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Watersheds and Rehabilitations Measures - A Review

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Abstract Freshwater scarcity remains a problem for millions of people around the world, especially in arid and semiarid regions. Watersheds provide human societies with many goods and services such as clean water, conservation of biodiversity, erosion control and carbon sequestration. Unlike other resources such as minerals and timber, the value of these goods and services is seldom expressed in monetary terms. Many countries have laws regulating access to and use of watershed resources however, these are often inefficient and difficult to implement. This paper hence reconnoitres sustainable watershed management and urges relevant institutions such as Environmental Protection Agencies, Water Research Institutes and Governmental Agencies of the need for a participatory integrated approach which includes the various physical, vegetative and human components within watersheds. It is concluded therefore that the fundamental social problem of watershed management is that it often distributes benefits and costs unevenly, making it a likely source of conflict between residents upstream and downstream. Watershed management practices should thus, be implemented in a manner that solves soil and water degradation problems but at the same time be socially and politically acceptable and economically feasible. The challenge here is to internalize the costs and benefits in such a way that all the stakeholders are part of a win-win scenario.

Keywords Watershed, Degradation, Resources, Scarcity, Stress

1. Introduction

Watershed degradation marks the deterioration in hydrological behaviour of river systems which reduces the health and potential of land and water by causing a water flow of inferior quality, quantity and timing. This process, predominantly human induced, have been a major source of conflict among various land and water users.

Degradation of a watershed can have various forms: depletion of water resources, soil erosion and land degradation, impoverishment of the vegetative cover, and damage to infrastructure. Surface runoff is one of the causes for the depletion of water resources on the one hand and soil erosion on the other hand. Another big problem is the pollution of water with various hazardous pollutant such as agrochemicals and microorganisms which poses health risks to the people who depend on that specific watershed for their sustenance [1]. Thus, prevention of pollution and hence, the protection of water quality, is crucial within a watershed.

Many forms of watershed degradation are evident as some form of direct damage to the soil and/or the ecosystem. In the case of soil erosion and deposition, the effects of degradation are manifested in the loss or transfer of soil, which has direct consequences in reducing the productivity of the site. With regards to soil degradation, the effects are manifested in a deterioration in the *in situ* properties of the soil again with direct consequences in term of reduced productivity. In the case of ecosystem alteration on the other hand, which includes changes to the vegetative cover and composition and the introduction of plant and animal pests, the immediate consequence is a deterioration in the quality of the entire ecosystem, which the land unit under threat supports [2].

Nevertheless, forest shield the soil surface from heavy rainfall. It helps reduce the rate of run-off by increasing the rate of infiltration and as a consequence, decrease the amount of flooding, mitigate soil erosion and limit the sedimentation of rivers, thus protecting the watershed. On the other hand, deforestation of watersheds especially around smaller rivers and streams can increase the severity of flooding, reduce stream flows by lowering the water table and increase sedimentation of rivers [2]. Accelerated erosion, soil salinization, impairment of water quality, landslides, siltation of rivers and dams and increased flooding downstream are other common adverse consequences of deforestation.

Watershed degradation in many developing countries threatens the livelihood of millions of people and constrains the ability of countries to develop a healthy agricultural and natural resource base. Increasing populations of people and livestock, particularly in the steep, mountainous watersheds of Nepal and the Himalaya region for instance, are rapidly depleting the existing natural resource base because the soil and vegetation systems cannot support present levels of

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use [3].

2. Watershed the Basic Hydrologic Unit

Watersheds are hydrologically connected geographic areas that contain interconnected environmental processes [4]. Rainwater, runoff, snowmelt and groundwater are all elements of this hydrologic entity. Other factors such as climate, land features, vegetation, and land use all affect the quality and quantity of water within the watershed. Hydrologic processes (evapotranspiration, flow, runoff, infiltration, seepage) within a watershed are interlinked and appropriately assessed within its confine [5]. Being that basic hydrologic unit, water from outside cannot enter the watershed and that from within leaves it from a well-defined point.

Wetlands are a major component of a watershed which directly affects water quality, acting as sediment basins, filters and sinks for nutrients that would otherwise cause river and lake eutrophication and trigger algal blooms. Because of their ability to absorb nutrients from water and promote nutrient cycling through plant take-up, wetlands can become highly productive ecosystems, characterized by seasonal changes in plant mix and grazing patterns for a variety of wildlife and domestic animals [6]. Wetlands may have significant effects on the hydrology of a watershed and its river system. They can be effective flood detention storages, reducing flood peaks downstream and attenuating the flood wave pattern. They alsoact as ground water recharge areas, which is a major source of freshwater, contributing about half of the total water consumed by humans for drinking, agriculture, and other purposes [7]. In addition, depending on the water table depth, groundwater may serve as a significant source of water to lakes, rivers and wetlands [8]. Groundwater protection, which includes consideration of both quantity and quality, is therefore crucial [9].

Watersheds are hence effective natural units that are used to analyse the essential physical, chemical and biological ecosystem characteristics and the effects of human influence on these factors in an area [10]. Its management hence includes the analysis, protection, repair, utilization and maintenance for optimum control and conservation of water in relation to other resources.

3. Research Method

This paper reviews ample secondary materials on watersheds, its usage and management across the world: specifically published books, journal articles, annual and technical reports of some relevant institutions as well as public and government documents. Content analysis of the connexion water use, watershed resources and management, and human appropriations has been carried out. Based on relevant literature, analysis and discussions have clearly provided the contextual justificationon the unsustainable means of human exploitation of the various watershed resources.

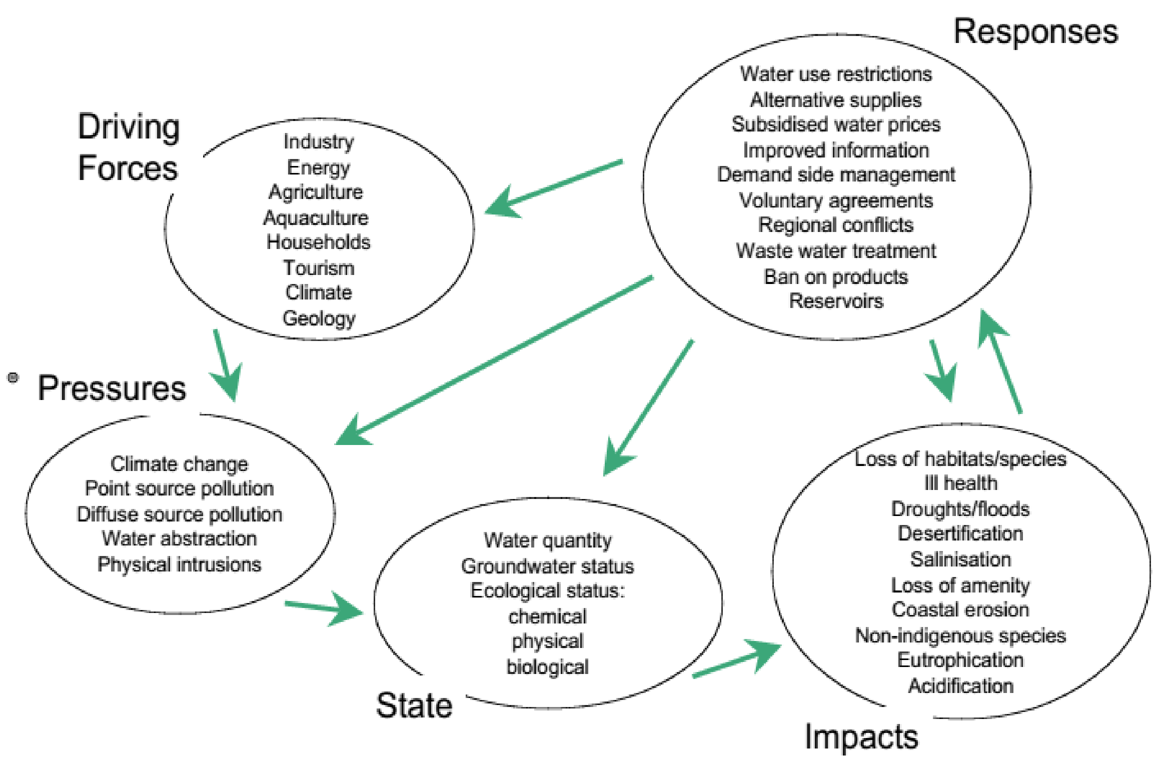

Figure 1. A Generic DPSIR Framework for Water [11]

The underpinning theoretical framework of the research is the Driving force, Pressure, State, Impact and Response (DPSIR)framework which is seen as giving a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made or to be made in the future. According to Figure 1, there is a chain of causal links starting with 'driving forces' (economic sectors, human activities) through 'pressures' (emissions, waste) to 'states' (physical, chemical and biological) and 'impacts' on human health, ecosystems and functions, eventually leading to political 'responses' (prioritisation, target setting, indicators) [11]. The DPSIR framework is useful to describe causal relationships of environmental problems. In order to better understand their dynamics, it focuses on the links between the DPSIR elements.

The aim of managing water resources is to safeguard human health whilst maintaining sustainable aquatic and associated terrestrial ecosystems. The DPSIR framework was hence adapted based on the European Environment Agency's work on water. The Framework allows a comprehensive assessment of the issues through the examination of relevant Driving forces and Pressures on the environment, the consequent State of the environment and its Impacts, the Responses undertaken and the interlinkages between each of these elements through the quantification and identification of the current state of and impacts on the environment and how these are changing with time. The state of water is determined by natural factors such as geology, climate and by the pressures exerted by human activities.

4. Current Water Conditions

4.1. State of the World's Water Reserve

As a culture, we have lost our collective memory of water as being the archetypal source of our dreams replacing it with water regarded as only stuff [12]. The core of the problem is that for most of us water flows by unappreciated and occasionally even unrecognized. The disheartening truth is that as a civilization we have become effectively blind to both the inherent beauty [13] and experiential delight [14] of water, failing to see the imminent danger that awaits us as in Table 1 and Table 3 with regards to water scarcity and stress.

Table 1. Status of Fresh Water Availability

Parameter	1995	2050[a]
Population (billions)	5.7	9.8
Population affected by water scarcity (millions)	166	1700
Population affected by water stress (millions)	270	2300
Countires affected by water scarcity	18	39
Countires affected by water stress	11	15

[a] Medium population projection [14];[5]

Renewable freshwater scarcity remains a problem for millions of people around the world, especially in arid and semiarid regions. The number of water scared countries increased from 7 in 1955 to 20 in 1995 and is projected to increase to 34 in 2025 [5]. This scarcity is accentuated by deteriorating water quality and according to table 1, the situation might worsen in the next 40 years if current trend continues unabated.

On a global basis, high sediment loadasindicated in Table 2 is carried by rivers draining very densely populated regions of the world such as the Yellow River in China and the Ganges River in India. The problem of erosion and sedimentation are accentuated by the misuse and mismanagement of resources within the watershed of the river systems. In most cases the activities of settlers around these water bodies promotes these negative effects. However, most of them depend on these activities for their subsistence.

Table 2. Runoff and Sediment Load in Major Rivers in the World [15]; [16]; [5]

River	*Drainage area (10^6 km^2)*	*Runoff (km^3/yr)*	*Sediment load (10^6 tons/yr)*
Amazon	6.2	6300	900
Danube	0.8	206	67
Ganges	1.5	971	1670
Irrawaddy	0.4	428	265
Magdalena	0.2	237	220
Mekong	0.8	470	160
Mississippi	3.3	580	210
Niger	1.2	192	40
Ob	2.5	385	16
Orinoco	1.0	1100	210
Yangtze	1.9	900	478
Yellow	0.8	49	1080
Yenisei	2.58	560	13
ZAIRE	3.8	1250	43

4.2. State of the World's Watersheds

Most of the world's watersheds are facing seriouse thrests as indicated in Table 3. From evidences arround the world, Lake Cocibolca is a major freshwater resource in Central America and the second largest lake in Latin America after Lake Titicaca. With a population of about 750,000, the watershed is a major area for agricultural production and the lake is beginning to be used as a source of water supply for some coastal towns; its role as a source of drinking water may grow in the future [12]. However, the watershed has lost most of its forest cover over the last century as cattle farming has expanded, exposing the watershed's fragile volcanic soils and steep slopes to erosion which is deposited into the confluence of the San Juan River and the lake. Other environmental problems stem from the use of agrochemicals, tilapia farming, and the flows of untreated or poorly treated wastewater from coastal towns. The result has been a reduction in water quality: nutrient levels are rising and there is evidence of agrochemical and bacteriological contamination. However, the extent of these problems is uncertain.

Watersheds in Trinidad's Northern Range are rapidly being degraded as a result of changing land use patterns. Among the commonly cited threats to Trinidad's watersheds are: expansion of housing development into forest areas, including both high income residences and squatter settlements; poor sanitation facilities and improper sewage disposal practices in upland areas and poor soil and water conservation measures on hillside agricultural lands [17]. There have been many concerns among various environmental management agencies, Non-governmental organizations, conservationists, and the general public that this degradation and loss of forest cover is having or soon will have an impact on water supplies and quality, particularly as the island's population increases. Traditional forest management approaches employed by the State have not been able to keep pace with these threats [18]. As a result a report by [19] contends that the hydrological response of rivers to rainfall has changed over the years due to land degradation.

Table 3. Watershed Threats [1]

Threat	Harmful Components and Uses	Environmental Consequences	Watershed Damage and Effects
Bioaccumulation: Marked increase in pollutants within the body of an organism over its life span	Air pollution and direct pollution discharge	Various species ingest water pollutants. Pollutants remain in the organism and accumulate over time. Pollutants in prey are passed on to predators.	Species at the top of the food chain may exhibit a concentration of the pollutants that is a million times greater than in the water itself causing increased instances of serious illness
Heavy Metals	Highly toxic substances such as mercury and lead.	Become increasingly toxic in species.	Potentially devastating damages to all affected species. Increased instances of serious illnesses for human and wildlife.
Industry Mining	Mine tailing such as lead, nickel, arsenic and cadmium. Acidic runoff from strip mines. Further pollutants from refinery smelters.	Direct disposal into waterways. Pollutants flowing into water-ways as runoff.	Increased instances of serious illnesses for humans and wildlife. Bioaccumulation
Oil Spillage	Various sources: oil tankers, ship bilge cleaning, oil tank leaks, automobile oil etc.	Oil and its by-products are toxic to plants and animals.	Large bird, fish and plant kills. Population declines that may last for decades
Pulp and Paper	Chlorine used for paper bleaching. Long living toxic by-products including furans and dioxins.	Long living compounds released as wastewater into waterways. Contributes to both air and water pollution.	Fish and vegetation kills. Long term threat of contamination.
PCBs Polychlorinated biphenyls	Were used in electrical transformers, various home and industrial uses. Clean up and disposal remains a challenge	PCBs remain active for years making contamination a long term problem	Long term contamination. Increased instance of serious illnesses for humans and wildlife
Forestry	Pesticide use Past use of DDT	Newer chemical pesticides, although shorter lived than DDT, are still toxic to people and wildlife.	DDT causes deformities and infertility, especially visible in birds at the top of the food chain. Although its use has been discontinued many populations have yet to recover
Thermal Pollution	Large quantities of water used to cool machinery Machinery cooling causes water to become heated	Releasing heated water into water bodies changes aquatic habitat Warm water holds less oxygen than cool water, a harmful consequence for aquatic species	Potential for invertebrates and fish to be killed. Habitat damage throughout watershed.
Radioactive Waste	Nuclear waste Thermal pollution	Radioactive waste remains dangerous for extended periods of time.	Exposure to the waste is harmful to people and wildlife.
Domestic Waste	Household hazardous waste Road, roof and lawn runoff Sewage, sewage treatment by-products and fertilizers	Our everyday domestic waste reaches waterways.	Health risk for people and wildlife. Depleted dissolved oxygen in watersheds.
Agriculture	Chemicals Fertilizers and pesticides Manure Erosion	Agricultural pollutants wash into waterways. Creates a cycle; replaced soil and fertilizers will again enter the water	Risk of well contamination. Oxygen depletion and siltation in waterways Potential suffocation of aquatic species

In the USA, current conditions and 'improvement development' within the Madison watershed has led to the destruction of most of the original wetlands. These wetlands, in many cases deemed unnecessary and useless have been replaced with agricultural fields, residential, industrial and commercial developments [6]. The loss of these wetlands has compounded the water-quality problems within the watershed. Small geographically isolated wetlands still exist within the watershed, although many have been severely degraded. Invasive species, such as reed canary grass, have taken over large tracts of these wetlands.

In Massachusetts, more than half of the population get their drinking water from groundwater sources. But for the past 50 years the preferred method for treating wastewater has been to capture it in big pipes and send it off to another location: a surface discharge wastewater treatment plant where it is cleaned and then discharged at the outer edge of Boston Harbour [20]. What this means is that a system has been created that is not sustainable. Thus rainwater has been cut off from the ground breaking the natural water cycle, yet it is expected that more and more water should be pumped out of the ground.

The water resources of the Volta Basin of West Africa are under severe stress due to poor climatic conditions and competing demands on its resources by the riparian countries who rely heavily on it for their socioeconomic sustenance [21]. The improper exploitation of these resources in the watershed has caused serious environmental problems, key among which is the diminishing resources and the size of the watershed [22].

In Ghana the Volta Lake, which is the largest man-made lake in the world, has been characterized by pollution of its river systems, draining of wetlands, aquatic weed invasion and increased environmental degradation [23]. Settlement growth in areas within the watershed considered to be potential biodiversity conservation priority areas, particularly in the White Volta, Lower Volta and around the Lake is of great concern as important habitat is lost through deforestation. This has resulted in intensive erosion leading to the siltation and sedimentation of the lake. A report by the Environmental Protection Agency of Ghanain 2001showed that surface water resources close to urban centres have exceptionally high faecal coliform counts [21]. The operations of several small-scale artisanal groups carrying out gold mining have led to serious degradation of the watershed in portions of the Black and White Volta Basins, whereas limestone mining in the Lower and Black Volta basins is also causing severe damage to these watersheds [23].

River Niger is the third longest river in Africa. Its watershed is the ninth largest in the world and an important asset for nine West African countries. Widespread environmental degradation and deteriorating natural resources in the watershed are results of unsustainable agricultural and ranching practices, bush fires and deforestation, pollution, erosion, siltation of water courses, and proliferation of aquatic plants [24]. Land degradation is also a major threat for productivity and food production, particularly in the Sahelian area in the mid-watershed [24]. An increasing dry climate and sedimentation associated with increasing demand for agricultural land have contributed significantly to the degradation of the watershed.

Water withdrawal already exceeds 50 percent of the renewable natural water in the Syrian Arab Republic, Tunisia and the Mediterranean watershed of Spain, and 90 percent in Egypt and Israel. Groundwater exploitation exceeds 400 percent in the Libyan Arab Jamahiriya [25]. The Mediterranean's unsustainable water consumption is caused by the overexploitation of groundwater and the increased use of fossil resources. Erosion and reservoir siltation have also contributed with an annual loss of useful capacity reaching 2 to 3 percent in northern Africa. If the current trend continues half of Morocco's useful capacity will be lost by 2050. The overexploitation of coastal aquifers has caused much seawater invasion and up to 90 percent of wetlands in Mediterranean areas have disappeared with a huge impact on ecosystems [26]. Conflicts of use and interest between upstream and downstream areas and cities and farm lands are likely to worsen as the management costs for water protection, urban sanitation and pollution control grow within the region.

4.3. Watershed Human Ecology

Most people live in watershed or river basin ecosystems that they have moulded to meet their needs throughout history. With the exception of a few residual and strictly protected areas, the ecology of most watersheds in many ways are human-made [25]. The relationship between human populations and watersheds has usually been adaptive, homeostatic and resilient.

Factors in watershed human ecology fall under four main headings, Figure 2: local population dynamics, local livelihood systems, external interests, and policies, norms and laws. Interactions among these factors largely determine a watershed's environmental conditions at a given time.

For instance, on the shores of the African Great Lakes, the Sudd and Niger delta wetlands and within the shallow inland lakes, households practise agriculture, fisheries and livestock grazing on private lands and common property resources. Crops are grown on land held under customary tenure, including those claimed during the seasonal retreat of lake water levels. Inundated areas that individual households have not claimed for crop agriculture are used for livestock grazing [27]. In the Umbria region of Italy, traditional smallholder livelihoods are based on a mix of cereal and legume cropping, tree cropping, animal breeding and forestry. Cereal, leguminous and fodder crops are planted on rotation in small valley plots with abundant water throughout the year. Olive trees, nuts and vineyards are cultivated on slopes up to 700m above sea level. Upland durmast, chestnut forests and rangeland prairies cover more than 70 percent of this rugged watershed area and provide fodder, fuelwood, timber, chestnuts and other forest fruits [28].

4.4. Watershed Economics

Watersheds provide human societies with many goods and services, such as clean water, erosion control, carbon sequestration and conservation of biodiversity [29]. Unlike other resources such as timber, livestock products or minerals, the value of these watershed goods and services are rarely expressed in monetary terms [25]. Watershed-generated environmental public goods and services as shown in Table 4 include regulation of water flow and quality, sediment delivery and the maintenance of landscape beauty. However, the value of a forest in controlling stream-bank erosion and sediment load in a river is not reflected in the market price of the forest land, neither is the value of a highland swamp in recharging an aquifer reflected in water prices.

Table 4. Watershed environmental services and uses [30]

Service	User
Improvement or stabilization of annual water flow	Drinking-water suppliers Hydroelectric facilities with multi-annual storage Irrigation
Improvement or stabilization of dry season flows	Drinking-water suppliers Runoff river hydroelectric facilities Irrigation
Low concentrations of suspended sediments	Drinking-water suppliers Hydroelectric facilities with multi-annual storage Runoff river hydroelectric facilities
Low concentration of sediment bed load	Hydroelectric facilities with multi-annual storage Irrigation
Low concentrations of fertilizer and pesticide residues	Drinking-water suppliers
Improvement of microbial quality	Drinking-water suppliers

Society generally attaches a high value to the positive externalities of watershed landscapes and will take action to guarantee that they are provided for and conserved. This is the primary justification for the public funding of watershed management programmes. Many countries have laws regulating access to and use of watersheds, but most of them are often inefficient and difficult to implement [25].

Command and control approaches of protecting the flow of benefits from watershed landscapes have often failed. Efforts have hence been recently made to create markets for these externalities. Table 4 summarizes the watershed related environmental services identified in some Latin American studies.

The values of watershed environmental goods and services can be categorized according to the total economic value framework [31];[32];[33]. This framework divides the total value into use values and non-use values Figure 3. Assessing the economic value of watershed-generated services is not straightforward. It makes costs and benefits transparent to decision-makers and the general public but it cannot assess moral or aesthetic considerations, such as the value of a resource that is needed for an ecosystem to function [34]. Intergenerational equity is also difficult to assess.

According to [18], giving an economic value to such services could in theory make it possible to establish markets between those who benefit from them (the “buyers”, for example water companies or downstream landowners) and those who contribute to maintaining them (the “sellers” or service providers, such as watershed residents and forest management agencies). These market incentives and rewards and any other associated contractual arrangements between buyers and sellers would in turn encourage protection of watersheds by giving an economic value to the services they provide [35];[36].

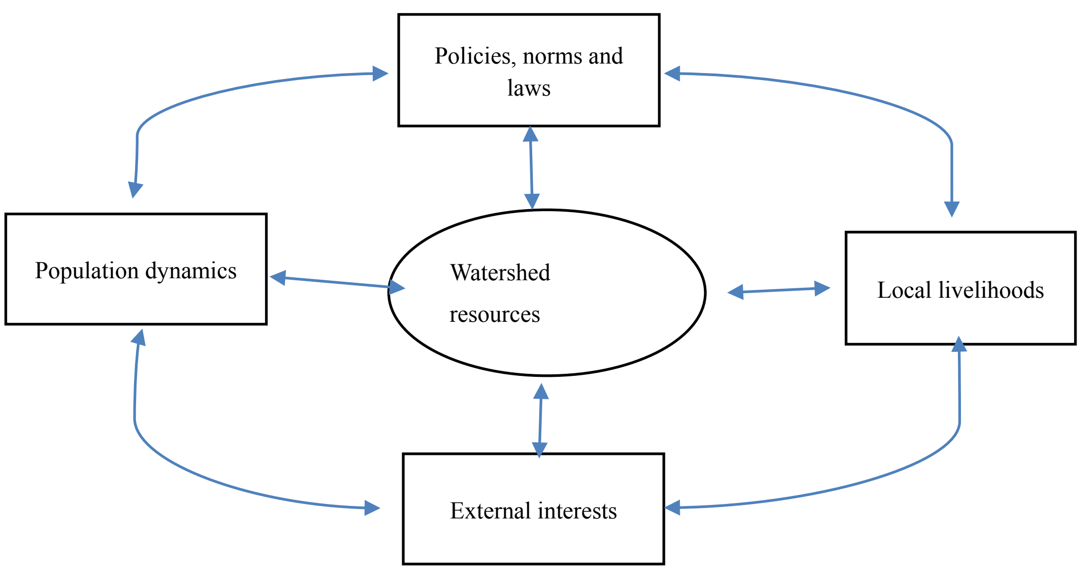

Figure 2. The human ecology of watersheds [25]

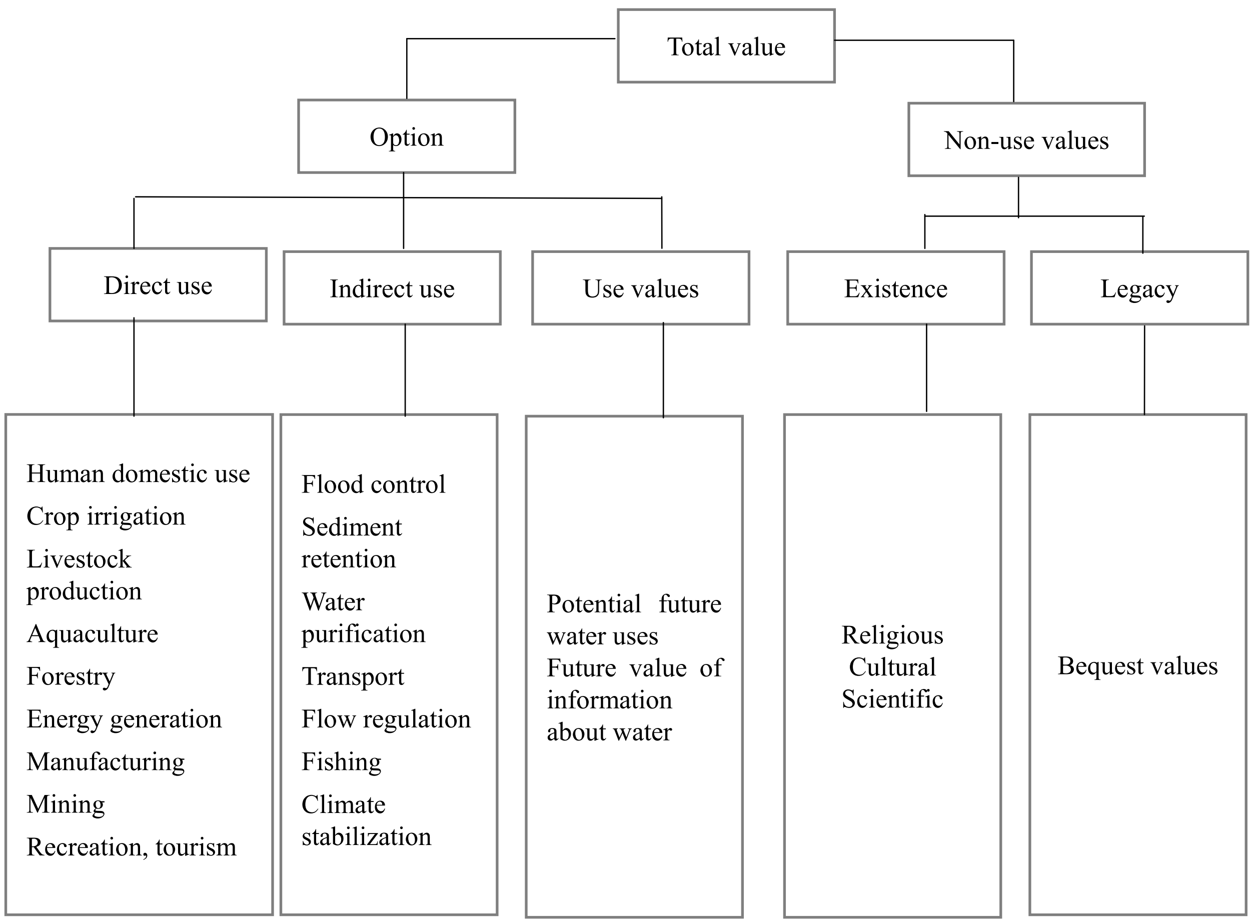

Figure 3. Total economic value framework as applied to watershed water resource [34]

5. Results and Discussion

5.1. Watershed Rehabilitation and Water Sector Reforms

Concern for the declining health of watersheds have led to the implementation of various management practices to restore the proper hydrologic functioning of degraded watershed lands [37]. Management practices to rehabilitate watersheds in poor condition include: controlling gullies and mass wasting with properly constructed check dams and other mechanical controls; protecting unstable stream channel from further damage; establishing protective tree, shrub, or herbaceous covers on degraded sites and further curtailment of timber harvesting, livestock grazing, and other exploitative land-use practices. Presently, restoring riparian ecosystems to retain their hydrologic equilibrium is a major focus of watershed management [38]; [39].

Over the last two decades, new strategies and supporting institutions for natural resource management have emerged throughout sub-Saharan Africa. There is a shift from centralized and State-driven natural resource management to decentralized and community-based regimes. As part of this, water sector reforms in several countries addresses the environment as a legitimate water user and emphasize pollution control [25].

Water management functions are increasingly being decentralized to the watershed level to enable stakeholders have more say in the management of water in their own areas. For instance, in 1998, Zimbabwe passed a new water act based on economic efficiency, environmental sustainability and equitable use. The act treats groundwater and surface water as parts of one hydrological system. Water cannot be privately owned, and water rights have been replaced with short-term water use permits; renewal is subject to water availability and evidence of efficient use. Watershed and sub-watershed catchment councils of stakeholders have also been formed [40].

In 1996, the Parliament of Ghana established the Water Resources Commission (WRC) to regulate and manage the country’s water resources and coordinate related government policies. The WRC comprises the major regulators and users in the water sector, providing a forum for integrating and balancing the different interests of water institutions and civil society stakeholders. Since 2001, a water management fund has financed conservation activities, information systems, local watershed management institutions and research [41]. The income of this fund comes from a raw water charge (a 0.7 percent tariff increase), licence fees and fines for offences.

Since 1994, government policies in South Africa have focused on equitable and sustainable social and economic development for the benefit of all. In 1997, the Cabinet adopted a National Water Policy with three main objectives: equitable access to water, sustainable use of water and efficient and effective water use. The National Water Act is based on these objectives and provides for the protection, use, development, conservation, management and control of South Africa's water resources [42]. A vital element of this strategy is the progressive decentralization of water resource management to catchment management agencies and local level water user associations which distribute the available water among competing user groups.

In Central America, the Lake Cocibolca watershed which is part of the corridor that passes from Lake Managua south to the San Juan River has been recognized as the best opportunity for ecotourism development [12]. The provision of direct economic incentives through the payment for ecosystem services programs and investments as well as supporting the growth of environmentally sustainable off-farm activities have helped reduced the pressure on the watershed. The Ministry of Tourism in Nicaragua has acknowledged ecotourism projects in the Lake Cocibolca watershed, including Ometepe Island, the Solentiname Islands and the San Juan River as one of the best opportunities to develop ecotourism and protect the watershed [12].

In the US however, storm water best management practices (BMPs) such as wetlands, rain gardens or grass swales installed within the stream corridor or upland areas have helped capture and treat storm water runoff before it reaches the streams. Stream bank root systems provided by riparian buffers have also prevent further stream channel erosion and sedimentation [6]. Furthermore, buffering zones provide the service of filtering debris and toxic chemicals from surface flow before it reaches catchment waters.

Hitherto, pervious surfaces such as unpaved ground which slows down the movement of storm water, allowing sediments, nutrients and other contaminants to infiltrate rather than flowing directly into the receiving water body are being recommended over impervious surfaces [9]. For instance, materials such as porous asphalt are available as an alternative to traditional impervious materials which have shown to effectively remove contaminants from storm water runoff. In a study examining runoff over porous versus impervious roads in Texas, scientists found that the porous asphalt removed approximately five times the amount of suspended solids [43]. Erosion can also be minimized by utilizing proper soil stabilization techniques. For example, [44] found that erosion control blankets successfully prevented soil erosion at construction sites.

5.2. The Thwarts of Watershed Rehabilitation Measures

To ensure sustainable watershed management, there is the need for an integrated and a participatory approach that includes the various physical, vegetative and human components within the watershed [3]. In most cases however, some of these elements are neglected.

The world is rapidly converting forest, wetlands and other critical habitats into agricultural lands and also diverting major rivers to produce food in other to meet the growing demands [45]. How to produce more and better food and maintain or improve critical ecosystem services without further undermining our environment has been a major challenge.

This calls for the assessment of watershed development and management approaches with a view to addressing biophysical, socio-economic, institutional and policy issues. Several reviews on the performance of watershed development projects [46]; [47]; [48]; [49]; [50]; [51]; [52] have diagnosed various limitations of watershed programmes, including the following:

- ➢ Landless and marginal farmers often benefit only marginally or not at all thereby increasing inequities at the village level.
- ➢ Domestic, livestock and ecosystem water needs often do not get adequately addressed in management measures.
- ➢ Downstream impacts of intensive upstream water conservation are not amply being considered.
- ➢ Costs at which the gains are achieved are considered to be high.
- ➢ Inhabitant's participation is often limited to the watershed project implementation stage.
- ➢ No/little building of institutions for long-term collective management of resources.

These problems arise because the interaction between the biophysical and the socioeconomic processes in watershed development is not properly addressed in an integrated manner. Results from a meta-analysis comprising 310 watersheds revealed that the mean benefit-cost ratio of watershed programmes was quite modest at 2.14 [47]. In India for instance, watershed development projects with insufficient understanding of land and water interactions have resulted in reduced access to common property water for poorer people, unsustainable rates of groundwater depletion, closure of catchments and serious downstream and environmental impacts [53]. The fundamental social problem of watershed development is that it often distributes benefits and costs unevenly, making it a likely source of conflict between residents upstream and downstream [3]. The challenge is to internalize the costs and benefits in such a way that all the stakeholders are part of a win-win scenario.

5.3. Strategies to Improve Watershed Rehabilitation Measures

Water is a resource that is most likely to cause trouble. Unless humans understood the value of water, they will never do anything sensible in terms of conservation [20]. Hence, urgent actions needs to be taken by policy and decision makers at the highest levels of government to expose the imminent danger of watershed degradation to the general public and set up participatory measures with the aim of halting and reversing the degradation processes.

To accomplish this, a balance between population and the environmental carrying capacity of upland watersheds must be achieved. In steep mountainous watersheds undergoing severe degradation, urgent policies and programme responses are needed within the next decade. Management practices implemented should not only solve soil and water degradation problems but must at the same time be socially and politically acceptable and economically feasible. Solutions must not ignore the basic needs of people living in upland watersheds; incentives may be needed to change existing land-use practices into environmentally sound and sustainable resource use. The instability of land tenure and the complexity of user rights which have over the years seriously constrained the development of best land use practices needed to stabilize forest and rangelands needs to be passionately addressed. Watershed management programmes cannot become effective on a sustainable basis until such constraints are overcome.

National programmes needs to unambiguously resolve inequities that result from implementing watershed management programmes. Resources should be reassigned from the politically and economically more powerful lowland communities who are often the major heirs of management measures to the increasingly penurious upland dwellers who must limi ttheir current livelihood activities. Good and working institutions are also needed in most countries to coordinate and effectively carry out the planning, implementation and monitoring of watershed management programmes. Notwithstanding, just as water and sediment flow in response to gravity, processes which do not necessarily coincide with political or institutional boundaries must also be recognized in management measures.

6. Conclusions

Watershed management projects and programmes are being implemented throughout the world. It is considered by many to be one of the most important development sectors now and will continue to be so unless these difficulties are addressed. As the trend continues towards empowerment of rural people to manage their natural resources, the integrated multiple use concepts of watershed management at the community and farm levels with linkages to local and State governments will become more viable.

The watershed management development approach is not perfect in any sense. It continues to evolve with time, with ever-changing development needs. Nevertheless, good watershed management will require the striking of a balance between economic objectives for productive land use and ecological objectives for the maintenance of ecosystem quality and diversity. This kind of approach requires the adoption of an ethic of ecologically sustainable development which in itself is the essence for the integrated watershed management approach.

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