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 country 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, Sagamatha (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 (Table 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.
Ecosystem restoration is an intentional human activity that initiates or accelerates the recovery 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 eruption, 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, corrective options fall along a continuum from passive to active. In passive restoration, the ecosystem requiring restoration is left 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 (food, fresh water, timber, fiber, and fuel) and advancing technology. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth (MEA, 2005b). Ecosystem restoration and other approaches (Box 1), in this context, are essential to return 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 information on ecosystem restoration needs and initiatives in Nepal.

Need of Ecosystem Restoration in Nepal
Loss and degradation of ecosystems have been observed 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

| 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)
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 turn 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 physiological 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; Table 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 (Table 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.

**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, gullying, 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 Frontal Thrust (MFT) 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)
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.
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 crucial role in the conservation 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 infrastructure 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 destruction and shrinking 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. Large global conservation efforts are ongoing but biodiversity decline is increasing and ecosystem degradations are continuing in protected areas (Craigie et al., 2010).

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Nepal has diversity in wetland ecosystems ranging from high altitudes to lowlands. These have very 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 very 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 harmful 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 Nepal 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.
References

Acharya, K.P., Dangi, R.B., & Acharya, M. (2011). Understanding forest degradation in Nepal. *Unasylva* (238) 62, 31-38. Retrieved December 12, 2014 from http://www.fao.org/docrep/015/i2560e/i2560e06.pdf.

Acharya, K.P., Poudel, B.S., & Dangi, R.B. (2008). State of Land Degradation and Rehabilitation Efforts in Nepal. Retrieved November 19, 2014 from http://www.iufro.org/download/file/7401/5122/Nepal_pdf/.

Bhandari, B.B. (2006). Wetlands: the Ponds of Kathmandu Valley. In R. Bastola and S. Yonzon (Eds.) *World Wetlands Day 2006 Celebration: Report*. Friends of Bagmati, Kathmandu, Nepal.

Bhattarai, K., Conway, D., & Yousef, M. (2009). Determinants of deforestation in Nepal’s Central Development Region. *Environ. Manag.* 91, 471-488.

BPP (1995). An Assessment of the Representation of the Terrestrial Ecosystems in the Protected Areas System of Nepal. Biodiversity Profile Project, Publication No. 15, Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Bradshaw, A.D. (1997). What do we mean by restoration? In K.M. Urbanska, N.R Webb, P.J. Edwards (Eds.) *Restoration Ecology and Sustainable Development*. Cambridge University Press, UK.

Brown, S., & Lugo, A.E. (1994). Rehabilitation of tropical lands: a key to sustaining development. *Restoration Ecology*, 2, 97-111.

CBS (2005). Statistical Year Book of Nepal. Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal, Kathmandu.

CBS (2013). *Environment Statistics of Nepal*. Central Bureau of Statistics, Thapathali, Kathmandu, Nepal.

Choi, Y.D. (2007). Restoration Ecology to the Future: A Call for New Paradigm. *Restoration Ecology*, 15, 351-353.

Craigie, I.D., Baillie, J.E.M., Balmford, A., Carbon, C., Collen, B., Green, R., & Hutton, J.M. (2010). Large mammal population declines in Africa have protected areas. *Biological Conservation*, 143, 2221-2228. doi:10.1016/j.biocon.2010.06.007.

Costanza, R., d’Arge, R., Groot, R. de, Farber, S., Grasso, M., Hannon, B., Limburg K., Naeem, S., O’Neill, R., Paruelo, J., Raskin, R.G., Sutton, P., & Belt, M. van den (1997). The value of the world’s ecosystem services and natural capital. *Nature*, 387, 253-260.

Dahal, R.K. (2006). Geology of Nepal. Retrieved December 10, 2014 from http://www.ranjan.net.np/ranjan/index.php/resources/geology-of-nepal.

Davis, M.A., & Slobodkin, L.B. (2004). The science and values of restoration ecology. *Restoration Ecology*, 12, 1-3.

DFRS (1999). Forest Resources of the Hilly Area of Nepal (1994-1998). Department of Forest Research and Survey, Kathmandu.

Dobremez, J.F. (1970). Biogeographie du central Nepal. Bull Ass. Geographes France, 379-380, 79-90.

DoF (2005). Forest Cover Change Analysis of the Terai Districts (1990-2000/01). Department of Forests, Kathmandu.

FRA/DFRS (2014). *Terai Forests of Nepal (2010-2012)*. Forest Resource Assessment Nepal Project, Department of Forest Research and Survey, Babarmahal, Kathmandu, Nepal.

Hoekstra, J.M., Boucher, T.M., Ricketts, T.H., & Roberts, C. (2005). Confronting a biome crisis: global disparities of habitat loss and protection. *Ecology Letters*, 8, 23-29. http://dof.gov.np/dof_community_forest_division/comm unity_forestry_dof (Retrieved November 19, 2014).

http://www.appliedeco.com/Projects/10Steps.pdf (Retrieved November 2, 2014).

https://www.iucn.org/about/union/commissions/cem/cem _work/cem_restoration/ (Retrieved November 3, 2014).

Ives, J.D. (1987). The theory of Himalayan environmental degradation: Its validity and application challenged by recent research. *Mountain Research and Development*, 7, 189-199.

Joshi, A., Joshi, K., & Shrestha, S.L. (2003). *Environmental Management and Sustainable Development at the Cross Roads*. AnKuS, Kathmandu, Nepal.

Kafle, G., Balla, M.K. & Paudyal, B.K. (2008). A review of threats to Ramsar sites and associated biodiversity of Nepal. *Tiger Paper*, 31, 9-11. Retrieved December 15, 2014 from http://www.fao.org/docrep/012/ak858e/ ak858e00.pdf.

Karkee, K. (2004). Land Degradation in Nepal: A Menace to Economy and Ecosystems. International Master’s Programme in Environmental Science (LUMES), Lund University, Lund, Sweden. Retrieved November 28, 2014 from http://info.thinkgeochemistry.org.uk/ Year%2010% 20Geochemistry/Year%2010/Soils/15KrishnaKarkee.pdf.

Khadka, S.R., & Schmidt-Vogt, D. (2008). Integrating biodiversity conservation and addressing economic needs: An experience with Nepal’s community forestry. *The International Journal of Justice and Sustainability*, 13, 1-13.

Maskey, R.B., Sharma, B.P., & Joshi, M. (2003). *Human Dimensions in Sustainable Land Use Management in Degraded Land Areas of Nepal*. A Paper prepared for presentation at the Open Meeting of the Global Environmental Change Research Community, Montreal, Canada, 16-18 October 2005.

Maskey, T.M. (1996). Status of Biodiversity in Nepal: A Review Paper. In Shengi, P (ed) Banking of Biodiversity: Report of the Regional Consultation on Biodiversity Assessment in the Hindu-Kush-Himalaya, 19-20 December 1995, Kathmandu, Nepal, pp 327-364. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu.
MEA (2005a). *Ecosystems and Human Well-being: Biodiversity Synthesis*. Millennium Ecosystem Assessment, World Resource Institute, Washington DC.

MEA (2005b). *Ecosystems and Human Well-being: Synthesis*. Millennium Ecosystem Assessment, World Resource Institute, Island Press, Washington DC.

MoEST (2006). *Implementation of UN Convention to Combat Desertification: Third National Report Nepal*. Ministry of Environment, Science and Technology, Kathmandu, Nepal.

MoFSC (2002). *Nepal Biodiversity Strategy*. Ministry of Forests and Soil Conservation, Babarmahal, Kathmandu, Nepal.

MoPE (2001). *Nepal’s State of the Environment (Agriculture and Forest)*, Ministry of Population and Environment (then), Kathmandu.

GoN (2003). National Wetland Policy. Retrieved December 15, 2014 from http://erg.com.np/wp-content/uploads/2014/09/878_en_National-Wetland-Policy-2059.pdf.

MoFSC (2009). *Nepal’s Fourth Assessment Report to Convention on Biological Diversity*. Ministry of Forests and Soil Conservation, Babarmahal, Kathmandu, Nepal.

MoFSC (2014). *Nepal’s Fifth Assessment Report to Convention on Biological Diversity*. Ministry of Forests and Soil Conservation, Babarmahal, Kathmandu, Nepal.

Niraula, R.R., Gilani, H., Pokharel, B.K., & Qamer, F.M. (2013). Measuring impacts of community forestry program through repeat photography and satellite remote sensing in the Dolakha district of Nepal. *Journal of Environmental Management*, 126, 20-29.

Noss, R., Nielsen, S., & Vance-Borland, K. (2009). Prioritizing ecosystems, species, and sites for restoration. In A. Moilanen, H. Possingham, and K. Wilson (Eds.) *Spatial conservation prioritization: quantitative methods and computational tools*. Oxford University Press, Oxford, United Kingdom, pp. 158-171.

Parker, V.T., & Pickett, S.T.A. (1997). Restoration as an ecosystem process: implications of the modern ecological paradigm. In K.M. Urbanska, N.R. Webb, & P.J. Edwards (Eds.) *Restoration Ecology and Sustainable Development*. Cambridge University Press, UK.

SCBD (2010). *Global Biodiversity Outlook 3*. Secretariat of the Convention on Biological Diversity, Montreal, Canada.

SCBD (2014). *Global Biodiversity Outlook 4*. Secretariat of the Convention on Biological Diversity, Montreal, Canada.

SER (2004). The SER International Primer on Ecological Restoration. Society for Ecological Restoration International, Science and Policy Working Group, Tucson, Arizona. Retrieved November 15, 2014 from .

TEEB Foundations (2010). Ecosystem Services and Protected Areas. In P. Kuma (Ed.), *The Economics of Ecosystems and Biodiversity*. The Ecological and Economic Foundations, Earthscan, London.

UNEP (2001). *State of the Environment, Nepal*. Regional Resource Center for Asia and the Pacific, United Nations Environment Programme, Pathumthani, Thailand.

UNEP (2014). *Convention on Biological Diversity (Ecosystem Conservation and Restoration)*. Retrieved November 28, 2014 from http://www.cbd.int/doc/meetings/cop/cop-12/official/cop-12-22-en.pdf.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., & Melillo, J.M. (1997). Human domination of earth’s ecosystems. *Science*, 277, 494-499.

WHO (2005). *Ecosystems and Human Well-Being (Health Synthesis)*. World Health Organization, Geneva, Switzerland.