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Review Article

Ecosystem restoration in Nepal: Needs and initiatives

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Abstract
Nepal, situated in the Central Himalaya, occupies a total area of 14,718,100 ha. About 86% of the total land area is covered by hills and high mountains, and the remaining 14% are the flat lands of the Terai. Despite the uniqueness and variety of ecosystems across the ecological regions; the ecosystems, are very fragile and prone to degradation both inherently and in response to anthropogenic activities. A product of young geological and adverse climatic conditions, excessive resource use and associated environmental degradation in the countri are responsible for the accelerated rate of natural disasters like soil erosion, land degradation and mass wasting, which in turn are making the ecosystems insubstantial. This review therefore aims to provide information on ecosystem restoration needs and initiatives in Nepal. With the existing natural and anthropogenic disturbances that are prevalent in the ecosystems of every ecological regions of Nepal, ecosystem restoration practices are of immediate need. Similarly, restoration approaches are of prime requisite in the protected areas also. Though started in project level basis and in conjunction with cross-cutting programs, ecosystem restoration interventions are in initial stage in Nepal. In this regard, future ecosystem restoration initiatives should be made successful with intensive efforts, appropriate technology and optimum inputs. It will be necessary to identify the areas requiring restoration, and plan for the implementation of appropriate activities for the successful restoration of degraded ecosystems in each ecological regions of Nepal.

Key words: ecological regions, ecosystem restoration, environmental degradation

Introduction
Nepal, situated in the Central Himalaya, occupies a total area of 14,718,100 ha. About 86% of the total land area is covered by hills and high mountains, and the remaining 14% are the flat lands of the Terai with altitudes varying from some 67 m in the south-eastern Terai to 8,848 m at the peak of the world's highest mountain, Sagarmatha (Mount Everest) in the north (MoFSC, 2009). Nepal's peculiarity in richness of biodiversity at ecosystem, species and genetic levels is a reflection of its unique geographic position and wide altitudinal and diverse climatic conditions. It incorporates the Palaearctic and the Indo-Malayan biogeographical regions and the major floristic provinces of Asia (the Sino-Japanese, Indian, Western and Central Asiatic, Southeast Asiatic, and African Indian Desert) creating a unique and rich terrestrial biodiversity (MoFSC, 2002). Nepal therefore harbors variety and variability in ecosystems types (T able 1), which are significant in the context of social, economic and environmental perspective.

An ecosystem is an integration of interacting organisms along with the physical environment, including matter and energy that they may assimilate in some specific direction (Parker & Pickett, 1997). Ecosystems and their services are planet's life-supporting systems and are fundamental to human well-being and survival (Costanza et al., 1997; TEEB Foundations, 2010). But many of the world's ecosystems have undergone significant degradation with negative impacts on biotic diversity, ecological function and peoples' means of securing the basic necessities of life: food, water, shelter and clothing (MEA, 2005a). Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any other period of time, due to increasing demand for resources

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(food, fresh water, timber, fiber, and fuel) and advancing technology. This has resulted in a substantial and lar gely irreversible loss in the diversity of life on Earth (MEA, 2005b). Ecosystem restoration and other approaches (Box 1), in this context, are essential to retum the degraded ecosystems to a close approximation of their conditions prior to degradation (Box 1). With accumulation of negative impacts on ecosystems in recent years, approaches towards ecosystem restoration have grown astoundingly with new ideas and opportunities (Choi, 2007; Davis and Slobodkin, 2004). This review therefore aims to provide infor mation on ecosystem restoration needs and initiatives in Nepal.

Ecosystem restoration is an intentional human activity that initiates or accelerates the recover y of an ecosystem with respect to its health, integrity and sustainability (SER, 2004). Ecosystems requiring restoration have been degraded, damaged, transformed or entirely destroyed as the direct or indirect result of human activities. In some cases, these impacts to ecosystems have been caused or aggravated by phenomena such as landslide, erosion, wildfire, floods, storms, or volcanic er uption, to the point at which the ecosystem cannot recover its predisturbance state or its historic developmental trajectory (SER, 2004). Although the common understanding of ecological restoration suggests human action, cor rective options fall along a continuum from passive to active. In passive restoration, the ecosystem requiring restoration is lef t as it is, to heal itself through ecological succession, soil building, and colonization of the area by species that has been extirpated directly or indirectly by humans (Noss et al., 2009). The ecosystems sometimes may recover remarkably well without human inputs, especially enough to incorporate the changes and recover ecological processes. But where profound physical, chemical and/or biotic changes have occurred, restoration may require substantial human intervention (Box 2).

Growing human activities have led to the degradation and depletion of ecosystems in Nepal or their parts thereof . Degradation processes can result in a variety of ecosystem responses, depending on the intensity, duration and scale of the impacts. Brown and Lugo (1994) have stated that the impacts of degrading influences, or stressors, vary depending on which system components and processes are affected. Restoration of ecosystem health and productivity in the context of changing ecosystems str ucture and climate is a growing issue. There is a developing realization that we will not be able to conserve the earth's biological diversity through the protection of critical areas alone. When applicable, ecosystem restoration should be an important component of conservation and sustainable development programs so that the livelihoods of people depending on these ecosystems can be sustained (https://www.iucn.org).

Table 1: Distribution of ecosystems in Nepal

Physiographic zone	Total number of ecosystems	Ecosystems inside protected areas
Terai	10	10
Siwaliks	13	5
Midhills	52	33
Highlands	38	30
Other	5	2
Total	**118**	**80**

Source: Dobremez (1970); BPP (1995); Maskey (1966); MoFSC (2009)

Box 1: Approaches of recovering degraded ecosystem

Restoration: Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. The goals of restoration include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure.

Rehabilitation: It shares with restoration a fundamental focus on historical or pre-existing ecosystems as models or references, but the two activities differ in their goals and strategies. Rehabilitation emphasizes the reparation of ecosystem processes, productivity and services.

Remediation: The act of remedying. To remedy is 'to rectify, to make good'. Here emphasis is on the process rather than on the endpoint reached (Bradshaw, 1997).

Reclamation: The main objectives of reclamation include the stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose. Revegetation, which is normally a component of land reclamation, may entail the establishment of only one or few species. Reclamation activities that are more ecologically based can qualify as rehabilitation or even restoration.

Enhancement: It is to rise in degree, heighten, intensify, or to increase in value, importance, attractiveness (Bradshaw, 1997).

Mitigation: It is an action that is intended to compensate environmental damage.

Ecological engineering: It involves manipulation of natural materials, living organisms and the physical-chemical environment to achieve specific human goals and solve technical problems.

Source: SER (2004)

Need of Ecosystem Restoration in Nepal

Loss and degradation of ecosystems have been obser ved across the globe (Hoekstra et al., 2005; SCBD, 2014; Vitousek et al., 1997). Studies have shown environmental degradation has reduced the capacity of ecosystems to function properly, provide services and act as buffers (Costanza et al. 1997; MEA, 2005b; WHO, 2005). Ecosystem degradation is one of the major environmental problems in Nepal also . Nepal's ecosystems are very fragile and prone to degradation both inherently and in response to anthropogenic activities (Maskey et al., 2003). Rugged mountainous topography, high variability in rainfall, unstable landforms and active geological processes

contribute to a high level of natural process of degradation. Therefore a product of fragile geological and extreme climatic conditions, resource degradation and associated environmental consequences are the parts contributing to the natural process of soil erosion, land degradation and mass wasting in the country (Ives, 1987; Karkee, 2004; MoEST, 2006; UNEP, 2001), which in tur n makes the associated ecosystems insubstantial. Type of land degradation in different physiographical and ecological regions of Nepal have been reflected in Table 2. Mountains, Hills and Terai regions of Nepal are experiencing differently about the type of land degradation. Difference in physiographical situations and exerting pressures within the regions undelay the corresponding changes on the ecosystems.

In Nepal, significant portions of degraded lands are forests and rangelands. (Bhattarai et al., 2009; T able 3). Rising demand and increasing utilization of resources (fuel and fodder) from forests and grasslands to sustain increasing growth of Nepal's population is one of the major cause for degradation of these ecosystems. The loss and degradation of forests has been increasing in the Siwaliks and Terai during the last few decades (T able 4). In Nepal, ecosystem degradation, mainly the forest degradation, has adverse environmental and social implications (Acharya et al., 2011). Ecological outcomes due to degradation have included a reduction in canopy cover, a decline in forest quality, loss of structure and change in composition, a decrease in the productive capacity of forests and grasslands, an increase in invasive species and loss of biodiversity (Acharya et al., 2011). The environment has undergone soil erosion, fragmentation of habitats and shifts in wildlife movement resulting from deforestation, encroachment, overgrazing, excessive use of fertilizers and construction activities (Acharya et al., 2008). Such damage has resulted in decline in forest productivity, provision of ecosystem services and has negative impacts on society and people's livelihood.

Box 2: Ecosystem restoration process

Assessment
- Conduct inventory and mapping of the ecological resources and describe the baseline conditions;
- Describe the site's history and map. Use existing aerial photographs, original land survey records and maps. Take support from historical descriptions, oral histories, logging records;
- Determine the cause of ecosystem degradation;
- Develop a hypothesis of how the original system worked. Review technical literature for related ecological studies conducted in the region, visit nearby natural areas;
- Develop checklist of ecosystem components and/or processes negatively impacted;
- Develop goals for each management unit by assessing the potential of that unit for restoration with reasonable effort, and specifying its desired future condition;
- Develop an implementation plan to accomplish the goals. Identify and schedule tasks, specify methods, estimate material costs and labor for each management unit with planning;
- Design a monitoring program to evaluate the success of the restoration.

Treatment
- Implement the restoration program. Establish administrative and field capacities to carry out tasks, install a monitoring program and then begin restoration work.

Monitoring and Evaluation
- Detail observation through time
- Prepare reports and papers that explain the project and describe results and evaluate the program.

Reformulate Treatment (if Required)
- Incorporate new information and ideas into the plan, revise goals, and modify and reschedule tasks.

Source: Modified from http://www.appliedeco.com

Table 2: Land degradation in different physiographic regions of Nepal

Physiographic region	Ecological region	Type of land degradation	Causes
Higher Himalaya (above 5000 masl)	Mountain	Rock falls, avalanches, glacial lake outburst floods	Unstable geology, weather extremes, climate change impacts, zone located in north of Main Central Thrust (MCT)
Higher Mountains (3000 – 5000 masl)		Slumping, gulling, landslides, rock falls, erosion	
Middle Mountains (1000-3000 masl)	Hill	Erosion (gulley, surface: rill and sheet erosion), riverbank cutting, landslides	Weather extremes, excessive fuel and fodder collection, over grazing, zone located in between MCT and the Main Boundary Thrust (MBT)
Siwaliks (500-1000 masl)	Terai	Erosion, landslides	Excessive fuel and fodder collection, over grazing, zone located in between MBT and Main F rontal Thrust (MF T) and the fluvial deposits
Terai (Below 500 masl)		Flooding, river shifting, river bank cutting, water logging, formation of river damaged areas	Overgrazing, geology passing through MFT

Source: Modified from Dahal (2006) and Joshi et al. (2003)

Table 3: Land area under degradation in Nepal

SN	Land use category	Degraded area (million ha)	Total land areas (million ha)	Percent of land degraded
1.	Poorly managed forest*	2.10	5.83	36.03
2.	Poorly managed sloppy terraces**	0.29	2.97	10.00
3.	Degraded rangeland/open land***	0.65	1.75	37.00
4.	Areas damaged by floods and landslides (1984 to 2003)	0.11	11.55	0.72
5.	Forest encroachment	0.12	5.83	2.04

Source: MoPE (2001); CBS (2005); DFRS (1999); DoF (2005); MoEST (2006)

** Includes estimated area of sbrubs and forests below 40% crown cover*
*** Area under millets and barley cultivation included*
**** Includes non-cultivated inclusions, grassland and encroached forest areas*

Table 4: Forest cover change in the T erai between 1978/79 and 2010/11 ('000ha)

Development region	District	LRMP*	DoF**	DoF**	FRA***	Rate of change	
		1984	1991	2001	2010/11	1991-2010/11	2001-2010/11
Far-western	Kanchanpur	71.9	58.1	57.5	56.2	-0.18	-0.25
	Kailali	96	79.2	73.2	71.2	-0.56	-0.31
Mid-western	Bardiya	53.6	50.6	47.7	46.6	-0.43	-0.24
	Banke	48.6	38.8	37.3	39	0.03	0.48
Western	Kapilvastu	34	43.3	40.8	37.5	-0.76	-0.95
	Rupendehi	12.3	7.8	6.7	6.5	-0.93	-0.31
	Nawalparashi	7.2	3.2	3.2	3.2	0.02	0.2
Central	Parsa	24.5	25.5	25.9	24.6	-0.19	-0.6
	Bara	32.9	32.6	32.2	30.8	-0.29	-0.49
	Rautahat	22	20.2	20.3	18.6	-0.43	-0.96
	Sarlahi	15.1	3.3	13.9	11.5	-0.74	-2.07
	Mahottari	10.8	9.5	10	9.4	-0.04	-0.61
	Dhanusa	0.2	0.3	0.5	0.3	-0.76	-5.7
Eastern	Saptari	2.4	2.7	2.1	2	-1.39	-0.12
	Siraha	0.4	2	1.7	2.1	0.39	2.57
	Sunsari	16.9	15.4	14.9	14.2	-0.45	-0.57
	Morang	30.9	24.2	23.7	23.5	-0.16	-0.09
	Jhapa	12.3	13.4	13.2	11	-1.06	-2.03
Total		**492.1**	**440.1**	**424.6**	**408.1**	**-0.4**	**-0.44**

*Source: FRA/DFRS (2014) *Land Resource Mapping Project; ** Department of Forests; *** Forest Resource Assessment*

Furthermore, a multitude of natural and anthropogenic factors contributing to the degradation of ecosystems are impacting Nepal. Table 5 shows the affected land area from different forms of erosion. Water erosion in different forms causes loss of huge amount soil from Nepal Himalaya. Similarly, wind erosion, chemical and physical deterioration of land area are also responsible for loss of soils.

Similarly, Table 6 gives the high rates of soil erosion from selected areas of Nepal. The table shows that large amounts of soil gets lost every year from these regions (Siwalik Range, Mahabharat Lekh and Middle Mountains) of Nepal. The loss of topsoil changes the catchment characteristics, represents a large loss of nutrients and inhibits the growth of vegetation, and thereby reduces the inertial capacity of ecosystems.

Table 5: Erosion affected land in Nepal

SN	Degradation type	Affected area (million ha.)	Affected area as % of total land area of Nepal
1.	Water erosion	6.7	45.4
2.	Wind erosion	0.6	4.0
3.	Chemical deterioration	0.3	1.7
4.	Physical deterioration	0.2	1.3

Source: MoEST (2006)

Table 6: Estimated soil erosion rate of selected sites in Nepal

Region	Location and characteristics	Land use	Erosion rate (tons ha^{-1} yr^{-1})
Siwalik Range	Eastern Nepal, South aspect,	Different land use ranging from forest to grazing	78,000-368,000
	Far western Nepal, South aspect sand stone foot hills of Surkhet	a. Degraded land b. Degraded forest, gullied land c. Severely degraded heavily grazed forest, gullied land	200,000 400,000 2,000,000
Mahabharat Lekh	Central Nepal, steep slope on Metamorphic and Sedimentary Rocks	a. Degraded forest and agriculture land b. Gullied land	315,000-1,400,000 630,000-4,200,000
Middle Mountains	Northern foothills of Kathmandu Valley	a. Degraded forest and shrub land b. Over grazed shrub land c. Severely gullied land	270,000-450,000 430,000 1,250,000-5,700,000
	South of Kathmandu Valley	75% dense forest	80,000
	Phewa Watershed	a. Protected pasture b. Overgrazed grassland c. Gullied overgrazed grassland	92,000 220,000-3,470,000 290,000

Source: CBS (2013)

Ecosystem restoration practices are also of prime requisite in the protected areas of Nepal such as national parks and wildlife reserves, conservation areas. Protected areas in Nepal are playing a cr ucial role in the conser vation of biodiversity and natural capital and have provided diverse environmental, social and economic benefits contributing to human well-being (MoFSC, 2014). But at the same time, anthropogenic activities have made such areas susceptible and subject to the problems like habitat loss and degradation, overexploitation of resources, unplanned infrastr ucture development, uncontrolled forest fires, climate change and pollution (MoFSC, 2014; SCBD, 2010). Invasive plant species such as *Mikania micrantha, Eupatorium adenophorum, Eupatorium odoratum, Lantana camara, Parthenium sp.* are proliferating in protected areas leading to destr uction and shrinkage of habitats of native flora and fauna (MoFSC, 2014). Inadequate awareness on ecological functions and ecosystem integrity amongst local communities contribute to degradation of ecosystems. L arge global conser vation efforts are ongoing but biodiversity decline is increasing and ecosystem degradations are continuing in protected areas (Craigie et al., 2010).

Nepal has diversity in wetland ecosystems ranging from high altitudes to lowlands. These have ver y high ecological significance and are important culturally, provide habitat for several wildlife species and are rich in biodiversity (MoFSC, 2014). These are also considered as sources of groundwater and fertile lands for agriculture. But most of the wetlands of Nepal are not managed sustainably so are in the process of disappearance and vulnerable to various threats such as human encroachment, over -exploitation of resources, drainage and underway with vegetation succession (Bhandari, 2006; Kafle et al., 2008). In this perspective, Nepal's wetlands also need restoration so that they can be sustainably used for the wellbeing of the people. National Wetland Policy of Nepal has highlighted the strategies regarding disappeared or disappearing wetlands of Nepal (GoN, 2003), but implementation of such strategies are taking place in ver y slower pace. Immediate actions are required before these wetlands get degraded and stops providing their peculiar services.

The outlined observations, data and information presented in this document indicate, in our opinion, that restoration plans, programs and initiatives are immediately required in Nepal. Start of restoration processes can be placed in the continuum between ecosystems having changes in initial dynamics in structure and functioning to extreme cases of ecosystem degradation.

Ecosystem Restoration Initiatives in Nepal

Ecosystem restoration programs and activities in Nepal are in their infancy. There is need to strengthen the restoration programs to reduce the har mful effects of anthropogenic intrusions on the natural environment. Restorations programs, in some cases have started in conjunction with other cross-cutting programs and initiatives like community

forestry program and protected areas management. Community forestry program is considered as one of the most successful forest resource management programs in Nepal, especially in the mid-hill regions of Nepal (Khadka & Schmidt-Vogt, 2008; Niraula et al., 2013). The program has improved the overall forest structure and dynamics in many areas. About 1.45 million households or 35% of the population of Nepal are involved in community forestry management programs. To date 17,685 Community Forestry User Groups (CFUGs) have been formed with a total area of 1,652,654 hectares of national forest handed over as community forests (http://dof.gov.np). In recent years, the government has also started scientific management of some production forests in the Terai under a collaborative arrangement to slow down the deforestation and forest degradation. Trees grown on farmland and other community-based forest management programs, including the community forestry, leasehold forestry, and buffer zone community forestry have helped to abate the deforestation and forest degradation in the regions (MoFSC, 2014).

Similarly, the Ministry of Forests and Soil Conservation, Government of Nepal has been implementing special landscape management programs like Terai Arc Landscape, Sacred Himalayan Landscape, and the Kailash Sacred Landscape and other regional Watershed Management Programs which are contributing as a tool for ecosystem restoration. Another landscape management program has been initiated by a consortium of INGOs and NGOs in the Chitwan-Annapurna Landscape, since 2011 (MoFSC, 2014). These landscapes conservation programs provide connectivity to several protected areas and have helped enhance ecological processes and conservation of threatened species.

Other governmental organizations of Nepal with their line ministries are also launching programs in areas connected to ecosystem restoration and rehabilitation. In Nepal, the governmental organizations working directly or indirectly in the field of ecosystem restoration are National Planning Commission, Ministry of Science, Technology and Environment, Ministry of Forests and Soil Conservation and Ministry of Federal Affairs and Local Development. Nepal being a signatory of Convention on Biological Diversity and Aichi Declaration has committed in support of Aichi Targets 5, 11, and 15 to implement ecosystem restoration programs. In this regard, Food and Agriculture Organization (FAO) has proposed establishment of the Forest and Landscape Restoration Mechanism (FLR Mechanism) to help countries achieve their commitments towards the Bonn Challenge (global movement launched at a ministerial conference in Bonn to restore 150 million hectares of degraded and deforested land by 2020) and the Aichi Biodiversity Targets. The FLR Mechanism will operate globally and its initial phase will span a seven-year period from 2014 to 2020. Its focus at the country level aims to support implementation as well as monitoring and reporting of forest and landscape restoration by facilitating a multi-stakeholder process; developing, compiling and disseminating tools and best practices related to FLR; supporting the establishment of pilot projects and helping broker new large-scale projects and programs; and supporting adequate quality control of well-established FLR efforts, to ensure compliance with accepted guidelines, norms and standards (UNEP, 2014). Similarly, national and inter national organizations have initiated some restoration activities through different restoration projects.

Conclusion and Way Forward

Ecosystem restoration can be successful with intensive efforts, appropriate technology and optimum inputs. Ecosystem restoration must include the consideration and intervention for both autogenic and allogeneic ecosystem processes. Restoration plans and approaches must seek for recovery of an ecosystem that has been degraded, damaged or destroyed with stable community succession points and balancing the energy and mineral flows.

Moreover, the inclusion and consideration to anthropogenic activities makes the restoration approaches successful. There is need of strengthening and implementing the restoration practices in Nepal. Restoration approaches are required and should go under application in a way to mitigate environmental degradation and biodiversity depletion. Similarly, the restoration needs and practices are important both inside and outside protected areas in Nepal. Biodiversity conservation can be enhanced only with sufficient and appropriate restoration plans and programs. There is immediate need of sensitizing and informing public about the roles and values of ecosystem services in Nepal. Identifying areas that need (immediate) restoration applications; determining type of degradation and appropriate restoration mechanisms, plans and approaches; enhancement and immediate restoring of the structure and functioning of the ecosystems with suitable treatment activities; determining post treatment considerations; and more research and capacity building on ecosystem restoration needs, strategies and applications are some points how the ecosystem restoration process can be initiated in Nepal. Since the Government of has already shown commitment towards strengthening, reviving and restoring the ecological processes of the ecosystems, it is necessary to work more on the ground to identify the underlying causes of ecosystems degradation in each ecological regions. Integrated ecosystem restoration approaches can be implemented to make it more cost effective and feasible in Nepal.

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