

REVIEW ARTICLE

STATUS OF WATERSHED AND NEED OF INTEGRATED APPROACH FOR SUSTAINABLE WATER RESOURCES MANAGEMENT IN NEPAL

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ABSTRACT

Watersheds are acknowledged as a paramount form of green substructure that provides us with important services like; drinking water, irrigation water, fodder/forage, pebbles/boulders, and timber including recreational, regulating, and other available services. The hills and mountains of Nepal are the watershed areas with the most fragile ecosystem and poor agricultural potential, as more than 15% of the total population of the country and 13% of the total land area is covered by Chure that has fragile ranges of hills. Hence, it can't be denied from the fact that many of Nepal's watersheds are in a state of physical and biological deterioration where landslides, soil erosion, floods, biodiversity loss, unsustainable water extraction, and farming practices are among the major issues leading towards watershed degradation. Therefore, proper strategies like developing stream and rainwater harvesting programs, strict implementation of EIA, IEE, adoption of SALT technology for income generation, etc. needs to be prioritized based on the principles of integrated watershed management while planning, monitoring & implementing soil and watershed management.

KEYWORDS

Watershed profile, Integrated approach, Watershed management, Strategies.

1. INTRODUCTION

Watersheds are increasingly recognized as an indispensable form of green infrastructure that provides a flow of economic benefits such as water filtration and storage, drinking water, irrigation water, recreation, soil formation, food, and timber, etc. (World Bank Group, 2019a). The UN conference on the water at Mar del Plata, Argentina in 1977, broadly termed "watershed as any surface area from which runoff resulting from rainfall is collected and drained through a common point" which is synonymous with a drainage basin or catchment area. Also, it's a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean. According to the DSCWM, "Watershed condition is an estimated index representing the current state of soil erosion in an area in comparison with that under natural or "well managed" condition".

Nepal's terrain is dissected by many rivers and streams to form a complex of watersheds operated by natural and human-induced processes. It varies greatly in size, from large basins to micro-watersheds. For Nepal, 5 to 25 km² sub-basin areas have been suggested as the size range of a sub-watershed (Achet, 1998). They have different characteristics because their rivers and streams originate from different physiographic regions. However, many of Nepal's watersheds are in a state of physical and biological deterioration resulting from overexploitation of watershed resources by their inhabitants. According to research findings, it is reported that about 10% of Nepal's area was covered with "much

degraded" watersheds, 19% to be marginally degraded while only 33 percent of the country was under "very good condition" watersheds (Singh and Kharel, 2004). Landslides, soil erosion, floods, biodiversity loss, and unsustainable water extraction and farming practices are among the major issues leading towards watershed degradation (Poudel, 2005a). In mountainous countries like Nepal, watershed management can contribute to important development goals and increase resilience to climate change. Hence, restoration and improvement of watersheds are crucial for the betterment of the national economy and the environment (DSCWM, 1998).

The main objective of this review is to shed light on the watershed management concepts, status, and techniques, identify constraints to the implementation and development of those techniques and prioritize conservation, use, and sustainable management of watershed resources to meet the demands of growing populations. Since watershed territorial units cover a large part of the world's land area, it is important to drive our attention to its management for its improvement on environmental quality and food security. Hence, participatory integrated watershed management has become the most accepted approach to managing watersheds.

2. MATERIALS AND METHODS

This study is based on the secondary information collected by reviewing various journal articles, proceedings, books. Pieces of literature were collected from different journals, articles, government institutions, and other relevant reports.

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3. RESULTS AND DISCUSSION

3.1 Watersheds Profile

According to a survey report, a total of 690 watershed polygons were generated over Nepal (DoFRS, 2017). The watershed boundary is not expected to follow the administrative boundaries like the new local levels but often the watersheds are shared between as well as among many local levels. Multiple counting while associating watersheds to administrative boundaries is still an issue. Therefore, one way to present this information would be to identify the watersheds with major proportions of the area under a certain local level.

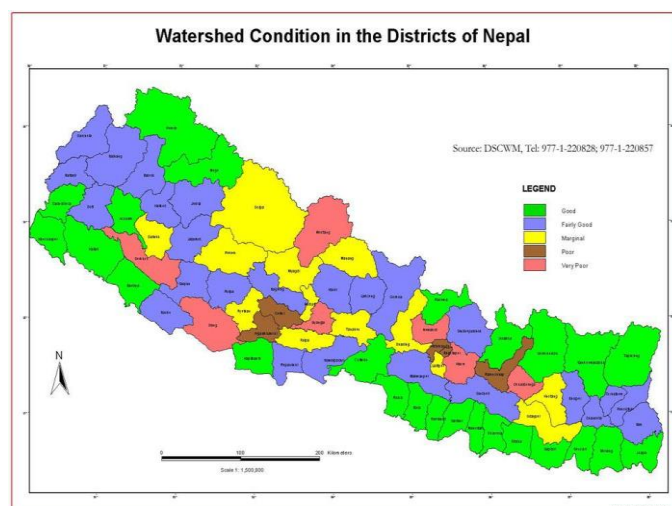
Table 1: Total number of watersheds and their area by provinces		
Province	Total watersheds	Square of area (sq km)
Province 1	127	26417
Province 2	50	9381
Province 3	91	20476
Province 4	88	22292
Province 5	93	18616
Province 6	144	30503
Province 7	97	19497
Total	690	147181

Source: Department of Forest Research and Survey, 2017

The total watersheds in each of the provinces differ and they range from 50 in Province-2 to the highest 144 in Province-6. This data provides information on the number and size of watersheds that are within reach of the local levels which can be an important input for watershed management planning.

3.2 Watershed Conditions in the districts of Nepal

The total annual flow of Nepal's rivers is roughly estimated at between 150 billion and 200 billion m³ (Gupta, 1975a) where the surface outflow runs through the four major river basins Mahakali, Karnali, Gandaki, and Koshi. The Siwalik, Chure is a very fragile range of hills in Nepal spreading from east to west between the Terai and the Inner-Terai is prone to erosion and subjected to rapid deterioration which comprises mainly sand, gravel, pebbles, and a conglomerate of sand and limestone and covers 13% of the total land area and more than 15% of the total population of the country (SAWTEE, 2016). The hills and mountains of Nepal are the watershed areas with the most fragile ecosystem and poor agricultural potential because of their steep slopes, fragile mountain geology, and poor soil profile. (Blaikie and Brookfield, 1987; Carson, 1992; Thapa and Weber, 1993a; Pandit and Thapa, 2004) figured out the problems such as land degradation, forest depletion, air pollution, poor water management, and food security in the country to be associated with watershed problems. These problems are further amplified by the improper management of upstream areas, where the government's effort is limited (Thapa and Weber, 1993b; Wagle and Bogati, 1999). Therefore, revealing people's encroachment upon, and destruction of, forests and pasture for commercial crop cultivation as the major cause.



Source: DSCWM

3.3 Major Problems in Watersheds of Nepal

3.3.1 Kali Gandaki watershed

The Kaligandaki watershed covers an area of 7600 km square comprising sub-watersheds from Mustang, Upper Kaligandaki, Myagdi Khola, Middle Kali Gandaki, Modi Khola, and Lower Kaligandaki. The major issue found in this watershed is that some of the parts are glaciated and glacial erosion cannot be even controlled by watershed management (World Bank Group, 2019b). Sedimentation has also been found to be another problem over here. Sheet erosion is the dominant process on the slopes of the lower watershed (Chalise and Khanal, 1997). Very low precipitation limits sedimentation mobilization on these slopes and soil erosion are typically confined to areas disturbed by human activities, e.g., cattle grazing (Fort et al., 2010). There is strong evidence that landslides are most prevalent along the southern slopes of the Annapurna and Dhaulagiri and in the Kali Gandaki Gorges in the upper Kali Gandaki watershed (Struck et al., 2015).

3.3.2 Lower Karnali watershed

The lower Karnali watershed stretches across parts of 10 municipalities in Bardiya, Kailali, Surkhet districts, comprising a protected area- Bardiya National park (USAID PAANI Program, 2019a) This watershed is a major source of drinking water for the inhabitants. According to PAANI's 2017 survey, water scarcity is an enduring concern in the watershed. Of 56% who reported that their water sources have been drying, 83% of the people faced difficulties in obtaining water due to drying water sources. Priority issues in the Lower Karnali watershed are drought, gravel mining, floods and inundation, degradation of aquatic habitats, and maintenance of traditional livelihoods. Similarly, increased human activity combined with climate change impacts is intensifying environmental degradation in many parts of the Lower Karnali watershed.

3.3.3 Lower Mahakali watershed

The Lower Mahakali watershed is located within the Kanchanpur district of southwestern Nepal and borders India to the west and south. The Mahakali River, Tilkeni Khola, and Jogbuda Nadi are the major water bodies of this particular watershed. Based on a series of community consultations, stakeholders, and literature reviews in late 2016 and early 2017, the priority issues of the watershed were found to be flood-creating inundations, river cutting, landslides, riverbed mining, a decline in fish stocks, unsustainable fishing practices.

3.3.4 Tila Karnali watershed

Tila Karnali watershed sits in the Karnali basin of Nepal in the northwestern part of the country and extends across Kalikot and Jumla districts. Hydropower is a rising concern in the watershed, as commercial interests seek to utilize the high flow rates of the steep rivers. Drought and drying water sources, forest degradation and wildlife poaching, ineffective solid waste management, declining fish numbers were observed as the priority issues in these watersheds as per multi-stakeholder workshop, household surveys, and field observations (USAID PAANI Program, 2019b).

Studies from eight micro-watersheds in Khageri Khola revealed 56 water sources as sub-watershed in Chitwan that were found decreasing with moderate (43%) to insufficient (32%) amount of water available for drinking where tap water and tube wells collectively fulfilled the water demand to 43% and 38% respectively (Shrestha and Manandhar, 2020).

The annual sediment measured at Tribeni in the Tamur, Sunkoshi, and Arun rivers were equivalent to losses of 61, 27, and 12 m³ ha⁻¹ in the watershed areas, respectively (Gupta, 1975b). Likewise, sedimentation survey of the Kulekhani Reservoir indicated that the average sediment contribution between the times it was dammed in 1982 to March 1993 was equivalent to a loss of 42 m³ ha⁻¹ per yr. across the 125 sq. km watershed where this rate increased to 415 m³ ha⁻¹ during the disastrous 1993 monsoon (Sthapit, 1996a).

Also, (Sthapit, 1996b) showed that the high rate of sediment contribution from the watershed to the Kulekhani reservoir under the extreme rainfall conditions in 1993 was mainly from slope failures and stream-bank cutting, rather than from surface erosion from agricultural land. The highest soil loss event observed in rainfed agricultural land was 25.96 t ha⁻¹ in the Jhikhu Khola during the premonsoon period (ICIMOD, 2007).

Similarly, 63 percent of turbidity in the Ghatte Khola watershed was solely explained by rainfall in the monsoon period (Winsnes, 2013).

(Schmidt et al.,1993a) their study found forest soil fertility in the highly populated Dhulikhel Watershed to be poor where total N, organic C levels, and 76% of the sites having available P levels were recorded below the critical range. Likewise, not only natural and environmental factors are having adverse impacts on watersheds but socioeconomic factors like migration are also among the major contributing factors.

The complex and interrelated effects of migration in the Harpan Watershed of Western Nepal was observed where the abandonment of 36% of the terraced cropland in the upper part of the watershed was due to shortage of labor, reducing the number of crops, and increasing vulnerability to natural disasters (Jaquet, et al., 2016).

Therefore, various studies indicate that the major sources of sediment are gully erosion, landslides, stream bank cutting, and sediment-laden flow. Conservation and management measures such as tree plantation, solar planning (solar power for water pumping system) for wildlife, construction of water tanks, and bamboo plantation have been adopted.

3.4 Review of Ongoing Watershed Management Strategies

The first watershed management program was initiated by the Department of Forestry during the mid-1960 with the assistance of FAO/UNDP (Upadhyay, 1985). It was a pilot project and implemented for a major watershed (Trisuli Watershed) covering three districts. However, the integrated approach didn't sustain longer. Hence, in August 1974, His Majesty's Government of Nepal initiated an independent department called the Soil and Water Conservation Department (renamed Department of Soil Conservation and Watershed Management (DSCWM) in 1978) under the Ministry of Forest and Soil Conservation. Since its establishment, the DSCWM has been planning, monitoring & implementing soil and watershed management activities based on the principles of integrated watershed management by piloting a program in four selected watersheds and river training activities at priority sites, and gradually expanded with the establishment of District Soil Conservation Offices (DSCOs).

In Nepal, watershed management is covered in seven pieces of legislation: Soil and Watershed Conservation Act, 1982; Land Act, 1964; National Parks and Wildlife Conservation Act, 1973; Environmental Protection Act, 1996; Forest Act, 1993; Water Resource Act, 1992; and Local Self-Governance Act, 1999 (Poudel, 2005b).

Table 2: Some projects carried out under watershed management

Project title	Supporting/participating agencies	Project objectives	Expected Impacts and outcomes
1. Watershed management projects			
Bagmati Watershed Project	HPCIDBC, DSCWM, MOUD WECS, DOI	To increased water security in the basin To increase water availability in the basin during the dry season and watershed conservation	Installation of rainwater in 2500 households harvesting to provide 45,000 m ³ of safe drinking water and recharge 135,000m ³ groundwater (BRBIP, 2017).
Phewa Lake watershed project	UNDP, FAO, DSCWM as lead agency	To control erosion and promote reforestation reduce sedimentation rate.	Sediment removal the program, Participatory approach, phased development and implementation (JICA, 2002)
Likewise, the Tinau watershed Project and Resource Conservation & Utilization Project were also carried out under watershed management projects.			
2. Integrated rural development projects			
Sagarmatha Integrated Rural Dev. Project (1979-1987)	Ministry of Panchayat and Local Development (MPLD) as leading agency	Establishing a clean drinking water supply and ensuring water and soil conservation.	Addressed the root causes of poor agricultural productivity in the area and worked to improve incomes and living standards for the poor.
Integrated Hill Dev. Project (1976-1983)		improve living conditions counteracting overexploitation of natural resources such as forests, land And water with a multi-sectoral approach.	Farmers' extension service (Tuki system), Forestry, erosion prevention, Water utilization and energy, Vegetable and fruit Cultivation.
Koshi Hill Area Rural Development Program (1980-1985) (KHARDEP)		DA, DF, DLDAH, Dept. of Irrigation & ADB/N, etc.	To strengthen local services and balance economic, social, development of the Koshi hill area to gain maximum benefit from Dharan Dhankuta road.
Likewise, Rasuwa-Nuwakot IRD, Rapti, Karnali-Bheri, Mahakali IRD projects were also included (ICIMOD, 1985)			
3. Sectoral development projects			
Community Forestry Project	Department of Forests as line agency, IDA/UNDP/FAO/HMG	To address the twin goals of forest conservation and Poverty reduction.	Protection-oriented, conservation-focused agenda and broad-based strategy for forest use, enterprise, and livelihood development.
Hill Forestry Project	Department of Forests as line agency ADB/Finland/HMG	To combat poverty in the mid-hills regions of Nepal.	environmental restoration of heavily degraded forest lands, access to forest products, access to forest products, improved supply of forage, availability of fuel.
Likewise, Sagarmatha Forestry Dev. The project, Hill Food Production Project, etc. were also included.			
4. Support Projects			
Support projects like; watershed Management and Conservation Education Project, Nepal Remote Sensing Project, Environment impact studies project, Forest research project, etc. are related to research, planning and informal training, and resource inventory (Upadhyay, 1985).			

Also, the following projects are among the USAID water security-related projects participating in Integrated Watershed Management Activities (Petersen, 1999a):

Digo Jal Vikas: Aims to improve water resource management in western Nepal.

Hariyo Ban II: With a motive to increase ecological and community resilience in biodiverse landscapes of Nepal

Knowledge-Based Integrated Sustainable Agriculture and Nutrition (KISAN II): To improve the agricultural market system enabling the participation of vulnerable communities.

Nepal Seed and Fertilizer Project (NSAF): To increase national crop productivity and food security of Nepal.

PAANI Program: Enhance the ability to manage water resources in Nepal.

Safe Wash II: Increase access to safe drinking water, sanitation, and hygiene promotion.

Promoting Agricultural Health and Alternative Livelihood (PAHAL): To improve nutritional status and increase the resilience of vulnerable rural households.

3.5 Constraints to the implementation of Watershed Management Techniques

The problems that affect watersheds are often complex and long-term in nature. Although watersheds provide an essential livelihood for their inhabitants, their natural resources are finite and often under pressure and high risk of degradation. The key problem is the unsustainable exploitation of natural resources that leads to poverty, insecurity, and social conflict. The causes of watershed degradation may vary from country to country but they do have common traits that include ecological, socio-economic, technical, and institutional issues which are often interlinked and typically consist of the following elements;

3.5.1 Ecological

- Damages caused by natural disasters (heavy storms, landslides, wildfire, etc.) About 1,140 ha of land in 35 districts of Nepal was lost in 1993 due to landslides and flooding during the monsoon. Similarly, around 41,800 ha of land was damaged in 1995 (Poudel, 2005c)
- Extensive and rapid deforestation and forest degradation through legal and illegal exploitation can reduce the replenishment of groundwater and increase the amount of sediment in surface water (MRC, 2003a)
- Clearing and conversion of land mainly into agricultural land use. Recent studies revealed that the rate of forest cover change increased by 0.6% at an annual rate from 1990/91 to 2000/2001 (DoF, 1999).
- Siltation and sediment discharge are declining on the mainstream, through deposits of sediment in reservoirs and irrigation systems of the tributaries (MRC, 2003b).
- Reduced biodiversity with known and unforeseeable impacts on ecological integrity and food production (MRC, 2000a).

3.5.2 Socio-economic

- Degradation of land through improper land use and unsustainable farming reduces productivity and income (DSE, 2001).
DSE, 2001: Integrated Watershed Management Planning. Training Manual.
- Increased competition for resource and resource allocation difficulties.
- Rural poverty in uplands causing migration to crowded urban centers.
- Increasing conflicts over land, forest, and water resources.

- Lack of access to knowledge and decision-making powers (MRC, 2000b).

3.5.3 Technical

- Increasing pollution through the use of chemicals, (pesticides and fertilizers) especially in the agriculture sector (MRC, 2003c).
- Poorly planned and executed development activities (roads, housing, mining, recreation, etc.) impairing streams and polluting the natural environment (FAO, 1990).
- Changes in river flow regime through the construction of dams for hydropower generation and irrigation storage.
- Over abstraction of surface and groundwater, particularly for irrigation.

3.5.4 Institutional

- National level planning procedures and guidelines do not sufficiently reflect watershed perspectives.
- Fragmented legal framework and weak law enforcement (Min et al., 2004).
- Inadequate access and unclear property rights related to land for resource users.
- Lack of well-trained personnel and decision-making mechanisms at the watershed level.
- Insufficient coordination combined with no clear mandate for national or cross-boundary collaboration.
- The traditional top-down approach is still prevalent and combined with a lack of understanding of participatory methods by government officials.
- Soil and Watershed conservation act has not been effective owing to overlapping responsibilities, lack of resources, and poor condition (Guragain et al., 2002)

3.5.5 Coordination problem

- Management strategies have called for people's participation, but there is a gap in understanding about the level of participation (Poudel, 2005d).
- Casual agreements and vague commitment between the agency and manpower.
- High living standards and infrastructural gaps between upstream and downstream communities. Satisfaction of upstream development needs and reconciling of conflicts are important challenges for watershed management in Nepal (Sheng, 1994).

3.6 Need to Promote Sustainable Watershed Management in Nepal

The related problems of soil erosion and watershed deterioration are the greatest stumbling block for the development of Nepal which is further aggravated by improper land-use practices, particularly in fragile landscapes. The government's Tenth Five-Year Plan (2002–2007) prioritized integrated watershed management to conserve the underground water and soil in the Chure-Bhawar and Terai areas by coordinating the work of agriculture and water resources sectors (NPC, 2002). Emphasis to develop SALT at suitable watershed areas is also prioritized in the Tenth Five Year Plan by participating in the farmer's users' group and through distinct coordination between the respective agencies.

Integrated watershed management involves working on the natural and human resources in a watershed by the social, political, economic, and institutional factors that operate within the watershed and its river basin (Easter et al., 1991). The major objective of Integrated Watershed Management is adopting land suitability systems and using them appropriately.

The soil loss from the watershed can be reduced by improving the

cultivation practices, increasing forest regions, and discouraging shifting cultivation. Reports from a study conducted in the Sardu watershed claims that about 52% of the total cultivated land lies in the steep slopes (30-60%) and people are using 22% of land for cultivation which is very steep (greater than 60%)(IUCN, 2011a). Therefore, this is just an example of one case study. While the majority of the population are following the same pattern of cultivation. On that account, there is a quick need to adopt the relevant conservation measures before cultivation to protect the soil loss.

Contour cultivation on maize is expected to decrease soil loss from the land ranging from slope 3-30%. Likewise, with the adoption of brushwood check-dams and agroforestry, soil loss is also expected to decrease from the lands of slope 30-60% (IUCN, 2011b). Studies from IUCN reported that the Shardu watershed loses its fertile soils by 65.39 tons/ha yearly but it is expected to decrease by 32.74 tons/ha/yr. if some correction on the land-use practices and conservation programs are adopted in the watershed (Khanal, et al., 2011).

Also, protected private and government-guarded forests had better soil fertility compared with protected panchayat forests which suggests that a recovery in soil fertility is possible if active management is carried out in the heavily used forest areas (Schmidt et al., 1993b). Hence, integrated watershed management through people's participation has become widely accepted as the approach that ensures sound sustainable natural resources management and a better economy for upland inhabitants, as well as people living in downstream areas.

3.7 Sustainable Integrated approaches for watershed management

The benefits achieved from conserving water, soil and other natural resources in a watershed are sustained and measured by upstream and downstream people without degenerating their resource base and environment”(Sheng, 2000). Due to water disputes related to social, legal, cultural, and economic issues in the Nakanbe river basin, the traditional way of managing water resources is very laborious where all the decisions are taken from people not belonging to that community(Menon, 2007). Hence, participatory action of local people is necessary for watershed Management. To manage these water disputes, the integrated Water Resources Management Approach (IWRMA) came into action which involves people's participation and combines all stakeholders, all environmental as well as structural factors into resolution problems (McNitt and Kepford, 1999)(Petersen, 1999b) (Kenney, 1999). Along with a participatory approach, forest management is also regarded as a key point for Watershed Management. Due to challenges faced in the time frame of hydrologic recovery, procedures such as ECA and WRENSS reported in the US are well managed to temporal and spatial scales useful for forest watershed planning and contribute to the hydrologic recovery of old disturbances(Betts et al., 2008). The Hindu Kush Himalayan Region is highly affected by water-induced disasters. To get rid of this issue of high rainfall events, flood communication has to be strengthened by mediums such as the Early Warning System. To predict flood water levels in prone areas, the global food discharge forecast with routing models works which finally helps to reduce the life and wealth of people (ICIMOD, 2019).

The idea of watershed Management mainly focuses on both soil and water conservation to get more benefit for water resources(Minella et al., 2009). Hence, water conservation has to be done following approaches such as use of vegetative cover, tillage, construction of dams, tree plantation for carbon sequestration, stream and rainwater harvesting program, developing early warning system against floods, etc.(Wolka, 2012). An integrated approach can be achieved through various aspects such as:

- The information on land availability can be achieved from satellite data and water availability should be evaluated indirectly with the help of water balance studies. Satellite remote sensing is used for surface/groundwater availability too(Srinivas, 1986). Therefore, watershed management solutions that lead to optimal use of water and land resources, are to be practiced.
- Soil physical and chemical constraints are major issues that retard crop growth for watershed development. Hence, proper care and investigation are to be made to ensure crop growth. Land use degradation should be assessed by the implication of various mathematical and empirical models to find the rate of soil erosion through the USLE. These USLE helps to protect the land cover and

encourage to make conservation practices a sustainable one(Wischmeier and Smith, 1965).

- EIA plays an important role in maintaining sustainable development which can be termed as "The positive impact of watershed projects about various components of environment can be identified and evaluated"(Tiwari and Sharma, 2015). EIA and IEE should be strictly made mandatory to avoid haphazard exploitation of sediment loads and pebbles, sands, and gravel. In developing countries, the neglect of dam construction results in heavy devastating conditions in which its management studies are mandatory(Garcia-Navarro et al., 1999). Hence, it is everyone's concern, and a component of EIA such as flood wave propagation, inundation mapping, dam breach analysis came into consideration(Adgolign and Rao, 2014).
- Likewise, intensive agriculture activities (cereal crops and chemical fertilizers used) on slopes greater than 30% should be avoided with the adoption of environment-friendly SALT which provides alternatives for income generation.

4. CONCLUSIONS

Watersheds are an indispensable form of green infrastructure whose management demands harmonized integration of relevant aspects for the holistic development of communities. However, many of Nepal's watersheds are in a state of physical and biological deterioration where soil erosion and watershed degradation problems have caused adverse impacts on the socio-economic condition of the country and its people.

The hills and mountains of Nepal are the watershed areas with the most fragile ecosystem and poor agricultural potential as more than 15% of the total population of the country and 13% of the total land area is covered by Chure, Siwalik which is one of the most fragile ranges of hills in Nepal. Therefore, various studies indicate that gully erosion, landslides, stream bank cutting, and sediment-laden flow are among the various sources responsible for sedimentation in watershed areas. Likewise, landslides, soil erosion, floods, biodiversity loss, unsustainable water extraction, and farming practices are among the major issues leading towards watershed degradation. DSCWM, Department of Forestry, Department of Irrigation, and many non-governmental organizations including USAID are conducting water security-related activities based on the concept of Integrated Watershed Management.

Although watersheds provide an essential livelihood for their inhabitants, the unsustainable exploitation of natural resources causes watershed degradation that includes ecological, socio-economic, technical, and institutional issues which are often interlinked and are the constraints to watershed management. Therefore, while planning, monitoring & implementing soil and watershed management, strategies should be prioritized based on the principles of integrated watershed management.

As soil conservation is basic to watershed conservation, management practices that focus on both soil and water conservation should be practiced such as the use of remote sensing system for land and surface/groundwater availability, stream and rainwater harvesting program, use of USLE models as encouraging sustainable practices to find the rate of soil erosion, strict implementation of EIA, IEE to avoid haphazard exploitation of sediment loads and pebbles, adoption of SALT technology for income generation, tree plantation for carbon sequestration, etc.

Henceforth, streamlining the spirit of watershed management on the one hand, and mobilizing people's participation on the other is what should be taken into account. Also, people's attitude towards new technologies, extension education, income-generating activities, tangible benefits from conservation activities, and a spirit of self-reliance are important factors to be considered.

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ABBREVIATIONS

HPCIDBC: High Powered Committee for Integrated Development of Bagmati Civilization

DSCWM: Department of Soil Conservation and Watershed Management

MoUD: Ministry of Urban Development

WECS: Water and Energy Commission Secretariat

DOI: Department of Irrigation

UNDP: United Nations Development Programme

FAO: Food and Agriculture Organization

DA: Department of Agriculture

DF: Department of Forestry

DLDAH: Department of Livestock and Animal Health

ADB/N: Agriculture Development Bank Nepal

IDA: International Development Association

HMG: His Majesty's Government of Nepal

USAID: U.S Agency for International Development

SALT: Sloping Agriculture Land Technology

IEE: Initial Environment Examination

EIA: Environment Impact Assessment

USLE: Universal Soil Loss Equation

ECA: Equivalent Clear-cut Area

WRENS: Water Resource Evaluation of Nonpoint Silviculture Sources

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