementation.

[1] Paper presented at the Workshop on Integrated Watershed Development and Management held from 7-8 August 2000 at the Asian Institute of Technology (AIT), Bangkok, Thailand .

CONSORTIUM MODEL AND PARTICIPATORY RESEARCH

The complexity of the new research paradigm requires a new approach to the organization of research and a special recognition of its key elements. Craswell and Latham (1998) identified these key elements in relation to user orientation, policy, equity, landscape, research intensity, knowledge and orientation/goals (Table 1).

The consortium model provides a research mechanism that engages different scientists and research institutions to handle a common problem and achieve a common goal in a coordinated and participatory mode. MSEC employs this mechanism in addressing the problem of soil erosion and land degradation.

Research planning and implementation are undertaken through consultation among concerned NARES, IARCs, ARIs, NGOs and farmers. A facilitator, a steering committee and an annual assembly are essential to ensure the effective operation of the consortium. The NARES plays the central role in the consortia playing the key role in the participatory research, but with a broad responsibility for underpinning applied and strategic research (Figure 1).

Table 1. Key Elements of New Paradigm for Research on Sustainable Land Management (Craswell and Latham 1998)

Element	Approach
User orientation	Participatory, community-based at all stages from planning to implementation.
Policy	Focus on policy and institutional issues that influence farmer and community decisions.
Equity	Consideration of equity, including gender analysis, in research planning and implementation.
Landscape	Integration of people, soil and water at every scale from plot to catchment.
Research intensity	Linking strategic, applied and adaptive research with technology development and participatory dissemination.
Knowledge	Reliance on both indigenous and scientific sources.
Orientation/goals	Linking increased productivity with natural resources conservation.

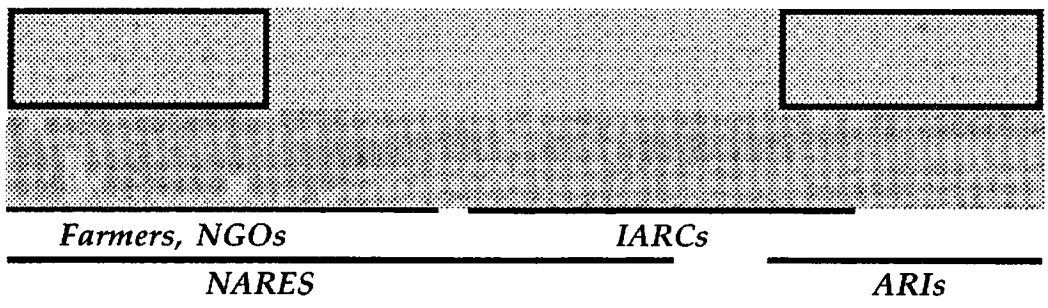

Figure 1. Primary Stakeholder Domains Across the Research Continuum of an SWNM Consortium (Craswell and Maglinao, 1999)

The consortium model is able to draw the interest of ARIs which can contribute significantly through strategic and basic research. In turn, the consortium provides a carefully considered development context for their more strategic interests. The whole idea of the program is to take a participatory approach in research planning with iterative discussions between and among farmers, NARES, IARCs and ARIs in the definition and implementation of the research process.

THE MSEC PROGRAM

The MSEC is one of the four consortia established through the soil, water and nutrient management initiative of the Consultative Group on International Agricultural Research (CGIAR). IBSRAM and PCARRD facilitated its establishment through consultations with the NARES. IARCs, ARIs, NGOs in and outside Asia.

The MSEC uses an integrated, interdisciplinary, participatory and community-based approach to research that involves all land users and stakeholders on a catchment scale. It focuses on the on- and off-site impacts of soil erosion, emphasizes community involvement, and provides scientific data for rational decision making at all levels. The MSEC draws on the comparative advantages offered by the NARES, IARCs, and ARIs which conduct research at different levels, ranging from the individual plot and farm to the catchment, regional, and national scales, to develop principles of global relevance. It is linked to the ecoregional program for humid and sub-humid tropical Asia led by the International Rice Research Institute (IRRI) based in the Philippines.

With major funding support from the Asian Development Bank (ADB), the MSEC has initiated soil erosion management research in six countries in Asia, namely; Indonesia, Laos, Nepal, Philippines, Thailand and Vietnam. A strong collaboration with another ADB-funded project executed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has made possible additional work in India, Thailand and Vietnam. The objectives of the program are:

- To develop sustainable and acceptable community-based land management systems that are suitable for the entire catchment;
- To quantify and evaluate the biophysical, environmental, and socio-economic effects of soil erosion, both on-site and off-site;
- To generate reliable information and prepare scientifically-based guidelines for improvement of catchment management policies; and
- To enhance NARES capacity in research on integrated catchment management and soil erosion control.

The program focuses on three major components to address the stated objectives. These are:

- Catchment research to evaluate the effects of different land management practices on water and nutrient flows in selected representative catchments;
- Capacity building of participating NARES in research on integrated catchment management and soil erosion; and
- Dissemination of research results for enhanced adoption of land management technologies and for more accessible information as concrete basis for decision making.

Outputs from its activities are expected to be generated in the first three years, but for some, a longer time frame is needed. In fact, the project is envisioned for a period of at least 10 years. These expected outputs are given below:

- Decision support tools and guidelines based on a better understanding of the on- and off-site effects of soil erosion;
- Alternative technologies and land management systems that are socially and institutionally acceptable to the communities in the catchment areas;
- Methodology for assessment of impacts and obtaining participation of farmers and other stakeholders in the management of catchments which includes policies that will improve the management of catchments by the local government and the communities;
- Information and communication strategies to effectively disseminate the results of the research to the farmers and other land users;
- Enhanced NARES capacity in integrated catchment management research; and
- Improved program management for catchment management research.

IMPLEMENTING THE RESEARCH PROGRAM

The implementation of the field research activities of MSEC follows an interdisciplinary, participatory and community-based approach. It started with the selection of representative catchments in participating countries by an interdisciplinary team using carefully defined criteria and methodological guidelines. Visits and dialogues with local institutions, scientists and farmers were facilitated by the NARES. This ensures that all stakeholder groups in the landscape affected by soil erosion, including farmers and policy makers, benefit from the knowledge generated, recognize the scope and severity of the problem, and make appropriate decisions about investments and land use policy in the sloping land areas. Final selection was made during the second annual assembly of the consortium in 1997 in Nan, Thailand.

More detailed site characterization, mapping and catchment instrumentation commenced with the funding support provided by the ADB late in 1998. The participatory rural survey and appraisal was conducted to validate the secondary information gathered earlier and identify the constraints and opportunities for improving land management practices in these marginal sloping uplands. It also provided information on the possible impact of soil erosion off-site.

Based on the capabilities of the national partners and the interests of participating international centers and advanced research institutions, the countries tentatively identified major research areas and specialization. It is expected that more specific areas will be identified in the course of project implementation. Special studies are offered as consultancies and theses for MSc and PhD students.

With the complete instrumentation of the catchments now in place, intensive data collection, monitoring and documentation of activities in the catchments are now ongoing. This will provide additional information that will refine the characterization of the sites, considering both the biophysical and socio-economic attributes. Research interventions will be introduced later after the catchments are calibrated and the technological options are agreed on in consultation with major stakeholders,

particularly the farmers. It is worth noting that some farmers in the sites directly participate in project implementation, providing assistance in simple data collection.

FIRST RESULTS

Characterization of the Selected Sites

The experimental catchments have already been established and designed for the project in all participating countries. They are now clearly delineated, characterized and fully instrumented for soil erosion and hydrological measurements. A total of 30 gauging stations (weirs, flumes, sediment traps) have been constructed in the experimental sites in Indonesia, Laos, Nepal, Philippines, Thailand and Vietnam (Table 2). Measuring devices such as automatic water level recorders and weather stations have also been installed. ICRISAT instrumented the sites in India and additional sites in Thailand and Vietnam. For some reasons, the field activities in Sri Lanka have been discontinued.

Table 2. Structures Constructed and Equipment Installed in the Different MSEC Catchments

Structure/Equipment	Number Provided and/or Installed						
	Indonesia	Laos	Nepal	Philippines	Thailand	Vietnam	Total
Area of catchment (ha)	139	73	124	91	71	96	-
No. of micro-catchments	4	4	4	4	4	4	24
Weir	4	5	5	5	4	5	28
Flume	1	-	-	-	1	-	2
Automatic weather station	1	1	1	1	1	1	6
Automatic water level recorder	5	5	5	5	6	5	31
Manual rain gauge	7	8	8	5	8	8	44
Staff gauge	15	15	15	15	15	15	90

The experimental catchments range from 80 to 160 ha with four smaller micro-catchments representing different land uses delineated within. All catchments (except in India) have slopes ranging from 12 to 80 percent, and an average annual rainfall ranging from 1077 to 2500 mm (Table 3). In some catchments water flows in the creeks only during the rainy season. The catchments are dominated by annual cash crops with some patches of perennials and primarily cultivated by ethnic minorities. In general, the model catchments represent a resource management domain[2] (see IBSRAM 1996) with common biophysical and socio-economic characteristics as follows:

- The soils are generally acid with low inherent fertility that declines rapidly under continuous cultivation without external inputs;

[2] Dumanski and Craswell (1998) defined a resource management domain as a spatial unit encompassing the environmental and socio-economic characteristics of a recognizable unit of land including the natural variability which is inherently characteristic of the area. An RMD can be defined at the field scale if the intent is to differentiate management practices employed by farmers, or at broad scales if the intent is to relate to management implications imposed through policies or programs, or at any level in between, provided that the linkages among the levels are illustrated.

Table 3. Updated Profiles of MSEC Catchments in Collaborating Countries

General Description	Catchment Name						
	Lalatola	Babon	Ban Lak Sip	Masrang Khola	Mapawa	Mae Thaeng	Dong Cao
Basic information							
Country	India	Indonesia	Laos	Nepal	Philippines	Thailand	Vietnam
Province	Bhopal	Semarang	Luang Prabang	Chitwan	Bukidnon	Phrae	Hoa Binh
Latitude	23°N	07°20'S	19°51'10"N	27°49'N	08°02'50"N	18°13'20"N	20°57'40"N
Longitude	77°30'E	110°E	102°10'45"E	85°32'30"E	125°56'35"E	100°23'40"	105°29'10"E
Elevation (m)		390-510		650-1400	1080-1505	400-480	125-700
Catchment size (ha)	75	139	80	124	91	100	160
Biophysical attribute							
Slope (percent)	<5	15-75	70-80	40-60	8-35	12-50	40-60
Geology and Landform		Basaltic lava	Shale	Gneiss	Basalt, pyroclastics	Siltstone, sandstone	Schist
Rainfall (mm)	1200	2500	1403	2200	2537	1077	1500
Soils	Vertisol	Inceptisol	Ultisol	Cambisol, Luvisol	Ultisol, Inceptisol	Alfisol	Latosol
Vegetation and Land use	Degraded forest, soybean, wheat sorghum, maize	Rice, maize, rambutan rambutan	Rice, maize, job tear	Forest, grasslands, rice maize, millet, potato	Forest plantation, open grassland, maize, potato, vegetables	Maize, soybean, mungbean, tamarind	Cassava, rice, maize, taro, peanut
Hydrology	Intermittent flow (water flows only during rainy season)	Permanent flow (water flows year round)	Permanent flow (water flows year round)	Permanent flow (water flows year round)	Intermittent flow (water flows only during rainy season)	Intermittent flow (water flows only during rainy season)	Permanent flow (water flows year round)
Socio-economic attribute							
Ethnic group				Gurung, Gharti, Brahmin, Chhetri	Talaandig	Hmong, Thai	Sandziu
Land tenure				With certificate of ownership	Private owner	Land use title	Land use right
Dominant crops	Soybean, sorghum, wheat	Rambutan, rice	Maize, job tear	Maize, rice, vegetables	Vegetables, maize	Maize, soybean, mungbean	Cassava, rice, maize, peanut
Agricultural Practices	Two crops in one year	Two crops in one year	One crop in one year	Two or three crops a year	Two crops in one year	Two crops in one year	Two crops in one year
Relevant Institutions	ICRISAT, CRIDA, JNKVV, IISS, NGO	CSAR, CIRAD, BPTP, AIAT	NAFRI, IRD	NARC, ICIMOD	PCARRD, DA, DENR, NGO SANREM, ICRAF, SEARCA	RFD, DLD, RID, ICRISAT, AIT, Bayreuth	MARD, NISF, VASI, ICRISAT

- Slopes are steep and soil erosion is the major land degradation process;
- The climate is warm, humid or sub-humid, and tropical or subtropical. Rainfall intensities in the wet season are generally high;
- The native vegetation is commonly rain forest, but large areas have been logged over, subject to shifting cultivation and covered with pernicious weeds like *Imperata cylindrica*. The area cultivated every year to subsistence food crops such as rice and maize is increasing (Garrity 1993);
- Steepland areas are remote and have been bypassed by government development schemes;
- The shifting cultivators in many areas are ethnic minorities, but increasingly upper catchments are being inhabited by lowland people unable to find land to cultivate elsewhere (IBSRAM 1997);
- Many governments now require the shifting cultivators to abandon their nomadic lives and settle in one place, but lack of land tenure remains a problem; and
- Off-farm employment through migration to cities and to other countries in the region is a major source of income (Renaud *et al.*, 1998).

Erosion and Land Use

Information on the current soil erosion and hydrological characteristics of and the farmers' agricultural production practices in the sites has just started during the year 2000 rainy season in all countries, except in Indonesia. As part of the catchment calibration process, this information will enhance the baseline characterization of the selected sites.

Initial results from Indonesia where one season of measurement had been completed show that catchment size and land use affect the amount of erosion measured

Table 4. Soil Erosion in Three Micro-catchments in the Babon Catchment in Indonesia

Item	Micro-catchment		
	Tegalan	Rambutan	Kalisidi
Area (ha)	3.2	2.0	38.5
Land use	Upland annual crop (covering about 50 percent of area) near the sediment trap, coffee and nutmeg on the upper slopes	Rambutan and some bare plots	Rambutan
Percent of area with slopes of 15-75 percent	87	100	93
Bedload (kg ha^{-1})	1092	179	7

Note: Observations made from 24 December 1999 to 30 April 2000.
Rainfall during the period was 2048 mm which is about 65 percent of the average annual precipitation in the area.

at the gauging outlet (Agus *et al.*, 2000). Observations from three micro-catchments, namely; Tegalan, Rambutan, and Kalisidi, within the Babon catchment showed a bedload of 1092, 179 and 7 kg ha^{-1} (Table 4). This was measured from 24 December 1999 to 30 April 2000, during which the area received 2048 mm of rainfall. This amount of rainfall represents about 65 percent of the mean annual rainfall in the area. The figures show that erosion does not seem to be very alarming in the catchments dominated by perennial tree crops. Moreover, in these catchments of similar land use, the Kalisidi micro-catchment which is 19 times larger than the Rambutan micro-catchment yielded only a small amount of bedload, about 26 times less than in the Rambutan micro-catchment.

The Tegalan micro-catchment, which is predominated by upland annual crops, had the highest bedload of 1092 kg ha^{-1} within the same period of observation. This amount is six times larger than that coming from the Rambutan micro-catchment which is a hectare less in size. This information shows that the Tegalan area could be an erosion "hot spot" and needs greater attention with respect to improving land management. It also indicates that with appropriate land use, erosion can be minimized.

Applying the Participatory Process

The participatory process in soil erosion management research on a catchment scale has been employed as early as the establishment of the consortium and the design of the research program that it would undertake. A series of consultation meetings and dialogues among various stakeholders, including the NARES, IARCs, ARIs, NGOs, donors and even farmer representatives was undertaken to agree on the design of the research and the various partners that would be involved. It took no less than two years for this process before a donor took stake in the project and provided funding support for the implementation of field activities. As earlier mentioned, ADB approved a three-year project late in 1998 to carry out the activities in seven countries in Asia.

Further carrying on the principles of participation, interdisciplinarity and collaboration, the NARES identified local institutions and project teams composed of researchers of different disciplines. Within the countries, collaboration among relevant partners has evolved (Table 5).

The organization of these teams from different institutions and disciplines enhanced the participatory, interdisciplinary and inter-institutional mechanism that the consortium advocates. Generally, this arrangement is committed through formal agreements signed between and among institutions. In the Philippines, the MSEC project agreed on organizational linkages allowing the coordination of activities down to the field level (Figure 2). Through this mechanism, the Lantapan Project Holders Committee serves as the integrating mechanism at the municipal level, NOMCARRD at the sub-national level, and PCARRD at the national level (Ilao *et al.*, 2000). IBSRAM serves as the facilitator and link among the various NARES, international centers and advanced research institutions. This arrangement hopes to optimize the use of scarce resources and enhance the synergy of different experts and institutions.

Down to the field, the participation of the farmers gets stronger during the

Table 5. Consortium Partners and Potential Research Activities in MSEC Collaborating Countries

Country	National partners	International centers and institutions	Proposed research activities
India	CRIDA, BAIF, IISS, JNKKV	IRD, ICRISAT	Agronomy; farming systems
Indonesia	CSAR, BAPEDA, BPTP, CSES	CIRAD,IRD	Agronomy; hydrological studies; institutional arrangements
Laos	SSLCC, NAFRI	IRD, ICRAF, NORAGRIC, IRRI	Hydrological studies; nutrient dynamics
Nepal	NARC	ICIMOD, Bayreuth U., IRD, IFPRI	Farming systems; nutrient dynamics; hydrological studies; institutional aspects
Philippines	PCARRD, CMU, BSWMDA, DENR, SANREM, UPLB, local government	ICRAF, IRD, SEARCA, ACIAR	Hydrological studies; institutional arrangements; policy studies; off-site impact; farmers' adoption; modelling
Thailand	RFD, DLD	ICRISAT, IRD, AIT, Bayreuth U.	Farming systems; off-site impact; nutrient dynamics and pollutants; hydrological studies; remote sensing
Vietnam	NISF, NEU, VASI	ICRISAT, CIRAD, IRD, IRRI	Farming systems; hydrological studies; institutional arrangements

surveys conducted to further refine the characteristics of the sites and solicit farmers input in identifying constraints and opportunities for tackling the problem of soil erosion and crop production. In most cases, the farmers appreciated their involvement in such kind of activities and became more interested in the project (Agus *et al.*, 2000; Ilao *et al.*, 2000). They also appreciated the value of the equipment installed in the field and even got interested in their care and protection. While the farmers did not consider soil erosion as their number one problem, indications at this stage show that they are willing to be actively involved in the project.

Evaluation of the Process

From the above observations, IBSRAM's experience showed some strengths and weaknesses of the approach (Maglinao and Penning de Vries, 1999). There being an increasing awareness of the effects of soil erosion and land degradation on agricultural productivity and the environment among farmers and other stakeholders, the project is essentially demand-driven. The objectives have been set to address the important issues as perceived by most stakeholders and the design process was carried out with their active involvement. However, because of the involvement of a broad range of stakeholders, the project design process has taken a relatively longer time from conceptualization and consultations to the start of implementation. It could be mentioned though that the delay was also due to the slow process in attracting

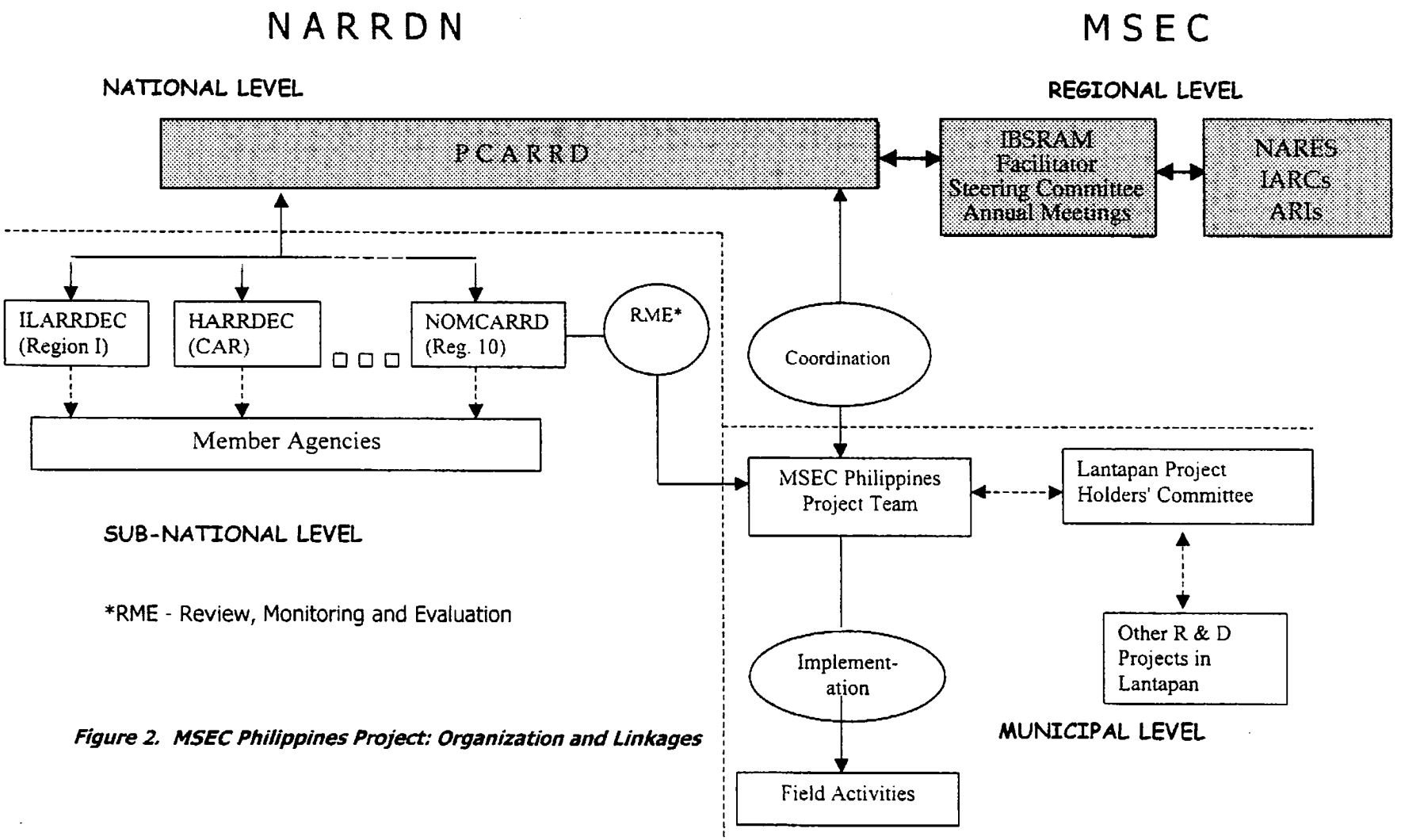

Figure 2. MSEC Philippines Project: Organization and Linkages

Figure 2. MSEC Philippines Project: Organization and Linkages

donors to provide funds for such a complex project. In addition, a formal agreement with the NARES was still needed for IBSRAM to release the funds for project implementation. This requirement had also delayed the implementation in some countries.

The project looks at both research and research methodology and further refinement of the design itself is also carried out. While the design intended to integrate biophysical and socio-economic aspects, the project has at present stronger focus on the biophysical aspects. In relation to this, IBSRAM published a review of the methods for the economic assessment of the on- and off-site impacts of soil erosion (Enters, 1998). In addition, the guideline on socio-economic site characterization has been prepared. Both documents were thoroughly discussed by the socio-economist members of the country teams during a recent workshop of MSEC. The socio-economic component in on-farm research and the evaluation of on- and off-site impact of erosion were the major emphasis of the meeting. All countries will come up with their characterization reports and proposed plans for impact evaluation.

While training on participatory approaches was conducted before project implementation, it still takes time for some partners to internalize the principles of participation, interdisciplinarity and integration. Participation is not a one-shot deal. It should be a continuing process such that you learn more about the approach while applying it. Moreover, there may be a need for making adjustments in the process depending on the kind of activity and the individuals or groups involved.

Participation also requires regular communication and dialogue among participants. Particularly for this kind of research, which implements new methodologies and involves a number of partners, there is no room for miscommunication. Communication between IBSRAM and the NARES, among the NARES, among the participating organizations and scientists and most especially with the farmers needs to be maintained.

SUMMARY AND CONCLUSION

Soil erosion and land degradation have remained a major problem in the marginal uplands of Asia. Lessons learned from past R&D efforts point to a need for a research orientation that will produce sustainable land management technologies and policies that are acceptable to the various users of the land. Discussions and consultations among various stakeholders concerned in natural resources management took sometime before an agreement on the new research paradigm and the consortium model was arrived at.

The Management of Soil Erosion Consortium now implements a project on soil erosion management on a catchment scale employing the principles advocated by the new paradigm. At this stage of the project when the experimental catchments have been characterized and instrumented for soil erosion and hydrological measurements, and some initial results are already coming in, MSEC has had the opportunity to apply the principles of the participatory research at one time or another. While it is still too early to make conclusive evaluation at this initial phase of the project, indications already show some strengths and weaknesses of the process. Consultations among stakeholders usually take a relatively longer time before an

agreement is reached, but implementation of what is agreed upon becomes more effective. Particularly for the farmers, they feel a sense of ownership of the project as they have been involved even at the planning stage.

The MSEC will pursue on implementing the project using these principles and it remains open for the participation of others who share the common goal of more sustainable management of our land and water resources. We thus strongly encourage the participation of ARIs and academic institutions in our work. Towards this end, this workshop will hopefully pave the way for the operationalization of the MOU signed between IBSRAM and AIT. The MSEC project could very well be linked to AIT's research and training programs and present good opportunities for students to be involved in practical, multidisciplinary and participatory research and case studies. These could be done both in Thailand and in other participating countries.

REFERENCES

Agus, F., Sukristiyonubowo, T. Vadari, C. Setiani, E. Lestari, and C. Tafakresno, 2000. Catchment approach to managing soil erosion in Kaligarang catchment of Java, Indonesia. Technical progress report submitted for the MSEC steering committee meeting, l3-15 June 2000, Bangkok, Thailand.

Craswell, E.T. and Latham, M., 1998. The soil, water and nutrient management program - An overview. l6th World Congress of Soils, ISSS, Montpellier, CD-ROM.

Craswell, E.T. and A.R. Maglinao. A catchment approach to research on soil erosion in the marginal uplands of Asia. Paper presented at the 2nd Asia-Pacific Conference on Sustainable Agriculture. 18-20 October 1999. Phitsanulok, Thailand.

Dumanski, J. and E.T. Craswell, 1998. Resource management domains for evaluation and management of agro-ecological systems. In: *International Workshop on Resource Management Domains*. International Board for Soil Research and Management, Bangkok. pp.1-13.

Enters T., 1998. Methods for the economic assessment of the on- and off-site impacts of soil erosion. International Board for Soil Research and Management. Issues in Sustainable Land Management no. 2. Bangkok: IBSRAM.

Garrity, D.P., 1993. Sustainable land use systems for sloping uplands in Southeast Asia. In: *Technologies for Sustainable Agriculture in the Tropics. ASA Special publication* 56. American Society of Agronomy, Madison. pp.41-66..

Greenland, D.J., Bowen, G., Eswaran, H., Rhoades, R., and Valentin, C., 1994. *Soil, Water, and Nutrient Management Research - A New Agenda. IBSRAM position paper*. IBSRAM, Bangkok.

IBSRAM, 1996. Proceedings International Workshop on Resource Management Domains. International Board for Soil Research and Management, Bangkok, Thailand.

IBSRAM, 1997. Model Catchment Selection for the Management of Soil Erosion Consortium (MSEC) of IBSRAM. Report on the Mission to Thailand, Indonesia and the Philippines. International Board for Soil Research and Management, Bangkok, Thailand.

Ilao, R. O., C.M. Duque, R.S. Yadao and M.T.L. de Guzman, 2000. Management of

soil erosion consortium: An innovative approach to sustainable land management in the Philippines. Technical progress report submitted for the MSEC steering committee meeting, 13-15 June 2000. Bangkok, Thailand.

Maglinao, A.R. and F. Penning de Vries, 1999. MSEC: Implementing a new paradigm in research on soil erosion management in Asian catchments. Paper presented at the Third International Symposium on Systems Approaches for Agricultural Development (SAAD III), 8-11 November 1999. Lima, Peru..

Renaud, F. Bechstedt, H.D. and Udomchai Na Nakorn, 1998. Farming systems and soil conservation practices in a study area of Northern Thailand. *Mountain Research and Development*. 18:345-356.

5. RUN-OFF CHARACTERISTICS BY MOVING STORM IN WATERSHEDS

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INTRODUCTION

Many cities and towns were founded near a river. Early development patterns show that the industry was located in the floodplain for easy access to water power and transportation, while businesses and houses typically were situated on the surrounding hills. Stormwater was not a major problem as the natural systems of ditches and swales quickly concentrated run-off into creeks draining directly to the river. Run-off from the downtown area was collected into a storm sewer and discharged creeks.

With continued growth and development, storm sewers were installed in commercial and residential areas, but still were allowed to discharge into the creeks. As such, each creek became the trunk line for a portion of the stormwater drainage network. Whereas the piped storm sewer systems were planned and designed for frequency storm events, no planning was undertaken to increase the capacity of the creeks. The pervasive attitude was to collect the stormwater at the development site and pipe it off-site for disposal. It was assumed that the creeks can accommodate any increases in run-off and no thought was given to downstream impacts.

Continued growth has tended to follow a pattern of development upstream from the river to the headwaters of the creeks. The resulting increased run-off rates and volumes frequently exceed the capacity of the creeks and flooding has become a more frequent and severe problem. This, coupled with the recent trend to build houses near or adjacent to "babbling brooks", has created the potential for greater flooding damages as the upstream portions of a watershed are built-out.

A further problem is now being recognized, that is, the popularly accepted practice of suing detention ponds for the on-site control of stormwater run-off is failing. The basic philosophy behind this method is to restrict the outflow peak rate from new development to the level that existed prior to land use change, and to provide temporary storage for any run-off, in excess of the allowed release rate. Conceptually, this should result in instream flows that do not exceed the capacity of the creeks and other natural streams. Ideal and simple as this approach may sound, it does not always prove to be an effective way to control stormwater. Fundamentally, this approach can lead to an coordinated system of ponds, and fails to acknowledge that a watershed and its internal drainage network function as a system. Too often, the cumulative releases from on-site detention facilities result in continued, if not aggravated, downstream flooding.

While several researchers were trying to describe the characteristics of moving storms other researchers have been actively attempting to develop methods whereby storms can be tracked across a watershed. These studies are similar, but of a different focus, than those techniques which sought to statistically explain the patterns and more emphasis on what is actually occurring.

Anderl, Attmannspacher and Schultz (1967) scanned the area using a radar to determine the aerial extent of rainfall in time. These data were fed to a reservoir model to update channel flows in real time. The weather radar was calibrated to rain gauges in the field which telemetered data back to the central processing station. They concluded that the impact of linking radar data to watershed models could significantly improve flood forecasting.

A technique for checking recording rain gauge data was presented by Hindi and Kelway (1977) . This method determines the storm velocity using a subset of rain gauges in a network. Theses storm velocities were used to check the rainfall catch of other rain gauges in the path of the storm. Assessment of the rain gauge reliability could be made from these computations.

Niemczynowicz (1987) appreciated the necessity of incorporating the dynamic nature of rainfall into run-off models.

Niemczynowicz presents the application of three storm tracking methods on a set of 12 rain gauges in Lund, Sweden. He concluded that a truly objective method is not available at present in which storms can be tracked from a network of rain gauges. However, when the gauges data are good, simple triangulation methods are as applicable as sophisticated spatial correlation methods.

Actual rainfall events are rarely static. In most cases, rainfall is continuously varying in space and time. Temporal variability is defined as the ability of the rainfall intensity to vary with respect to time. Spatial variability is the property of the intensity to vary in space. These variabilities can have significant influence on the run-off characteristics of watersheds.

Although it is widely recognized that temporal and spatial variability of precipitation can affect run-off, the ability to model these influences with existing models is limited. Most existing models can accommodate temporal variability but assume spatial uniformity over the watershed. Spatial variability can be approximated in existing models by subdivision of the watershed into smaller sub-watersheds and plane units. However, this approximation still assumes spatial uniformity over each sub-unit of the watershed and, therefore, is not a true representation of the physical system.

In this presentation, the run-off characteristics in the case of moving storm in the watershed were reviewed using GIS technique.

GOVERNING EQUATION

Newton's Law

For a particle of water having mass m, the expression of Newton's law is:

$$m\frac{\partial v}{\partial t} = F \qquad (2\text{-}1)$$

where t is time and F is the net force acting on the particle. The variation of v with time at a given location, $\partial v/\partial t$ is the acceleration.

Motor Force

In hydraulics the total head, H, is defined as the following expression:

$$H = z + y + \frac{v^2}{2g} \tag{2-2}$$

This head is an energy per unit weight and has dimension of a length. The term z (the elevation) is the contribution of the potential energy (gravity), y represents the pressure energy, $v^2/2g$ represents the kinetic energy. The flow is in the direction of a drop in total head. The motor force per unit weight is the negative of the head, that is - $\partial H/\partial x$. This term is dimensionless, is called energy slope and denoted Se. An explicit expression for the energy slope is obtained from Eq. (2-2), thus:

$$S_e = -\frac{\partial H}{\partial x} = -\frac{\partial z}{\partial x} - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x} \tag{2-3}$$

or since $-\partial z/\partial x$ is the slope of the terrain, S_0:

$$-\frac{\partial H}{\partial x} = S_0 - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x} \tag{2-4}$$

De Saint-Venant Equation

Division of Eq. (2 1) by the weight of the particle (mg) yields:

$$\frac{1}{g}\frac{\partial v}{\partial t} = \frac{F}{mg} \tag{2-5}$$

and F/mg is the net force per unit weight. This net force is the difference between the motor force and the resistance (friction) force. Since the motor force per unit weight is - $\partial H/\partial x$, Eq. (2-5) can be written as:

$$\frac{1}{g}\frac{\partial v}{\partial t} = \frac{\partial H}{\partial x} - S_f \tag{2-6}$$

where S_f is the friction force per unit weight, a dimensionless quantity and which we shall call by analogy, the friction slope. Use of the expression for - $\partial H/\partial x$ in Eq. (2-4) to eliminate it from Eq. (2-6) yields:

$$\frac{1}{g}\frac{\partial v}{\partial t} = S_0 - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x} - S_f \tag{2-7}$$

Bringing the derivatives with respect to x on the left-hand side, one obtains the de Saint-Venant equation:

$$\frac{1}{g}\frac{\partial v}{\partial t} + \frac{v}{g}\frac{\partial v}{\partial x} + \frac{\partial y}{\partial x} = S_0 - S_f \tag{2-8}$$

which is a nonlinear partial differential equation.

Expression for the Friction Slope

The friction laws have been obtained empirically from experiments under steady and uniform conditions of flow. One can see from Eq. (2-8) that in this case, since $\partial v/\partial t = 0$ (steady flow0 and $\partial v/\partial x$ and $\partial y/\partial x = 0$ (uniform flow), that friction slope equals terrain slope. Experience has shown that this friction slope depends upon flow characteristics such as velocity hydraulic radius.

Chezy's Law

Chezy proposed the relation:

$$S_f = \frac{v_2}{c^2 R} \quad (\text{or} \quad v = C\sqrt{RS_f}) \tag{2-9}$$

where R is the hydraulic radius (ratio of cross section area by the wetted perimeter) and C was, in principle, a constant. In reality C depends on the flow. For laminar flow, theory has shown that Chezy's C is related to the Reynolds number, Re, as:

$$C = \sqrt{\frac{gR_e}{2}} \tag{2-10}$$

where the Reynolds number is defined as:

$$R_e = \frac{\rho v R}{\mu} = \frac{vR}{\nu} \tag{2-11}$$

where the μ is the viscosity of water and $\nu = \mu/\rho$ is the kinematic viscosity. For a shallow flow (case of overland run-off) R=y. Combination of Eqs. (2-9), (2-10) and (2-11) provides an expression for the specific discharge, i.e., discharge per unit width of flow, q, in terms of the depth of flow, namely:

$$q = vy = \frac{gS_f}{2\nu} y^3 \tag{2-12}$$

Strickler-Manning's Law

For turbulent flow, Manning's relation is the most commonly used, that is:

$$v = \frac{1}{n} S_f^{1/2} R^{2/3} \tag{2-13}$$

where n is Manning's roughness coefficient. For shallow flow, the specific discharge has the form:

$$q = \frac{1}{n} S_f^{1/2} R^{3/5} \tag{2-14}$$

For both laminar and turbulent flows of shallow depth, the specific discharge is proportional to a power of the depth. It has the general form:

$$q = \alpha y^n \tag{2-15}$$

In the case of overland flow, since the terrain details are extremely complex and poorly known, it is hard to understand if the flow is laminar or turbulent or to estimate effective roughness and slope. In practice the parameters α and n are obtained by calibration based on simultaneous data of rainfall and run-off. Note that Eq. (2-15) has the typical form of a rating curve utilized to convert measurements of river stage into estimates of discharges. Parameters of the rating curve are obtained by calibration with joint observations of stages and discharges at the gauging station.

Continuity Equation

If A represents the flow cross section and Q represents the discharge, mass conservation is expressed mathematically in the form:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0 \qquad (2\text{-}16)$$

For shallow wide uniform flow, the area per unit width is y and the discharge per unit width is q, and Eq. (2-16) by division by the width simplifies to:

$$\frac{\partial y}{\partial t} + \frac{\partial q}{\partial x} = 0 \qquad (2\text{-}17)$$

This equation expresses the fact that if over an infinitesimal length (i.e., very short distance, say dx), more water enters upstream than leaves downstream over a short time interval (say dt, and $\partial q/\partial x < 0$ since q decreases as x increase), then the amount of water in storage in the short reach of length dx must increase with time (thus $\partial y/\partial t > 0$).

For mass conservation a positive $\partial y/\partial t$ must compensate a negative $\partial q/\partial x$, and vice-versa.

Kinematic Wave Equation

Over the overland plane the conservation of mass is not given by Eq. (2-17), which only considers change in storage due to rainfall or from infiltration losses. The equation (2-17) completed to account for these effects is:

$$\frac{\partial y}{\partial t} + \frac{\partial q}{\partial x} = r - i \qquad (2\text{-}18)$$

where r is the rainfall rate and i is the infiltration rate.
Note that all the terms in Eq. (2-18) have dimensions of a velocity (length over time). Equations (2-15) and (2-18) provide two equations for the two unknown y and q. Elimination of q between the two equations yields:

$$\frac{\partial y}{\partial t} + n\alpha y^{n-1}\frac{\partial y}{\partial x} = r - i \qquad (2\text{-}19)$$

where the chain rule of differentiation has been used (i.e., $\partial q/\partial x = (dq/dy)\partial y/\partial x = n\alpha y^{n-1}\,\partial y/\partial x$). Equation (2-19) is the so-called kinematic equation.

SELECTION OF EXPERIMENTAL WATERSHED AND DECISION OF ISOHYETAL MAP

Selection of Experimental Watersheds

The Bok-ha river basin located in Inchon, Kyangigi Do, Korea, was selected as the applied watershed. The Bok-ha river basin has an area of 161.9 km^2, the river length of 23.16 km and now, consists of agricultural area with mild slope and forest. In order to obtain the characteristics of the basin as the input data of HEC-1, DEM is settled. DEM is the method which expresses digitally the variation of the continuing surface uneven. DEM data were saved as the segment shape and the segment with the same scale expressed the same elevation in the surface. DEM is developed to model the uneven surface but now DEM is used to express uneven as well as the continuing variation of the other characteristics and could be set up through the artificial satellite image, the aerial photograph and the digital map. In this study, the contour layer and the river layer were established by digitizing of the contour line, the elevation point, and the river network in 1/50,000 topographic survey map, and then DEM with 10mX10m segment shape was settled. Scanner, AutoCAD, Arc/Info and Arc View were used for this study. Figure 1 shows the inclination map near the Bok-ha river basin from DEM data. In this figure, the dark area is steep slope and the bright area is mild slope. Through this DEM, the basin boundary could be fixed and the characteristics of the basin could be obtained with the sub-basin.

Figure 2 shows the sub-watershed. In Figure 2, No.1~No.21 indicate the number of the sub-watershed to each other.

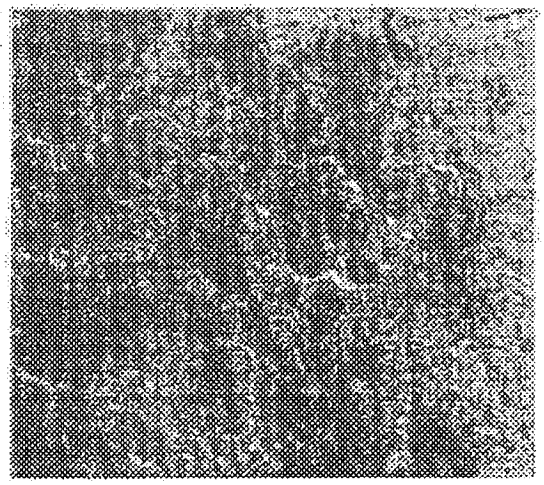


Figure 1. Map of Bok-ha River Basin

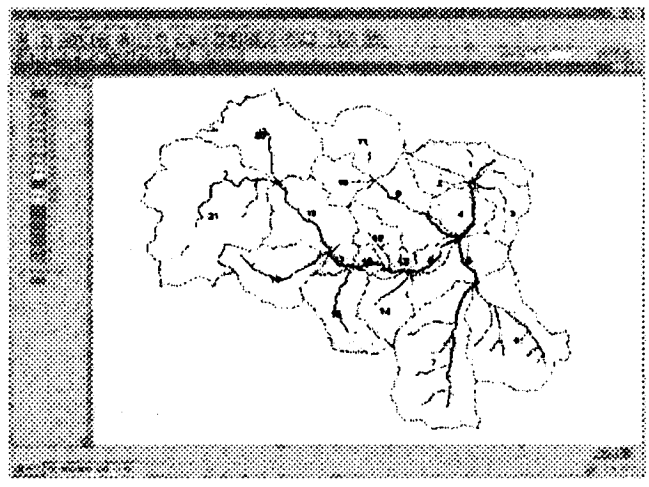


Figure 2. Subbasin of Bok-ha River Basin

Drawing of Isohyetal Map and Application in the Basin

To analysis the rainfall-run-off depending on the variation of the time and space using the existing method, is very difficult. Forecasting the rainfall due to the abnormal weather and the typhoon in summer is not easy. The damage due to this rainfall is increased but considering its characteristics is very difficult. The rain is varied with the time and the damage is added by the rain variation.

As shown in Figure 3, the typhoon as the example of the moving storm, moved across the West-middle area from the West sea in July and moved across the middle area from the South-west sea in August. In September, it moved across the South costal area mainly. In order to analyze the run-off with the time and spatial variation of the rainfall, the real time data in the basin should be used but using the real time data in the existing analysis method is very difficult and the moving storm data is not easily obtained. Therefore, in this study, the variation of the run-off is simulated using the selected moving storm model after drawing isohyetal map with 1 hr unit using the GIS. The 1 hr unit data which is obtained from the 67 rainfall gauging stations between July 30, 1999 and August 4, 1999 in which it was influenced by the typhoon, Olgar, was used. In order to select the moving storm model, the isohyetal map between 16:00 and 23:00 August 2, 1999 is drawn up.

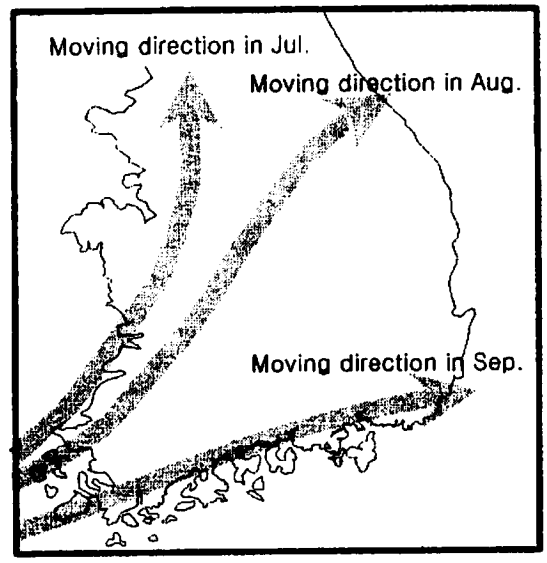


Figure 3.
Moving Direction of Major Storms in Summer in Rep. of Korea

The CAD file of the basin boundary and the longitude and latitude coordinates of the 67-rain gauging stations are transformed to the TM-coordinate and then the isohyetal map is analyzed using the Arc/Info and showed using Arc View. The flow chart for this isohyetal map is shown in Figure 4.

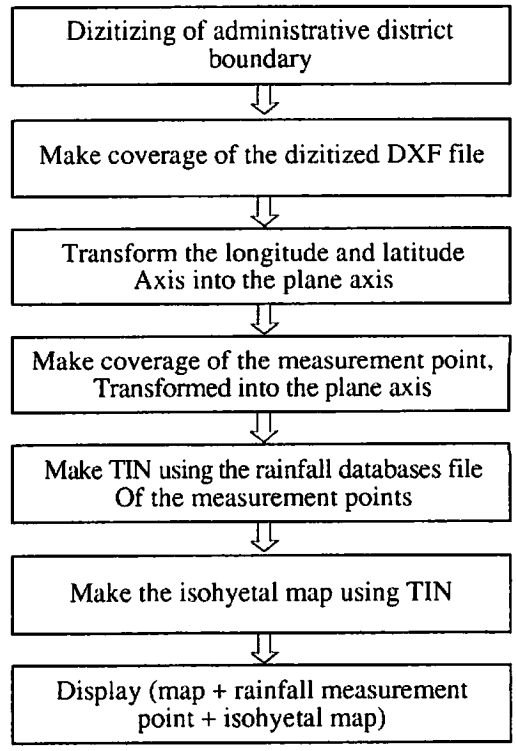
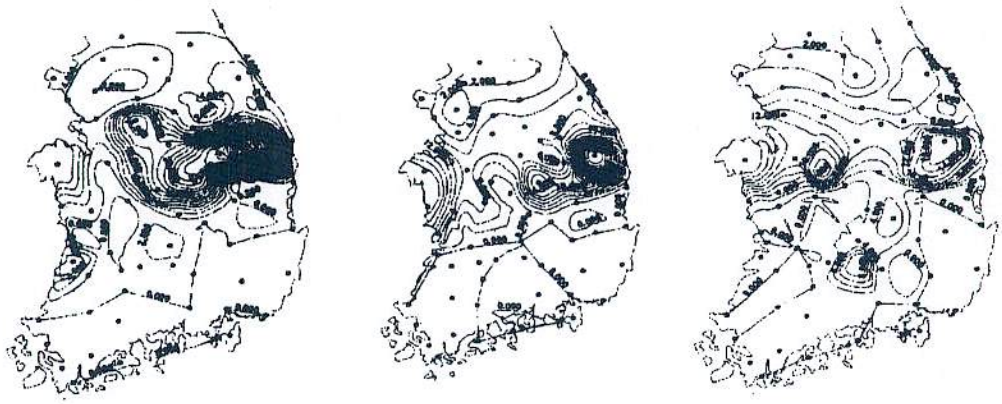


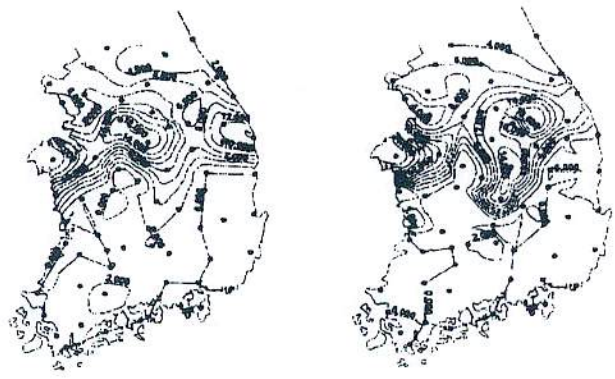
Figure 4.
Flow Chart for Isohyetal Map

The isohyetal map is obtained with the time interval of 1 hr as shown in Figure 5. As shown in Figure 6, the Chun-yang gauging station located in Chun-yang meon, Bongwha Gun, kungbuk is selected for analyzing the moving storm. The run-off is simulated. Figure 7 shows the rainfall discharge. As shown in Figure 7, the rainfall discharge is 1.0 mm in the beginning of the rainfall. As the time passed the rain was increased to 57.0 mm and then decreased to 2.5 mm. Therefore, the moving storm which has maximum discharge of 57.0 mm was selected and the run-off discharge was considered as the selected moving storm in the Bok-ha river basin. In this case, the moving velocity of 5.5 m/sec was selected. Because the selected velocity of the moving storm was in the range of the velocity of the typical typhoon, the selected velocity was reasonable for the application.

a. 16:00, 2, Aug. b. 17:00, 2, Aug. c. 18:00, 2, Aug.



d. 19:00, 2, Aug. e. 20:00, 2, Aug. f. 21:00, 2, Aug.



g. 22:00, 2, Aug. h. 23:00, 2, Aug.

Figure 5. Isohyetal Map Between 16:00 and 23:00, August 2, 1999

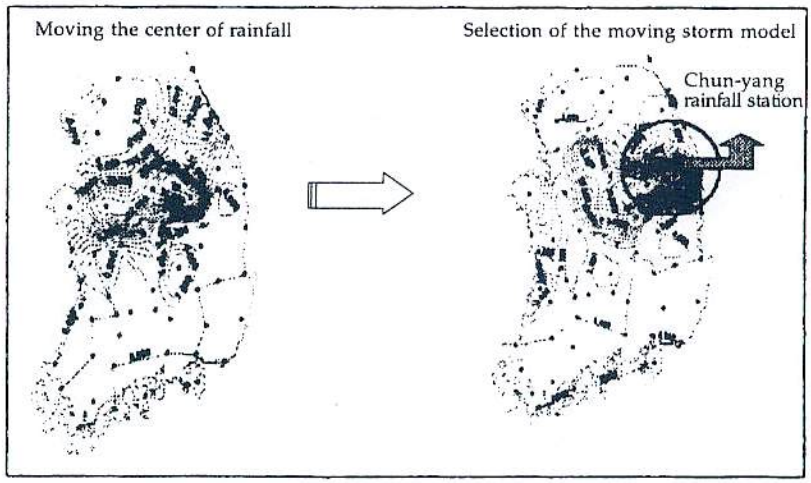


Figure 6. Variation of the Rainfall Intensity Between 16:00 and 19:00, 2 August

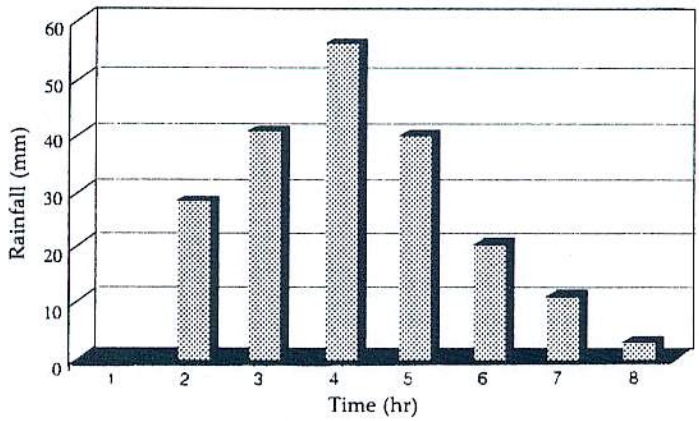


Figure 7. Data Between 16:00 and 23:00. 2 August, Chun-yang Rainfall Station

RUN-OFF CALCULATION

The run-off in the watershed was simulated using the HEC-1 program (1990) which was developed at the Hydrologic Engineering Center, US Army Corps of Engineers. The effective rainfall was determined using the Curve Index which was developed at the US Soil Conservation Service. The curve numbers are divided depending upon the soil type, plant vegetation, land use and hydraulic condition of the soil in the watershed.

The analysis of the run-off was divided into two different flows which are the overland flow and the stream flow. In the overland flow the kinematic wave equation was applied and the Muskingum-Cunge method was applied in the stream flow. In the above two different solution approaches, the same governing equations were applied but the simplification of the full dynamic equation was different from the other approach.

The kinematic equation is derived from the assumption that the energy slope was the same with the channel bed slope. The equation was developed combining the continuity equation (Eq. 3-1) with the assumption (Eq. 3-2).

However, in the Muskingun-Cunge method the diffusive approach written in (Eq. 3-3) was applied.

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q_l \tag{3-1}$$

$$S_f = S_0 \tag{3-2}$$

where, Y, A, Q, q_l, S_f, S_0 indicate the stage, cross sectional area, discharge, lateral inflow per unit length, friction slope and the channel bed slope. Also, x and t indicate the length and time in the longitudinal direction.

Kinematic equation was shown in Eq. 3-4 which was developed by combining Eq. 3-1 and Eq. 3-3. The finite different approach was developed to determine the unknown run-off. The run-off was gradually calculated by applying the finite different approaches.

$$\frac{\partial A}{\partial t} + \alpha m\, A^{(m-1)} \frac{\partial A}{\partial x} = q_l \tag{3-4}$$

$$\frac{\partial Q}{\partial t} + C\frac{\partial Q}{\partial x} = \mu \frac{\partial^2 Q}{\partial x^2} + C\, q_l \tag{3-5}$$

In Equation (3-4) and (3-5), α, m are the coefficients, which are different depending upon the applied equation.

RUN-OFF VARIATION IN THE DIRECTION OF MOVING STORM

Selection of the Direction of the Moving Storm

Four different directions of top-bottom, left-right and two different diagonal directions were selected. The moving storms moved with two different ways (such as top → bottom and bottom → top in the top-bottom direction). The directions are indicated in Figure 8. The movement of the storms was applied using the Arc Macro Language (AML) in the Arc/Info GIS program. At first, the coverage of the moving storms were made and then the dates were input through each coverage. The starting and ending points were input and the moving storms were moved with the moving velocity and time intervals.

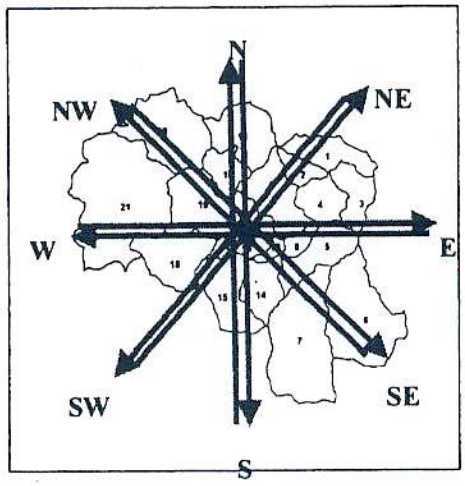


Figure 8. The Moving Direction of the Rain

Figure 9 is the flow chart of the calculation of the average rainfall intensity in the sub-watershed.

Rainfall Distribution in Changing the Directions of the Rain

The rainfall distribution by moving the rain is different depending upon the direction of the rain. The rainfall distribution was obtained with 10-minute intervals. Because of the distance of the watershed, the time in which the rain stays in the watershed was varied depending upon the direction of rain movement. Figures 10 and 11 indicate the rain movement in the direction of NW and SE. In the figures the rainfall distributions after 10 min., 30 min., 1 r, 4 hr, 5 hr 50 min. and 6 hr 10 min. from the rain beginning are shown. The rainfall distributions in the sub-watershed were very different with time progress.

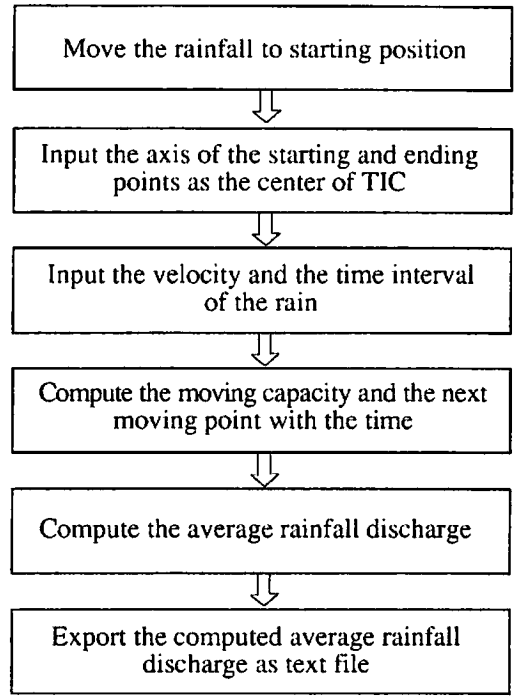


Figure 9.
The Flow Chart for the Program of the Moving Storm

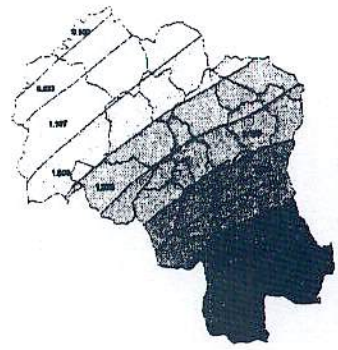
RUN-OFF SIMULATION BY CHANGING THE DIRECTION OF RAIN MOVEMENT

The Run-off Simulation by Changing Moving Direction

The dark portions in Figures 10 and 11 represent the larger rainfall intensity which varies depending upon the moving direction with time. The simulation run-off with the different rainfall intensity are shown in Figures 12 and 13 indicating the different peak discharges. Time-to-peaks were obtained. The peak discharge is depending upon the time and moving direction. The maximum discharge of 494.55 m^3/sec was obtained in the SE direction. The minimum discharge of 228.38 m^3/sec was obtained in the N direction. The difference in discharge was 226.17 m^3/sec which was obtained because of the characteristics of the watershed such as the length, slope, and detention time. Table 1 and Figure 14 indicate the variation of the peak discharge, namely; the larger discharges were obtained in the NW and SE directions but the smaller discharges were obtained in the S and N directions. Also, the discharges in the direction NE and SW are less compared to the directions of NW and SE. This is because the NE and SW diagonal line was smaller than that in the NW and SE directions. Also, the discharges in the E and W directions were larger compared to the S and N directions. This is the rain that continued for a long time because the width of the watershed in the E and W directions was wider compared to that in the N and S directions.

After 10 min. start of the rainfall

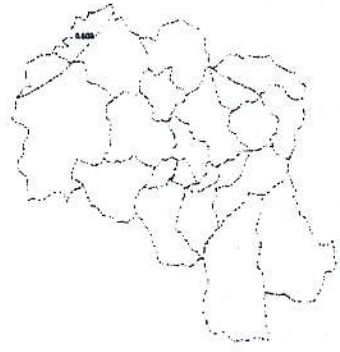
After 30 min. start of the rainfall



After 1 hr. start of the rainfall

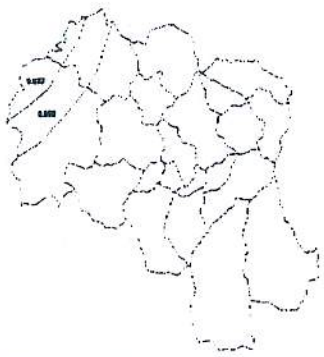
After 4 hr. start of the rainfall

After 5 hr. 50 min. start of the rainfall



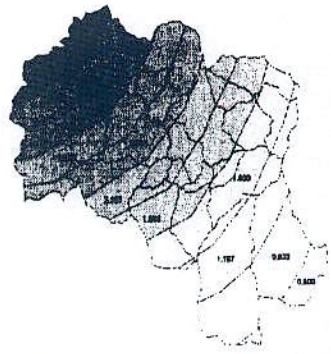
After 6 hr. 10 min. start of the rainfall

Figure 10. Moving Storm with NW-direction After 10-min. Beginning and 6 hr. 10-min. Ending of Rainfall



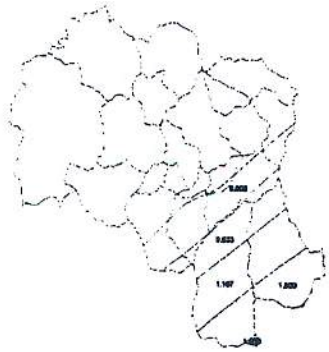
After 10 min. start of the rainfall

After 30 min. start of the rainfall



After 1 hr. start of the rainfall

After 4 hr. start of the rainfall



After 5 hr. 50 min. start of the rainfall

After 6 hr. 10 min. start of the rainfall

Figure 11. Moving Storm with SE-direction

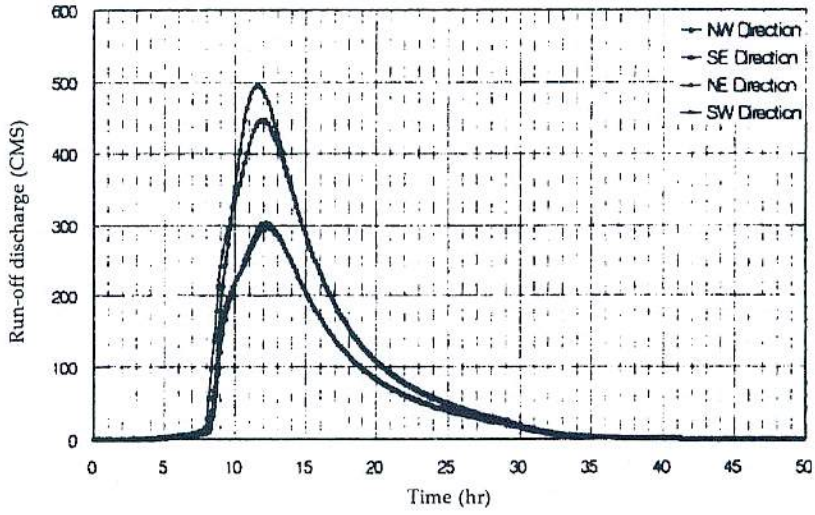


Figure 12. Run-off Discharge Variation with NW, SE, NE, SW Directions

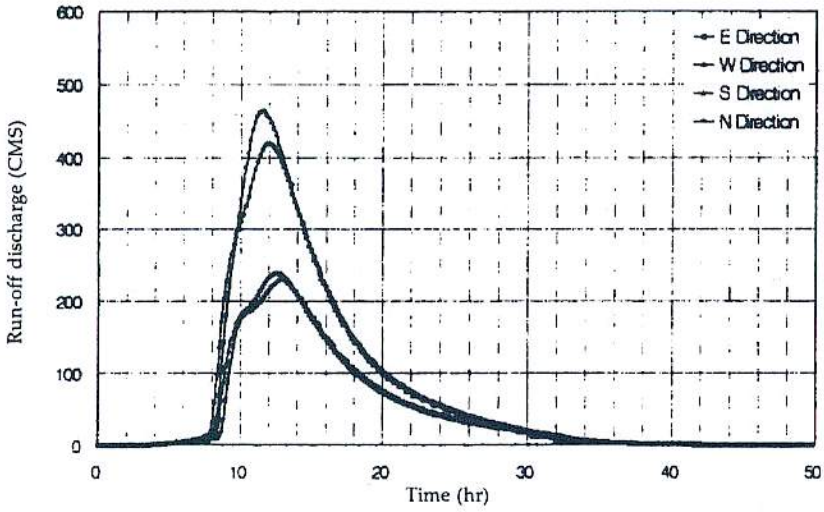


Figure 13. Run-off Discharge Variation with E, W, S Directions

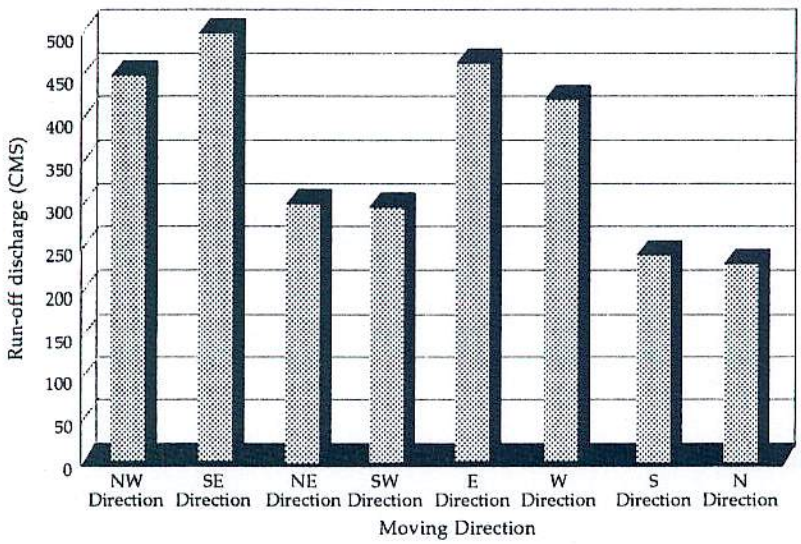


Figure 14. Peak Discharge Variation with Moving Direction

Table 1. Discharge with Moving Direction

(unit m^3/sec)

Moving direction	NW direction	SE direction	NE direction	SW direction	E direction	W direction	S direction	N direction
Peak discharge	445.94	494.55	303.13	296.17	462.67	418.83	238.97	228.38

Table 2. Time-to-Peak with Moving Direction

Moving direction	NW direction	SE direction	NE direction	SW direction	E direction	W direction	S direction	N direction
Time delay to peak discharge	12 hr	11 hr 30 min.	12 hr 10 min.	12 hr 20 min.	11 hr 30 min.	12 hr	12 hr 30 min.	12 hr 50 min.

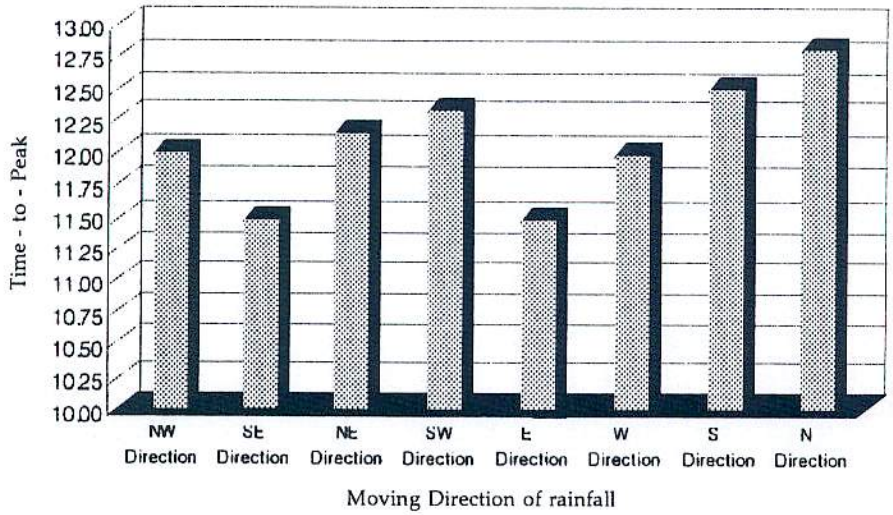


Figure 15. Run-off Variation by Moving Velocity of Rain

Run-off Variation by Moving Velocity of Rain

The run-off difference by changing the moving velocity was compared. The moving velocity was changed from 5.5 m/sec to 11 m/sec. Figures 16 to 19 show the run-off variations by changing the moving velocities. As shown in the figures, by changing the moving velocities time-to-peak was varied with faster movement in the moving velocity of 11 m/sec.

In the moving velocity of 11 m/sec, the rain left the watershed within 2-3 hours. The peak discharges were less in the faster moving velocity. The peak discharge in the moving velocity of 11 m/sec were 1/5.5 - 1/7 compared to the moving velocity of 5.5 m/sec. Also, the figures show the difference between the hygrographs.

The two different peak discharges are indicated in the velocity of 11 m/s even though the only one peak discharge was indicated in the moving velocity of 5.5 m/sec.

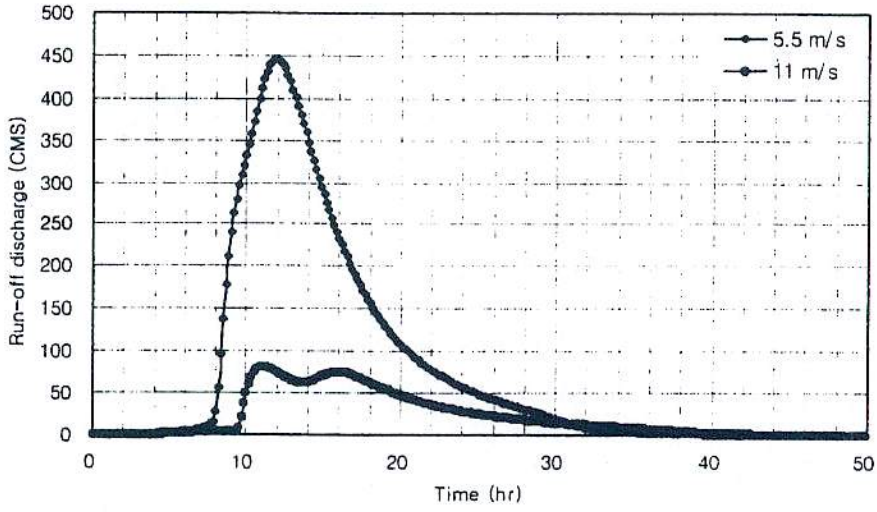


Figure 16. Run-off Variation with Moving Velocity in NW-direction

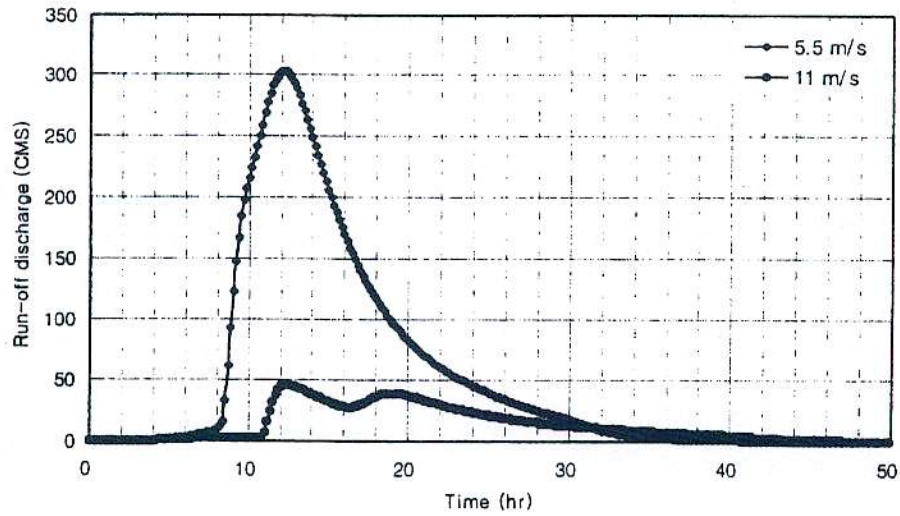


Figure 17. Run-off Variation with Moving Velocity in NE-direction

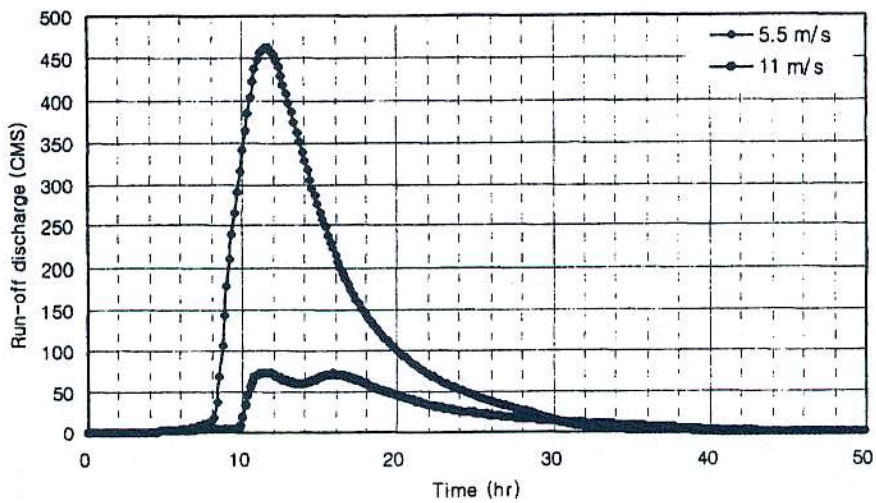


Figure 18. Run-off Variation with Moving Velocity in E-direction

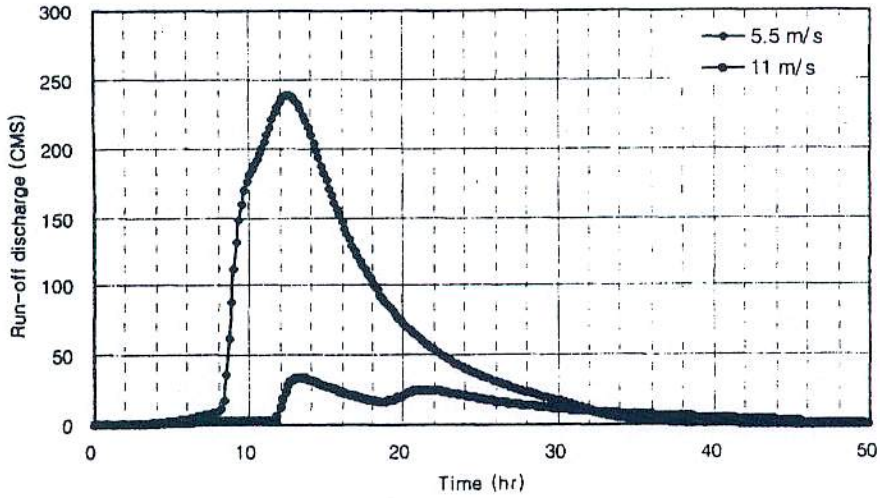


Figure 19. Run-off Variation with Moving Velocity in S-direction

SUMMARY

Even thought the distribution of the rainfall in the watershed is spatially and temporally varied, the simulation of the run-off from the watershed is frequently conducted with the constant rainfall distribution assumption. However, the run-off simulated with this assumption indicates over the certain accuracy limitation and the difference by this assumption is bigger in the case of the moving storm which can be frequently indicated with the typhoon, cyclone and hurricane and so on. In this presentation, the run-off characteristics of the moving storm are investigated using GIS technique and the isohyetal map observed from 16:00 to 23:00 on August 2, 1999 to the Chun Yang rain gage. The run-off simulated by the moving storms moving to the eight different directions is compared with the others and indicates the big difference with the maximum run-off in the SE direction in the Bokha experimental watershed. Also, the run-off by the moving storm having different moving velocities is compared with the others and indicates the big difference with the bigger discharge in the slowly moving storm. Through the simulation using GIS technique in the watershed, the advantages of the easy preparation of the data and the short computational time can be obtained.

REFERENCES

Ko, D. G., Park, N. H., 1998. "Time and Spatial Analysis of Rainfall Using GIS." Conference Proceedings of Korea Water Resources Association, pp. 690-695 (In Korean).

Kim, K. T., 1998. Analysis of Run-off Response using GIS, Ph. D. Dissertation, Inha University (In Korean).

Choi, G. W., Lee, H. S., Ahn, S. J., 1992. "Simulation of Moving Storm in an Watershed Using a Distributed Model", Journal of Korea Water Resources Association, KWRA, Vol. 25, No. 1, pp. 101-109 (In Korean).

Ham, C. H., 1996. A Study for Drawing out of the Hydrologic Geology Information using GIS, Ph. D. Dissertation, Chunbuk National University (In Korean).

David, A. E., 1994. A Geographic Information System Procedure to Quantity Drainage Basin Characteristics", *Water Resources Bull.*, Vol. 30, No. 1, pp. 1-8.

HEC, 1990. HEC- 1 Flood Hygrograph Package User's Manual. US Army Corps of Engineers, Hydrologic Engineering Center.

James, J. M., and David, A. E., 1991. *An Automated Method to Quantify Physical Basin Characteristic,* USGS Water Resources Invert. Report 91-4034, pp. 558-561.

Jenson, S. K., and Domingue, J. O., 1988. "Extracting Topograpic Structure From Digital Elevation Data for Geographic Information System Analysis", *Photogrammetric Engineering and Remote Sensing,* Vol. 54, No. 11, pp. 1593-1600.

Marshall, R. J., 1980. "The Estimation and Distribution of Storm Movement and Storm Structure, Using A Correlation Analysis Technique and Rain-Gauage Data", *Journal of Hydrology,* Vol. 62, pp. 53-62.

Niemczynowicz, J., 1984. "Investigation of the Influence of Rainfall Movement on Run-off Hygrographs Part I and Part II," *Nordic Hydrology,* Vol. 15, pp. 57-84.

Niemczynowicz, J. and Dahlblom, P., 1984. "Dynamic Properties of Rainfall in Land", *Nordic Hydrology,* Vol. 15, pp. 9-24.

Richardson, J. R., 1989. *The Effect of Moving Rainstorms on Overland Flow Using One-Dimensional Finite Elements,* Ph. D. Dissertation, Dept. of Civil Engineering, Colorado State University, Fort Collins, Co.

Warwick, J. J., Haness, S. J., and Dickey, R.O., 1991. "Integration of an ARC/INFO GIS with HEC-1", *Water Resour. Plang Mgmt, and Urban Water Resour, Proc. of the 18th Conf.*, pp. 1029-1033.

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Taipei

INTRODUCTION

The Rep. of China (ROC) is a mountainous island with a total area of about 36,026 km^2. North to South distance is about 384 km, whereas East to West distance is about 144 km. The Central Mountain Range runs North to South, dissecting the island into two halves. Flatland with less than 100 m elevation comprises 26.4 percent of the total area. The remaining 73.6 percent is slopeland. Forest cover in higher elevations is about 46.6 percent. Along the Central Mountain Range, there are about 20 peaks exceeding 3,000 m high. Rivers originate from mountain tops flow East and West to the Pacific Ocean and Taiwan Strait, forming narrow river valleys as a result of torrential river flow. Suitable reservoir sites are limited.

The average annual rainfall in ROC is about 2,515 mm. However, rainfall is unevenly distributed both temporally and spatially. The North, central, South and East areas receive about 62 percent, 78 percent, 90 percent, and 79 percent of the total rainfall during the months from May to September, respectively. Wet and dry seasons are very pronounced. The available water resources are limited. Due to increases in population, economic development, housing areas, and agricultural land, slopeland ecology has been damaged, resulting in soil erosion, ruined water retention capacity, accelerated water pollution source, and the risk of severe soil erosion and water pollution problems in reservoirs.

The construction of new reservoirs is becoming more difficult and was essentially halted due to the adverse natural environmental conditions and the public opposition based on non-economical and non-technical arguments.

The pressure of water demand is increasing in ROC. The only viable water resources strategy is to enhance the protection and management of the existing reservoirs and to utilize their storage capacity on a sustainable basis. However, the protection of reservoir requires an integrated management approach. It also needs a firm implementation of government rules and regulations as well as public compliance and cooperation in order to achieve effective results.

CURRENT STATUS OF RESERVOIR WATERSHEDS

The topography of ROC is very steep. Rivers are short with swift flow. Rainfall is both unevenly distributed in space and time. Annual rainfall at the Central Mountain Range often exceeds 3,000 mm. Typhoons and heavy rainstorms bring most of

the annual rain. Flood waters often carry large sediment load downstream and deposit in reservoirs. According to statistics, the average annual rainfall in the country is about 2,515 mm and is about 2.6 times the world average (973 mm). Due to pronounced wet and dry seasons, topographic limitation, and lack of large natural lake storage, the total storage capacity of reservoirs is small although rainfall is plentiful. Therefore, water supply using reservoir storage is rather difficult. Water becomes one of the precious natural resources. The population density is second among countries all over the world. The annual per capita rainfall resource for ROC is only about 3,500 m^3, as compared to 6,500 m^3 in Japan; 32,000 m^3 in USA; 14,000 m^3 in the People's Rep. of China; 8,400 m^3 in France; 4,500 m^3 in UK; and 4,900 m^3 in Germany. ROC is not the poorest with water resource. However, available water resources are extremely limited by the temporal rainfall distribution and the topographic effects. The supply and demand of water resources foresee a severe imbalance in the future.

To adjust the water resources supply and demand imbalance between wet and dry seasons, the construction of reservoirs to increase the storage capacity is needed. Reservoirs should also have multi-objective functions. Besides public water supply, reservoirs should provide water for irrigation, power generation, flood control, industrial and recreational water supply. They should also improve citizens' living environment and standard as well as enhancing economic development. This policy should be one of the top government priorities. Many well-built reservoirs have been in operation for years. Suitable reservoir sites are becoming scarce. Due to recent population growth, increased land use demand, and uprising environmental awareness, construction of new reservoirs has encountered numerous non-technical problems such as land rights, local resident oppositions and eco-environmental impacts. The water supply goal is becoming hard to reach. Therefore, the protection of reservoir life span, increasing existing reservoir storage and water quality improvement are the most important targets for present water resources policies.

Reservoirs in ROC can be grouped according to their effective use into single-purpose and multi-objective reservoirs. Currently, there are 44 reservoirs. Their storage capacities are shown in Table 1.

Table 1. Distribution of Reservoirs Grouped According to Storage Capacity and Effective Use

Item	Storage Capacity (10^6 m^3)							
	< 1	1-10	10-20	20-30	30-40	50-100	>100	Total
Number	12	14	4	2	3	2	7	44
Single-purpose	12	9	-	-	-	1	1	23
Multi-objective	-	5	4	2	3	1	6	21

The major objective of the single-purpose reservoirs is either for domestic water supply or irrigation only. The multi-objective reservoirs are used for irrigation, domestic water supply, power generation, flood control, recreation, and industrial water supply. Governing agencies are the Taiwan Water Supply Corporation, Irrigation

Associations, Taiwan Power Company, Taiwan Sugar Company, Water Resources Bureau, and Reservoir Administrations.

Disregarding their usage, whether single-purpose or multi-objective, reservoirs in the country cannot compare with those in USA and Japan (Table 2). For flood control effectiveness, USA reservoirs can reach as high as 17 percent; whereas Japan is 3.9 percent and ROC is 2.3 percent. As for the effectiveness of water supply, USA reservoirs is about 23 percent; whereas Japan is 10 percent and ROC is only 4.7 percent.

Table 2. Comparison of Effectiveness of Reservoirs, 1995

Item		Country		
		ROC	Japan	USA
Catchment area (km^2)		3,400	7,000	170,000
Number of reservoirs		44	28	17
Catchment area/reservoir (km^2)		77	250	10,000
Rainfall	- Annual rainfall (mm)	2,500	1,800	1,500
	- Largest rainfall	1,127 mm/day	800 mm/day	280 mm/2days
Annual discharge/reservoir (m^3)		$127x10^7$	$300x10^7$	$8,000x10^7$
Average per reservoir	- Storage capacity (m^3)	$6.1x10^7$	$30x10^7$	$1,800x10^7$
	- Storage/annual discharge (%)	4.7	10	23
	- Flood regulation (m^3)	$3x10^7$	$9x10^7$	$135x10^7$
	- Flood regulation/ annual discharge (%)	2.3	3.3	17

Table 3. Comparison of Soil Erosion at Selected Reservoir Watersheds

Reservoir name	Watershed area (km^2)	Annual soil erosion depth (mm)
Shihmen	763	2.8
Tehchi	582	2.0
Tsengwen	481	7.8
Jihyuetan	334	0.5
Wusheh	205	5.9
Mingteh	61	4.1
Wushantou	60	26.7
Akuntien	32	13.4
Peiho	27	14.9
Average	-	8.7

Water Quality Degradation

Land use pattern for the reservoir watersheds in ROC is very complex. Agricultural activities, residential areas and human activities are creating many pollution sources. Water quality degradation is becoming more serious. According to investigation reports of the Environmental Protection Administration, the reservoir eutrophication

Table 4. Calson Eutrophication Index (TSI) for Major Reservoirs

Reservoir name	1993	1994	1995	1999
Hsinshan	++	+	+	++
Feitsui	N.D.	+	-	+
Shihmen	+	++	+	+
Paoshan	++	+	+	+
Yunghoshan	++	+	+	+
Mingteh	++	++	+	+
Tehchi	N.D.	+	+	-
Wusheh	+	+	+	+
Liyutan	N.D.	N.D.	+	++
Jihyuetan	-	-	-	+
Jenyitan	++	++	++	++
Nantan	++	++	+	++
Peiho	++	++	+	++
Wushantou	+	++	+	+
Nanhua	N.D.	N.D.	+	+
Changmin	++	++	+	++
Akuntien	++	++	++	N .D
Chenchinghu	++	++	++	++
Fengshan	++	++	++	++
Tsengwen	++	+	+	+

Note: ++ indicates TSI > 50, severe eutrophication;
+ indicates TSI = 40~50, fair eutrophication;
- indicates TSI < 40, less eutrophication; and
N.D. indicates no data.

index is deteriorating. The rate and types of water pollution sources shown in Table 4 is increasing, which is affecting the water supply.

INTEGRATED RESERVOIR WATERSHED MANAGEMENT

According to Rule No. 9 of the Soil and Water Conservation Act, every stream watershed is to be planned and managed through an integrated approach by the responsible government agency along with other related agencies. Medium and long-term management and treatment plans should also be developed, emphasizing prevention to conserve soil and water resources and to utilize the land appropriately. The ultimate goal is to ensure suitable use of soil and water resources. Individual watershed must be treated in stages from upstream forest to midstream slopeland, along with flood control and drainage downstream, in order to prevent disaster and to preserve the land.

Integrated reservoir watershed management has been rather effective in a few reservoirs in the past. A lot of working experience has been gathered. Because of social and environmental changes, modifications are needed to develop more adequate integrated conservation plan. The planning goals and important work details

are listed as follows:

Goals

Reservoir sustainability -- For sediment-laden and eutrophic reservoirs, use water quality improvement, riparian zone treatment, and sediment removal along with sediment and water quality monitoring to control the sediment and pollution sources of the watershed;

Environ-ecological water supply -- In order to restore both the environment and landscape for maintaining the natural environment and ecology of the watershed, reforestation and tree planting work are necessary to allow for unrestricted self-generation and self-cleansing water supply. The reservoir watershed conservation engineering work needs to be ecologically sensitive also;

Integrated disaster prevention -- Every reservoir watershed should be treated as one entity. All responsible agencies should work together to assess the sediment source areas within the watershed. If needed, the landslide areas, gullies and wild creeks must be treated along with farm road soil and water conservation work. Emergency funds must be set aside to provide immediate relief for unexpected disasters; and

Socialized management -- In order to minimize land destruction due to overdevelopment, community involvement must be strengthened through promotion of water resource conservation campaigns, community awareness, and combined academic and non-governmental organizations' efforts. The participation of the local community should provide new opportunity for implementing watershed management work.

Important Tasks

Reservoir sediment removal -- Use mechanical dredging and pumping to remove sediment from reservoir bottom;

Riparian Zone Treatment -- Treat the 50-m buffer zone from the reservoir top water level;

Reforestation and nourishment -- Plant new trees and nourish the old plantings;

Landslide treatment -- Protect side-slope and prevent disaster occurrence through rock slipping and sliding stabilization;

Wild creek and gully treatment -- Use revetments, submerged dams, check dams, and flow regulation to treat gullies and wild creeks;

Farm road soil and water conservation -- Assist farmers to construct conservation work such as bench terraces, hillside ditches, drainage ditches, side-slope stabilization, and drainage facilities;

Water quality improvement -- Divert polluted water and assist in solid waste disposal, detention pond and grass waterway construction, and other improvement facilities;

Ecologic-friendly engineering work -- Select appropriate sites to construct eco-environmental friendly as well as safe structures;

Community water resources campaign -- Assist local communities to build water storage, supply and other water-related facilities and organize water resources education and promotion activities.

Water quality monitoring program -- Integrate reservoir watershed water quality monitoring work;

Sediment monitoring program -- Integrate reservoir watershed sediment monitoring work;

New emergency disaster treatment -- Treat temporary emergency disasters; and

Miscellaneous works - Other related reservoir protection works.

EXPERIENCE OF TEHCHI RESERVOIR WATERSHED TREATMENT

General Description of Tehchi Reservoir Watershed

The total area of the Tehchi Reservoir Watershed is about 612 km^2, about 1/2 the entire area of the Dachia Stream Basin. Its administrative boundary is split between Taichung, Nantou (8,000 ha), and Ilan (400 ha). The land right belongs to: the Forestry Bureau (National Forest Land), Veterans Affairs Commission (Wuling Farm and Fushoushan Farm), Aboriginal Affairs Committee (Aboriginal Reservation land), and Ministry of Interior (Sheipa and Taroko National Park). The population density is low and is mostly concentrated in Chiayang, Lishan, Sumou, Wenshan, Wuling, and Fushoushan. After the completion of the East-West Passway in 1960, the people were attracted to this area, resulting in over-cultivation. At present farmland on the upslope of the reservoir watershed is about 3,800 ha. The transient tourist population is estimated to exceed 2 million each year. Due to low soil fertility, over-fertilization and pesticide application often occurs. Uncontrolled open solid waste disposal is common in this watershed with inadequate waste disposal and incinerator facilities. Untreated domestic sewer is directly discharged to drainage ditches and eventually flows to the reservoir. The large nutrient load has created an uncontrollable population of seaweed. During summer, the watercolor always turns brown. The seaweed, so far, has not yet affected the operations of the 5 Taiwan Power Company hydroelectric power generation stations. However, the water is subsequently delivered to the Shihkang Dam and the Fengyuan Water Supply Corporation to supply domestic water for most Taichung residents. Therefore, the quality of the water supply should not be neglected. The success or failure of soil and water conservation in the watershed upstream is closely related to the quantity of water storage as well as the quality of water supply.

Importance of Reservoir Watershed Treatments

In the old days, the upstream watershed of the Tehchi Dam, which was completed in 1973, was well forested. Inconvenient traffic has deterred human intervention. Population was only about 762 in 1959. Ground cover was adequate. After the construction of the East-West Passway, population increased in a fast pace. About 200 km of roads, farm roads, and forest roads were added. Cultivation without soil and water conservation practices and unlawful deforestation destroyed dense forest. As a result, bare soil, landslides, and sedimentation became a serious risk. Experts suggested immediate implementation of watershed treatment to control the sediment sources. The Taiwan Power Company, taking up on the recommendation of the combined Taiwan Provincial Government technical team for forest hydrology

and soil and water conservation, then invited the Council of Agriculture, Veterans Affairs Commission, Department of Civil Affairs, Road Construction Bureau, Forestry Bureau, Soil and Water Conservation Bureau, and Forest Research Institute to organize a special task force on Dachin Reservoir Watershed Management.

The timing of this task force coincided with the completion of the East-West Passway. In order to provide job placement for the retired veterans, the government passed the "East-West Passway Resource Development Act." Due to improved transportation and the natural surface conditions, the virgin forest within the watershed was gradually destroyed and replaced with apple and pear trees. At that time import of both fruits were restricted and thus prices were high. Huge profits were generated with temperate fruit planting. Therefore, the rate of cultivation and deforestation accelerated the forest destruction in the watershed. In 1973, sediment deposited at Dachin Station was 2.14 million m^3. The designed life span of the reservoir is about 113 years. If the sedimentation rate increases, the life span will be reduced. Therefore, watershed management has a direct effect on the longevity of reservoirs. To sustain reservoir operation, appropriate land resource development, proper soil and water conservation, and eco-environmental preservation are needed. Since Tehchi Dam can control 46 percent of the Dachia Stream Watershed, successful Tehchi Reservoir Watershed management besides power generation benefit may directly and indirectly protect the livelihood and properties of the residents downstream.

Treatment of Reservoir Watershed

Since the beginning, the task force has studied the problems associated with Tehchi Reservoir Watershed:

Man-made erosion -- Cultivation, road construction, tree cutting, and forest fire;

Geologic erosion -- Natural landslide, riverbed erosion; and

Tehchi Reservoir Watershed management strategies -- a) Conservative farmland use: policy implementation, soil and water conservation; b) Forest management: reforestation, deforestation areas; c) Road soil and water conservation: side slope stabilization, landfill construction; d) Sediment control works: landslide treatment, check dam, channel and stream regulation; e) Hydrological and meteorological observations; and f) Research studies,

Watershed management work often depends on the cooperation between central and provincial government agencies. The Taiwan Power Company cannot perform the work alone. With widespread deforestation land destruction, the Ministry of Economic Affairs established the "Tehchi Reservoir Watershed Administration" in 1973.

In 1973, the Administration, along with the Taiwan provincial government, requested the assistance of the Department of Soil and Water Conservation, National Chunghsin University to begin a study on a "Tehchi Reservoir Watershed Soil and Water Conservation Integrated Plan." The Executive Yuan approved the report of this plan in 1975. The plan was then implemented by the provincial government in 1977 and completed in 1982. This was the first phase of the integrated management and treatment work for this watershed.

A second phase planning research team was set up in December 1980 and headed by the Chinese Society of Soil and Water Conservation. The planning report was submitted in 1982. However, the proposed budget exceeded NT$0.83 billion. Implementation negotiation lasted for more than two years before being approved in 1986. The second phase lasted from 1986 to 1992. To avoid discontinuity of the watershed treatment work during the time in between the first and second phase, funds were obtained through the 1980 approved study on "Enhancement of Tehchi Reservoir Watershed Steep Slope Farm Land Soil and Water Conservation Practices and Maintenance Guide" to sustain the treatment plan for 3 years (1982-1985).

The Chinese Society of Soil and Water Conservation also headed the third phase treatment plan, with support provided by the Tehchi Reservoir Watershed Administration. The plan lasted from February 1990 to April 1991 and was approved in 1993 for a 5-year implementation. The total budget was about NT$1.1 billion supported by the Ministry of Economic Affairs, Council of Agriculture, Taiwan Provincial Government, and Taiwan Power Company. The Executive Yuan approved the fourth phase plan, completed by the Chinese Society of Soil and Water Conservation, on May 22, 1997 for five years (1997-2002). The total budget is about NT$0.92 billion.

Accomplishment of Reservoir Watershed Treatment

The major accomplishments during the 26 years (1967-1971; 1977-1997) of treatment at Tehchi Reservoir are as follows:

Conservative farm land use -- Soil and water conservation treatment on 753.39 ha farm land; 54,918 m drainage facilities; 6,737 m farm roads; 1,311 ha vegetative cover; 10 gully control sites; 9 agricultural workshops; 1,546 ha soil and water conservation maintenance work;

Forest management -- Performed nourishment work on 80,149 ha; 7,501,666 m^2 fire protection line maintenance; 14.5 km forest roads; 2,137 ha replanting;

Sediment control -- Stabilized 12,754 m^2 side slope; 85,219 m^2 landslide treatment; 27 check dams; 139 channel repair; 46 check dam repair; 3 landfills;

Road soil and water conservation -- Constructed soil and water practice at 72 sites;

Riparian zone -- Constructed 8,300 m fence; 74 landslide treatments; 1 experimental site on vegetative and drought-tolerance grass; 12 below top water level slope stabilization work;

Soil and water observation -- Set up 11 automatic rain gauge stations; improved hydrologic station equipment; conducted reservoir sediment yield estimation studies; validated hydrologic characteristics of the Peilu Stream Research Station; conducted rainfall-runoff relationship and floodwater warning system studies;

Research studies -- Set up hydrological measurement instruments at the Peilu Stream Research Station; canopy interception and stemflow observations; forest road erosion measurements; streamflow profile measurements;

Pesticide and fertilizer protection Management -- Established disease control calendar for fruit trees; established disease control calendar for vegetable crops; pesticide screening for disease control of fruit and vegetable crops; disease chemical resistance studies; pesticide buffer zone study; watershed farm land soil texture study; fertilizer application study for fruit and vegetable crops; fruit and vegetable

planting demonstration plots; fertilizer screening and extension; fertilizer movement and water quality degradation relationship study;

Water quality monitoring and control program -- Continued monitoring of reservoir and watershed water quality; assess the non-point and point sources pollution load; watershed water quality modeling and watershed best management practices determination; and

Natural eco-environmental preservation and green landscape -- Conducted watershed animal and plant species survey; promoted eco-environmental preservation; green landscape environment demonstration.

Benefits of Reservoir Watershed Treatment

The benefits of treatment plan can be subdivided as tangible and non-tangible benefits. The tangibles are as follows:

1. Net benefit on farm land production increase;
2. Benefit of reduction in transportation cost;
3. Benefit of reduction in raw material cost for farmers;
4. Reduction in road maintenance budget;
5. Reduction in tourism income loss;
6. Reduction in public water supply pollution treatment cost;
7. Improved sedimentation and water storage capacity of reservoirs, reduce power generation loss due to low water storage and other water supply benefits; and
8. Minimized the reduction in reservoir life span and loss in power generation.

Unresolved Watershed Problems

1. *Reclaim Illegally Cultivated Steep Farm Land for Reforestation*

According to the conservation laws, illegally farmed land on steep slope exceeding 28 degrees or 55 percent that was classified in 1978 as suitable for forest should be reclaimed for reforestation in three stages: 1st stage - immediate reclamation on land with landslide occurrence; 2nd stage - restricted and expired development land reclaim within a year; and 3rd stage - deteriorating fruit plantations reclaim in year 1989.

The Executive Yuan approved the Reclamation and Reforestation Act in 1979. The 1st and 2nd stages were completed in 1980 and 1984, respectively. The 3rd stage was approved in 1991. The Taiwan Provincial Government began public announcement in June 1993 and terminated rental agreements in four years to reclaim 1,171 ha of illegally cultivated land. The job resettlement compensation amounted to NT$1,050 million and will be paid by the Taiwan Power Company, Ministry of Economic Affairs, and Taiwan Provincial Government. The Taiwan Provincial Government will support the reforestation budget.

This Act has stirred up a lot of pledges from the local farmers, aboriginals and congressmen asking for reassessment, higher compensation and longer-term livelihood support from the government. The Executive Yuan had agreed to early positive dealing with the job resettlement and livelihood support problems.

2. *Farming Problems in Yeouhsing Stream*

Streambed vegetable farming along Yeouhsing Stream has resulted in serious

reservoir eutrophication problem due to excess fertilizer and pesticide use. The Executive Yuan approved in 1999 a 2-stage reclamation and reforestation plan. The Ministry of Economic Affairs, Taiwan Power Company, and Taiwan Provincial Government will share the compensation budget. The illegal streambed farms will not be compensated. The Ministry of Economic Affairs has carried out negotiation for years without any agreement. The Veterans Affairs Commission, after more than one year time, proposed changing the original plan to a Farm Land Soil and Water Conservation Plan asking for a budget of NT$0.4 billion to implement soil and water conservation works to develop recreational agriculture in Yeouhsing Stream. The proposal at present is still pending.

3. *Aboriginal Land Return Campaign*

The aboriginals in Tehchi Reservoir requested reservation land expansion on the basis of insufficient land distribution. However, the current count of aboriginal population in the watershed is about 1,000. The assigned reservation land area has already reached 2,400 ha, more than sufficient than allowed. Among the illegally farmed land, the aboriginal people are not using about 60 percent of the aboriginal reservation land. Careful consideration and thorough evaluation are, therefore, needed to face the true meaning of taking care of the aboriginal rights, especially on the issue of ecology preservation, soil and water conservation, and water quality and quantity protection.

Recent lifting of fruit import ban has drastically reduced its profit. Vegetable price, in the other hand, rises after a typhoon and heavy rainstorms. Vegetable farms make much higher profit than fruit plantation. Therefore, fruit trees are being cut and replaced with vegetables all over the watershed areas. The Forestry Bureau has found this activity even within the National Forest Reserve. The same activity found in the aboriginal reserve land and Veterans Affair Commission farms has not been prosecuted. The responsible land management government agency should stop this farm expansion and enforce strict rules. However, there is no law to stop vegetable planting. On land suitable for farming, farmers can plant vegetables easily by installing bench terrace. However, for the sake of water quality protection and sediment control, it is not wise to cut down fruit trees and replant vegetable crops that require constant tillage and high rate of fertilizer use.

4. *Reservoir Sedimentation Problems*

The designed sedimentation rate in Tehchi Reservoir is about 1.1 million m^3 per year. After completion, the Taiwan Power Company routinely checked this rate. In 1978, the actual measured rate was 1.5 million m^3. With the intensive sediment control, land use, soil and water conservation and riparian zone treatments, the sedimentation rate is reduced to 0.65 million m^3. This is due to the fact that much of the sediment is temporary retained behind almost 100 check dams built along the main and tributaries of the Dachia Stream. Possibilities of a massive sediment rush to the reservoir after a significant storm remain very high.

5. *Land Right Problems*

The cultivated land area is about 3,800 ha within this watershed. Frequent tillage and large amount of pesticide and fertilizer use are common for fruit and vegetable

farms. Experts have found that excess pesticide and fertilizer are the main source of water quality problem in the Tehchi Reservoir. Other factors include natural landslides, domestic and tourist sewer and solid wastes, and flowing wood debris in the reservoir. The rules and regulations for the three land administration agencies are all different from each other. Unfair judgment often occurs. Therefore, finding a way to standardize and synchronize all the involved agencies to enhance land use change monitoring in the watershed is urgently needed.

6. *Difficulties in Cooperation Among Agencies*

There are many watershed related agencies. In the Central Government under the Executive Yuan there are the Construction and Planning Administration, Council of Agriculture, Bureau of Economic Planning and Development, Veterans Affairs Commission, Ministry of Economic Affairs, Ministry of Transportation and Communications, Environmental Protection Administration, Sheipa National Park, Taroko National Park, Wuling Farm, Fushoushan Farm, Water Resources Bureau, Tourism Bureau, and Tehchi Reservoir Administration. At the Provincial Government level, there are Department of Agriculture and Forestry, Department of Civil Affairs, Department of Reconstruction, Department of Transportation, Soil and Water Conservation Bureau, Forestry Bureau, Aboriginal Affairs Committee, Department of Land Administration, Agricultural Chemicals and Toxic Substances Research Institute, Department of Environmental Protection, Tourism Administration, and County Police Department. At the local government level there are Taichung County Government, Nantou County Government, Ilan County Government, Lishan Scenic Districts, Government of Heping Shiang, Environmental Protection Bureau, Heping Branch Police Office, Tungshi Forest Administration, 2nd Engineering Office of the Soil and Water Conservation Bureau, the 5th Sect. 2nd Zone of Highway Bureau, and Dachia Power Plant. Utility agencies include Taiwan Power Company and Public Water Supply Corporation. Many agencies are involved and each has their own jurisdiction. Different standpoints usually create difficult collaboration.

7. *Reservoir Water Quality Problems*

During summer time, 14 km of the Tehchi Reservoir is covered with seaweed. Water above the mid-stream becomes eutrophic and gives out foul smell. Water color turns brown. Since 1976, three years after the reservoir completion, water had shown abnormal color. The worst water quality is concentrated near Lishan drainage ditches and Yeouhsing Stream. This deteriorating water quality problem has raised concern by people living in Central Taiwan and environment groups. Luckily, after being used five times for power generation, the stirring action of the turbines and the long distance of self-cleansing, there is only trace of seaweed at the Hsinteinlun Power Plant. However, the increased seaweed population also increases the hydrocarbon and protein organic compounds and affects the quality of water supply. Also, the accelerating seaweed population is alarming. In 1983, the observed seaweed count was 300/ml. However, in 1990 it has risen to 22,000/ml, indicating an ever-increasing nutrient source from human origin is being delivered to the reservoir. This problem deserves much needed attention.

8. *Ecological Preservation Problems*

In early years, check dams were being built at suitable sites along the tributaries to control sediment flowing into the reservoir. Although the sediment yield has been reduced, the aquatic environment was damaged. Fish habitat was destroyed during construction. The water quality is unsuitable for fish and insects living in the original stream channels. Many engineering structures have to be removed after two to three years of completion, wasting a lot of valuable funds. This problem was not expected in the very beginning.

DISCUSSIONS AND RECOMMENDATIONS

To ensure the longevity of the reservoir and the hydraulic structures, to protect human lives and properties, and to improve water quality, large reservoir watershed treatment work needs to include:

1. Watershed protection;
2. Promotion of farm land soil and water conservation and improvement of slopeland farming;
3. Reforestation and forest management;
4. Landslide and gully control;
5. Road soil and water conservation;
6. Sediment control engineering work; and
7. Mining area soil and water conservation.

In the old days, the Wusheh Reservoir Watershed even included career and technical training for job resettlement of farmers. In recent years, reservoir watershed conservation work also added riparian zone, proper fertilizer use and pesticide application advice, and ecologic preservation. The approval of the Soil and Water Conservation Act in 1994 requires reservoir watersheds to designate as special soil and water conservation areas that need long-term soil and water conservation plans. Strict rules and regulations are used to control land use type and to strengthen reservoir watershed conservation work.

Results have indicated that the benefit/cost ratio for Shihmen and Tsengwen Reservoir integrated watershed management is about 1.42 and 1.23, respectively. This shows that reservoir watershed conservation is a well-invested public utility. The Taiwan Government has invested NT$6.9 billion over the last 20 years (1971-1991) in reservoirs and ordinary watershed treatments. About NT$4.9 billion was used for major reservoir watersheds. Just for Tehchi Reservoir alone, a total of NT$2.74 billion was invested from 1968 to 1991. At present, the sedimentation at the Tehchi Reservoir has substantially reduced to about 8 percent of the total reservoir capacity. However, the water quality and eutrophication problems are still deteriorating.

Considering all aspects that include academic theory, technology, socio-economy and politics, the proposed integrated watershed treatment program is as follows:

The Watershed Conservation Policy and Method Should be Problem-oriented

1. Solve the slopeland over-cultivation and illegal land use problems.
2. Establish riparian zone to improve watershed soil and water conservation. Stop fertilizer application and natural soil nutrient loss.

3. Restrict construction of roads (farm roads) in reservoir watershed according to the Soil and Water Conservation Act.
4. Promote and spread the concept of soil and water conservation. Help the public realize the importance and need for watershed conservation. Promote the concept of watershed and water resources protection, not to illegal use of land, not to over-cultivate, not to over-construct. Develop an educational, promotional, and extension program and spread the idea of water protection to the public, local residents, and legislators as well as land users through schools, education institutions, government agencies, and conservation organizations. Government agencies work hand-in-hand with local farmers to implement necessary soil and water conservation programs and promote appropriate land use.

Collaborate and Improve Agency's Policies and Strategies

1. *Improve and intensify agency s management and structure*
   Enhance reservoir watershed agencies' lateral and vertical relationship and cooperation for all government levels. Set up departmental soil and water resources agencies to develop feasible collaboration mechanism and work implementation.
2. *Compromise rules and regulations*
   There are many laws and regulations for watershed management. Some are strict, but some are not. The field workers always find it difficult to follow and have excuses to just ignore.
3. *Develop assistant programs and alternate practices to improve watershed land use*
   Encourage and assist farmers to change jobs. Provide job opportunity for watershed protection work to relief slopeland cultivation pressure. Develop rational standard for compensating landowners suffer loss due to land use restriction during watershed treatment implementation. Assist farmers with proper application of fertilizer and pesticide to reduce non-point source pollution and to protect reservoir water quality.

Promote Reservoir Watershed Community Participation

Currently, a lot of developed countries have emphasized community management and participatory catchment management. They treat the watershed as a community and relate it to the residents. As such, Liyutan reservoir in Sanyi, Miaoli County was selected for a pilot study. With the help of academic institutions, training camps were held to organize forest protection troops, and water devoted groups. The ultimate water resource protection goal is to provide the watershed residents the direct involvement in watershed protection work and to achieve a "four-win" situation in water, land, forest, and people.

CONCLUSIONS

In recent years, per capita income in ROC has increased. The living standard has risen. Industry and commerce has prosperously developed. The demand for water has also increased. At the same time, the development and deterioration of reservoir watershed has accelerated resulting in water pollution and water resources degradation.

The uprising resistance on new water resources development has prompted urgent protection on existing reservoir watersheds.

After a reservoir completion, the natural environmental conditions and land use activities of the watershed may affect the reservoir water quality, water quantity, and reservoir life span. Besides examining the effectiveness of the treatment plan, the government should implement the integrate reservoir watershed conservation plan to systematically treat the entire watershed. Also, it should promote reservoir watershed community participation and encourage public voluntary involvement in community construction work. The combined cooperation among residents, governments and experts would be very effective in conserving the watershed. A handbook for the design of ecologic-friendly watershed structure is necessary to enhance the promotion of ecological engineering methods to maintain water resources and to conserve natural ecology. Also, the water conservancy rules should be based on the principle that users must pay. This principle can be used to develop the compensation policy for implementing water resource conservation work. All these should improve the overall reservoir watershed problems, reduce reservoir sedimentation, increase water storage, improve water quality, extend reservoir life span, reduce drought risk, and achieve sustainable use of water resources.

In the future, ROC water conservation work should focus on the following directions:

1. Determine the feasible special watershed (e.g., reservoir watershed) goals, policies, and strategies, according to appropriate, basic, and theoretical principles. This will raise the public awareness on water conservation .
2. Use suitable land use criteria to classify rational land use to attain the best and wise land use goal within the reservoir watershed. The classification goal should try to be simple, open, original, natural (forest cover), and rational (appropriate land use and satisfy soil and water conservation principles), in order to use the natural water and soil resources appropriately.
3. During this process, landowners may be restricted and suffer loss. A rational subsidy and compensation standard based on fairness, unbiased, and democratic principles should be established. The public should also be educated with the personal and community rights and sacrifices. This will help indirectly to promote the awareness of proper compensation requests. However, this approach will take long time to witness positive effect.
4. Increase manpower to enhance organization structure and integrate rules and regulations. The government should set a good example to perform adequate conservation work on the public-owned land. These will establish public trust and extend authority to prosecute over-cultivation and illegal land use, and further accomplish reservoir and ordinary stream watershed conservation treatment.

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REFERENCES

Dachin Reservoir Watershed Treatment Special Task Force, 1972. Dachin (Tehchi) Reservoir Watershed Management - 1st Phase Treatment Work Report. (in Chinese).

Dachin Engineering Office, Taiwan Power Company, 1974. Tehchi Dam Construction Completion Report (I). (in Chinese).

Tehchi Reservoir Administration, Taiwan Provincial Government, 1975. Report of 1st Phase Integrate Soil and Water Conservation Treatment Plan at Tehchi Reservoir Watershed. (in Chinese).

Tehchi Reservoir Administration, Taiwan Provincial Government, 1983. Report of 2nd Phase Integrate Soil and Water Conservation Treatment Plan at Tehchi Reservoir Watershed. (in Chinese).

Tehchi Reservoir Administration, Taiwan Provincial Government, 1991. Report of 3rd Phase Integrate Soil and Water Conservation Treatment Plan at Tehchi Reservoir Watershed. (in Chinese).

Tehchi Reservoir Administration, Taiwan Provincial Government, 1996. Report of 4th Phase Integrate Soil and Water Conservation Treatment Plan at Tehchi Reservoir Watershed. (in Chinese).

Water Resources Bureau, Ministry of Economic Affairs, 1987. Working Report of Long-term Water Quality Monitoring Study in Dachia Stream. (in Chinese).

Industrial Research Institute, 1987. Final Report of Land Use Monitoring System in Tehchi Reservoir Watershed. (in Chinese).

Cultural Center, Taichung County, 1987. Historical Development of Dachia Stream Watershed, Taichung. (in Chinese).

Department of Environmental Protection, Taiwan Provincial Government, 1999. Revised Taiwan Water Category: Streams in Central Taiwan. (in Chinese) .

Electric Source Field Team, Taiwan Power Company, 1999. Report of Sedimentation Measurements in Tehchi Reservoir. (in Chinese).

Water Resources Bureau, Ministry of Economic Affairs, 1987. Study Report of Water Quality Monitoring and Management Model in Tehchi Reservoir Watershed. (in Chinese).

Hsu, S .K., M.T. Hsien and J.D. Cheng, 1997. Report on Conservation of reservoir Watershed in Taiwan. (unpublished) (in Chinese).

Hsien, T.T., 1997. Proceedings of Integrate Conservation of Water Resources and Reservoir Watershed in Taiwan. Center for Water Resources Conservation and Disaster Prevention. (in Chinese).

Chen, H.H., 1999. Study on the effect of betel nut plantation on the hydro-environment. Journal of Chinese Soil and Water Conservation 30 (4). (in Chinese) .

2. INDIA (1)*

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INTRODUCTION

Watershed is a geo-hydrological unit which drains to a common point on a natural drainage system. However, in due course of time, the term has evolved to cover even those areas where distinguishable drainage lines do not exist. In the context of Indian situation, watershed includes: watershed with distinguishable drainage lines and watershed with non-distinguishable drainage lines.

a) ***Low rainfall and desert areas*** -- In such an eco-system, watershed means an index catchment, but supports large underground aquifers or groups of small aquifers beneath the earth's surface;

b) ***Drainage congestion areas of the Himalayan foot hills*** -- Such eco-systems are found in the drainage congestion areas of the Himalayan foothills. In this eco-system the area that drains into a common depression (*chaur*) / or a cluster of depressions is meant the watershed for planning and action; and

c) ***Coastal saline areas*** -- Under these eco-systems, the area bounded by creeks is taken for survey, planning and implementation of project activities.

Watershed works are taken in those areas where irrigated land is less than 35 percent, hence in succeeding paragraphs watershed areas would be synonymous to rainfed areas.

WATERSHED DEVELOPMENT IN INDIA

Role of Watershed Areas in Socio-economic Development of India

Agriculture plays a key role in the socio-economic development of the country as it provides livelihood to about 64 percent of the labor force and contributes 27.4 percent to gross domestic product. Agriculture accounts for about 18 percent share of the total value of the country's export, 36 percent of this comes from rainfed areas that contribute 45 percent of the total foodgrains, 91 percent of pulses, 58 percent of rice, 67 percent of cotton, 86 percent of groundnut, 90 percent of coarse cereals and 25 percent of wheat. Due to all this and much more rainfed areas contribute 9 percent to the nation's GDP and 10.26 percent to the total export. In India, rainfed areas have tremendous untapped export potential.

As mentioned, agriculture contributes 27 percent to the nation's GDP of which 33 percent comes from rainfed areas which is covered by 67 percent of the total cultivable area.

* One of two country reports presented each by two participants from India during the seminar which focuses on Rajasthan State, hence not necessarily a duplicate of each other. ...Ed.

Degraded/Scarce Natural Resources in Watershed Areas

Vast rainfed tracts of India hold the key to ecological health of the country but this health is deteriorating due to over-exploitation and mismanagement of natural resources. This degradation further results in poor socio-economic conditions of farmers in a cyclical relationship which is illustrated in a triangular schematic diagram (Figure 1).

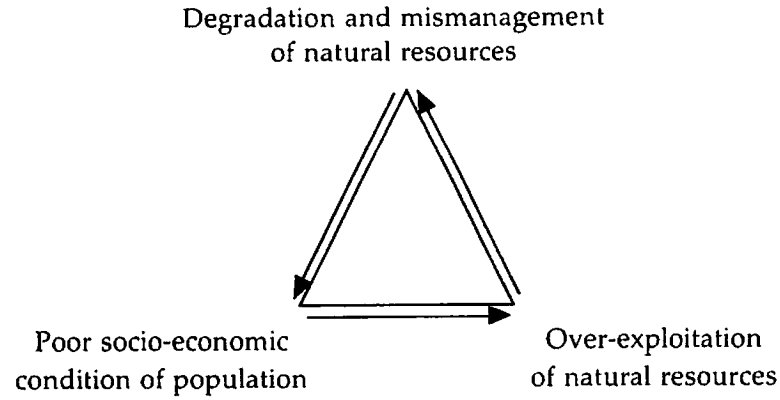

Figure 1. Triangular Schematic Diagram Among Natural Resources, Population and Mismanagement

Status of Land Resources

Recent estimates indicate that a total of 141 million ha of land in India representing 42 percent of the total geographical area is subject to water and wind erosion. The annual average loss of nutrients is between 5.4 million mt and 8.4 million mt. Indian remote sensing agency has identified 64 million ha as wasteland that accounts for 20 percent of the total area (Table 1).

Table 1. Wastelands in India

Category	Total wastelands (km^2)	Percent of total geographical area covered
Gullied and/or ravine land	20,553.35	0.65
Land with or without scrub	194,014.29	6.13
Waterlogged and marshy land	16,568.45	0.52
Land affected by salinity/alkalinity-coastal/inland	20,477.38	0.65
Shifting cultivation area	35,142.20	1.11
Under utilized/degraded notified forest land	140,652.31	4.44
Degraded pastures/grazing	25,978.91	0.82
Degraded land under plantation crop	5,828.09	0.18
Sands-Inlands/coastal	50,021.65	1.58
Mining/industrial wastelands	1,252.13	0.04
Barren rocky/stony waste	64,584.77	2.04
Steep sloping area	7,656.29	0.24
Snow covered/glacial area	55,788.49	1.76
Total	638,518.31	21.17

These lands can be brought under vegetative cover with appropriate water and soil management. Non-agriculture areas increase year after year. As forests are devoid of any vegetation, land availability is decreasing (Table 2). The only way to provide the needs of the system on earth would be to reverse the process and improve productivity.

Table 2. Land Use in India

(Unit: Million ha)

Land use classification	1950-51	1993-94
Geographical area	328.7	328.7
Reporting area	284.30	304.90
Area for non-agriculture uses	9.4	22.0
Barren and un-cultivable area	38.2	19.0
Culturable waste	22.9	14.5
Old fallows	17.4	9.7
Forests	40.5	68.4
Permanent pastures, etc.	6.7	11.2
Land under misc. trees, etc.	19.8	3.7
Net sown area	118.80	142.10
Current fallows	10.70	14.3

Status of Water Resources

India is endowed with a good number of rivers the water of which is not uniform hence, there is scarcity of water in some pockets of the country and abundance in others. India receives an average of 1,853 billion cubic meters (bcum) annually of which only 1,100 bcum could be put to beneficial use. Huge quantities of flowing water causes floods. Out of the 418 bcum utilizable ground water resource, 100 bcum are being exploited at present.

The ultimate irrigation potential of the country is evaluated at 113 million ha of which 72.19 mha is irrigated. The irrigation potential of large dams have reached capacity and the creation of new ones are falling into disfavor due to high investment cost and displacement of large population.

There are years of low and high rainfalls in the country and the problem is how to save water from excess years for use in the deficit years. Later onset of monsoons, early withdrawal of monsoon, and long dry spells between two rains, pose additional problems. Rainfall is received during a period of three months. Thus, in the perspective of a full year, the real constraint is how to reallocate rain water in time to meet water requirements during the dry months of winter and summer and how to conserve the excess water received in the rainy season, in the early period of July-August, for later utilization in the months of September and October.

India's national policy intends to promote technically sound, economically viable, environmentally non-degrading and socially acceptable use of country's natural resources—land, particularly water and its genetic endowment to promote sustainable development of agriculture. The government accords abiding importance

to improve the quality of the country's land and soil resources, harvest rain water, augmentation of biomass production through agro- and farm-forestry and other livelihood options for the watershed community.

Watershed approach was the only vehicle for achieving the twin objectives of enhancing production while simultaneously preserving natural resource base. Moreover, it is the proper management unit as it handles, manages collectively, effectively and simultaneously all the natural resources. With this scenario in view, the Government of India has prepared a 25-year perspective plan for watershed development to cover 63 m ha with 76 thousand million Rupees with the objectives given below:

Objectives of Watershed Management

- To promote the socio-economic development of village community through optimum utilization of the watershed's natural resources, employment generation and development of the human and other economic resources;
- To conserve soil, rainwater and vegetation effectively and harvest surplus water to create water sources in addition to ground water recharge;
- To promote sustainable farming and stabilize crop yields by adopting suitable crop management system, thus increasing the yield per ha;
- To cover the non-arable areas effectively through afforestation, horticulture and pasture land development based on land capability classification;
- Special emphasis to improve the economic and social condition of the resource-poor and disadvantaged sections of the watershed community, thus enhancing the income of individuals by adopting alternate enterprises; and
- Restoration of ecological balance.

WATERSHED DEVELOPMENT IN RAJASTHAN STATE

More than any other state in the country Rajasthan depends on rainfall for meeting all its biomass needs. If the target of 4 percent of agriculture growth is to be achieved, all rainfed areas will need to contribute substantially to incremental output. When we say this, we cannot neglect the largest state of the country, Rajasthan.

Socio-economic condition

Over 75 percent of the population of the state lives in rural areas, depends on agriculture and livestock production for their livelihood. The contribution of agriculture to the state's GDP is about 40 percent which is higher than that of the national average. Per capita income in rural areas is significantly below the national average, with 43 percent of the rural population estimated as living below the poverty line.

Land Resources

Rajasthan, India's largest state, covers 342 lac ha. Of this, only 55 lac ha have assured means of irrigation 65 percent of which is irrigated by open dug wells/tube wells. Some 244 lac ha are rainfed, of which 131 lac ha are degraded wasteland, pasture land, barren land. Nearly 61 percent of the total area of the state is desert.

The soils in this region are desert, sandy soil and poor in water holding capacity with poor nutrient status, resulting low productivity. About two-thirds of this area is heavily subjected to wind erosion (Table 3).

Table 3. Land Utilization Pattern, Rajasthan

Land Use Details	Area (lac ha)
Total geographical area	342
Total area under cultivation	168
Rainfed area (excluding 55 lac ha irrigated area)	113
Other rainfed areas dependent on rain	131
Waste land	26
Pasture land	17
Waste lands which can brought under cultivation	50
Barren lands	38
Total productive area dependent on rain	244
Total area treated by WDSC department from 1974-75 to 1999-2000	22
Balance area, which needs watershed development programs	222

Water Resources

Rajasthan has barely 1 percent of the total water resources of the country as against its 12 percent share in total geographical area. The average annual rainfall ranges from 150 mm in the West part to 900 mm in the East. Precipitation during the monsoon is highly variable from year to year. Some 90 percent of the precipitation occurs between July and September. Moderate to severe drought is common, occurring in three out of every five years. Some 71 percent of net cropped area in the state is semi-arid and receives an annual rainfall less than 600 mm. A large fraction of precipitation goes waste as runoff without being tapped for recharging of aquifers. Due to the scarcity of surface water, Rajasthan depends on ground water resources to a great extent. Due to extensive use of ground water for irrigation and its inadequate recharge, water level is depleting at an alarming rate of 1-1.5 meter per year posing a serious threat. The sustainability of wells is critically dependent on rainfall; thus, almost the whole of the state is rainfall dependent.

Livestock Resources

Though livestock population is highest in the state (4.8 million heads) the productivity of the livestock is low due to lack of adequate pastures and fodder resources. According to census records, the constant annual increase in the bovine population (2 percent) causes further deficiency in availability of fodder resources even for domestic animals. There is no scope for increasing the area under cultivated fodder crops, rather there has been shrinkage in the extent of grazing lands due to extension of cultivation of marginal lands for crops. Nomadism is, therefore, quite prevalent in desert areas. Livestock raisers of arid areas depend on available grazing lands but vegetative resource of these lands is sparse and soils have poor regenerating capacity.

Land availability per capita is decreasing, this would render conventional cereal crops uneconomical. Therefore, there is a strong need to supplement the existing income of farmers with other activities like livestock development, horticulture, sericulture and agro-forestry.

WATERSHED DEVELOPMENT – RAJASTHAN'S STRATEGY

The government of India has formulated a strategy for watershed development right from the selection of watershed, implementation to the post project maintenance after withdrawal of the project. Rajasthan has adopted the same strategy.

Approach and Strategy

a) Participatory approach for empowerment of Community. People's participation is the key to sustainable watershed development programs;

b) Demand-driven project proposals of the community;

c) Equity for resource poor and women. In all watershed development projects thrust is on improving equity;

d) Flexibility in choice of technology. Taking into account of the high degree of heterogeneity in the socio-economic and agro-ecological conditions in rainfed areas, a high degree of flexibility is provided in the choice of appropriate, affordable, replicable and indigenous technologies at the watershed level.

e) Linkages of watershed community with Panchayat Raj Institutions. An important element of long-term sustainability is to forge linkages with permanent institutions in the area. So, linkages are forged between the *Panchayats* and the watershed communities.

Based on the above strategy, department is implementing various watershed schemes/projects.

IMPLEMENTATION OF PROJECT

Territorial Delineation

As per the revised guidelines of NWPDRA, the following procedure is adopted in the selection of watersheds:

- All watersheds in DDP blocks are to be saturated under Desert Development Project only.
- All watersheds in DPAP blocks are to be saturated under Drought Prone Area Project only.
- In the remaining blocks NWDPRA, IWDP and EAS would operate.

Identification of PIA and Watershed Development Team (WDT)

Reputed NGOs, research and training institutions, Krishi Vigyan Kendras, Panchayat Raj Institutions and state government line departments are eligible to become project implementing agencies. A Watershed Development Team (WDT) comprising of four members is being formed to provide technical guidance to the implementers.

Selection of Watershed

The State Remote Sensing Application Center, Jodhpur (Rajasthan) has prepared "Watershed Atlas of Rajasthan." Watersheds have been delineated into macro/micro in each block. These have been prioritized on the basis of two important parameters: i) extent of availability of cultivable arable lands; and ii) drainage density. Besides this priority watershed with preponderance of resource poor, SC/ST population is given importance. Willingness of the community to participate contributes in the program. The average size of a watershed is 500 ha making it coterminous with a single village in most cases. Community organizations at the watershed level are formed consisting of user groups (land and water resource based), self-help groups (consisting of women and landless families), watershed committee (consisting of representative members from UG, SHG, *Panchayat*, etc.), and Watershed Association (consisting of all members of watershed area).

Preparation and Approval of Watershed Development Plan

The overall plan is prepared based on PRA exercise and different types of surveys of the following practices for the watershed development:

a) Management of natural resources (private land, common land and water resource);
b) Improvement of farm production system of the land owning families; and
c) Improvement of livelihood support systems for landless families.

The watershed association approves the plan at the village level in a formal meeting and later it is submitted for administrative and financial approval to the District Nodal Agency.

The most critical step for empowerment of the local community and assurance of their active participation in the program is to entrust the planning and execution of development works under the project to them. The department of watershed development and soil conservation, first adopted this strategy and later it was adopted throughout the country. Committees of the villager called Users' Committee were formed to undertake activities like planning, execution, post project maintenance of watershed development works in collaboration with government department and village community.

ACTIVITIES UNDERTAKEN IN WATERSHED DEVELOPMENT PROGRAMS

Based on the project plan, the following activities on the treatments of arable lands are being carried out by the users/watershed committee of villages, under the technical guidance and supervision of department:

Need-based Conservation Techniques

a) Contour bunds constructed along the contour to check soil erosion or *in situ* moisture conservation fortified with local vegetation;
b) Cultivation along contours;
c) *Khadin* (indigenous water harvesting structure) to harvest rainwater in desert area and flat lands;

d) *Tanka*. Masonry runoff storage tank to harvest surface runoff;
e) Shelter belt plantation across wind direction on the field boundary to protect wind erosion; and
f) Sand dune stabilization by establishing chess board pattern strips of vegetation.

Production Measure / Alternative Land Use Methods

a) Agro-forestry plantation of plants increase the incomes of the farmers by providing fruits, milk, meat and other edible products which form the part of food and livelihood for the rural people. Forests also provide food fodder and fuel and means of earning income;
b) Mixed horticulture: mango, lemon guava and pomegranate are mainly planted under this activity which is a good source of nutrition and income to the farmers;
c) Organic farming is encouraged to maintain the fertility of the fields;
d) Homestead kitchen gardens include seasonal vegetables for local use like tomatoes, beans, peppers and eggplants; and
e) Mixed cropping.

Conservation Measures

a) Earthen check dams to harvest runoff and prevent soil erosion;
b) Vegetative filter strip at junction of arable and non-arable lands to protect the arable land from erosion by runoff from non-arable lands; and
c) V-ditches constructed parallel to contour lines in areas of gentle slope to conserve *in situ* moisture and check velocity of runoff.

Production Measures

Afforestation of wastelands and pasture development includes over-seeding of grass like Dhaman Sewan, Stylo hamata and planting of shrubs and trees to meet the timber fuel and fodder requirement of the community. The pasture is protected by ditch-cum-bund fencing fortified with live fencing through thorny vegetation like *thor* and *deshi babool*.

Treatment of Drainage Lines

a) Earthen check dams are usually constructed in *nallah* bed across the drainage line and supported with vegetation and preferred in rills/gullies to collect sufficient soil and water;
b) Bank stabilization for drains/*nallah* so that they are not eroded further. This is done by constructing earthen bund fortified with vegetation, safe disposal structure and stone pitching at vulnerable points;
c) Loose stone check dams which are constructed in small- and medium-size gullies using locally available stones/boulders as dry masonry;
d) Gabion or woven wires check dams are used in gullies of moderate slope and small drainage areas;
e) Dug out pond which is water harvesting structure to store surplus runoff water;
f) Anicut which is a weir like structure across the natural drain/*nallah* for impounding the water.

EVALUATION FOR IMPACT ASSESSMENT

The works have been evaluated from time to time and the key findings of evaluations studies contracted to the NGO, Research Institutes are as follows:

a) Farmers find water harvesting and drainage line treatment works more useful than other works;
b) Considerable increase in water table in wells;
c) Increased levels of production and productivity;
d) Increase in employment opportunities;
e) The community as a whole is sharing benefits of project activities;
f) Farmers have become more interactive and participative; and
f) Area under irrigation has increased.

APPRECIATION OF COMMENDABLE WATERSHED DEVELOPMENT WORKS

The Department of Watershed Development and Soil Conservation has received eight National Productivity Council awards, One Indira Priyadarshini Vrikhshamitra Award and another one on Rajiv Gandhi *parti bhoomi* award for the excellent work done by the Department in watershed development.

CONSTRAINTS IN WATERSHED DEVELOPMENT

Soil conservation programs in the state are being executed since the 1950s, earlier by the Agriculture Department and, after 1991, by the Watershed Development Department. A lot has been learned through these programs. In early 1950s, only soil conservation works were taken on individual field basis. In the early 1970s the emphasis was given on good potential crop varieties, moisture conservation practices, input oriented cropping. This, however, did not last long because of uncertainties in quantity of rainfall coupled with resources poor of farmers. By the end of 1970s emphasis shifted to water conservation and water harvesting techniques. Good results were obtained but need for vegetative conservation measures and promoting simple low cost water management technologies were felt. Looking to this in early 1980s, the emphasis was on low cost technologies based on sectoral approach where forestry, horticulture, soil conservation, agriculture in general, and animal husbandry were planned and implemented independently. But the funds for integrated development were not made available by the departments at the time. In the mid 1980s the concept of integrated watershed management was adopted. Though the approach was holistic it was not sustainable after the withdrawal of the project. In the early 1990s, the emphasis was given on participatory integrated watershed management for sustenance of the programs.

Thus, there were periodical shifts in the policies for improvement but still there are some constraints in watershed development programs which hinder its sustainability and adaptability.

a) ***Capacity Building and Local Leadership*** -- Ironically, it appears that the very same factor, i.e., people's participation and decentralization of program administration are highly inadequate for sustaining this development, specially in areas where

the program has proceeded too fast—fulfilling the target for completion of works without waiting for the required institution building and leadership formation at the grassroots level. Due to social constraints women could not be included in many parts of the programs.

b) ***Expert and Independent Evaluation*** -- Despite the wide coverage of the program in the country launched in 1997, there is virtually no institutional mechanism in place at various levels for evaluation of the program, particularly by taking up long-term studies.

c) ***Convergence of Agriculture Development Program*** -- Due to financial constraints, watershed programs could not satisfy all the needs of the community, hence the need is to converge watershed development programs with other rural development programs for effective and economic integrated development.

d) ***Technological Constraints*** -- The ideo-type gene-based approach succeeded in commercial agriculture of irrigated agriculture. The standard package of technology which tends to narrow down the bio-diversity and promote monoculture, appears to be inappropriate for rainfed areas. Probably for rainfed systems, bio-diversity holds the key. The diversified mixed farming system necessitates the location specific research for involving viable technologies and practices. However, so far, the dryland areas have not received the priority they deserve in respect of agriculture research.

e) ***Infrastructural Constraints*** -- Roads, markets and *mandis*, input supply points and storage godowns are poorly developed in rainfed areas because there is little to market, handle and store. In this situation, it appears imperative to promote socio-economically appropriate homegrown inputs. The collection/production of herbal and medicinal plants, which are available largely in the rainfed areas, would also generate supply pressure.

f) ***Policy Constraints*** -- The price support for coarse cereals and adequate mechanism for procurement needs attention.

g) ***Microscopic Coverage*** -- There is great potential for watershed development but the area so far treated on watershed approach is a "drop in the ocean." The gap between the area requires treatment.

h) Wind erosion and shifting sand dunes are not given due emphasis. There is need to stabilize sand dunes, and a small but successful project in Pushkar Gap, Ajmer (Rajasthan) has shown the way where shifting dunes have been stabilized by *moonja* plantation.

i) Watershed works are being executed only in unirrigated areas but the catchment of different irrigation projects also need soil conservation measures for their sustainability.

j) ***Post Harvest Technologies*** -- These need to be given due emphasis in watershed programs for better employment opportunities and food security.

FUTURE PLANS OF THE DEPARTMENT

In view of the foregoing constraints, the future strategy of the Department are as follows:

a) ***For Better Involvement of Community*** -- The first year of the project would emphasize mainly on awareness generation and capacity building of the community.

Emphasis will be given on training to the users' group and self-help group organizations.

b) *Convergence of Programs* -- Not all of the felt needs of the watershed community as reflected in the PRA exercise will be able to be financed through the project resources. Advantage must be taken of the regular on-going production program of the line departments (agriculture, horticulture, livestock, fisheries, sericulture, forestry) as well as rural development programs of the DRDAs/ZPs to bring about requisite convergence. The department has launched an ambitious scheme, namely; Gandhi gram Yojana, dedicated to the sacred memory of father of the nation. In this scheme, one village from each Panchayat Samiti will be selected and developed on the basis of convergence of watershed development and all other rural and socio-economic development schemes. Five principles, namely; voluntary donation of labor, family welfare, education of girl child, tree plantation and improved livestock breeding will be the basis for the selection and development of Gandhi Gram villages.

c) ***Emphasis on Large Area Coverage*** -- There is an immense need for rainfed area development on watershed approach in Rajasthan. Efforts will be made to treat more and more rainfed areas through the Ministry of Rural Development-sponsored DDP, DPAP schemes and Ministry of Agriculture-sponsored NWDPRA as per revised WARASA-JANSAHBHAGITA guidelines.

d) ***Emphasis on Research*** -- In recognition of the fact that technologies of rainfed farming are more heterogeneous, great attention will be paid for promoting research in the watershed areas. Research stations will be provided with 100-500 ha mini-watershed area for development by adopting new technologies.

e) ***Impact Evaluation*** -- During and at the end of the project impact evaluation will be carried out and remote sensing, satellite imaginary and other modern technologies will be used.

3. INDIA (2)*

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INTRODUCTION

Bench Terraces in Kashmir and Water Harvesting Tanks in the Chola region in South India provide evidence of the earliest watershed development works in the country. The Imperial Council of Agriculture Research established the Dry Farming Research Stations in 1933 who attended the problems of cultivation in rainfed areas and drylands. This was followed by the program of "Wattband" in the Punjab foot hills and bunding and later contour bunding in the then Bombay province based upon the Bombay dry farming methods. Contour bunding increased the yield on dry lands by 25 percent followed by another 25 percent increase after following the agronomic package warding off famines with contour bunding built assets which provided employment thus giving access to food by the poor. Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Dehradun took up 42 small watersheds during 1956 where greater emphasis was on surface hydrology, succession of natural vegetation, grazing and bunding, etc. People's participation was introduced in 1974 at four locations. At that time the Ministry of Agriculture adapted a simple strategy "No watershed-No money releases to the State". This was a focussed approach towards watershed management. This experience was further elaborated in 1982-83 in 47 watersheds spread throughout the country.

STATUS OF INTEGRATED WATERSHED DEVELOPMENT PROGRAM

Drought-Prone Areas Program (DPAP)

The basic objective of this program is to minimize the adverse effects of drought on the production of crops and livestock and productivity of land, water and human resources. The program also aims at promoting over all economic development and improving the socio-economic conditions of the resource poor and disadvantaged sections in the program areas.

At the present time, this program is now in operation in 947 blocks of 155 districts in 13 States in the country. The corresponding physical area for treatment under the program is about 7.45 lakh km^2.

Since the introduction of common guidelines under the DPAP, 6,251 watershed projects were sanctioned in four different batches of which 6,057 have been taken up. In addition, 2,278 watershed projects were sanctioned during 1999-2000.

* One of two country reports presented by two participants from India during the Seminar which focuses on Orissa State, hence not necessarily a duplicate of each other. ...Ed.

Desert Development Program (DDP)

The DDP was started in 1977-78 in the hot desert areas of Rajasthan, Gujurat and Haryana and the cold desert areas of Jammu and Kashmir and Himachal Pradesh. The objective of the program was to mitigate the adverse effects of desertification and adverse climatic conditions on crops, human and livestock population, combact desertification and restore ecological balance in the area as well as to improve the socio-economic conditions of the resource poor.

Under the DDP 227 blocks of 40 districts with an area of 457,432 km^2 in 7 States are covered: Andhra Pradesh, Gujurat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka and Rajasthan.

Under DDP from 1995-96 to 1998-99, 2202 watershed projects had been sanctioned in different batches out of which 2,194 watershed projects have been taken up by the States. Over and above these projects another 520 new watershed projects have been sanctioned during 1999-00.

Integrated Wastelands Development Program (IWDP)

The scheme has been under implementation since 1989-90 in the areas of non-forest wastelands through the Ministry of Rural Development in July 1992 along with the National Wastelands Development Board (NWDB). From April 1, 1995 the scheme was implemented on watershed basis under the common guidelines for the watershed development. The Department of Land Resources follows the National Remote Sensing Agency's estimates.

The scheme is focusing on the development of wastelands through community participation following a watershed approach under common guidelines with effect from April 1, 1995. It is a project-based ridge to valley approach for *in-situ* soil and water conservation, afforestation, emphasizing sustainable rural livelihood support system and capacity building by encouraging people's participation.

About 247 IWDP projects in 25 States with a total outlay of Rs.778.12 crores to treat a total project area of 15.98 lakh hectare were sanctioned up to 1999. The Ministry of Rural Development is also making provision for a greater role of Panchayati Raj Institutions, self-help groups and users' groups, particularly the landless from SCs/STs and other backward classes in watershed programs. During the first two years of Ninth Plan period (1997-98 to 1998-99), the financial achievement was 115.95 crores covering a physical achievement over 193,000 hectares. Another 39 watershed projects covering an area of 3.83 lakh hectares have already been approved by the Project Sanctioning Committee.

Employment Assurance Scheme

The scheme was initiated on 2nd October, 1993 in the rural areas of 1,778 blocks of 261 districts in the drought-prone, desert and hill areas of the country. From 1996 the Intensive Jawahar Rozgar Yozana was merged with this scheme. At present the scheme is in operation in all the 5,448 rural blocks all over India. The primary purpose is to guarantee employment and wages or access to food through manual labor and building of rural assets at the same time. The money is allocated according to the demand of the area basing a demand driven project for which no fixed allocation is

made. Half of the scheme funds are now envisaged to be spent on Watershed Basis in DPAP and DDP areas according to the common Guidelines of the Watershed Development.

In 1999-00 Rs.176.67 crores of this scheme was released for watershed projects in 17 States. It is estimated that annually more than Rs.100 crores are available from this scheme for watershed development.

National Watershed Development Project for Rainfed Areas (NWDPRA)

The NWDPRA was launched in 1991 during the Eighth Five-year Plan in 25 States and two union territories. The project continued during the Ninth Five-year plan with the purpose of increasing agricultural productivity and production in rainfed areas through sustainable use of natural resources. The measures included under this program are treatment of both arable and non-arable lands, treatment of drainage lines, and production systems in arable and non-arable lands. The emphasis is on multiple/mix/strip cropping, preferably of legume components, organic farming, dry land horticulture and production systems. Then project also provides for suitable institutional framework for promoting people's participation.

During the Ninth Five-year Plan, the NWDPRA was considerably restructured with greater decentralization and community participation, higher degree of flexibility in the choice of technology and suitable institutional arrangements for ensuring long-term sustainability and targeted to treat 2.25 million hectares of rainfed areas at a cost of Rs.1020 crores.

River Valley Projects (RVP)

This is an ongoing scheme from the Third Plan. Its primary purpose is to reduce sediments flowing into the River Valley Project reservoirs. The watersheds selected for development under this scheme are somewhat special in comparison to the watersheds of the other schemes. The All-India Soil and Land Use Survey Organization (AISLUS) is engaged in the task of priority delineation and detailed soil survey for guiding the treatment of degraded areas and improving land capabilities. By employing the Silt Yield Index (SYI) method, AISLUS has been able to categorize watershed according to the magnitude and criticality of degradation into very high, high, medium, low and very low areas. The AISLUS has so far surveyed 34,160 sub-watersheds in the country and categorized 11,206 sub-watersheds out of 34,160 sub-watersheds covering an area of 292.9 lakh hectares. At the end of Eighth Plan period 33.59 lakh hectares were treated under the scheme with an expenditure of Rs.673.894 crores.

Flood Prone Rivers (FPR)

The FPR scheme is also implemented within watersheds. It was started in the Sixth Plan after devastating floods in some rivers. The purpose was to reduce flood hazard by controlling run-off and sediments generated in the catchments. Within small watersheds, the watershed treatment reduce flooding besides increasing production. At the end of Eighth Plan period 8.71 lakh hectares were treated under the scheme with an expenditure of Rs.264.77 crores.

Watershed Development Fund (WDF)

A Watershed Development Fund (WDF) was established at the National Bank for Agriculture and Rural Development (NABARD) with the objective of Integrated Watershed Development in 100 priority districts through participatory approach. The fund (Rs.200 crores) will be utilized to create the necessary framework conditions to replicate and consolidate the isolated successful initiatives under different programs in the government, semi-government and NGO sectors.

The activities under the WDF are taken up under guidance of a high powered steering committee constituted with representatives from the Ministry of Agriculture, Ministry of Rural Development, Ministry of Finance (Banking Division), representatives of State Governments, NABARD and selected NGOs from different States. The secretarial support is provided by NABARD. Utilizing WDF mode of assistance by NABARD, it is contemplated to have a spread of the program in 14 States.

Externally/Internationally Aided Watershed Project

These are projects primarily funded by the World Bank. DANIDA, Swiss Development Corporation, EEC, KFW, FAI/UNDP, DFID and the Government of Netherlands. They are mostly NGO-oriented.

WATERSHED MANAGEMENT AND LAND USE PLANNING

Watershed management implies management of watershed resources viz., land, water, vegetation, human and animal. While managing the resources of the watershed, emphasis is placed on sustainability of the intervention. It will be of interest to know the causes of watershed deterioration before discussing land use planning.

Causes of Watershed Deterioration

Some of the important causes of watershed deterioration are:

a. Agricultural lands - Family agricultural operations;
b. Forest land - Removal of forest cover for fuel wood in timber;
c. Grass land - Uncontrolled grazing;
d. Fire hazards - Accidental or otherwise but results in loss of organic matter and micro-organism;
e. Road, rail and canal network - Developmental activities are not done as per scientific norms and creates problems, specially in reducing the capacity of the natural drain system; and
f. People's apathy - Absence of people's participation in the developmental programs.

All the above points individually and collectively result in the deterioration of the watershed and, the consequence of such deterioration are:

a. Low agricultural productivity, including biomass;
b. Erosion and denudation of the land;
c. Quick siltation of reservoirs, lakes and channels;
d. Poor quality water yield;
e. Occurrence of floods and droughts; and

f. Poverty

Principles of Watershed Management

The main principles of watershed management are:

a. Utilizing the land according to its capability, i.e., land use concept;
b. Maintaining adequate vegetative cover on the soil for controlling soil erosion, mainly during rainy season;
c. Conserving maximum possible rainwater at the place where it falls, in arable land by contour farming;
d. Draining out excess water with safe velocity to avoid soil erosion and storing it in ponds for future use; and
e. Preventing erosion in gullies and increasing ground water recharge by putting a *nullah* and gully plug at suitable intervals.

From the principles enumerated above, it is amply clear that land use in watershed management should be decided on land capability classification. Land capability classification refers to a systematic arrangement of various types of land according to those properties that determine the ability of land to produce common cultivated crops, grasses and other plants on sustainable basis.

Objectives of Land Capability Classification

a. The land capability maps containing technical data related to soil survey help in land use planning;
b. Hazards of soil erosion and difficulties for using the land are indicated in land capability map;
c. Land capability classification indicates the most intensive profitable and safe use of land; and
d. With the help of land capability classification farmers can make best use of their land since the scientific and technical data are interpreted for each class of land.

Rainfed Agriculture and Watershed Management

The average annual rainfall in India is around 114 cm or a volume of 370 million mm(M) ha.m of which 123 M ha.m is lost in evaporation, 167 M ha.m is run-off and the rest of the 80 M ha.m goes into the subsoil annually. While about 43 M ha.m gets absorbed in the top layer of the soil, thereby contributing to the soil moisture, the remaining 37 M ha.m accounts for the ground water from rainfall. According to estimates, the average annual ground water recharge from rainfall and seepage from canals and irrigation systems is 67 M ha.m of which 40 percent is extractable economically. The present utilization of ground water is approximately 13 M ha.m and about 14 M ha.m is available for further exploitation and utilization.

Although the rain water inflow is good its utilization is poor. On the other hand, the dependency on rainfed agriculture is very high. Hence the strategy to meet the increasing demand of agricultural production is to initiate micro-level watershed planning. Apart from the area under agriculture, there are vast stretches of denuded forests, over-grazed pastures and barren lands. It is estimated that about 100 M.ha wastelands are presently lying under-utilized or idle, and posing a

threat to agriculture and environment. Watershed development provides an opportunity to generate employment and income through the development of these wastelands.

LAND USE CLASSIFICATION SYSTEM

During the planning and designing of the project report the land use classification is considered a key factor and is absolutely necessary to check out the plan programs of the project for optimum utilization of water and land resources. For the land use classification of the watershed area, ordinarily seven factors are taken into consideration: agriculture, forestry, farm forestry, orchards, grazing lands and grass lands, miscellaneous uses and existing engineering structures.

Characteristics of Land Capability Classes

There are eight identified classes, I to VIII. Lands under class I to IV are suitable for cultivation whereas class V to VIII are not suitable for cultivation but very well suited for forestry, grass land and wild life. Their important characteristics are:

Class I: Lands usually free from hazards. They are deep (more than 90 cm), nearly level, well drained, and have medium fertility. Excepting for good farming practices, these lands do not require any soil conservation measures. These lands have no limitation for use and may be used for pasture development or agro-forestry.

Class II: Lands that have moderate soil depth (up to 45 cm) gentle slope, mild erosion and moderately low soil fertility. These are suitable for permanent cultivation but right combination of soil conservation measures is an essential requirement.

Class III: Lands that have moderate slopes, shallow depth, severe erosion hazards, very poor or very rapid internal drainage and thus have moderate to severe restrictions for permanent cultivation. These lands require very good soil conservation measures.

Class IV: Lands suitable only for limited cultivation. The hazards in these lands are more serious as compared to class III lands. Use for agriculture is very much restricted and is best maintained by perennial vegetation. Maintenance requires special measures which are difficult and are very costly.

Class V: Lands not suitable for cultivation but suited to permanent vegetation. These lands do not require special measures except good range or wood land management practices such as stocking with carrying capacity and prevention of fire.

Class VI: Lands with moderate limitation under grazing or forest use. Measures such as fencing, contour furrows, ridges and water spreaders are beneficial.

Class VII: These lands are generally very shallow with very steep slope, very severely eroded or cut into gullies and highly susceptible to wind erosion. It is not possible to apply pasture improvement and water control measures. The lands are best suited under permanent forest and vegetation and for

restricted grazing, conservation practices require more intensive practices in this type of land.

Class VIII: Lands that are absolutely barren and unfit for economic use. They cannot be used even for grass land and forestry. Lands which are rocky, swampy, and lakes and ponds that are permanently wet and difficult to drain, sand in desert region, very deep gullies affected by severe salinity where no vegetation can grow, come under this class. These lands are only suitable for wild life, recreation and watershed protection.

ENHANCING LAND CAPABILITY

The need for enhancing land capability in the country can be gauged from the following:

a. In 2001 we have a population of roughly 1.03 billion and in 2050, when the Planning Commission expects population to stabilize due to the operation of demographic forces, we expect to have a population of about 1.64 billion. It is a large population and so are its own problems.
b. India has the largest net sown area in the world, which also means that there is absolutely no possibility of expanding the area under foodgrain. Today we have almost 57.1 percent of the total land area of the country under agriculture operations. Compare this to China which has 10.3 percent of the area under agriculture.
c. India has almost 57.7 percent of the population dependent upon agriculture, down from 63 percent in 1985.
d. For a population of 1.64 billion, roughly 440 million mt of foodgrains is necessary compared with only 228 million mt today.
e. The average productivity of foodgrains in the country is about 1,800 kg/ha.

It is this increase in foodgrains production that shall require significant enhancing of the land capability. The area under irrigation from the present 28 percent may rise to a maximum of 40 percent by 2050. That means over 60 percent of the cultivated area will continue to be rainfed even 50 years later. To this end, the Planning Commission initiated a 25-year perceptive plan on watershed for the country.

GOVERNMENT STRATEGY FOR SUSTAINABLE WATERSHED DEVELOPMENT

The government of India has emphasized the need for a unification of the multiplicity of watershed development programs within the framework of a single national initiative. Hence, a Common Approach for Watershed Development program was jointly formulated and adopted by the Ministry of Agriculture (MoA) and the Ministry of Rural Development (MoRD). This common approach/principles for the implementation of the selected watershed development programs of the two central ministries is formulated on the broad framework as mentioned below:

a) Convergence on selected program components/activities with commonality in approach;

b) Rationalization of unit cost norms depending on nature of program content, work items and institutional arrangements;
c) Feasibility of territorial delineation to be decided in terms of eligibility criteria, ministerial mandate, program focus and development objectives;
d) Scope for enlarging the process of capacity building involving local bodies/ NGOs, community groups and extension functionaries;
e) Broad-basing of financial resources through forging inter-institutional credit linkages; and
f) Unified approach supporting program measures and building suitable institutional framework for ensuring long-term sustainability.

Implementation Strategy

The participatory approach will enable the program to evolve into a national movement of watershed development that fosters implementation ability at the local level and creates community infrastructure and micro watershed projects through active involvement of Gram Panchayats, local self-help groups and NGOs.

Watershed projects are to be implemented through a watershed community (WC) as is necessary, particularly about the total financial resources available to them before commencing the planning process, including the mode of expenditure before starting the implementation phase.

One suitable project implementing agency (PIA) will be responsible for the developmental activities being carried out by the WC in terms of overall facilitation, co-ordination and supervision of the whole program.

In all watershed development projects, thrust would be on improving and strengthening the socio-economic status of the landless and women by considering the following steps:

a. Focus on development of poor quality and marginal lands owned by resource poor families;
b. Preferential allocation of usufruct rights over the farm products from the developed common land to landless households/women groups;
c. Equitable rights to all households in any new water resource developed under the project;
d. Construction of new water harvesting structures near the land/recharged wells, including drinking water wells owned by resource poor;
e. Ground water to be treated as a common property resource;
f. Equal employment opportunities and wage rates for implementation of watershed works;
g. Due emphasis on livelihood support systems for landless households; and
h. Utilizing the services of the landless poor and women in the post project management of common property resources.

Program Content and Components

The watershed program is categorized into two major components: development and management.

The development component is to be executed through the Watershed Association

for which funds are to be released directly to the Watershed Committee. Under this component, natural resource management and production system management are necessary.

The management component comprises of sub-components like administration, community organization and training. The community organization includes activities like organization of new institutional set up at the village level along with entry point activities, infrastructure development, preparation of project proposal and adaptive research.

Apart from this, the following components are to be emphasized under the common approach:

a. Integrated development of natural resources;
b. Approach for problem soil and leased/patta land;
c. Construction of water harvesting structures for micro level situations;
d. Strengthening linkages between conservation measures and production/livelihoods system;
e. Flexibility in choice of technology;
f. Research input in watershed development through a research organization;
g. Extension support through line departments; and
h. Convergence between watershed projects and ongoing production and rural development programs.

Principles of Project Management

The following are the principles of project management:

a. Size of watershed unit, i.e., micro-watersheds (500 ha to 1000 ha);
b. Selection of PIAs from reputable NGOs, research and training institutions and State government line departments;
c. Broad basing of watershed development team (WDT);
d. Approval of watershed plan/action plan by the community;
e. Administrative approval of the watershed plan;
f. Empowerment of the Watershed Association;
g. Transparency in all aspects of project management; and
h. Post project maintenance of community assets.

Institutional Arrangements

Three organizations are to be established for the implementation of the project: community-based organizations, PIA for a cluster of 2-10 watersheds and autonomous support organizations for capacity building.

Other committees are to be arranged for reviewing, guiding and providing policy directives for the successful development of the project. They are the Management Committee, District Watershed Committee and Watershed Association/ Watershed Committee.

Capacity Building

To overcome the constraint of inadequate capacity, particularly at the PIA and Watershed Committee levels, a major orientation in the techniques of participatory

approaches and capacity programs are pre-requisites to finalizing the selection of PIA or watershed site. For this purpose the following specific steps are considered:

a. Orientation of members of various management committees and institution heads;
b. Training of State level trainers drawn from various organizations in the State.
c. Training of faculty members of autonomous support organizations at the district level.
d. Training of PIA/Watershed Development Team identified for each cluster of 2-10 watersheds; and
e. Training of office bearers of the Watershed Association, Watershed Committee, user groups and self-help groups.

Financial Aspects

Unit cost norms – The unit cost norms will range from Rs.4500 to Rs.6000 per hectare depending upon location during the Ninth Plan period. With this provision a total amount for a 500 hectare unit watershed would range between Rs. 22.50 lakhs and Rs.30.00 lakhs.

Exception to unit cost norms – Where treatable forest area in the selected watershed is in excess of 25 percent, the unit cost norm may be modified upwards by the State Watershed Committee or in accordance with norms approved by the Cabinet Committee on Economic Affairs.

Allocation of funds by components –

Management Component:

Administrative cost	10.0 percent
Community organization	7.5
Training Program	5.0

Development Component:

Natural resource management	50.0
Farm production system for land-owning families	20.0
Livelihood support system for landless families	7.5

Cost norms for structures – The cost estimates would be estimated as per standard schedule of rates in the respective areas. Apart from this, the ceiling on other financial aspects may be considered such as: Financial ceiling on selected items of work; Ceiling on entry point activity; Ceiling on sundry other items; Flexibility in reallocation of funds; Cost sharing by community; and Watershed development fund for the maintenance of assets by the community.

Monitoring and Evaluation

The monitoring of progress at the district level and those of the physical and financial progress and concurrent evaluation by internal as well as external agencies may be made to assess the success of the projects using remote sensing, satellite imagery and other modern techniques for evaluation of watershed projects.

SUSTAINABILITY AND EQUITY ISSUES IN WATERSHED MANAGEMENT

In order to ensure the success and sustainability of watershed development, several key factors such as creation of awareness in the community about the project, their involvement in planning and implementation and building of local institutions for project management in future have to be addressed.

The Watershed Mission in Orissa which was organized in June 2000, while recognizing that watershed development is not just about soil and water conservation, has developed a set of success criteria for monitoring the impact of the watershed program.

Although circumstances may greatly vary from project to project, it is important that a few measurable and quantifiable criteria are fixed for watershed development as follows: (i) physical development; (ii) financial management; (iii) human capital development; (iv) social capital development; and (v) post project sustainability.

Physical Development

a. Successful timely completion of works and activities under the project; and
b. Sustainable impact on productivity and income.

Financial Management

a. Work should be completed within the cost estimates;
b. Financial records/registers should be maintained properly;
c. Annual audit statement of accounts should be maintained; and
d. The recovery and rotation of revolving funds should be more than 80 percent.

Human Capital Development

a. Proper capacity building of the PIA, WDT, user groups, self-help groups and watershed volunteers on technological as well as participatory management aspects should be done; and
b. Thorough training should be given to watershed secretaries, volunteers and community organizers on job-related aspects, including maintenance of records.

Social Capital Development

a. Self-help group (SHG);
b. User group (UG); and
c. Watershed Committee/Watershed Association (WC/WA).

The SHG should be about 75 percent of the watershed households who are directly or indirectly dependent on watershed and enrolled as members of at least one SHG. A separate SHG should be organized for women, agricultural laborers, shepherds and other economically weak sections. All developmental activities are carried out by the concerned UGs. The Watershed Committee should implement all project works without any contractual system.

Post Project Sustainability

a. Functioning of new SHG/UG for longer duration;

b. Functioning of WC beyond the project period;
c. Convergence of ongoing schemes in the area for the benefit of SHG/UG members; and
d. Linkage with credit and input institutions as well as with agricultural research institutions and universities.

Impact Parameters

The following specific parameters will be measured and records kept right from the beginning of the project period and after completion of the project to determine the success of the watershed development works implemented in the watershed:

a. Average level of water in the open wells in the watershed area in May/June below surface (in meters);
b. Area cultivated under different crops in Kharif/Rabi (in ha);
c. Productivity of the two principal crops in Kharif/Rabi (in qtls/ha);
d. Peak migration of labor to other areas during the period January to May (no. of persons);
e. Number of trees surviving in the watershed area;
f. Population of cattle, sheep and goat;
g. Amount of savings in banks by the self-help groups;
h. Amount of voluntary contribution deposited in the Watershed Development Fund; and
i. Drop-out rate in the local primary school between Class-I and Class-V.

While all parameters should increase from year to year, parameter d, f and i should decrease successively if the watershed has been effectively integrated with all activities.

REFERENCES

Watershed Mission, Orissa, 2001. "Mission Document". Department of Agriculture, Government of Orissa, India.

Kanda, Mohan (editor), 2000. Vasundhara - An Anthology of Land Resources in India. Department of Land Resource, Ministry of Rural Development, Govt. of India.

Soil Conservation Society of India, 1998. "The Challenge of Our Watersheds", Proceeding of the Development Centre on Watershed Management for Asia and Far East, New Delhi.

Department of Land Resources, Ministry of Rural Development, Government of India and Soil Conservation Society of India, New Delhi, 2000. "Proceeding of the International Conference on Land Resource Management for Food, Employment and Environmental Security".

Annual Report, 1999 - 2000, Ministry of Rural Development, Government of India, New Delhi.

Annual Report, 1999 - 2000, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi.

"Info - Aislus", 1997. All India Soil and Land Use Survey, IARI, Campus, New Delhi.

Anil Agrawal, 2000. Drought - Try Capturing the Rain. Centre for Science and Environment, New Delhi.

Rajesh Rajora, 1998. Integrated Watershed Management. Rabat Publication, Jaipur, India.

Srivastava, R.C. and others (eds.), 2001. Training Manual for Watershed Management Technology for Eastern Region. Water Technology Centre for Eastern Region, Bhubaneswar, Orissa.

Samra, J.S. and Dhyani, B.L., 1998. "Elements of Participatory Watershed Management in India". Proceedings of the Workshop on Watershed Development and Regeneration of Degraded Land, Ministry of Rural Areas and Employment, Govt. of India, New Delhi.

Anna Hazare, 1998. Address to the Workshop on Watershed Development and Regeneration of Degraded Lands, Ministry of Rural Area and Employment, Government of India, New Delhi.

Garg, Saurabh, 1997. Innovations in Administration - Developmental Initiations in Forging Partnership with Amorphous Group at village level - The Kalahandi Experience. International Conference on Creativity and Innovation at Grassroots for Sustainable Natural Resource Management, Indian Institute of Management, Ahmedabad.

Garg, Saurabh, 2000. Management of Quality Service Delivering in Government. Orissa Journal of Public Administration, January-March 2000.

Kar, Gouranga, 2001. Remote Sensing for Sustainable Watershed Management. Kurukshetra, A Journal on Rural Development, March 2001.

4. ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

Iran has a total area of about 1,650,000 km^2. It lies between 25 and 40 degrees North latitude and 44 and 64 degrees East longitude. Iranian territory is composed to a large extent of mountains surrounding the saline, sandy, and rocky deserts of the central plateau and forming a closed basin containing many kinds of accumulations.

The country has a great variety of soils formed by factors such as climate, vegetation, topography, parent rock and time. To these must be added the factor of man, who, in a country with a long history such as Iran, has effected considerable changes in soils by plowing, irrigation, harvesting and other works. The effect of these genetic factors is discussed later.

PHYSIOGRAPHIC DIVISIONS

Mountains – There are two major mountain ranges in Iran each of a different character. These are the Alborz, running almost from West to East, and the Zagros, extending from Northwest to Southeast.

Plateau – The area within the V of the mountain ranges a high plateau with its own secondary ranges, and gradually slopes down to become desert which continues into southern Afghanistan and Pakistan. This plateau is dissected and includes mountains and foothills, other hills, lake basins and several alluvial plains. Elevations range from about 500 to 2,500 m.

Region of Khuzistan and low-lying southern coastal plains – This includes the vast low-lying Khuzistan plain in southwestern Iran; which is a continuation of the Mesopotamian plain and other low-lying plains on the coast of the Persian Gulf and the Gulf of Oman. These coastal areas vary from a very narrow strip bordered abruptly by steeply sloping hills or mountains to wide deltaic or alluvial plains.

Caspian Sea coastal area – The Caspian littoral is a narrow coastal plain with an average width of about 50 km, produced by a general retreat of the sea, which at one time probably extended as far as the foot of the Alborz Mountains.

GEOLOGY

Iran is situated between the Eurosiberian platform in the North and a deltaic platform in the South. Iran participates of both, with the Caspian littoral and the Khuzistan Plain. Between the Alborz and the Zagros ranges there is a wide and high central plateau. From the Southeast Iran can be divided into seven main structural units: Khusistan Plan, autochthonous folded zone of the Zagros system, thrust

folded zone of the Zagros system (Iranides), central plateau, Alborz range, and the kopet-Dagh or Turkeman-Khurasan range, Northeast of the Alburz Caspial littoral.

CLIMATE AND ENVIRONMENT

The climate is an extremely important soil-forming factor. Although Iran is predominantly an arid and semiarid country there are considerable variations in climate from one part of the country to another. These variations, influenced by orography and physiography, are reflected in the climate provinces of Iran. Iran, lying between the temperate Caspian Sea and the warm, sub-tropical Persian Gulf, with its great mountain ranges, vast steppes and barren deserts, with its fertile plains and vast wetlands, has within its boundaries a great variety of environmental conditions caused by the diversity in temperature, humidity, geology and topography. Elevations range from over 5,000 m to below sea level. Temperatures range from severe cold to extreme heat. Precipitation may range annually from 2,000 mm or more in the Caspian coastal plain to less than 100 mm in the center of Iran.

Due to such extremes, a great variety of vegetation can be found in the country from verdant rain forests in the North, to mangrove swamps along Persian Gulf Coast; from grassland steppes to dry shrubland desert; and from dwarf, high-mountain plants to lush marshlands. This great diversity in vegetation, in turn, provides a variety of homes, or habitats, for many kinds of wild animals.

PHYTOGEOGRAPHY AND ECOLOGY

The phytogeographical and ecological regions of all the countries in the Near and Middle East characterized by the lack of rainfall during the hot season, Iran has by far the greatest variety of regional climate and, consequently, of soil and vegetation types.

It has wet forests like those in central Europe, central Asian-like steppes, deserts of the saharasind type, and subtropical mangroves. Vegetation varies according to climate. The original vegetation consisted, and still consists, in a considerable extent of oak and beech in the more humid sections of the North, and a thin cover of grasses and/or scattered shrubs in the semiarid and arid interior. Many variations between these two extremes, consisting of treegrass, grass-shrub, or tree-grass-shrub combinations, often occur within a short distance of one another throughout the country because of its destruction by man.

LAND USE CLASSIFICATION

Land Use Map

Classification is the best method to achieve a systematic arrangement of ideas and phenomena. Generally, land use plans start with two procedures, i.e., a land classification (by natural condition, transportation availability and current land use) and a site classification by the capability of development. The objective of land classification is to distinguish what exists and to enable the planner to appreciate the inherent difference in quality of lands at his/her disposal .

By preparing the land use map we can achieve to the mentioned objective and for preparing this map these steps must be taken into account: determining the scale of land use map; determining the basic information and their scale; determining the land use levels; surveying the project area, legend definition; and map unit definition as follows: geo referencing, preparing the base map, field control and necessary adjustments, completing the map according to additional information, area planimetring and preparing the final report.

Unit Definitions

Considering to the above procedure, and by taking the above-mentioned steps, the land use map will be obtained. The main categories of this map are as follows:

a. ***Farm land*** – The farm land consists of paddies and fields with several kinds of crops and trees;
b. ***Rangeland*** – Rangelands are generally located higher planes than farmlands much of which are on steep slopes and are not suitable for cultivation;
c. ***Forest*** – Generally, the forest type refers to the lands with more than 10 percent of crowns;
d. ***Waste land*** – This type refers to coverless lands or lands without ability for grazing and commonly known as barren lands;
e. ***Wet lands*** – Wetlands generally refer to saturated lands and they maybe with or without vegetation cover;
f. ***Surface water sources*** – The sources are seas/lakes and reservoirs; and
g. ***Man-made land*** – This type refers to the regions which are used for residential and industrial purposes.

WATERSHED MANAGEMENT AIMS

The most basic aim of watershed management is to implement a comprehensive, coordinated and incorporated management on all resources of a watershed basin to achieve a suitable, logical and optimum use of human, agricultural and natural resources of land. Under such a condition, the wasted water and soil erosion should be reduced.

Of course, this explanation declares the final aim of watershed management, and to gain this, the watershed management, policy has been determined in one processing as follows:

a. Ecological protection and reclamation of degraded watershed or in those which are being degraded and have been spoiled more than 25 percent of their natural productive potential or those which soil erosion rate of more than 10 mt per year;
b. Reclamation and developing of social and economical conditions of the watershed as if the job-providing and income at least 80 percent of soil and watershed resources can be applied; and
c. Optimum use of all the economical resources of watershed basin by considering four principles of sustainable development, environmental protection, participation of basing settlers, and maximum usage.

SOCIO-ECONOMIC ROLE OF WATERSHED MANAGEMENT

Watershed management can play an important and very positive role in the social and economic development of the country. Some of these impressions are listed as below:

a) ***Protection and development of potential capacities of production*** – Today it is clear that the production capacities in the agriculture sector and natural resources are being wasted as farmers do not pay attention to the principles and programs of watershed management. This means that every year the huge volume of productive soil and water get wasted, and day by day production ability decreases in these sectors. One of the first results of watershed management activities is to stop these damages and to protect the basic investments of the country for providing different woods and agricultural products.

b) ***Reducing the dangers of human and natural catastrophes (flood and landslide)*** – The damage of flood or unnatural erosion to fundamental structures and natural investments in the country can be reduced through implementing of watershed management programs.

c) ***Increasing agricultural production efficiency*** – This requires proper use of farm inputs such as fertilizer, pesticides and machinery.

CHARACTERISTICS OF WATERSHED MANAGEMENT

The characteristics of watershed management in solving problems such as flood, sedimentation, decreasing underground water resources, degradation of forests and ranges and decreasing efficiency of dry land farms may expedite the solutions in different parts of water, farms, and other natural resources. However, about the only suitable and recognized solution is watershed management plants methods and vision.

Watershed management programs can present the basic solutions of problems and prevent present aspects more than challenging the case in a determined time. It is obvious that preventing is always easier, cheaper and more impressive than challenging.

5. MONGOLIA

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INTRODUCTION

Mongolia is located in the center of Asia and covers an area of 1,566,500 km^2 as a mountainous country. Basically, its topography consists of mountains, hummocks and high denudation plains, forming three major regional stages on its surface. Mountains are found mainly in the northern and western regions and denudation plains in the southeast.

Mongolia has 7 natural zones: the high mountain, Taiga forest, mountain forest steppe, steppe, desert-steppe, Gobi desert and wetlands.

One of the world's great deserts, much of the Gobi is a daunting place of bare rocky mountains, sand dunes and huge desert flats relieved by well-watered oases.

Mongolia's wetlands are diverse - glaciers, lakes, rivers, streams, marshes, oases, etc. and in each of the 6 zones described above, the wetlands support distinctive animals and plants.

Almost 4,000 rivers are present, with a total length of 67,000 km. Mongolia's northern part is well-watered by lakes and rivers. These belong to the three different basins: the Arctic Ocean, the Pacific Ocean and Inland Basin of Central Asia.

The continental watershed crosses Mongolia's northern regions and divides the country into two unequal parts with dissimilar climates. North Mongolia continues the East Siberian natural scenery while the Southern section, taking up two-thirds of Mongolia's vast area, belongs to the arid desert and semi-deserts of Central Asia. The peak of Tsogt Chandmana Uul, at the end of the Khentii Mountain Range, is the watershed of three huge drainage basins some 80 km South of Ulaanbaatar, at 1,854 meters above sea level.

The biggest rivers are the Selenge (992 km) of the Arctic Ocean Basin, the Kherlen and Onon of the Pacific Ocean basin, and Zavkhan and Knovd of the Central Asian Basin. The rivers have good waterpower resources. They are flooded with rainfall in summer.

Mongolia has 16 large lakes, each more than 100 km^2. The biggest is the Uvs Nuur whose waters cover 3,360 km^2. Mongolia's Northern part is well-watered by lakes and rivers. The river joins Orhon River that is one of main tributary of the Selenge River, which pours into the Baikal Lake.

The rivers are rich in fish. The water temperature of the rivers and lakes reaches 15 to 23°C. Many small lakes occur in the steppe and Gobi region. Oases occur in the Gobi desert. The steppe and the Gobi desert zone are rich in ground water supply. The ground water is used for drinking. Mongolia has about 400 springs.

ROLE OF WATERSHED AREAS IN SOCIO-ECONOMIC DEVELOPMENT

Mongolia's population is estimated 2.4 million with an average annual growth rate of 1.8 percent. As Mongolia transferred into the market economy system after 1990 the economic condition was difficult due to increasing of inflation rate. Production capacity slowed down. The country's population rose from 2,075 in 1990 to 2,429,700 in 1999. The population of the capital city Ulaanbaatar - the administrative, political, economic, cultural and scientific center of the country was 773,700 in 1999.

Table 1. Population Distribution

(Unit: thousand persons)

Indicators	1990	1995	1996	1997	1998	1999
Urban population	905.9	1,129.2	1,134.4	1,148.0	1,164.9	1,395.8
of which Ulaanbaatar city	536.6	612.1	624.9	638.4	652.2	773.7
Rural population	1,197.4	1,119.6	1,148.7	1,167.6	1,184.2	986.7
Total	2,075.5	2,293.9	2,329.9	2,363.3	2,396.3	2,429.7

Water plays an extremely important role in man's life not only because it is indispensable for sustenance of life but also due to its metabolic importance in a wider sense. Thus water is a necessity for agriculture, domestic use, irrigation, and hydropower and for the development of most industries.

During the same period, the total gross domestic product (GDP) of the country increased from more than 550 million to 87,369 million togrogs. Agriculture, hunting and forestry, as a group led in the GDP followed by mining and quarrying (Table 2).

Table 2. Gross Domestic Product, at Current Prices

(Unit: million togrog)

Industries	1995	1996	1997	1998	1999
Agriculture, hunting and forestry	209,145.9	283,033.1	298,894.3	306,240.5	315,352.2
Mining and quarrying	66,023.5	67,232.6	119,229.6	68,346.1	82,153.4
Manufacturing	66,377.8	38,392.5	54,981.8	47,493.8	50,365.6
Electricity, gas, and water supply	9,237.0	17,820.9	18,262.8	20,074.1	20,238.5
Construction	9,237.0	17,820.9	18,262.8	20,074.1	20,238.5
Transport, storage and communication	35,074.2	47,868.8	64,080.1	71,977.0	76,106.5
Total	550,253.7	646,559.3	832,635.6	817,393.4	873,679.2

The value added of the agriculture sector was 35.7 percent of GDP in 1999. The population of livestock (house, camel, cattle, sheep and goat) reached 33.6 million head in 1999. The agricultural land of Mongolia is 130,358 thousand ha, of which 296.3 thousand ha is for crop production. That produced 169.4 thousand mt of wheat, 63.8 thousand mt of potato, 39.0 thousand mt of vegetables in 1999.

PRESENT STATUS OF WATERSHED MANAGEMENT

The watershed area of the country remains under government control as common property. The Ministry of Nature and Environment has the responsibility for the investigation, monitoring, conservation and protection of the natural and social environment (Figure 1).

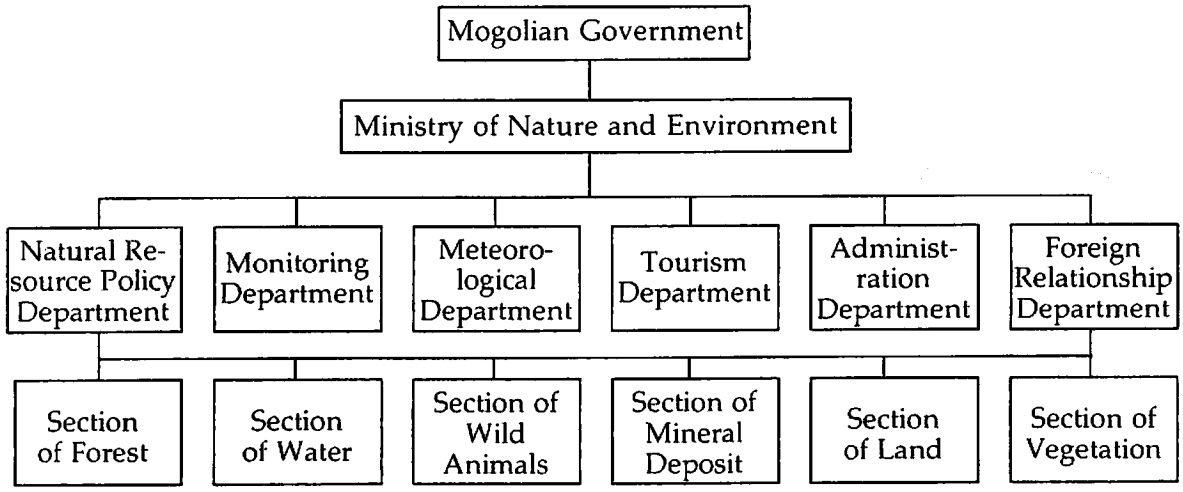

Figure 1. Flow Chart of Government Administration

The USAG (Water Facilities Exploitation Department) is one of the departments under the Ulaanbaatar City Administration. It services the water supply facilities, including the water sources, supply stations and sewerage facilities.

The municipal water supply system in Ulaanbaatar started in 1955 with only ten wells with the total capacity of 4,500 m^3/day with the aid of former Soviet Union. An organization for municipal water supply under the administration of the municipality was established in 1959. The sewerage system was constructed in 1963.

About 80 percent of the total demand of water is supplied from groundwater resource. There are 107 guard points, 14 stations working and researching the rule and quality—structure of water.

Some 30.8 percent of the population are supplied with integrated water supply for drinking system; 24.8 percent by transportation service that loads water; 35.7 percent drinking from wells and 9.1 percent drinking from rivers, streams, spring water and snow ice water. The water supply problem of 170 rural areas (total 345 rural areas in Mongolia) needs to be resolved soonest. Most of the rural people drink from the river, steam and water for pasture irrigation.

Some 150 water irrigation systems with simple engineering make irrigates 50 thousand ha of crop lands. However, about 18 percent of them are no longer serviceable with the result that some 4,000 ha of crop land have remained without water in the last 10 years.

MAIN ISSUES IN INTEGRATED WATERSHED MANAGEMENT

1. The need to improve the water supply system and to renovate the construction for watersheds;

2. The need to provide comfortable conditions of water usage and cleaning standard of sewage system;
3. The need to install water meters for water consumption to cut off unproductive expense of water and to establish economical mechanism and beam for using with economically.

LAND USE CLASSIFICATION SYSTEMS

Land use in Mongolia is classified into six main specifications: the agriculture land, urban land, highway and engineering network area, forest area, watershed area and reserved land (Figure 2).

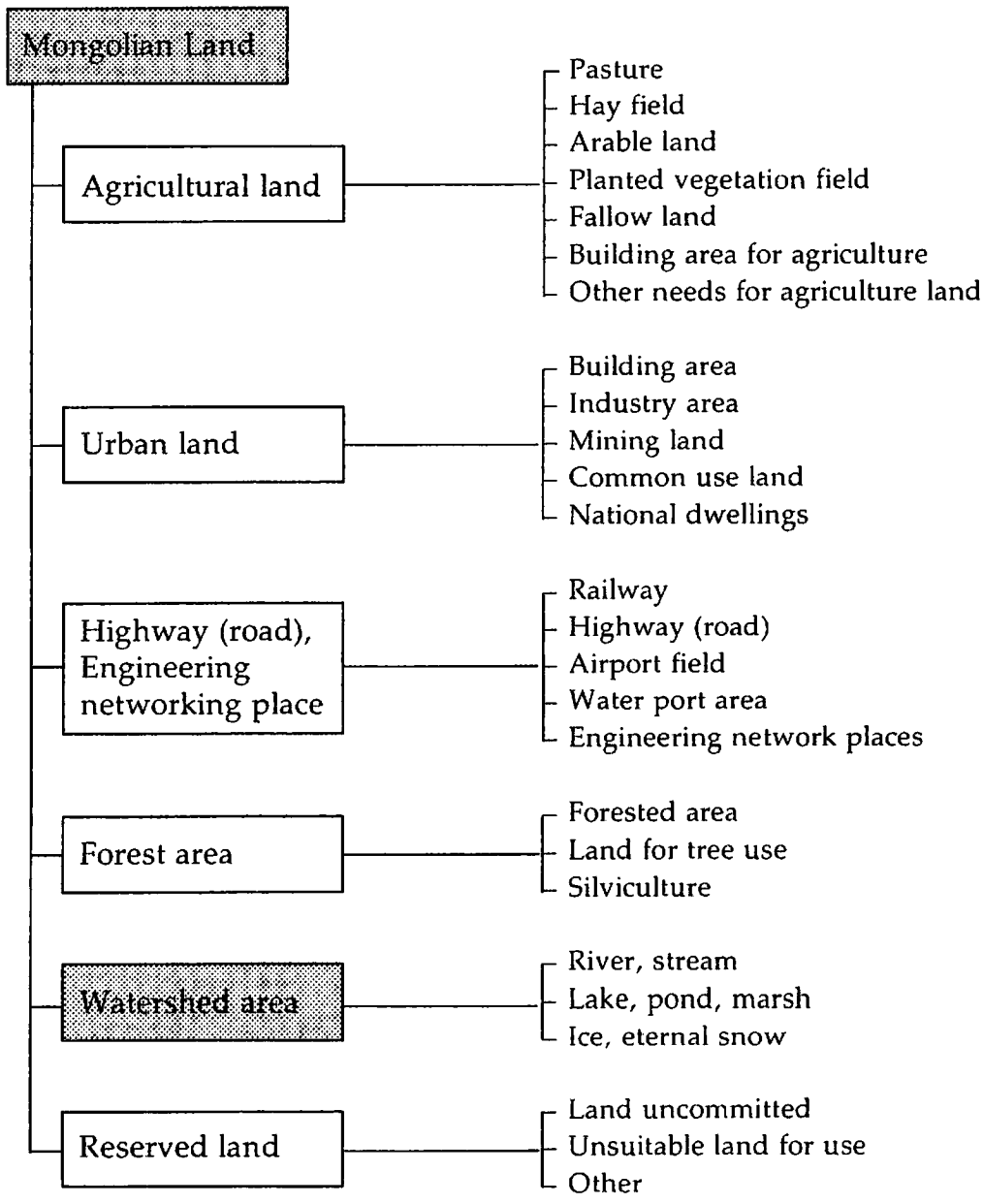

Figure 2. Land Use Classification

ROLE AND POLICY OF GOVERNMENT IN SUSTAINABLE WATERSHED MANAGEMENT

The Mongolian government's main role is to invest and formulate legal conditions of watershed management, to maintain water resource, to provide the integrated watershed management and to participate in international projects. The government coordinates all activities of watershed management according to environmental laws: Water Law (1974), Forestry Law (1974), Hunting Law (1974), Law on Underground Natural Resources (1989), Air Quality Protection Law (1989), General Environmental Law (1990) and Draft Land Law (1991). Environmental conservation is controlled on the basis of these seven environmental laws.

a. Water Law prescribes the standards of water quality and scope of management;
b. Forestry Law regulates the deforestation of small forests; forests around an oasis in the Gobi desert.
c. Hunting Law prohibits the hunting for 17 species of animals, 2 species of fish, and 8 species of birds.

Specific Government Policies

Water source and value of quality

a. Master plan for the protection and exploitation of water resource, mapping of economic zones and improving investigation work of zonal territory;
b. Research and investigate water sources in urban areas to provide reliable water supply and improve the quality of water; and
c. Registration of water quality, resource and water usage.

Water use

a. To determine the future urban and integrated watershed management development;
b. To improve current drinking water supply standards; and
c. To reconstruct, renew and expand the construction of water supply system.

Protection of water source

a. To calculate long-term influence of surface and ground water usage for protection;
b. To protect land with vegetation cover; and
c. To build new purification system for water of domestic and industrial use.

6. NEPAL *

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INTRODUCTION

Nepal is a land-locked, mountainous country located in the middle belt of the Himalayas. The country shares common boundaries with the People's Republic of China in the North and India in the South, East and West. The total land area of the country is 147,181 km^2. Nepal has a number of watersheds, ranging from big river basins to smaller micro-watersheds.

There are 33 rivers whose total watershed areas exceed 1,000 km^2. The big perennial rivers, called the first grade rivers, are Mahakali, Karnali, Narayani and Sapta Koshi with their sources in the snow and glaciers in the Himalayan region. The second grade rivers are Babai, West Rapti, Bagmati, Kamala, Kankai and Mechi. These rivers originate from the middle hills and are fed by groundwater, including springs. The seasonal fluctuations in these rivers are higher than that of the first grade rivers. The third grade rivers have their sources in the Siwalik range and are much smaller with negligible or no flows in the dry seasons. Nepal is one of the richest countries of the world in terms of fresh water resources availability. Nepal has an annual average surface water availability of about 1.5 mil. m^3/km^2 corresponding to about 11,200 m^3/person.

The climate of Nepal is extremely diverse, determined by weather systems moving in from Southwest in summer and from the West during winter, characterizing sub-tropical to arctic temperature regimes as well as arid to humid moisture regimes. The diverse nature of topography and the pronounced dry and wet monsoon seasons are the main factors responsible for the wide rainfall variability.

The average annual rainfall in the country is about 1,814 mm (varying between 250 mm to 6,000 mm). However, there is a sharp spatial and temporal distribution in precipitation. About 80 percent of the total annual precipitation occurs within the months of June to September. Based on present data, the available annual surface run-off is estimated at 220 billion cu m and the annual recharge estimate of the groundwater is about 5.80 billion cu m.

The mountains are vulnerable to land slides, erosion, sediment transport, deposition and other mass wasting phenomena owing to the rugged topography, fragile geological conditions, high seismic activity, soft and thin soil cover and high intensity rainfall in short periods.

* The views expressed herein are personal and do not necessarily represent that of the HMG of Nepal.

ROLE OF WATERSHED IN SOCIO-ECONOMIC DEVELOPMENT OF NEPAL

The population of Nepal is about 22.5 million with an annual growth rate of 2.3 percent. The annual per capita Gross National Product (GNP) is only about US$210 and the corresponding growth rate in the recent years has been low (about 2 percent). Nepal's economy is dominated by the agriculture sector, which alone accounts for about 41 percent of the Gross Domestic Product (GDP). This sector employs close to 80 percent of the workforce that is severely under-utilized and remains idle most of the time.

The primary components of watersheds are land, water, flora and fauna. The resident population harnesses these components to either prosper or sustain their livelihood. Watersheds in Nepal are of vital importance to the people as the entire economy and the socio-cultural practices are dependent upon them. Various land uses, especially agriculture, forests, shrubs and grasslands, extraction of raw materials thereof and harnessing of water resources for drinking, household and industrial usages, irrigation and hydropower are activities that are all determined by the quality and the carrying potential of the watersheds.

Until almost a century ago, the hills of Nepal accommodated the majority of the population. The presently densely populated southern belt of the terai was a dense tropical forest rampant with endemic malaria and inhabitable conditions. The mountains of the north provided harsh and adverse physical and climatic conditions. The middle ranges of mountains and hills with intermediate valleys offered relatively better opportunities and conditions. Because the population was very low and traditional environment friendly practices were adopted, the watersheds were not overtly stressed and the available natural resources could easily absorb the pressures exerted upon it.

The forests provided fuel wood to farmers, fodder for livestock, green manure for field crops and easily met the minimal requirements of timber and other products. Forests also have the potentialities to contribute to the industrial development of the country by providing raw materials for forest-produce-based industries. In higher mountains, the pastures provided good opportunities for raising sheep and other livestock. Assorted species of livestock are sources of dairy products, food, drought power and even manure for crop cultivation. The economic mainstay of field crops could be practised successfully relying on both vegetative and livestock resources. To meet the requirements of other necessities, which are neither produced nor possessed in the watersheds, bartering of the agro-forestry products was also a common practice.

Watersheds are also important from the vital viewpoint of water resources. Watersheds interact with the hydrological cycle determining largely the availability of water as it is involved in every step of interception, run-off, percolation, evapotranspiration and storage. Important sources of drinking water and irrigation have dwindled or even dried up because of changes in the quality of the watershed. These have led to strong socio-economic consequences.

Additionally, the diversified flora also provides valuable herbs and plants that have been used for medicinal and cosmetic purposes. Large amounts of rare medicinal herbs and plants are regularly exported. Eco-tourism is also an important revenue

earner in Nepal. It has been found that almost a quarter of the tourists visit Nepal in order to enjoy the eco-tourism based on forest resources.

Recently the population exploded along with access to better health care, preventive measures and high birth rates. This has increased the output requirements from the resource base leading to enhanced primary stresses on the watersheds, specially the agriculture lands and the forestry sector. The combination of population growth and loss of farmland has resulted in a reduction in per capita availability of agricultural land. The average land holding size has also dwindled to less than one ha/farmer. Small land holdings with even smaller plots and rudimentary agricultural developmental facilities have rendered agriculture incapable of meeting the requirements of the common man. Growing numbers of livestock and intense grazing have led to increased erosion of the pastures, aggressive timber collection has reduced the forest cover and triggered off watershed deterioration.

Deprived of the required quantity and quality land, and other non-farm employment opportunities, the common man is forced to go in for meagre jobs to other places or is compelled to encroach into the forest and pasture lands in an attempt to fulfil the minimal needs of food, fodder and fuel wood.

STATUS OF WATERSHED MANAGEMENT

In Nepal the southern range of hills, the Siwaliks, and the middle mountains are more susceptible to watershed deterioration. The Siwaliks have soils, mainly conglomerates and loose formations that are easily eroded. This area also consists of good tropical forests that have greater economic value and thus are more prone to gross deforestation. The middle mountains suffer from the excessive exploitation of the natural resources due to increased population pressures and limited availability. An assessment of district watershed conditions (Department of Soil Conservation and Watershed Management) showed that a third of the country's 75 districts were considered, on average, to have marginal to poor watershed conditions. Some of the districts that were considered to have better conditions also possessed some land units that were poor or even very poor.

Past Approaches

The watershed management in Nepal started from the mid '60s with the main aims of forest and pasture management and soil conservation. The traditional approaches were terracing of sloping lands for soil conservation and attempts at forest management through nationalization of forests. The approach essentially consisted of top-down planning, implementation and monitoring of watershed related projects. The programs were purely governmental approach with little consideration to the existing users and consumers and eventually failed on the grounds of sustainability. However, it did provide a valuable lesson and raised the awareness among the policy makers and implementers.

Present approach

At the present time, the bottom-up approach has been encouraged in order to ensure public participation in an attempt to usher in sustainability concepts. The

emphasis has been placed on a demand-driven approach to increasing productivity and conserving the resource base. Emphasis has been given to a program approach instead of a project approach. The concept of integrated watershed management has been institutionalized. The present prescription has made participatory approach mandatory as means of planning, maintaining and operation of the watersheds as well as benefit sharing. Community mobilizations through Community Development Groups (CDGs) are to be necessarily availed so that the sense of ownership arises among the locals who stand to gain from the program implementation.

The government has institutionally established the Department of Soil Conservation and Watershed Management under the Ministry of Forests and Soil Conservation. At present, the watershed management activities are expanded to 55 districts out of a total of 75 districts through district offices. These mainly carry out the activities of land productivity improvement, erosion and hazard prevention, protection of physical infrastructures, soil conservation, community forestry and extension programs. These are also carried out to trigger demonstration effects in the communities.

The Soil Conservation and Watershed Management (SCWM) programs of the government can be encapsulated into the following five different components: land-use planning; land productivity conservation; protection of infrastructure; prevention of natural hazards; and community soil conservation extension services.

Although these are components of the SCWM programs, some of these activities are also often carried out by a multiple of agencies, mainly the Department of Soil Conservation and Watershed Management, Department of Irrigation, Department of Forestry, Department of Water Induced Disaster Prevention and Department of Local Development.

The recent watershed management efforts have been able to achieve wide spread public awareness and substantial community partnership at the operational level. Recognition of the requirement of integrated watershed has also been achieved at the conceptual level. The programs implemented have stressed upon group mobilization and empowerment through trainings, demonstrations and study tours. The whole process has increasingly been made transparent with methodologies for public involvement, auditing as well as encouraging local and international non-governmental organizations (NGOs and INGOs).

The concept of integrated watershed management has been felt necessary and is recognized to be the best possible solution to enhance the conditions of the watersheds. This is yet to be implemented at the field level in the true sense. The nearing completion of the "Water Resources Strategy" report of Nepal has also initially identified that the basin-wise planning and management of the resource needs to be adopted.

ISSUES/CONSTRAINTS IN INTEGRATED WATERSHED MANAGEMENT

The main areas of problem in Nepal in the watersheds are soil erosion and soil loss, scarcity of water (required quantity at the right time and place), biological degradation, and financial and economic problems.

Although detailed data regarding soil erosion overall in Nepal are lacking, limited measurements of sediment show that values for the country exceed the world average by almost twice the magnitude (Alford 1992). The direct and primary effect

of soil erosion is soil loss and nutrient leaching, resulting in reduction of land productivity. Soil loss is more apparent than mass wasting in the mountainous region. The presence of seasonal heavy rains on unprotected soils lead to loss of topsoil and erosion. Forest depletion, overgrazing, poorly maintained marginal land and fires have altered the natural vegetation cover and leaving soil exposed to natural forces of erosion. This has impoverished the land base.

A study in central Nepal of soil loss from sloping farmlands under farmers' practices, indicates a soil loss of 20 mt/ha/year from rainfed marginal land, indicating a nutrient loss of 300 kg of organic matter, 15 kg of nitrogen, 20 kg of phosphorus, and 40 kg of potassium (Carson 1992). It becomes clear that soil erosion is a key cause of decline in soil fertility. These soil changes resulting from soil erosion will, in time, reduce crop yields and thereby farm incomes and household nutrition. Uncontrolled and continuous soil erosion will greatly reduce the soil depth and soil nutrient content, leading to abandonment of farm lands.

Decrease in the yields of main food crops has also been observed. For example, in Nepal, from 1970 to 1990, the average national yields of maize dropped from 1,869 to 1,599 kg/ha/year (HMG/N 1990, cited by Carson 1992). Increasing population and decrease in crop yields make it more difficult to meet basic needs. Farmers in the mountains have to cultivate lands intensively and/or clear more land on steep slopes, resulting in further depletion and degradation of land resources. The challenge to the farmers of Nepal, therefore, is to produce food for the ever-growing population while conserving agricultural soils.

Soil loss in regenerating forest with good ground cover is the least, whereas it is the highest in exposed and non-crusted soil surfaces. Soil loss in good forest areas tends to fall below 1 mt/ha/year whereas in degraded forests it exceeds 4 mt/ha/year. Ploughed land in pre-monsoon period is highly susceptible to soil loss during high intensity and low frequency rainfall events. This is more pronounced in rainfed terraces, about 10 mt/ha/year, which is quite higher than that from the lowland irrigated areas.

The off-site effects of soil loss have broader economic and environmental implications. Soil loss increases sediment and nutrient loads in streams. Higher sediment loads have led to siltation of riverbeds in the *Terai* as well as damaged or reduced the utility of dams and canals and damaged river structures. Eroded soils clog reservoirs and rivers and often cause flooding in the lowlands. One of the most cited examples is that of the Kulekhani Reservoir in Central Nepal, which was built to supply water for a peaking hydropower plant. The lifespan of the reservoir has been reduced to half of the targeted design and one quarter of the expected lifespan due to serious soil erosion. The unusual rainfall in 1993 alone resulted in sedimentation of 5.12 million cu m, which is 6 percent of the designed storage capacity of the reservoir and is about 60 times higher than the expected annual sedimentation (Sthapit 1995; Galay *et al.* 1995).

River courses that are in proximity to urban centers have been exploited by sand and gravel mining such that the hydraulic characteristic of the rivers themselves are drastically changed which bring about morphological changes in the river and undermine the safety of the riverine structures such as bridges, training works, etc. In some places, sand and gravel quarries in the watersheds have also been mined extensively

such that apart from bringing about visible scars in the landscapes, they have also contributed to deteriorated water quality.

An acute problem that is being increasingly faced these days is the problem of water rights and shortages. There are water use conflicts within the same community for different uses as well as between different communities for the same or different usages. In the hill areas, a single source of water is often under dispute for utilizing it even for the basic needs of drinking water supply. Conflicts between irrigation and hydropower development have also led to an impasse in operating or developing hydropower schemes. Similar problems are also emerging between the tourism sector and the hydropower sector, as the latter often entails diverting an appreciable amount of water to different basins or the same basin at a point further downstream which renders the river unattractive for tourism activities such as white-water rafting and kayaking.

The Kathmandu Valley, which houses the capital city of Nepal, faces acute shortage of water even for drinking and household purposes through out the year. The about-to-be implemented Melamchi Water Supply scheme is facing stiff criticism and resistance from locals of the Melamchi basin who perceive the water diversion to Kathmandu valley as detrimental to their future needs. The seasonal abundance of water in some areas may be misleading as the same area may be facing acute water shortages in the drier seasons. A proper watershed management approach along with suitable interventions are thought to alleviate these problems.

Consequences of poor watersheds or inappropriate siting of human interventions can be understood by the damage of hill roads by landslides. For example:

a. 400 to 700 cu m of landslides/km/year occur on hill roads;
b. 10 to 25 percent of hill roads along river valleys are completely washed out every four to five years; and
c. 3 to 9 thousand cu m of landslides/km occur every year during hill road construction periods.

Another problem that is faced in agriculture usage of land is fragmentation, especially in the hills and mountains, where the parental properties are fractioned off and distributed among the natural heirs. This has often made mechanization and implementation of modern farming techniques impractical and uneconomical.

The general issues in watershed management are related to the working strategies and operational procedures for support activities. These are:

Conceptual issues – There is still confusion about the concept and scope of watershed management which is often confused as and taken to be similar to forestry, agriculture, upland conservation, integrated land development, or natural resource management. It has been perceived as a mixed bag of multiple activities.

Institutional and organizational issues – The institutions mandated to undertake these activities often have a lesser resource outlay and a greater demand. There is multiplicity in the operation in regards to various activities and various institutions that lack a coordinated approach. The Community Development Group (CDG) envisaged to be at the core of all watershed activities is often not recognized by the other sectoral agencies. This creates a problem in streamlining resources and diverse programs for an integrated approach.

Policy and legal issues – The policies are more oriented towards conservation and utilization and are not comprehensive but are fragmented. These appear to be inadequate to coordinate national and local efforts and interests. The challenge still lies in developing a clear-cut and precise policy that is achievable and effective with the available resources in terms of human, financial, social and technical aspects of the country. For example, the community-based organizations (CBO) established for the watershed management activities are registered by law under the provisions for non-profit-making organizations. And yet, to make the organization financially viable it must be allowed to run and profit from its operations. The present legal provisions do not allow this.

Technical issues – The expertise available in Nepal is limited to those that were trained abroad in different scenarios. The recent methods of resource management that are applicable to the indigenous conditions are yet to be employed in Nepal. The prerequisites of the present expertise are a strong database and research, aspects that are both rare in Nepal. Computer applications, GIS and remote sensing and modelling techniques may be familiar to some local experts, but most are still unaware or the ground realities often render these techniques impractical due to problems that undermine the adopted approach.

Management issues – A multidisciplinary approach encompassing all the major avenues of development is required to be adopted rather than a pure sectoral approach. Coordination among the various line agencies, identification of priorities and matching these with the required resources are crucial issues. Furthermore, educating and mobilizing the people, staff and even the policy makers is the need of the hour. The local people need to be empowered in terms of basic management and operational skills.

Investment issues – The returns of the investment in watershed management are accrued after long time and often no direct effect may be seen. When this needs to compete with other pressing needs of the State, especially in a resource starved country like Nepal, there is bound to be major shortfalls in the outlays compared to the demand.

Participation issues – Participation on the part of people who are struggling to meet two meals a day can hardly be expected to be satisfactory. In developed countries, the rich are taxed for the benefits of the community and activities that help the "lesser well to do" people. In Nepal views also exist claiming that the participatory approach tries to tax these very poorer sections of the society! The government extends subsidy, as the local people cannot completely undertake the watershed management activities. This often leads to certain pitfalls such as the benefits not being equitable, increase of components that guarantee higher subsidy, inflating the costs such that the subsidy portion covers all the costs, etc. The issues remains on how to obtain true participation from the beneficiaries; make judicious use of their contributions; how to make the programs self-sustainable, regenerative and demonstrative, etc.

A major problem that the NGOs have in working in this sector, including the CDGs formed specially to work in this area, is that they are not entitled to earn money, make profits and require special profits from the Central bank to obtain

loans. This is not possible for small NGOs and CDGs working in the rural areas. The specific issues that are evident mostly in Nepal can be listed as below.

a. Excessive use of marginal land for agricultural practices (hill slopes), and settlements (Terai plains and Siwaliks);
b. Excessive erosion and soil loss in the upland areas and sedimentation, siltation and flooding in the down stream areas;
c. Population and livestock pressures on the natural resources of the watersheds;
d. Conversion of forests into agriculture lands;
e. Deterioration of ecological balance;
f. Declining terrestrial and aquatic biodiversity;
g. Decline in agricultural productivity;
h. Excessive sand, boulder and gravel mining;
i. Urbanization and industrializations of certain watersheds;
j. Excessive groundwater extraction and use of dry water flows;
k. Disposal of untreated wastewater into water bodies along with solid waste dumping;
l. Weak enforcement of existing legal provisions and monitoring; and
m. Lack of adequate legal framework and want of integrated institutional structures.

The government has initiated policy level changes and have endeavored to reduce multiplicity of efforts and to ensure a concerted effort. Practical implementations to address these issues are still lacking in the macro-level. However, there are some countermeasures being taken at some specific project levels. The major countermeasures are construction of check dams, and *sabo* engineering works in landslides and riverbanks, plantations of forests and fodders trees as well as special grasses, terracing, promoting better cropping patterns, educating and empowering the local residents.

LAND USE CLASSIFICATION SYSTEM

Land resource base supports the livelihood of the Nepalese. The great diversity in landscape and climate is reflected in the complex usage of land. In general, land use category includes agriculture, forest and pastures, snow cover and other lands. However, these areas were later broadly classified as cultivated, grass, forest and shrub lands as indicated (Table 1). The major portion is under forest cover followed by agriculture land.

There are increasing pressures on different land uses, specially the forests and the grazing lands. The possibilities of land use changes have been identified in Nepal based on land capability. These are:

a. In the Southern plains, the Terai, the land capability analyses show that forests are occupying good agriculture lands;
b. Throughout the hills and the mountains, a large part of the land currently under agriculture is more suited for forestry purposes; and
c. In the country as a whole, there are more degraded grazing and shrub lands, and the forests have been reduced to shrub lands.

Table 1. Land Use Pattern

Land Use	Total Area ('000 ha)	Percent
Cultivated land	3,052	21
Non-cultivated land inclusions	998	7
Grass land	1,745	12
Forested land / forest plantation	5,518	37
Shrub land / degraded forest	706	5
Other land	2,729	18
Total	14,748	100

The presently ongoing "Ninth Five-Year Plan" of Nepal proposes the strategy to make land-use effective by maintaining necessary coordination among various bodies for the economic and social development and making maximum use of the sector-wise resources on the basis of climatic and topographical variations. The responsibility for land use has been extended to the local bodies to apparently make it more effective.

The classifications adopted in Nepal that have any special significance in terms of watershed management are those that relate to delineation of national parks, conservation areas and reserves. Apart from these the land-use classification systems used in Nepal have only the purpose of land registrations and determination of revenues. Apart from the designated areas, there are no significant restrictions that curtail the conversion of land-use. The land-use classification at any particular watershed is determined by the local community (CDGs) and the local district offices following mainly the traditional or communal usages, property rights and land capabilities.

ROLES IN SUSTAINABLE INTEGRATED WATERSHED MANAGEMENTS

In Nepal, the government has been the main agency responsible for bringing about better changes in the livelihood of the people. The role of the government has been to provide the manpower, expertise and the major funding as well as to educate and mobilize the local people. Thus, along with the annual resource allocation (budget approval) the government has to take the lead role in identifying programs, implementing and monitoring and evaluation activities.

At the field level, the district offices prioritize the sub-watersheds of 15 -25 km^2 according to the "Guidelines and Methodology for Sub-watershed Prioritization in Watershed Management and Planning" which uses a methodology based on physical and social parameters. In each sub-watershed, the area is divided among 20 - 50 households to form the CDGs. Participation is voluntary without any compulsions. These CDGs are the in-situ institutions responsible for mobilization, planning, implementation, coordination, management, sharing of benefits, etc. The government agencies extend their support to these CDGs which are then encouraged to adopt an integrated development approach that not merely looks at soil conservation but the overall socio-economic upliftment within the watershed.

There are a number of NGOs and INGOs that are working in the sector of watershed management. These are often limited to small watersheds or limited by time as of being for short periods or a one-time efforts. The international community has also been involved in this sector in Nepal. Bilateral and multilateral assistances have been used in various parts of the country. These include the Bagmati Integrated Watershed Management Program (Commission of European Communities), Sustainability Community Development Program (UNDP - an Agenda 21 Program), Community Forestry and Watershed Conservation Project (JICA), Nepal-Denmark Watershed Management Project (DANNIDA) and a couple of others.

The Bagmati Integrated Watershed Management Program – The Bagmati Watershed Project was initiated in 1975 supported by the Commission of European Communities, and is focussed on the reforestation and gully control works in the Kathmandu Valley and Kavre District. A technical soil conservation package consisting of terrace improvement, catchment ponds, gully and landslide control through water management and reforestation, and also trail improvement and ropeway construction were completed. Recently, the Bagmati Integrated Watershed Management Program II is in progress with an aim to "reduce erosion in the Bagmati catchment and to introduce sustainable improvements in the management of 23 selected priority sub-watersheds in the Bagmati River catchment, thus improving land productivity and the living standards of the people. The program has adopted a more holistic approach and expects to reduce erosion, improve farm and community forest incomes, communal resources and infrastructure protection activities. Greater emphasis has been extended to the plight of women and children in the area.

The Sustainable Community Development Program (SCDP) – This was formulated in line with Agenda 21 (Earth Summit, 1992). SCDP is a UNDP-assisted program in Nepal to promote sustainable development in the country. The development objective of SCDP is to support the government's efforts in building local institution's capacity to manage environment and natural resources integrating socio-economic development through local community initiatives in remote and degraded watersheds for sustainable community development. The program now covers six districts of Surkhet, Kailali, Dang, Humla, Myagdi and Okhaldhunga.

GOVERNMENT POLICIES IN SUSTAINABLE WATERSHED DEVELOPMENT

The government of Nepal accords high priority to environmental considerations and management of natural resources. Degradation of watersheds, loss of topsoil and deforestations are phenomena that are increasingly arresting the attention of the whole nation. The government has given priority to soil conservation and watershed management program. Though the policies do not necessary spell out Integrated Watershed Management, it can be inferred from the various policy documents that a concerted effort at adopting an integrated approach is being made presently. The various projects, carried out with full support by the government, have already initiated such holistic approaches.

The underlying basic principles of the present policies are community participation and mobilization from the conceptual stage of any program to final completion,

and then operation and maintenance. It is recognized that the long-term effects of the soil and watershed conservation would be on development and this would be sustainable if the common resources are managed by local people. The policy statements are available in the Ninth Five-Year Plan and other policy statements.

The soil conservation and watershed management policy is built upon the principles of participatory land use development and improvement focussing on implementation of integrated watershed management activities. This also includes projects of improving land productivity, poverty alleviation activities based on the micro-watershed activities and erosion hazard mitigation.

The soil conservation and watershed management policy is also linked to other sectoral papers such as the Forest Sector Policy (1988) and the Agriculture Sector policies such as the Agriculture Perspective Plan (APP). Some salient features of the policy of the soil conservation and watershed management program are identified as follows:

a. Preparation of a holistic people-oriented integrated watershed management program;
b. Prioritization of sub-watersheds based upon the physical conditions of each watershed;
c. Unit of a planning, implementation and management unit of the common resources has been reduced to a very manageable size of about 25-50 households;
d. A minimum contribution of the farmers is mandatory to avail of State assistance; and
e. Watershed areas can be declared protected so that the area can be developed according to the land use program for that area.

The present draft report on Water Resources Strategy has also identified that the common resources are dwindling and a comprehensive approach to the development of the water sector is necessary. Relevant supporting policies have also been promulgated in the irrigation, hydropower development and forestry sectors. The APP has also stressed great emphasis on poverty alleviation through resource mobilization in the agriculture sector.

The cumulative effects of watershed deterioration are: decline in farm and forest produces, high sediment loads in valleys and plain areas, destruction of the common resources and reduced efficiencies of the developed infrastructure projects. Therefore, there is a need to regulate land uses through land zoning, improve the environment with proper resource management and ultimately implement integrated watershed management practices. The recent shift in the scope and activities of watershed management programs in Nepal have begun to yield promising outcomes. A more concerted effort streamlining the government's various activities to the needy areas seems to be required along with suitable institutional restructuring.

7. PAKISTAN

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INTRODUCTION

Pakistan is situated between 24 and 37 North latitudes and 61 and 75 East longitudes. It occupies a surface area of 87.98 million ha of which 61.8 million ha (70 percent) have been surveyed. It has lofty mountains and towering peaks with heights up to 8,534 m in the Northern and Western regions. The Southern fringe is a sandy desert.

The country has a continental type of climate. Annual precipitation varies widely from less than 125 mm to 1,500 mm. Monsoon precipitation dominates in some areas while in other parts a winter precipitation pattern prevails. Some 60 to 70 percent of the monsoon rain is received during the months of July, August and September, while the rest of it is received in the winter months from December to February. The average temperatures vary considerably. In winter it falls few degrees below the freezing point and in summer it exceeds 38°C in the Northern zone and 49°C in the Southwest.

Half of the country's area forms the Indus Basin, yet only 25 percent of it is under cultivation. Eighty percent is irrigated and 20 percent is rainfed. Forests encompass 5.4 percent (4.74 million ha) of the total area. The rest, 32.3 percent of the land, is unclassified. The land utilization profile is shown in Table 1. The forests area of 4.74 million ha is distributed according to types as shown in Table 2..

Table 1. Land Utilization

Land Use	Area (million ha)	Percent
Forest	4.74	5.4
Productive	1.48	
Protective	3.26	
Arable land	20.54	23.4
Culturable waste	11.03	12.5
Not available for cultivation	23.25	26.4
Unclassified	28.42	32.3
Total	87.98	100.0

Table 2. Characteristics of Forest Area

(Unit: 000 ha)

Forest Type	Area	Productive	Protective
Coniferous	1,959	931	1,208
Irrigated plantations	392	142	250
Riverine	296	246	50
Mangrove	347	-	347
Scrub	1,702	158	1,544
Others	41	-	41
Total	4,737	1,477	3,260

THE WATERSHED

The watershed of Pakistan is divided into six physiographic regions which are briefly described below:

Northern Mountain Regions – This area forms the catchments of the river Indus and Jhelum. The irrigation system of the Indus Basin depends exclusively on the flow of these rivers. This region comprises mountain ranges of the Himalayas, Karakuram and Hindu Kush. The total catchment area of the upper Indus in the hills is 332,170 km^2, out of which 209,668 km^2 fall in Pakistan. Land slides, snow avalanches and other earth movements are quite common and attributed to improper land use because of growing human and livestock population. The major problem associated with soil and water conservation in the region is socio-economic in nature. According to hydrological studies, soil to the magnitude of 200 to 380 mt/ha is eroded annually from this region.

The Upland of Northern Punjab – This region is relatively small (1,600 km^2) but a highly complex area. Haro and Swan rivers drain this area. The whole of it has been subjected to geological erosion on large scale. Improper land use, unsuitable agricultural practices, dense population and over-grazing are the main factors contributing towards accelerated erosion.

Western Mountains Region – The area comprises the catchments of Kohat, Toi, Kurram and Zhob-Gomal risers. The mountains are devoid of vegetative cover, therefore, flash floods are common. Groundwater resource in this area is exploited through a unique system of underground water channels (Karezes).

South West Balochistan Plateau – This region comprises extensive areas of Chaghi and Siahan range. It is not a water producing area due to extreme aridity. Annual rain is about 40 mm. Vegetation is scanty everywhere. In depressions and on hill flanks grass patches and bushes exist, which are used for grazing purpose.

Coastal Belt – This belt includes the catchments of the Hub, Dasht and Poraliaud rivers in the Southern part of the country. Run-offs are usually moderate because a major part of precipitation being seasonal is either absorbed by soils or evaporates.

The Indus Plains – The Indus Plains cover 160,000 km^2 and forms the core of the country's mass land. It is drained by the Indus river and its tributaries: Jhelum,

Chenab, Ravi and Sutlej. Extensive irrigation system comprising three storage reservoirs at Tarbela, Mangla and Chashma, 16 barrages, 12 inter-river link canals, 2 syphons and 43 main canals have been constructed to provide ensured and regular supply of water for irrigation and drinking purposes.

WATERSHED MANAGEMENT ORGANIZATIONS

There is no single entity responsible for watershed management in Pakistan. The major government agencies vested with the responsibility are the four Provincial and Azad Jammu and Kashmir (AJK) Forest Departments: Water and Power Development Authority (WAPDA), Soil Conservation Directorate of Punjab, Agriculture Department, and Agency for Barani (Arid) Area Development (ABAD). The Murree Kahuta Development Authority and Capital Development Authority are also involved to some extent in watershed management practices in their respective jurisdictions.

The two major watersheds, namely; Tarbela and Manga, are being managed by the Forest Department of North West Frontier Province (NWFP) and WAPDA, respectively. The watersheds play a pivotal role in enhancing the economic life of Tarbela and Mangla reservoirs; uplift of the socio-economic condition of the local inhabitants; improve the environment of the watershed and the downstream area resulting in an overall positive impact on the national economy.

The activities of the Directorates of Soil Conservation are limited to the Northern narrow belt of Punjab adjoining AJK. The Murree Kahuta and Capital Development Authorities are working in Kala Chitta, Murree and Margalla Hills. The Forest Department NWFP is also carrying out watershed management measures in the Northern Zone (Dir and Swat districts). The Balochistan Forest Department is managing the watershed areas in Zhob, Lorali and other Northern and Southern hilly regions of the province.

Besides, a number of NGOs are also active in the watershed areas. However, their activities are at local levels but carry a lot of significance in motivating the communities to participate in the watershed activities and also to shoulder the post-project responsibilities.

ROLE OF WATERSHED AREAS IN SOCIO-ECONOMIC DEVELOPMENT

1. Agriculture

The agriculture resource base of the country is expanding gradually. Additional areas are cropped as more water is becoming available due to better water management practices. However, due to the prevailing drought condition the expansion has been restrained in order to meet the demand of the existing irrigated lands. The government, in the Three-Year Development Program (2001-04) has estimated an increase in annual agricultural growth rate from 3.4 percent ((2000-01) to 4.4 percent (2002-04). Its accomplishment depends, among other inputs, on the availability of required volume of water at the appropriate timings. It can be achieved with the development/conservation of available water resources.

Increased availability of water is coupled with sustainable watershed management. To achieve this end, some shortcomings like lack of commitment, non-workable methodologies, limited availability of infrastructure and inadequate allocation of financial resources should be addressed.

2. Drinking Water

The availability of fresh water for drinking has declined significantly during the last decades. The underlying reasons for the diminishing water quantity are climate change, increase in demand and mismanagement of water storage and application. High rate of siltation from the denuded catchments and deterioration of water quality are posing serious threat to the people. The relationship between the achievement of the government's clean drinking water objective and the need to conserve the country's fresh water resources in clean and healthy state is already recognized. To accomplish this objective, the government is taking up concrete actions which, inter alia, include the better management of the watersheds for ensured supply of clean drinking water to the dwellers of the watersheds as well as those living downstream in the plain areas.

3. Irrigation

In the water supply Pakistan enjoys a unique position as the Indus Basin Irrigation System is one of the largest and oldest in the world. In the past, its productivity has been comparatively low because of the inefficient use of water and outdated irrigation practices. In recent years more sophisticated methods of water management have been evolved and control over the Indus river and its tributaries has gradually increased. Ground water has acquired importance as a supplemental source of irrigation water. As the largest and heavily invested system of irrigation is directly related to the water coming from the upland catchment areas of Tarbela and Mangla reservoirs, every development in these areas affect the irrigation system. Proper watershed management of drainage areas of these reservoirs is quite helpful in reducing sedimentation thereby increasing water availability for irrigation purpose.

4. Population Welfare

Pakistan is one of the most populous countries in the world with annual growth rate of 2.17 percent. About 70 percent of the population live in the rural areas. It places a great burden on the natural resources for agriculture, timber, fuelwood and fodder production. Realizing the gravity of the population problem, the government has given special attention to the level of the investment in the Population Welfare Program which envisages a multi-sectorial approach in adopting a communication strategy, population education and service delivery. The basic requirement of the population, i.e., timber, fuelwood, fodder and food grain can be met with to a larger extent through increased afforestation, soil and water conservation practices, pasture and rangeland management and other related measures.

5. Forestry

Pakistan's forests and rangelands cover some 4.74 million ha and 6.12 million ha, respectively. The demand of the rapidly growing population for food, fodder, timber and fuelwood has resulted in severe degradation of the forest resource in the

Northern watershed which, in turn, is adversely affecting the productivity of the irrigated low lands being the main resource base for the country's agriculture.

The government lays greater emphasis on mobilizing efforts for intensive afforestation in the watershed areas, social and farm forestry on marginal private lands and involvement of local population through NGOs for promoting sustainable forestry.

6. Hydropower

The prosperity and welfare of the state depends on the support of rapid economic growth for which adequate and assured input of cheap hydropower plays an important role. An ambitious program, i.e., Vision 2025, of water and hydropower development has been prepared to meet the prevailing shortages in this sector. It has been planned that 35 projects of water and hydropower development will be implemented under this program. Watershed management again plays a pivotal role in enhancing the economic life of the water reservoirs for regular generation of cheap hydropower.

7. Flood Control

The process of deforestation and degradation of the catchment areas of the Indus and Jhelum rivers in the North and denuded watersheds of hill forests of the Western hilly regions, cause colossal losses, every year, to private properties and public infrastructure in the downstream plains. Huge funds have been expended on the flood protection works to check the onslaught of recurring floods.

LAND USE CLASSIFICATION SYSTEM

Pakistan being a densely populated country, is highly dependent on its natural resources. Land holdings are commonly small due to which lust for grabbing more and more land is very common. Farmers tend to use every piece of land for agriculture without considering its suitability. Tarbela and Mangla Watershed Management Projects introduced the concept of better land use planning for the implementation of integrated watershed management activities according to the land use classification system. Under this system land is divided into eight classes according to its capability as described below:

Suitable for Cultivation

(1) Land subject to no or very slight limitations. Very good land that requires only good management;
(2) Land subject to moderate limitations. It is good land that requires only easily applied conservation treatment;
(3) Land subject to severe limitations. It is moderately good land and requires intensive conservation treatment; and
(4) Land subject to very severe permanent limitations. It is fairly good land and should be farmed only occasionally.

Suitable for Permanent vegetation

(1) Land subject to such permanent limitations that it should be used only for grazing, forestry or wild-life. Requires only good management;

(2) Land subject to moderate permanent limitations under grazing or forestry use. Moderate restrictions in use are needed;
(3) Land subject to severe permanent limitations under grazing or forestry use. Severe restrictions in use are needed; and
(4) Land that has some limitation that makes it unfit for cultivation, grazing or forestry. It is best suited for wildlife, recreations, or small water storages.

The total working area of 2.029 million ha in the Tarbela and Mangla Watershed Management Projects is classified as: 0.638 million ha for cultivation; 0.377 million ha for range management and 0.848 million ha for afforestation. Besides, 0.166 million ha were categorized as unproductive land comprising streambeds and rock outcrops. This area is suitable for development of wildlife, recreation and construction of small water storages/ponds.

STATUS OF WATERSHED MANAGEMENT

The mountain areas of Pakistan are important for many reasons, notably, the customary roles they play as the nation's watershed. These focus attention for those interested in forestry; conservation of water, land and wildlife resources; scenic beauty and as centers of intense agricultural activity. In the major watersheds, the source of the Indus waters are the Northern areas, NWFP and the mountainous areas of the Punjab. Excluding Balochistan, about 23 million ha of watershed areas in the upper Indus and its tributaries lie within Pakistan. The watersheds suffer from very unfavorable soil and moisture regimes. Their management for forestry, agricultural, soil and water conservation purposes leaves much to be desired. Of the 34.28 million ha of non-arable land in Pakistan, some 17 million ha are in Balochistan, but the watersheds of Balochistan have little association with the rest of the country since they drain either internally or direct into the Arabian Sea. Balochistan's major irrigation areas, however, depend on the Indus water and thus on its upland watershed.

The largest potential of water lies in the Indus Basin. Its rivers draw water from *albation* (summer snow melt) and precipitation. All these rivers rise in spring and early summer with snow melt and monsoon rainfall and have a combined peak discharge in July or August. The annual average mass flow of water in the rivers Indus, Jhelum, Chenab and Kabul is 172 cu m. For this purpose two multipurpose dams at Tarbela across the river Indus and at Mangla across river Jhelum have been constructed for water storage of 9.5 MAF and 5.88 MAF and its regulation for irrigation and generation of hydropower. At peak flood level more than 30 MAF of water flows down into the Arabian Sea.

The need for watershed management stems from the holistic link between land use and watersheds' physical and biological characteristics. Watershed management stresses the basic relationship between uplands and lowlands. Upland areas produce water, wood, forage and recreation received or enjoyed by the inhabitants of down-stream areas. The prime link between the uplands and low-lands is water; important both in delivery and quality. The upland watersheds produce about 90 percent of the country's water for hydropower, irrigation, domestic supply, ground water recharge, on-site farming and natural vegetative growth.

The coniferous forests are located comparatively on steep slopes. As such they are not managed under the clear felling or uniform systems but are managed under a selection system which prescribes tree harvesting of specific size. During the last many years, successful efforts to change the system of management of the Kaghan valley forests from a selection system to intensive forest management, where trees are felled in small groups which are regenerated artificially by planting nursery-raised coniferous seedlings have been made. At lower elevations forests of Pinus *roxburghii* are managed under Punjab shelterwood system which is a modified form of the uniform system. The scrub forests provide valuable protective cover to the watersheds and are a source of fuelwood and fodder to local communities. The main management objective of these forests is to protect the watersheds while maintaining production.

CONSTRAINTS IN THE INTEGRATED WATERSHED MANAGEMENT

Unrelenting pressure on Pakistan's natural resources has been exerted by population explosion. The country's population growth rate has accelerated in every decade since independence (1947). Since the formulation of the First Five-Year Plan (1955-60) the policy makers are reflective of the cognizance of adverse implications of unchecked population growth for socio-economic advancement of the country. The population welfare program has been subjected to changes and experimentation. Lack of political support has been a major hindrance. Despite the fact that family planning program is over 40 years old in Pakistan, the environments are hardly receptive if not hostile. Onwards from the 7th Five-Year Plan increased allocations for health and education, and the accompanying Perspective Plan (1988-2003) emphasized the need for greater attention to be paid to the social sectors if Pakistan is to alleviate poverty and environmental degradation. A greater emphasis has again been laid in the Three-Year Development Program (2001-04), on controlling the consistent growth of population and provision of basic amenities. Socio-economic conditions of the people living in and around forests in the mountain ranges of Himalayas, Karakuram and Hindu-kush are substandard. Small land holdings, lack of communication network causing difficulty in transportation of essential commodities, extremely low purchasing power, tribal hold, nomadic life styles and lack of awareness are some of the factors which encourage deforestation for bringing more and more areas under cultivation to carve out new grazing lands and meeting the requirements of heating and cooking. Land is grabbed by cutting and burning trees. On account of lack of proper system for implementation of the policies and infrastructure in the mountain areas to improve the socio-economic conditions of the communities living around forests, the environmental degradation could be hardly checked.

Pakistan has been profligate in its use of scarce energy resources. Economic instruments have contributed to excessive energy consumption. Electricity has been under priced partly as an anti-inflationary measures. In view of the limited supply of the natural gas it has also been under priced. Fuelwood prices have, by and large, been left to the market. The government has not intervened with sufficient effect, through the price mechanism or program resources to conserve trees and forests. Consequently, the country's 80 percent forests location in the watersheds have substantially declined.

Apart from the above, the other main issues/constraints in the integrated watershed management briefly are:

Training and Education

The implementation of watershed management program needs trained manpower. The Pakistan Forest Institute, Peshawar has been declared as a focal point for watershed management, research and education in South Asia. Over the years with the assistance of FAO/UNDP and GTZ, staff has been trained for imparting education and conducting research. Continuity in the training and education for watershed management at the regional level is essential for which Pakistan looks forward to involve and receive the input of international organizations for the introduction of new concepts and constant flow of knowledge. For an integrated watershed management approach, the induction of women into the forestry profession through training programs is the need of the hour. The forestry schools are required to be strengthened to train technicians in accordance with the modern concepts of watershed management.

There are many agencies implementing their development programs in the country. In order to educate the professionals of these agencies regarding watershed management and integrated activities, training programs are required to be introduced at the Pakistan Forest Institute, Peshawar and at other universities in the country.

Watershed Research

Watershed research is being conducted by the Pakistan Forest Institute, Peshawar and the Pakistan Agricultural Research Council. There is a need to investigate large scale land-use change effects and test models on watershed recovery. Social and technological studies are required to check out a future course for watershed management.

Lack of Coordination

The watershed management activities are currently being managed by different organizations at micro- and macro-levels without the required coordination for improvement of the watershed areas in forestry, agriculture, drainage, livestock, fodder production and dairy products for development of socio-economic conditions of the people. The resources of the concerned line organization need to be coordinated to accomplish the goal of sustainable as well as integrated watershed management.

Availability of Funds

Funds are not allocated/released as per requirement of the annual phasing chalked out in the project document. It results in cost and time over-runs, on the one hand, and delayed/decreased benefits, on the other.

While approving the project for implementation, all the technical, economic and financial aspects should be looked into deeply and once the project is approved, the financial managers should ensure provision of funds according to the approved annual phasing.

ROLE OF GOVERNMENT/PRIVATE SECTORS

The government at the federal and provincial levels are playing a major role in the development of sustainable watershed program in the country. It provides financing for the implementation of the projects, arranges funds from foreign donors agencies and also monitors these projects through concerned agencies. The government also carries out activities like holding seminars/workshops at national and provincial levels, organize special walks and arrange tree plantation campaigns to create awareness among the masses for better understanding of the usefulness/necessity of protection of environment through proper management of watershed areas; and to achieve better coordination among the implementing agencies for integrated watershed management. A National Conservation Strategy has also been formulated to reinforce watershed management activities in the country on scientific lines.

The implementation of various watershed programs over the past 50 years in the country at micro- and macro-level has resulted in increased awareness in the farming community in the private sector about the integrated watershed program. The farmers have learnt better methods of cultivation, improvement of pastures and afforestation of waste lands by raising nurseries on self-help basis. A number of micro-projects at the regional level are being implemented by various NGOs, e.g., the National Rural Support Program, Aga Khan Rural Support Program, Provincial Rural Support Program, Sarhad Rural Support Corporation, World Wide Funds and Margalla Hills Society, Islamabad, etc. The NGOs have considerably enhanced public awareness at grass root level through motivation, education and providing incentives through financial and commodity packages. However, a lot in this respect is yet to be achieved.

At present, the Tarbela and Mangla Watershed Management Projects are the major programs which are being implemented by the government and foreign donors. These projects for the last 40 years have been carrying out a number of watershed management activities like afforestation of bare and denuded lands, improvement of cultivated/range lands, slopes stabilization and construction of soil conservation structures for overall improvement in land use. These measures, besides increasing the life of reservoirs through reduction in sediment inflow, have substantially contributed towards improvement of the socio-economic condition of the people through increasing forest wealth, improved agricultural output and better environment. This has also created awareness on the part of farmers regarding environmental degradation. It is one of the major achievements of the watershed programs carried out under these projects.

WATERSHED POLICIES (1988)

Pakistan is confronted with the problems of degradation of watersheds, annual loss of 40 million mt of fertile soil due to erosion, siltation of Tarbela and Mangla reservoirs, reduced hydropower generation, devastation by floods causing an estimated loss exceeding Rs.2.5 billion per year, desertification, declining agricultural and livestock production, vanishing wildlife and biodiversity and increasing environmental pollution. Reduced supply of regulated water from the watershed areas

coupled with the inadequate ground water recharge is threatening the agricultural production and food security of Pakistan.

Sustainable integrated watershed management is required to reflect the emerging needs and aspirations of the people. As an instrument of evolutionary changes, policy interventions should keep pace with demographic trends and dynamic politico-socio-economic processes. These require an explicit policy for the forestry sector comprising forests, watersheds, rangelands, wildlife, and fragile ecosystems.

The revised forestry sector policy is in the line with the guiding principles adopted at the United Nations Conference on Environment and Development (UNCED) held at Rio de Janeiro in June 1992 and the national aspirations. In addition, it is based on national commitment made by Pakistan to implement various international conventions.

From the principles enunciated in the Rio declaration, the following eight policy imperatives emerged:

(l) Conservation : Conservation of ecosystems, soils, water, watersheds, safeguarding biodiversity (plant and animal genetic resources) and national heritage sites;

(2) Sustainability : Sustainable management of natural resources to ensure perpetuity of tangible and intangible benefits for the present and future generations;

(3) Basic needs : Ensuring the supply of goods and services, i.e., fuelwood, timber, fodder, non-wood products and recreation;

(4) Economic needs : Maximize domestic production to minimize reliance on imports;

(5) Participation : Managing the resource through active partnership with communities living around forests and other beneficiaries;

(6) Education : Awareness raising to conserve and develop the forestry sector resources and enhance capacity of professionals to meet the emerging challenges with appropriate technologies;

(7) Research : Strengthening technical and socio-economic research capabilities.

(8) Institutions : Strengthen existing institutions in natural resource management, encourage private sector participation in forestry and increase public and private sector collaboration.

RECOMMENDATIONS

1. For the improvement of watershed management programs, the implementation agencies must have qualified and trained expertise in various fields such as forestry, soil conservation, infrastructure development, range management, social mobilization and public relations.
2. All activities should be planned and executed in an integrated and coordinated manner keeping in view the existing land use and land capability classification of the watershed area.

3. Creation of public awareness plays a key role in the success of sustainable development of watershed programs which can be achieved through a comprehensive consultative process with all stakeholders right from the inception stage up to the completion of the program.
4. A Steering Committee comprising all the stakeholders, including the project executing agencies, administration, representatives of NGOs and community should be constituted on permanent footing to oversee and guide the implementation of the program and monitor/evaluate the impact for future feedback.
5. In order to achieve the envisaged benefits in the planned time, the provision of required funds well in time should be ensured by the Finance Managers.
6. An effective media campaign should be launched to increase public awareness regarding benefits of integrated watershed management program throughout the duration of the project.
7. An incentive plan for the local communities such as alternative fuel as substitute for wood, fodder for livestock, employment opportunities and other welfare activities should be made as an integral part of all watershed management programs to lure the support of local communities .

8. PHILIPPINES

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INTRODUCTION

The Philippines has a total land area of 30,000,000 ha of which around 50 percent is characterized as forest land. As of 1994, only 5,686,055 ha were stocked with forest trees (Forest Management Bureau, DENR, 1994). This is only half of what was existing 20 years earlier. To conserve and protect the forest, the old growth dipterocarp forest areas have been placed under the National Integrated Protected Areas System (NIPAS) since January 1992. Thus, logging in these places have been prohibited since then.

There are 125 proclaimed watershed forest reserves as of March 2001 (Table 1) covering a total of 1,499,334 ha. These watersheds provide valuable resources such as water, timber and land which are vital to society. Considering the worsening negative impacts of local and global phenomena such as the El Niño, La Niño, and global warming, the need for proper watershed management becomes more imperative than ever.

Ecologically, the forest gives invaluable environmental benefits by providing watersheds for the rivers, by serving as an effective protector of soils and regulator of water flows and carbon cycles, and by providing habitats for multitudes of animals and plant life.

Table 1. List of Proclaimed Watershed Forest Reserves (as of March 2001)

Region	No.	Area (ha)
CAR	6	113,008.98
Region 1	10	6,167.00
Region 2	5	119,261.00
Region 3	8	221,385.10
Region 4	35	107,399.54
Region 5	11	37,724.95
Region 6	9	131,777.00
Region 7	7	104,380.89
Region 8	9	30,599.24
Region 9	4	11,456.00
Region 10	4	114,970.00
Region 11	6	111,337.29
Region 12	2	169,271.83
Region 13	7	38,241.44
ARMM	2	182,354.00
Total	125	1,499,334.26

ROLE OF WATERSHED AREAS IN SOCIO-ECONOMIC DEVELOPMENT OF THE PHILIPPINES

The importance of watersheds in the socio-economic development of any country can never be over emphasized. Proper watershed management can lead to improved standard of living through the maintenance and enhancement of existing and development of new, sustainable livelihood opportunities for those individual households and communities whose welfare needs are met wholly, or in part, by the utilization of watershed resources.

Sustainable watershed management can provide an array of on-site and off-site economic, social and environmental benefits. These benefits are as follows:

a) Economic Benefits

In suitable areas and with the appropriate practices (including conservation and mitigation), the following ranges of economically valuable activities are currently being undertaken within the individual watersheds in the Philippines.

Forestry	- felling of natural forest trees for timber, poles and fuelwood; and - harvesting of minor forest products, e.g., rattan, vines, wild foods, etc.
Water Supply	- for domestic or industrial use from surface or ground water sources; - for irrigation of annual and perennial crops; and - used for hydroelectric and geothermal power production .
Agriculture	- annual crop production (dry land and rainfed/irrigated paddy); and - perennial crop production (fruit trees, coconut, rubber, coffee, etc.)
Livestock	- small-scale backyard production/stall feeding, e.g., pigs, poultry; - large scale intensive production of pigs and poultry; and - ranching/extensive grazing.
Fishery	- aquaculture in reservoirs and fish ponds; - fresh water fishing; and - coastal/in-shore fisheries, including exploitation of mangrove and coral reef resources.
Infrastructure	- protection of dams, weirs and irrigation structures; and - protection of roads, bridges, houses, factories, etc.

b) Social Services

The following indicate the range of social service functions that can be provided by the watersheds.

Tourism	- eco/cultural-tourism; - scenic landscape preservation; and - beach-based tourism.
Recreation	- mountain climbing,

- water sports; and
- wildlife watching .

Historical and Cultural
- protection of historical monuments;
- protection of indigenous cultures, beliefs and knowledge; and
- protection of areas of cultural importance (burial places, sacred sites, ancestral monuments, etc.).

Health
- control of water-borne diseases; and
- prevention of malnutrition.

Social Welfare
- livelihood security;
- social equity and poverty alleviation;
- reduction in risk of loss of life and property due to natural disasters; and
- regulation of rural-urban migration.

c) Environmental Services

The following indicate the range of environmental service functions that can also be provided through improved watershed management.

Biodiversity
- preservation of endangered flora and fauna species;
- preservation of ecosystems; and
- preservation of natural and agricultural gene pool.

Soil Conservation
- soil erosion control; and
- maintenance of soil fertility.

Water Conservation
- retention storage; and
- quality control.

Micro-climate Amelioration
- amelioration of temperature extremes;
- rainfall/humidity enhancement; and
- wind speed reduction.

STATUS OF INTEGRATED WATERSHED MANAGEMENT IN THE PHILIPPINES

Traditionally, the Department of Environment and Natural Resources (DENR) has been the primary government agency vested with jurisdiction and administrative control over the country's watersheds. Through the years, other government agencies have been given authority and administrative control over watersheds which support major power plants and irrigation structures. These agencies include the National Power Corporation, Philippine National Oil Commission and National Irrigation Administration.

In recent years, the management and administration of more watersheds have been translocated from DENR to other sectors. A number of watersheds are now under the control of local government units (LGU) in line with the Devolution Law mandating LGUs as comprehensive land use managers. By virtue of authority and responsibilities as provided for in the water code of the Philippines, some local water districts are also now vested with the jurisdiction and control over a number of

watersheds. In the passage of the Indigenous People's Rights Act (IPRA), the indigenous communities also became administrators of the country's watersheds within their domains. In the coming years, it is likely that more agencies, groups and even individuals can be authorized to control and regulate the use of watersheds in the country, all in accordance with the principle of participatory and collaborative watershed management.

Philippine watershed management is a process that involves the planning and implementation of both technical and policy initiatives to enable the natural and human resources of individual watersheds to contribute to one or more of the following development aims:

a. Improved standard of living for those households and communities whose welfare needs are met in part or wholly from the utilization of the watershed resources;
b. Improved maintenance, enhancement and protection of those important areas that are important for preservation of present biodiversity within the flora and fauna of the Philippines;
c. Improved care and management of the natural resources within the individual watershed areas; and
d. Improved rainwater management within the individual watershed areas so as to provide water of the quality and quantity required by the different water users within and downstream of the watershed.

The challenge for watershed management in the Philippines is to find ways in which the above aims can be met simultaneously. In a limited number of cases watershed management will call for total protection of areas (e.g., for biodiversity preservation or wildlife protection). However, for most in the Philippines the ultimate aim of any watershed management program is to promote the use of the natural resources (soil, vegetation, fauna, etc.) within a watershed for economically productive purposes, in ways that meet the requirements of those downstream for water and flood protection. This requires the development and adoption of improved forest, crop and/or livestock management practices that are not only productive but also conservation effective. Such practices will enable the users of the watershed's resources to increase tree, crop and/or livestock production in ways that would enhance and sustain, rather than degrade, their natural resource base.

ISSUES/CONSTRAINTS IN THE INTEGRATED WATERSHED MANAGEMENT IN THE PHILIPPINES

Many of the Philippine watersheds today are in varying state of degradation characterized by soil erosion, erratic streamflow, diminishing groundwater resource, loss of biodiversity, micro-climate deterioration, and declining land productivity. Watershed degradation in the Philippines is attributable to a wide range of physical and socio-economic factors but in reality is a complex, often localized issue.

This section discusses the causes of degradation in the Philippines and the solutions required to reverse the trend.

a) *Natural hazards* – the major natural hazards in the Philippines, i.e., the bio physical conditions which act as predisposing factors for watershed degradation are:
   - High rainfall causes flood, soil erosion and leaching causing decline in soil fertility;
   - Periodic El Niño and La Niño; and
   - Country's warm tropical climate which causes rapid decay and mineralization of soil organic matter.

b) *Direct causes of watershed degradation* - various types of human activity can also be identified as direct causes of watershed degradation.
   - Deforestation and removal of natural vegetation;
   - Over-exploitation of vegetation for domestic use and commercial sale;
   - Inappropriate agricultural practices;
   - Overgrazing;
   - Poor water resource management;
   - Unregulated land conversion; and
   - Industrial activities.

c) *Indirect causes of watershed degradation* - indirect causes of watershed degradation are the underlying reasons why inappropriate types of land use and management are practiced and usually relate to the socio-economic circumstances of the land users and/or the social, cultural, economic and policy environment in which they operate.
   - Population growth and movement into the uplands;
   - Population growth and developments in the lowland;
   - Land tenure;
   - Misconceptions about watershed management;
   - Poverty and economic disadvantage;
   - Lack of markets;
   - Inappropriate conservation technologies;
   - Lack of access to credit;
   - Limited institutional support services;
   - Conflicting institutional mandates; and
   - Under pricing of watershed resources.

Measures undertaken to address the above issues/constraints are anchored on the following guiding principles: holistic, integrated and multiple-use management and development of watersheds; multi-sectoral and inter-disciplinary planning; sustainable watershed management and development; participatory and equitable watershed management and development; and efficiency in resource utilization.

(a) Holistic, integrated and multiple-use management and development

A watershed is a complex natural system that easily responds to the alteration of any one of its components. To manage it sustainably it is, therefore, essential to treat all components with equal importance, and ensure that the integrity of the system and its biophysical as well as socio-economic processes are maintained. Thus, an

integrated approach is essential whereby, among other considerations, management strategies are chosen on the basis of its impacts on the entire system and not solely on a particular system components.

Multiple-use management is defined here as a paradigm of managing resources for the optimum and sustained production of various goods and services for the benefit of the greatest number of people. It is a relevant principle to watershed management because a watershed can be managed to produce many goods and services that are essential to society.

(b) Multi-sectoral and inter-disciplinary planning

Watershed management is multi-sectoral and an inter-disciplinary undertaking as it involves the planning, appraisal, implementation and monitoring of a wide range of development activities. This includes not only forestry and agriculture but, depending on the specific watershed, also fisheries, mining, water supplies (for irrigation, livestock and domestic use), energy generation and infrastructure development.

Successful watershed management should recognize the multi-dimensional nature of the task. Along with the biophysical dimension, the social, cultural, financial and economic dimensions must be considered.

Watershed management must also be in line with the priority goals of the individual households and communities that are either expected to adopt them or will be affected by them. For instance, at the community level, watershed management programs may call for cooperation among different social and ethnic groups. They may also have a direct or indirect impact on the activities of other local interest groups such as logging companies, traders and fishermen.

(c) Sustainable watershed management and development

Good watershed management requires the identification, development and dissemination of improved technologies and land management practices that are both productive and conservation effective. Thus, when the biophysical and socio-economic circumstances permit, improved watershed management should promote production-oriented land use enterprise (upland farming, grazing, orchards, etc.) managed in such a way as to provide sustainable economic benefits to the land user, not only for the present but also for future generations.

The Philippine Strategy for Watershed Resource Management has defined sustainable development by the following criteria:

- Ecological sustainability;
- Social and cultural sustainability;
- Economic sustainability;
- Institutional sustainability; and
- Political sustainability.

(d) Participatory and equitable watershed management and development

Sustainable participation of major stakeholders is essential due to the complex nature of a watershed and the magnitude of the tasks needed to be performed. The benefits derived from the watershed must be equitably shared among all stakeholders

who are willing to participate and invest in the management of the watershed resources. Some of the major stakeholders are the state, forest communities, local government units, water users and forest-based industry sector.

(e) Efficiency in resource utilization

The capital resources associated with watershed management are often scarce and socio-economically valuable. It is important to ensure that land, water, timber and other watershed resources are allocated and used efficiently. That is, environmental and economic benefits derived from resource use are maximized and the associated costs minimized. To attain this, it is necessary that all watershed resources are properly accounted for and appropriately priced.

LAND-USE CLASSIFICATION SYSTEMS PREVALENT IN WATERSHED AREAS

There has been no land-use classification system that is being specifically adopted for watershed areas. In the Philippines, lands with slope greater than 18 percent are classified (by law) as forest lands, and those with slope below 18 percent are considered alienable and disposable (allocated to non-forest uses). The main drawback of this slope-based system is the inadequate representation of the important biophysical features determining the productivity and sustainability of an area.

The general classification of land for multiple use has been adopted from the Bureau of Soils and Water Management as a way of classifying watersheds. This land evaluation employs an integration of environmental dimensions to identify and map pedo-ecological zones which represent the broad environmental management units composed of association of soils and their environment. The adoption of environmental dimension in the physical units allow the identification and selection of land uses and cropping systems which will be productively sustained over time without endangering the quality of the physical environment.

Certain criteria were also set to classify a particular watershed as either a ***priority*** or ***non-priority*** watershed. Guidelines were established for the prioritization of watersheds for improved management.

For a watershed area to be considered a national priority, the following criteria should be met:

1. Supports a national irrigation system;
2. Primary source of water supply for major urban centers;
3. Supports a large scale power generation facility;
4. Has resources other than water that contributes to a national economy;
5. Has a major contribution to the livelihood of a large number of rural households;
6. Possesses areas of cultural and/or historical importance, and bio-diversity; and
7. In a degraded state, it poses risk of damage to downstream areas.

At the local level, the following are the set criteria:

1. Source of water supply to local communities;

2. Supports communal irrigation systems;
3. Contains other resources that contributes to local community;
4. Has a contribution to the livelihood to local community;
5. Has cultural and/or historical importance or bio-diversity; and
6. In degraded state that pose risk of damage to downstream areas.

Other primary criteria are the biophysical, social and economic factors. There are also secondary criteria that include project/watershed management status, stakeholders' interest, etc.

At present, there is a so-called guideline table (Table 2) for watershed classification which focuses on the overall rating of the biophysical condition of the watershed. As indicated, the overall rating is being based on the sum of scores for: vegetative cover, soil degradation, water resource degradation, biodiversity, and conservation effectiveness of existing land uses.

Table 2. Overall Rating of Biophysical Condition of the Watershed

Rating	Indicators			Overall Score *	Percent
	State/Condition of Watershed	Priority in Managing the Watershed	Focus of Watershed Management		
Very high	Undegraded	Preserve the present condition	Protection and preservation	21-25	81-100
High	Good	Maintain and enhance the present condition	Protection and preservation, scope for some corrective actions	16-20	61-80
Moderate	Fair	Prevent further degradation and improve the present condition	Mixture of protection, prevention and corrective (rehabilitation) action	11-15	41-60
Low	Poor	Reverse the present degradation	Corrective (rehabilitation) action	6-10	21-40
Very low	Very poor	Degradation may be so severe as to have passed the point at which it can be rehabilitated.	Limited to closure; allows nature to take its course over a long period	5	20

* Based on the sum of the scores for: a) vegetative cover; b) soil degradation; c) water resource degradation; d) biodiversity; and e) conservation effectiveness of existing land uses.

ROLE OF GOVERNMENT AND PRIVATE SECTORS/NGOs IN SUSTAINABLE WATERSHED DEVELOPMENT IN THE COUNTRY

Practically all of the major programs on watershed management and development are spearheaded by the government both at the national and local levels. The role of the government in the sustainable watershed development of the country is given in the following aspects: policies, research and extension, appropriate technologies, decision support systems and information and education campaign (IEC).

a) ***Policy*** – The policies provide the general direction and legal framework for the management of watersheds which ensure that they are properly managed, protected and conserved for the present and future generations (various policies and legislation are given in the next section);

b) ***Research and extension*** – Comprehensive R & E are essential to the success of watershed management. Research is required to generate vital information for the development of sound policies and technologies. On the other hand, extension is needed to make the information and technologies accessible and available to the end users. Researches are done collaboratively with state universities and colleges while extension is coordinated with the local government units.

c) ***Technologies*** – The availability of environment-friendly technologies for watershed-resource utilization creates more opportunities for productive enterprises in the watershed management than what is possible with production-intensive technologies. The technologies must also be compatible with the culture, tradition and needs of the users.

d) ***Decision support systems*** – These are useful in watershed management facilitating data collection, analysis, reproduction, extension, organization, storage and other data management processes, and providing database and tools for policy and project formulation, evaluation, implementation and monitoring at all levels (biophysical database).

e) ***Information and education campaign*** – A tool used to elevate the awareness and appreciation for watershed management concepts, principles, and practices; and building up the technical capability of all sectors participating in watershed management (e.g., DENR, LGUs, NGOs, private entities, etc.).

*f) **Community-based Resource Management Projects (CBRMP)***

The CBRMPs are being pushed through by the government. The aim of the projects is to reduce rural poverty and environmental degradation through support for locally generated and implemented natural resource management projects.

An example is the Claveria Land Care Association (CLCA), a community-led initiative that came about in recognition of a need for farmers to work together in the development and dissemination of conservation farming practices. It is composed of over 1,000 members with 500-600 farmers having installed contour vegetative barriers as a soil conservation measure within their fields. The CLCA has 24 *barangay* level chapters and numerous sub-chapters. They are operating 28 community nurseries through volunteer efforts of their members and without any outside financial

support. The objectives of CLCA are to improve agricultural and agro-forestry production, diversity, and processing in a sustainable manner.

The role of NGOs, on the other hand, is focused in program design and implementation. NGOs local insights and links with local institutions offer many advantages. They are well versed in grass roots advocacy and with the right message could be very effective means of disseminating the principles and practice of productive and conservation effective multiple use watershed management. The original credit for the development and packaging of the sloping agricultural land technology (SALT), widely promoted in the Philippines is due to the Mindanao Baptist Rural Life Center in Davao del Sur. Much of the pioneering work with the development of participatory rural appraisal tools has been undertaken by a variety of NGOs active in the southern part of the Philippines. Aside from local NGOs, international NGOs like IIRR and World Neighbors, have been at the forefront of promoting alternative low cost soil and water conservation techniques in the Philippines.

BRIEF ACCOUNT OF THE GOVERNMENT POLICIES

The following is a list of current legislative acts and policies that are relevant to watershed management in the Philippines:

a. PD 705 (1975) - Provides for the adoption of the multiple-use and sustained yield concepts on forest management; defines critical watersheds in relation to downstream infrastructures and facilities; prohibits commercial logging and grazing operations within critical watersheds; and authorizes the President to proclaim portions of the public domain as forest and watershed reservation.
b. PD 1067 (1976) - The Water Code of the Philippines governs the ownership, appropriation, utilization, exploitation, development, conservation and protection of water resources.
c. PD 1515 (1978) - Vests the jurisdiction and control over watershed reservations to the Ministry of Energy.
d. LOI 845 (1979) - The Ministry of Energy is given the jurisdiction over all watershed areas and reservations.
e. LOI No. 917 (1979) - Declares certain areas, including critical watersheds and proclaimed watershed reservations as wilderness areas.
f. LOI No. 1002 (1979) - Vests the National Irrigation Administration (NIA) the authority to manage, develop and rehabilitate the watershed areas of Pantabangan and Magat Multi-purpose Dam Projects.
g. Proclamation No. 2149 (1981) - Declares certain areas, including watershed reserves as environmentally critical and within the scope of the EIS (Environmental Impact Statement) system.
h. EO No. 192 (1987) - Mandates the DENR as the primary government agency responsible for the management, conservation and development of the country's forest lands, including but not limited to watershed areas.
i. EO. No. 223 (1987) - Vests in the PNOC (Philipine National Oil Company) jurisdiction on the management of certain areas supporting hydropower and geothermal project.

j. EO 224 (1987) - Management of certain watershed area was transferred to the jurisdiction of National Power Corporation pursuant to the energy-generating program of the government.

k. EO 375 (October 15, 1996) - Provides for the creation of the Presidential Task Force on Water Resource Development and Management mandated to oversee and coordinate the adoption and implementation of water resources policies and programs.

l. National Integrated Protected Area System Act (NIPAS Act) or RA No. 7586, 1992) - Includes proclaimed watersheds forest reserves as initial components of the NIPAS.

m. Philippine Mining Act of 1995 (RA No. 7942) - Provides that proclaimed watershed reserves, old growth or virgin forests, wilderness areas, mossy forests and NIPAS areas, among others, are closed to mining applications. Mining contractors are also required to undertake environmental protection and enhancement programs to include among other things re-vegetation, watershed development and water conservation.

n. RA 8041 Water Crisis Act of 1995 - Directs the government to adopt urgent and effective measures to address national water crisis; provides for the identification and designation of critical watersheds where development undertakings are to be suspended.

o. RA 4850 (1966) - Amended by PD 813, creation of the Laguna Lake Development Authority as a corporate body to carry out the development of the Laguna Lake region.

p. Master Plan for Forestry Development (MPFD) - Provides for the integrated and holistic management of our watershed; proposes a set of strategies essential to watershed management in the country.

q. The Philippine Environment Code (PD 1152, 1996) - Prescribes management guidelines aimed to protect and improve the quality of Philippine water resources.

r. The Agriculture and Fisheries Modernization Act (RA 8435, 1997) - Prescribes that the Department of Agriculture will coordinate with the Department of Environment and Natural Resources concerning preservation and rehabilitation of watersheds to support irrigation systems; promotes development that is compatible with the preservation of the ecosystem in areas where agriculture and fisheries activities are carried out.

s. The Indigenous People's Rights Act (RA 8371, 1997) - Ascribes rights of the ICC/IPs (Indigenous Cultural Communities/Indigenous People) sustainable use, manage, protect, conserve land, water and other areas of economic value; ascribes the right to formulate and pursue their own plans for sustainable management and development of land and natural resources; provides that government adopts effective measures to implement laws that will preserve the quality of surface and ground water that may affect ancestral domains.

(PD - Presidential Decree; LOI - Letter of Instructions; RA - Republic Act)

9. SRI LANKA

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INTRODUCTION

Sri Lanka's total land are estimated at 6.27 million ha, about 51 percent of them are agricultural lands, which include all cultivated and sparsely used crops lands and home gardens. Sri Lanka is comprised of 103 river basins where all the agricultural lands are located. Most of the river basins have programs to harness thee water resources for development activities such as irrigation, hydropower generation, and drinking water supply.

The role of watersheds in the socio-economic development program can be discussed in the following points of view:

a. Use of watershed areas for agricultural production;
b. Use of run-off water or stream flow of watersheds for hydropower generation;
c. Use of river flow on irrigation of down stream areas for agricultural production; and
d. Use of river flow for drinking water supply.

Agricultural Production

Watershed areas help socio-economic development since such areas are used for various types of agricultural production. Our major agricultural products such as tea, rubber and spice crops come from those areas and benefit a large number of local population. The cultivation of such crops from exchange earnings and families involves in the production process as shown in Table 1.

Table 1. Cultivated Area and Foreign Exchange Earnings, Selected Crops Grown in Watershed Areas

Crop	Area (1000 ha)	Foreign exchange earnings (Rs. millions)	Gross National Product (percent)
Tea	195	43,728	2.4
Rubber	159	2,305	0.4
Coconut	439	9,119	2.9

Irrigation Water

Irrigation water is a significant contribution to the country's economy since large areas of agricultural lands are irrigated by diverted river flows and individual reservoirs. Of total 732,475 ha of paddy land, 327,748 ha are under major irrigated land. There are 176,380 ha of minor irrigated paddy land and considerable areas of irrigated other crop lands existing. Since the irrigation water comes from watersheds, it shows the importance of watersheds in the country's economy. Water availability for irrigation systems depend on the level of management of watersheds since soil erosion adversely affects irrigation systems. Therefore, watershed areas influence heavily the socio-economic development of the country.

Hydro Power Generation

A great portion of potential hydropower generation in Sri Lankan rivers are tapped now. The activity is very important for the economic development in the country. In 1999, an estimated total power generation of 3,382 NW was generated from existing potential power at 1,691 MW; hydro power, 1,143 NW; thermal power, 454 NW; and wind power, 3 MW.

Drinking Water

Drinking water for urban areas are obtained from streams or river flows which comes from watershed areas. Activities in the watershed area influence the flow rate of the streams specially during the dry season. Water is a limited resource that is controlled by watershed conditions. Therefore, the management of watershed is important to the drinking water supply in the down stream areas.

STATUS OF WATERSHED MANAGEMENT

As an agricultural country, Sri Lanka's prosperity is mainly dependent on optimal utilization of available land and water resources on sustainable basis. However, at present, shifting cultivation has increased at the expense of natural forest giving results to considerable rate of deforestation. Mountainous areas are extremely important for watershed management in Sri Lanka since these watersheds store bulk of country's water supply. Deterioration of the vegetation in these watersheds cause soil erosion, degradation of lands, siltation of reservoirs, decline in river flow during dry periods and promote the occurrence of flash floods and land slide during heavy rainy seasons.

Activities are conducted by various government organizations and by some NGOs to curb abuse of watersheds. Individual government departments have their own responsibilities on conservation, education and policy planning in watershed management. But they do not have integrated approach. However, at some places, there are projects that facilitate those organizations to work in an integrated manner. The responsibilities of various government departments with respect to watershed management are given below.

Ministry of Forestry and Environment (MFE) -- There were 2,147,000 ha of Sri Lanka's total land area covered by natural forest in 1999. There were 190,000 ha of forest plantations in the country. The role of the Ministry of Forestry and Environment

is to formulate policies relevant to forestry, management of forest reserves, development of forest resources and gathering data relevant to forest, including watershed management.

Department of Agriculture (DOA) -- The DOA is responsible for the modernization of farming systems, protected agronomic practice and soils and water management. Its major activity is the dissemination of technologies among farmers.

Department of Animal Production and Health (DAPH) -- The DAPH is responsible for the establishment of animal breeding centers, breeding better grasses and fodder varieties for animals, animal care and education and extension aspects of the animal care.

Department of Wildlife Conservation (DWLC) -- The DWLC's main responsibility is to make boundaries of wildlife sanctuaries and protect them.

Land Use Policy Planning Divisions (LUPPD) -- The LUPPD's responsibility is to prepare land use plans, map them and carry out land suitability assessments reports.

Survey Department (SD) -- The SD conducts surveys, mapping and boundary marking activities.

Mahaweli Authority of Sri Lanka (MASL) -- The Mahaweli Authority is responsible for direct watershed management in the upper Mahaweli areas. In addition, they monitor the hydrological situation and sediment transport in other rivers also.

Land Commissioner s Department (LCD) -- The Department's main responsibility is to regulate land tenure and land ownership.

Agrarian Service Department (ASD) -- The ASD regulates paddy land ownership and supply various kinds of services to farmers. In addition they set up farmer organizations and work on minor irrigation activities in the paddy fields.

Irrigation Department (ID) -- The ID undertakes operation and maintenance of irrigation and drainage systems in the paddy producing areas and monitor river flow and gather data on water situation.

Even though the country is small it has very complex management situation. The country consists of 8 provincial councils and the central government. Most of the above departments are attached to the central government and some activities are devolved to provincial councils. Administration decisions in the watershed areas may be taken in different levels such as national and provincial (district and divisional) levels. In the district level, there are forums such as district development committee and district agricultural committee, wherein all the department heads in the district meet and discuss relevant matters. The divisional levels also hold forums where divisional officers of the departments meet. Local problems and issues are discussed in those forums. But in general, they discuss the immediate problems and issues such as marketing, irrigation, water shortages and drinking water supply.

MAIN ISSUES IN INTEGRATED WATERSHED MANAGEMENT (IWM)

The national and provincial (districts and divisional) level bodies meet regularly to make decisions on issues affecting watershed management. There are monthly meetings at district levels where development issues are discussed. The main problem existing is that the subject of watershed management is not discussed at those

meetings. However, they discuss activities of bad watershed management, such as encroachment, illicit tree felling, etc. But they do not study the core problems of such happenings and so that convenient remedial measures are not given.

However, several projects are carried out on integrated watershed management covering part of the watershed areas of the island. The main issues are presented below:

Main Issues

a. There is no permanent organization in the watershed areas to carry out activities of the IWM..
b. Most of the existing management bodies (district and divisional secretariats) do not consider the IWM as an urgent issue.
c. Line agencies (government departments) have their own activities and targets to achieve, but do not bother to achieve integrated targets or activities outside the responsible area.
d. There are large numbers of institutions that deal directly or indirectly with the activities of watershed management in the national level. There are over 20 institutions that operate under four ministries which are directly related to watershed management. In addition, there are several other ministries, international agencies (IIMI) and some NGOs involved in soil conservation and watershed management activities. Some of the functions related to watershed management have been decentralized to the provincial level and the relevant Provincial Councils have the authority on such activities. Some of those pertain to irrigation, and agriculture, including extension, promotion and education.
e. Government departments and other services sectors do not provide assistance to the settlers who create problems in the watersheds. Some poor people create more problems. There is no such government organization or NGO to solve the real problems of poor farmers. They only provide patch solutions, so the core problems exist and land degradation continue.
f. Management boundaries of the district and divisions are not compatible with watershed boundaries so that the management decisions do not tally with real needs. The effect of activities in one area may adversely affect to another area where another management unit operates.
g. The poor economy of the country does not absorb excess people in the watershed area for alternative jobs, resulting in increase in land encroachment, inconvenient land use, and ending up to poor watershed conditions.

Measures undertaken to address issues

a. Several projects have been set up to carry out IWM activities in the central hilly country.
b. The Ministry of Forestry and Environment, Ministry of Agriculture and Ministry of Mahaweli Development are carrying out awareness program among officers and also farmers about the importance of watershed management, especially IWM. This will help to open minds of officers in the decision-making bodies of the district and divisional levels on IWM.

LAND USE CLASSIFICATION SYSTEMS IN WATERSHED AREAS

The land use classification in Sri Lanka was done considering the factors of soils, topology and climate. Soil maps show a wide variety of soils in the country. Immature brown soils are easily eroded, hence need special soil conservation measures. But most stable soils like red yellow podsolic and reddish brown latosolic soils occur on steep slopes, so they too are prone to high erosion. The 14 major soil groups in the country are distributed among 4 topographic classes: flat to undulating (0-8 percent slope); rolling to hilly (8-30 percent slope); hilly and mountainous (30-60 percent slope); and extremely steep (over 60 percent slope).

Wide variety of soils, climate and topography and susceptibility to erosion, land slide, or loss of fertility, make evaluation of land capabilities for various uses, exceedingly complex. The suitability of lands for major land uses in Sri Lanka has been assessed using generalized geographic information system. Data on soils, climate and topography have been analyzed to arrive at overall land suitability estimates for the entire country. These data can be used only to obtain an overall notion of land suitability for national scale planning. They indicate, however, that thousands of ha of agricultural lands are located on marginally suitable or unsuitable lands.

Land sustainability is given for each agro-ecological region in terms of suitability classes and sub-classes as defined according to the FAO framework for land cultivation. Four suitability classes were identified as: highly suitable; moderately suitable; marginally suitable; and not suitable.

Land suitability sub-classes are identified in terms of the dominant kind of limitations that reduce the productivity of land for a given use. With these information one can determine land suitability for any of the identified land utilization type for a given land unit. It also helps to identify areas where changes in land use or land management practices are necessary and provide information on planning new projects.

Land suitability is described in quantitative term using a scale of different suitability ratings. The technical suitability, however, does not necessarily imply socio-economic feasibility. In a recent study 18 potential land utilization types (LUTs) are identified specifying the inputs and level of management assumed for each. Optimal land quality specifications for each LUT is then defined. Finally, each land unit (30 land map units) in different agro-ecological regions are matched with land qualities of the mapping units and land quality requirement of the land utilization types. The land qualities considered were: moisture availability, oxygen availability, nutrient availability, resistance to erosion, dry period availability, solar radiation availability, land space availability, flooding hazard, temperature region, accessibility and forest hazard.

ROLE OF GOVERNMENT AND NGO IN SUSTAINABLE WATERSHED DEVELOPMENT

Sustainability of watershed depends on the activities of the people living in the area of the watershed. It is the government's duty to help people to use watershed in a sustainable manner. The role of the government in sustainable watershed development can be summarized as: generate knowledge and technologies; disseminate

technologies; mobilization of resources that help people to use appropriate technologies; prepare policies and regulations on the use of common and natural resources; integration and co-ordination of activities in the watershed areas; institutional building and conflict management; and collecting data for the users.

The private sector, including individual farmers in the watershed area are directly responsible for the condition and existence of a healthy watershed. Therefore, their responsibility is to work according to the guideline given by the government. The NGO sector also helps people to work on watershed development and they generally carry out the following activities: institutional building; dissemination of technology and create awareness; introduce women participatory programs; and resource mobilization.

Major Programs

a. Mahaweli Approach (MA)

The Mahaweli development program is a multipurpose water resources-based project. It is one of the largest development programs in Sri Lanka. The success of this programs depends on the flow of the Mahaweli River and the inflow rate to the reservoirs. Hence, the MA is concerned on the upper Mahaweli catchment in the aspect of hydrological situation of the watershed area. The MA has a special concern on increased flood flows, lower base flows, high sediment flows and pollution of water bodies. To carry out the required activities, the MA has established the upper Mahaweli environment and forest conservation division (EFCD) the objective of which is to promote the protection and scientific management of the catchment areas. The long-term goal of EFCD is to "integrate catchment conservation into all development activities in the upper Mabaweli catchment area".

The EFCD provides information, technologies and initial material inputs to the government agencies, NGO and private sector groups and individuals who operate in the area such that they are able to implement conservation measures successfully. In addition, the EFCD acts as mobilizer, co-ordinator and catalyst in all aspects of conservation.

b. Participation

Watershed management is based on participation. Staff members of EFCD carry out training programs with local people and other government agencies and private sector individuals on issues related to conservation of soil, water and vegetation. These training programs are designed to explore and utilize the self-help power of the people. The components of this activity are: educate people to identify issues on natural resource, which affect their lives; collective work on solutions; formulating system development plans through training; and making linkages with other similar activities.

c. **Conservation**

The team work on three aspects of conservation are on farm, off farm and forest. The objective is to identify, develop and adopt ecologically suitable, economically viable and socially acceptable conservation practices and to introduce them to land

users in the catchment area. This team carries out the following activities: identification, testing and adoption of ecologically viable land use system; establishment of demonstration models on collaboration with co-operating agencies and farmers; promotion on soil conservation measures; and data collection for the benefit of land users.

Sri Lanka-German Mahaweli Watershed Management Project (UMWP)

The objective of this project is to assist the MASL and other agencies in taking necessary actions to ensure ecologically acceptable management of the natural resources in the upper Mahaweli catchment area. The main activities are: identification, testing and adaptation of ecologically viable soil, water and forest conservation system and techniques; promotion of the same through participatory approach; awareness creation, training and mobilization of various land user groups, including school children; and co-ordination with co-operating agencies.

Sri Lankan-British Environmental Management and Sustained Development Project (ENDEV)

The objective of this project is to assist MASL with collection of accurate information for watershed management. With the results of this activities, problem area can be identified and solutions can be applied.

The main activities are: updating the upper catchment area at 1:10,000 land use and vegetation map; developing the land use planning case studies and promoting the use of maps among land users; further development of geographic information system and remote sensing capabilities for the upper catchment area; and monitoring the sediment transport in streams and sedimentation of reservoirs.

NATIONAL FORESTRY POLICY

The objective of the National Forestry Policy is to conserve forests for posterity, with particular regard to biodiversity, soils, water and historical, cultural, religious and aesthetic values. It emphasizes the need for safeguarding the remaining natural forests for posterity in order to conserve biodiversity, soil and water resources and the need for increasing the overall tree cover in the country.

REFERENCES

Alwis, Jayawardena and Dimantha, 1981. Land classification. Land Use Division of Irrigation Department, Sri Lanka.

Bandaratilaka, H. M., 1997. Status and policies on watershed management in Sri Lanka.

Dayananda Kariyawasam, 1996. The Social Dimension in Watershed Management Sri Lanka.

Jayasinghe, J., 1994. The formation of a forest policy in the context of national land use policies. Ministry of Lands, Sri Lanka.

Manthrithilaka, H., 1995. The Mahaweli approach in watershed management, Proceeding of the Workshop on Watershed Management, Sri Lanka.

Nimal Gunawardana, 1999. Basic concept of land and watershed management 11th Intensive EIA Training Workshop, 1999, Sri Lanka.

Nayakakorale, H. B., 1995. Activities related to watershed management in the Department of Agriculture, Sri Lanka.

10. THAILAND

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INTRODUCTION

Land use classification and watershed management are unseparated activities which play very significant role in watershed resource development and socio-economic development of the country, especially for those using agriculture and industry as a base for generating the national income. For the developing countries having abundant water resource such as Thailand, the forest, land and water resources as well as environment could be mutually constructively utilized in sustainable ways if land could be suitably used.

Watershed classification in Thailand is the macro-land-use planning project initiated in 1979 by the Royal Thai Government (RTG) which corresponds to the agreement made in Agenda 21 and that of the Worldwatch Institute statement. It was the initial step to conserve the watershed ecosystems of the country by the wise use of natural resources concept. This project used the land-use classification approach and thus anticipated a useful tool for watershed management to produce good quality water resources with appropriate utilization of land, water, mineral, forest and other natural resources.

This presentation describes the land-use classification for integrated watershed management development in Thailand. To do this, the watershed resource situation and characteristics of watershed classification and its land-use practices resolution were informed. A real watershed class distribution and forest as well as water resources in 25 main basins of the country were presented and discussed. The general overview of land-use classification is for the application of watershed resources to formulate a plan by linking it with the budget plan.

STATUS OF WATERSHED MANAGEMENT IN THAILAND

In 1982 the Cabinet approved the Office of Environmental Policy and Planning (OEPP) to be the lead agency to carry out a "watershed classification project" with technical assistance from Kasetsart University and financial support from IUCN. The result of watershed classification study for the entire country was endorsed by the Cabinet in 1995.

The land degradation, flood and drought increased the demand for water and flow timing in 25 main basins. The increasing population and irrigated farming were predicted in Table 1. Past national development efforts have been concentrated in agricultural production which is the highest source of income and still important until now.

Table 1. Prediction Average Run-off and Water Quantity Required, by Region and by Main Basin of Thailand up to Year 2010

Region	Drainage area (sq.km)	Average annual run-off (BCM)	Predicted population 2000	Predicted population 2010	Predicted water demand for all sectors (BCM) 2000	Predicted water demand for all sectors (BCM) 2010
Northern region	138,370	40.68	9,469,658	10,408,883	14.706	28.866
Northeastern region	166,680	37.18	21,456,018	24,131,509	11.843	23.296
Central region	55,291	9.45	16,690,244	18,448,766	37.947	73.145
Eastern region	36,438	21.12	4,564,047	5,263,281	7.325	13.854
Western region	43,185	16.60	3,337,760	3,693,820	7.043	13.855
Southern region	72,102	75.86	8,510,501	10,073,596	8.145	15.834
Country Total	512,066	200.89	64,028,228	72,019,855	87.009	168.850

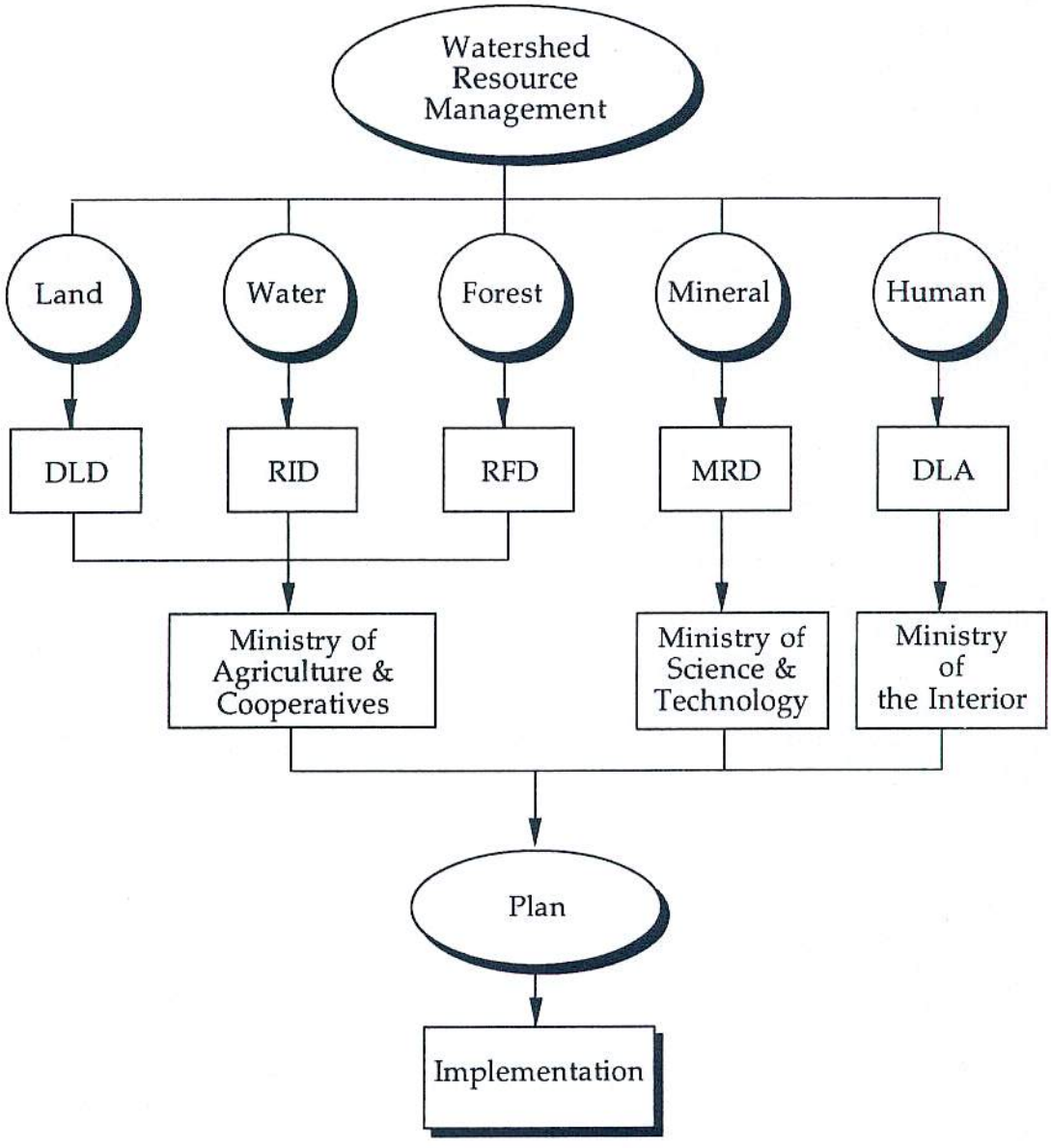
The present status of land use in Thailand is that the forest and paddy areas were reduced and that for the urban area increased showing that the situation of land use in Thailand is changing from agricultural to industrial.

The present status of land-use classification for the master plan of watershed management for the future is thus urgently needed. Besides planning for better water yield for downstream consumption, a reduction in flood damage and reservoir siltation, the improvement of people's quality of life by means of sustainable agricultural and forestry productivity with better environmental condition of country is anticipated. To concisely propose such a "Watershed Management Program" with the RTG, and relevant agencies, cooperating institutions, private sector and NGO, the aim should be planned in short, immediate and long terms so that watershed resources in this country could be sustainably managed for next generations.

ISSUES ON THE INTEGRATED WATERSHED MANAGEMENT

The issues on integrated watershed management can be summarized into two concerns: organizations and planning policy. The master plan went through a top-down planning. The conceptual framework at the time stated only organization and did not include people participation for watershed resources management (Figure 1). Also, there are too many executing agencies. The Watershed Classification Regulation was promulgated on the 8th Nation Economic Social Development Plan and focused the main aim on "Man" as the center for development. The conceptual framework that people should have the right to participate in natural resources was taken into the master plan formulation. The watershed classification scheme and its regulation was proposed as a base of land-use model. The comprehensive community-based land-use planning was designed and implemented by various agencies. Watershed network committees for resource planning and management in national, regional, main basin, sub-basin and community watershed levels were also recommended for establishment. Private sector and NGO representatives should have the right to participate as committee members. Bottom-up planning should be initiated at the community level and submit it to be integrated with the top-down planning of the government.

In 1996, the OEPP was commissioned to conduct a study on the critical watershed condition in Thailand. The project was carried out in cooperation with the Kasetsart University. Two main watersheds were selected: the Yom watershed covering an area about 22,000 sq km for seven provinces in the North and the Pong watershed covering an area about 15,600 sq km for seven provinces in the Northeast. As a result of the study, a model for critical watershed analysis was developed (V. Surin).



Legend: DLD = Department of Land Development
RID = Royal Irrigation Department
RFD = Royal Forest Department
MRD = Mineral Resource Department
DLA = Department of Local Administration

Figure 1. Organization of the Watershed Resource Management

LAND USE CLASSIFICATION SYSTEM IN WATERSHED AREAS

Five classes of watershed areas were agreed upon in order to develop land management plans for water resource, forest and agricultural crops.

1. **WSC1: Protected or conservation forest and headwater source** -- This class is divided into the sub-classes: WSC1A and WSC1B.
   a. The WSC1A represent protected forest areas and include the headwaters of rivers. The areas are usually at high elevations and have very steep slopes and should remain in permanent forest cover.
   b. The WSC1B are those areas which have similar physical and environmental features to WSC1A. However, portions of these areas have already been cleared for agricultural use. These areas may be followed or cultivated; they, therefore, require special soil conservation protection measures. Where possible, they should be replanted to forest or maintain in permanent agro-forestry.
2. **WSC2: Commercial forest** -- These areas are designed for protection and/or commercial forests where mining and logging will be allowed within legal boundaries, usually at high elevations with steep to very steep slopes. Landforms usually result in less erosion than WSC1. The areas may be used for grazing or crop production if accompanied by appropriate soil protection measures.
3. **WSC3: Fruit-tree plantation** -- These areas cover uplands with steep slopes and less erosive landforms. The areas may be used for commercial forest, grazing, fruit trees, or certain agricultural crops with need for soil conservation measures.
4. **WSC4: Upland farming** -- This class describes those areas of gentle sloping lands suitable for row crops, fruit trees and grazing with a moderate need for few soil conservation measures.
5. **WSC5: Lowland farming** -- These are gentle slopes or flat areas needed for paddy fields or other agricultural uses with few restrictions.

Method for Watershed Classification

The method developed for watershed classification herein utilizes a multivariate statistical analysis for establishing relationships between variables and watershed class number. It was developed for mapping watershed classes based on the best, currently available data for the variables; slope, elevation, land form, geology, soil and forest cover. The method requires the creation of data set with numerically scaled values for the mentioned variables with a known watershed class number given in 1 sq km with grid size of 1:50,000 topographic map. This data set was used to develop a prediction equation for an area. The combination of variables and prediction equation becomes a unique solution for a region. Workshops were employed as strategy to reach the agreement among concerned agencies on the variables and equation to be used, including mapping method and land-use practice criteria in each regional watershed.

ROLE OF GOVERNMENT AND PRIVATE SECTOR/NGOs IN SUSTAINABLE WATERSHED DEVELOPMENT

According to the environment degradation in the form of water shortage, flood and drought and sedimentation problems which would normally lead to silting up river channels in the downstream areas resulting in flooding is caused by mis-management of watershed resources.

The following analysis of watershed management situation is presented as the preliminary vision for the planning. The detail are as table follow.

Table 2. Watershed Management Situation

Level	Medium- and Long-Term Goal(s)	Alternative Option(s)
Policy	• Establishment of one National Economic, Social and Environmental Development Board (NESEDB).	• Maintenance of NESEDB and NEB advised by a large number of sub-committees.
Institutional	• Establishment of a National Watershed Management Agency. • Establishment of a comprehensive five-year planning system at all levels of government. • Decentralization of budgetary authority. • National Watershed Management Program launched.	• Maintenance of multiple planning procedures at national and provincial levels. • Centralized budgetary authority maintained. • Establishment of a Ministry of Natural Resources and Environment (MNRE).
Legislative	• Promulgation of Watershed Management Act with provisions for a public consultative process.	• Promulgation of a Comprehensive Water Resource Management Act. • Promulgation of the Draft of Water Resources Act.
Human Resource	• Professional expertise on watershed management strengthened at central, regional, provincial and local levels. • Participatory approaches to watershed management institutionalized. • Public awareness raised throughout the RTG and Thai civil society.	• Maintenance of expertise scattered in a number of RTG departments, universities and NGOs. • Establishment of a Thailand Watershed Development Institute.
Research	• Establishment of a Strategic National Watershed Management Research Program.	• Maintenance of research projects scattered in several different departments and universities.

Source: Institutional Support to MOSTE. 1997.

GOVERNMENT POLICIES FOR SUSTAINABLE WATERSHED DEVELOPMENT

Primarily, the resources have been misused which caused drought, flood and siltation. The government policies need to be transparent that can be easily examined. Both conservation and utilization of natural resources (soil, water, forest and mineral) need to go side by side. Human resources could express idea and use the local wisdom to solve the problems of water resource in order to maintain sustainable development for upstream and downstream. The priority of critical watershed ranging from 1-25 needs to be done in order to draw the plan and develop in the right direction.

SUMMARY AND CONCLUSION

In watershed management concept, land use classification is one of the most important factors for integrated natural resources such as water, land, forest and minerals with the human resources. Realizing these problems, the RTG initiated the watershed classification project with Cabinet regulation on land-use practices aimed at improving natural resources such as stream water quality and flow timing from upland watersheds.

REFERENCES

Anukularmpal, A. (1992). Policies for development of water resources. Paper presented in International Training Course on Natural Resource Management for Sustainable Development, organized by the Faculty of Environment and Resource Studies. Mahidol University, Salaya, Nakhon Pathom, Thailand.

Faculty of Laws (1996). Organization Structure for Natural Resources and Environment Administration in Watershed Area of Thailand. Final report submitted to Office of Environmental Policy and Planning, Ministry of Science Technology and Environmental. Thamasat University, Bangkok, Thailand. (in Thai)

MOSTE (1997). Concept Paper of Strategies and Institutional Arrangements for Natural Resources and Environmental Management in Watershed Areas in Thailand. Ministry of Science Technology and Environmental, Bangkok, Thailand.

Tangtham, N. (1996). Paper presented in International Seminar Workshop on Advances in Water Resource Management and Wastewater Treatment Technologies, 22-25 July 1996, on the occasion of 6th Anniversary Suranaree University of Technology.

Tangtham, N. (1998). Revised from the "Thai Forestry Sector Master Plan" Watershed Management subsector to submit to International Symposium on Comprehensive Watershed Management (ISWM-98), 7-10 September 1998, Beijing, China.

V. Surin (undated). Natural Resources and Environmental Management Coordination Division, Office of Environmental Policy and Planning, Bangkok, Thailand. (in Thai)

11. VIETNAM

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INTRODUCTION

Vietnam is located entirely in the tropical zone of the northern hemisphere and has a total land area of 331,689 km^2. The country is part of the southeast region and borders with the People's Republic of China from the North, with Laos and Cambodia from the West, and has a coastline with the East Sea (South China Sea) from the East and South. Vietnam has the shape of the letter "S", spreading from 8°33 to 23°23 of North latitude and from 102°10 to 109°26 of East longitude. Its territory is prolonged in the North-South direction with 3,260 km coastline. The highest mountain in the North is Fanxipan (3,143 m); the highest mountain in the South is Ngoc Linh (2,598 m).

In Vietnam there is a dense network of rivers and springs with plentiful water resources. In the country there are 2,360 rivers greater than 10 km in length. However, with regard to those rivers that formed relatively closed catchments, in the country are 106 catchment areas which ranges from 11 km^2 to 810,000 km^2. Rivers in Vietnam mainly are small, except nine river systems with basin area of greater than 10,000 km^2. The annual average volume of surface water is about 835,000 million cu m, of which 315,000 million cu m are found in Vietnam's territory.

CHARACTERISTICS OF VIETNAM S SOILS

Lying in the humid tropics with the monsoon regime, being impacted by both zonal and azonal factors, the soils of Vietnam have general characteristics as follows:

A. Vietnam soils consist mainly of groups and types (units) which are frequently found in the humid tropics and subtropics where the weathering intensity is strong. They could be classified under the 7th column of FAO-UNESCO's system, including Acrisols, Ferralsols, Plinthosols, Lixisols and Alisols.

   There is a large area of azonal soil groups, such as Fluvisols, Gleysols and Leptosols (FAO-UNESCO 1st column). Other soil groups occupy smaller areas but play specifically important roles such as Arenosols, Andosols, Luvisols, Histosols, Cambisols (scattered in 2nd, 3rd, 4th columns) that have formed the abundant and diversified features of the Vietnam soils.

   Soil groups that occupy large areas and play important roles in the development of agriculture are Fluvisols, Acrisols and Ferralsols. These three soil groups cover about 93 percent of the total land area, in which Fluvisols is 21.6 percent; Acrisols, 63.2 percent; and Ferralsols, 8.2 percent.

B. Soil groups and types that are influenced by zonal factors are almost steep soils:

soils with slope less than 15° occupy 9.2 percent, 15°-25° occupy 13 percent, >25° occupy 77.8 percent; slope affected by soil forming process in both horizontal and vertical directions. The movement of clay in depth is apparent when their micromorphology is observed and a clay coating along the soil crack in the soil profile is often found. These form the B Ferralitic horizon (in Ferralsols) and B Argic horizon (in Acrisols) which characterize humid tropical soils.

C. Soil groups and types that have zonal property, after a long period of evolution process, their original characteristics derived from parent rocks and weathering materials were transformed due to the humid tropical conditions and without proper protective measures: soils are acid and very acid; and low content of organic matter, high decomposition level, low humification rate, mostly organic matter exists as mobile form and weakly linked with sesquioxides. They have low CEC, low base saturation, accumulation of mobile Fe and Al. Phosphate is precipitated, especially in Ferralsols groups.

   Besides, the strongly eroded skeletal soil group (Leptosols) occupies nearly half a million ha which resulted from erosion process and formation of concrete and laterite. About one million ha of hard rocks are also found in Vietnam.

D. Within the deposited soil groups, the following groups largely exist: Fluvisols, Thionic Fluvisols and Salic Fluvisols, of which Fluvisols consist of 50 percent in area. However, the dynamics and transformation of soil properties and acreage of Thionic Fluvisols and Salic Fluvisols, their evolution made them owing to characteristics similar to that of Fluvisols.

   The fertility of Fluvisols is closely related to the nature of the river system, and those having the highest fertility are neutral and less acid soils of the Red River and Mekong systems. Nevertheless, the acid Fluvisols has a greater share. Their properties are commonly distinguished by their medium content of organic matter, medium to poor in total nitrogen content, poor in available potassium, and low in CEC and base saturation. These characteristics should be taken into consideration in order to increase yield and output of annual crops.

STATUS OF WATERSHED MANAGEMENT, ISSUES AND CONSTRAINTS

Vietnam is an agricultural country with approximately 80 percent of its population living in the countryside, of which 70 percent are engaged in agricultural pursuits.

Before 1988 Vietnam faced critical agricultural situations as the production of crops was low, hence, living standard of people was very low. In late 1980s, the government introduced a series of institutional and economic reforms and changes in agricultural policies. In the early 1990s, Vietnam embarked on a move from centrally planned to market economy. Total rice production increased from 18 million mt in 1986 to 27.5 million mt in 1995; 29.6 million mt in 1996 and 30 million mt in 1997. Vietnam is now self-sufficient in food and become one of the world's leading rice exporters. In 1999 Vietnam exported 4.5 million mt; in 2000, 3.4 million mt. Vietnam is a country of many watershed areas that play a vital supporting role in the socio-economic development by providing water for domestic use, food production, irrigation, hydropower, industries and other human needs. Since Vietnam has

gained its unity in 1975, all of watersheds have remained under government control as common property. During the last 25 years, in Vietnam many efforts in the field of water resources development and management were made by the state and the people. Some noticeable achievements were gained such as:

a. The Red River water resources planning has been set up for: flood control, water supply, drainage, waterway transportation and setting up documentations on the exploitation of the Red River main streamline. Thanks to this planning, many hydraulic works were built, especially hydropower plant Hoa Binh.
b. Water resources use for the development of zone planning in the central part of the country, Southern East part of the Mekong River delta. Many reservoirs were constructed in many places of the country.

Between 1995 and 2000 Vietnam started industrialization, modernization, rural development moves which strongly influenced planning for water resources development. The problems of water use, water resources pollution, the fight against the rapid exhaustion of water resources caused the government to set up water resources development strategy, and to establish planning for integrated water resources use and conservation.

The Vietnam law on water resources, approved in 1998, concerned not only policy-makers but also experts in soil and water management. During the last five years, many considerable achievements were obtained in water resources development and watershed management. All of the small and average grade levels of watersheds have been based on planning designs proposed by the Vietnam Institute of Water Resources Planning. Many of irrigation and drainage systems have been improved and upgraded. Vietnam already has irrigators' organizations which can provide a good framework for irrigation development and improving operation and maintenance of irrigation system and flood control.

The main concept in irrigation development in Vietnam is "investment share between the State and the people". The main policies in the operation and maintenance management are "collection water fees from beneficiaries to cover operation and maintenance expenditures and irrigation management transfer from State-operated company to farmers-based organization".

For major irrigation systems which cover more than 500 ha each, the government shoulders 60-70 percent of the construction cost and the farmers shoulder 30-40 percent by way of contribution of labor in system's canal and on-farm canal development.

For minor irrigation system, which covers less than 500 ha each, the government supplies pumps or building materials such as cement and steel equivalent to 20-30 percent of the total construction cost. The balance is funded by farmers. Many irrigation systems which cover 100-200 ha each in the deltas are funded by farmers (agriculture co-operatives) 100 percent of the construction cost. Small irrigation systems in remote mountainous areas are funded by the government 200 percent of total construction cost.

Vietnam has plentiful rainfall with an annual average of about 1800-2000 mm. In addition, three-fourths of the total natural area is steep land. On one hand, these natural conditions have resulted in the loss of topsoil by sheet erosion/surface wash and

"terrain deformation" by gully and/or hill erosion or mass movement, trend in the amount of soil removed by water. On the other hand, they have caused sedimentation of reservoirs/waterways, flooding and pollution of water bodies with eroded sediments.

It can be stated that in Vietnam human activities in many cases strongly aggravated the disadvantages of the soil fertility. The most pronounced constraints to be addressed in plant nutrient management, are interalia, soil organic depletion, low CEC, phosphorus fixation, erosion, run-off and leaching. To a lesser extent, physical properties and micro-elements are also problematic. The main practices proposed for integrated nutrient management are: to create a stable soil body with high carrying capacity, address phosphorus fixation, exploitation of biological sources of potassium, appropriate liming, diversification of farming systems, supply of multicomponent fertilizers and the right use of fertilizers.

In view of Vietnam's very long coastline, salinity intrusion has impacted on coastal areas. The characteristics of salinity intrusion into estuaries of the Red River System have been studied based on many year's of measuring the data of salinity concentration at stations along the estuaries. It was found that in the dry season, the salinity intrusion length is as long as 20 km in the main river and more than 20 km for some tributaries. In the main river and tributaries with high freshwater discharge, the maximum salinity concentration is observed in January while for the tributaries with low freshwater discharge, the maximum salinity concentration is observed in March.

Seawater intrusion and acid production from acid sulfate soils during dry seasons, and the export of acid through drainage systems during the wet season, are major constraints to agricultural and aquatic production in Vietnam's lower Mekong Delta. The massive freshwater flows which inundate much of the Mekong Delta during the wet season nourish the Delta's highly productive and essential rice crops. During the dry season, the Mekong River flows are so low that sea water intrudes into the lower reaches of the River, producing brackish water conditions that are unsuitable for rice growth. At present approximately 2 million ha of land are subject to dry season salinity with saline water extending 50 km inland. Increasing diversions of upstream Mekong flows for dry season irrigation, both in Vietnam and in countries upstream, threaten to exacerbate saltwater intrusion into productive lands. To limit saltwater intrusion into agricultural areas, saline water intrusion floodgates have been installed or are planned for much of the lower Mekong River.

The unleveled terrain has caused water logging in places where there is contradiction between the terrain's low elevation and sea or river high level during wet season. Water logging usually occurs in wet season in both the Red River delta and Mekong River delta.

LAND USE CLASSIFICATION SYSTEMS PREVALENT IN WATERSHED AREAS

In Vietnam there are some prevalent land use classification systems which can be briefly described as follows:

a. Land use classification has been carried out in accordance with administrative

units such as the district or province. In this type of land use classification, the total area of the administrative unit is classified as follows: agricultural land - irrigated land, water logging land, land for rice, for subsidiary crops, annual industrial crops, perennial crops and grass land; land for forest; water surface for aquaculture; pastoral land; land for transportation use; urban land; and other land.

b. Land use classification has been carried out in accordance with sustainable development point of view. In this type of land use classification, the total land is classified as follows:
   - Land used for 2-3 rice crop/season: 51 soil units in which mainly Fluvisols, Gleysols, Arenosols are soil groups.
   - Land used for rice and subsidiary: 59 soil units with areas of 409,622 ha, also distributed mainly on soil groups such as Fluvisols, Gleysols, Arenosols.
   - Land used for perennial crops/trees consists of 62 soil units with 1.2 million ha. On these soil units grow tea, coffee and rubber.
   - Land used for fruit trees consists of 30 soil units with area of 187,000 ha, distributed on soil groups as Fluvisols, Thionic Fluvisols, Acrisols, Ferralsols.

Water Resources Development

Since May 1975, when the policy of agricultural extension service was aimed at increasing food production, the systems of canals were quickly developed. From the 1980s, a series of water resources development projects of the government have been carried out in several areas of the country.

ROLE OF GOVERNMENT AND PRIVATE SECTOR IN SUSTAINABLE WATERSHED DEVELOPMENT

Vietnam obtained its independence in 1945. But just from 1954, North Vietnam started socio-economic development. From its founding to date, all of the watersheds in Vietnam have been controlled by the government as common property. Land fund was managed by the State through three levels: agricultural cooperative, district and province. During the last five decades, institutional arrangements for watershed management at all levels were periodically modified. From 1954 to 1975, North Vietnam was at war. During that period, food production was of primary importance. Most of the arable lands were used for agriculture purpose. During the period 1960 to 1988 when agriculture cooperatives were active, land use ....

.....(incomplete)

GOVERNMENT POLICIES FOR SUSTAINABLE WATERSHED DEVELOPMENT

Since 1945, the Vietnamese government has tried the best to sustainably develop the national natural resources. Many significant policies were issued and implemented. Recently, some important policies have been issued and implemented:

a. Renovation of agricultural economics management—an important landmark.
b. Transfer of forest and agriculture land to farmers for long-term use. Farmers have the right to exchange, to rent, to inherit, or mortgage land.

The laws on water resources in addition to the law on land resources are the beginning on issues of policies and documents based on the following principles:

a. Water is natural resource and common property under control of the government;
b. Human right on water use differs from other rights of ownership;
c. The right of water use is controlled and managed by the government;
d. The judicial defense for the present and future water users must be agreed upon with factors related to environment protection;
e. The State has the right to supervise water use in areas threatened by water pollution or exceed exploitation of water.

REFERENCES

Berthold Schrempp (1995). Policies and Programs of the Watershed Management/ Forestry Sector of the Mekong Secretariat. Report in Seminar on Land Use and Water Resources Planning for Tropical River Systems: Strategies and Experiences.

Ian White, Mike Melville and Jes Sammut (1996). Possible Impacts of Salinewater Intrusion Floodgates in Vietnam's Lower Mekong Delta. Report in Seminar on Environment and Development in Vietnam.

Le Van Hoc (2001). Water management on the river basin and organization patterns. *Agriculture and Rural Development Review* (No. 3, 2001).

Nguyen Tu Xiem (1999). Soil fertility features and integrated plant nutrient management in Vietnam. *Vietnam Soil Science Journal* No. 12 1999.

Nguyen Trong Sinh (1997). National Program of Science and Technology "Balance, Protection and Effective Utilization of National Water Resources" named KC12. *Water Resources Bulletin*, No. 314.

Phan Sy Ky (1997). Development of agriculture, forestry and hydraulic works in the Dong Thap Muoi region over ten years. *Water Resources Bulletin*, No. 318, 319.

To Trung Nghia (2001). Flood management and control in the region and Vietnam. *Agriculture and Rural Development Review* (No. 3, 2001).

To Trung Nghia, Le Phuong Van (2001). Some achievements in water resources planning and development. *Agriculture and Rural Development Review* (No. 3, 2001).

Tran Khai, Le Thai Bat (1999). The existing soil environment of Vietnam by the year 1999. *Vietnam Soil Science Journal*, No. 12, 1999.

Vietnam Soil Science Society (1996). Explanatory note of the Vietnam soil map at scale 1/1,000,000.

Vu Thanh Ca (1996). Salinity intrusion in the Red River Delta. Report in Seminar on Environment and Development in Vietnam.

Vu Trung Tang, Nguyen Xuan Huan, Vu Ngoc Thanh (1993). Bac Bo Delta Estuarine Area.

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	Pakistan	Mr. Rashid Ali
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	Thailand	Mr. Kosit Lorsirirat
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	Philippines	Dr. Wilfredo Cabezon
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2. PROGRAM OF ACTIVITIES

(23 - 27 April 2001, Rep. of Korea)

Date/Time	*Activity*
April 23 (Mon.)	
Forenoon	Registration Opening Session Resource Presentation I: *Participatory Management Systems for Sustainable Watershed Development* by Dr. Friz Penning de Vries
Afternoon	Resource Presentation II: *Sustainable Watershed Management System and Water Quality Control in the Rep. of Korea* by Dr. Sang Eun Lee Country Paper Presentation I Welcome Dinner hosted by APO
April 24 (Tues.)	
Forenoon	Resource Presentation III: *Scientific Basis for Integrated Watershed Management – A Landscape Ecological Approach* by Dr. Hojeong Kang Country Paper Presentation II
Afternoon	Field Visit: Rural Research Institute, Korea Agriculture and Rural Infrastructure Corporation
April 25 (Wed.)	
Forenoon	Resource Presentation IV: *Participatory Research on Catchment Management: The IBSRAM Experience in Asia* by Dr. Friz Penning de Vries Resource Presentation V: *Run-off Characteristics by Moving Storm in Watersheds* by Dr. Gye Woon Choi
Afternoon	Country Paper Presentation III
April 26 (Thurs.)	
Forenoon	Field Visit: Water Resource and Environmental Research Division, Korea Institute of Construction Technology
Afternoon	City Tour Farewell Dinner hosted by KPC
April 27 (Fri.)	
Forenoon	Distribution of 'Seminar Highlights' for Group Discussion Syndicate Discussion
Afternoon	Syndicate Discussion Outcome Presentation by Group Summing-up by the Resource Speaker Closing Session