



ECORESTORATION *for* SUSTAINABILITY

EDITED BY

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Arnab Banerjee
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Preface

Environmental degradation is causing a severe impact to the Earth's ecosystems. Unsustainable development and anthropogenic pressure has altered the natural balance. From this perspective, sustainability has become a major goal, namely, to frame a greener and cleaner earth for future generations. The worst hit of unsustainable development is habitat degradation. Therefore, ecorestoration and other ecological practices are extremely important for ecological sustainability. This exciting new book covers all the aspects of ecorestoration and sustainability issues, as well as an insight for future directives.

In the context of the modern world, environmental degradation is increasing at an unprecedented rate. Degradation is taking place in various spheres of the environment, including air, water, soil, and other natural resources, resulting into depletion of natural resources all over the globe. Therefore, it is the need of the hour to restore the ecosystem. In this context, ecorestoration approaches in the form of eco-friendly technologies need to be formulated to promote protection and conservation of the various ecosystems. Ecorestoration approaches has wide dimension in the form of ecorestoration of freshwater bodies, soil and mined out wasteland, degraded forest, biodiversity, and other degraded ecosystems. In the present attempt, current trends and issues surrounding the various forms of degradation processes of the environment along with new innovative technology to restore or rehabilitate the various ecosystem of the Earth would be of prime focus to develop the importance of ecorestoration. Further, this would have a multidisciplinary approach that would address the various issues of the sustainability through ecorestoration and livelihood development. It includes research findings, review, new technology briefings, case studies, opinion and views, policy and legal frameworks, and others.

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Ecorestoration for Environmental Sustainability—An Introductory Framework

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Abstract

Managing forests is a key strategy for offsetting C (carbon) footprints in the globe. Deforestation and other unsustainable land use practices promote C emissions into the atmosphere. Anthropogenic environment of the entire global earth ecosystem is showing an abrupt change. Such changes are evident from various forms of natural calamities and hazards that is leading toward an unsustainable environment for the mankind to live in the upcoming times. Ecorestoration is an approach that integrates various principles from diverse disciplines and applies them on diverse habitat types of the earth surface. Ecorestoration has become a key element and issue to address diverse and major environmental issues, such as food security, biodiversity conservation, regulation of the economic growth, water quality, health and safety issues, climate change mitigation, and adaptation. Therefore, ecorestoration should work for societal upliftment leading to overall environmental sustainability. Ecological restoration too some extent leads to generation of employment opportunities. In this connection, one report briefs that ecological restoration process in United States has generated more than one lakh twenty five thousand jobs directly along with creation of 95,000 jobs indirectly. Proper policy and planning is required for successful implementation of

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the ecorestoration approaches. Further, strategies such as developing climate resiliency of the novel ecosystems and agroecosystem, developing green infrastructure and nature-oriented solution practices needs to be focused for overall environmental sustainability.

Keywords: Ecorestoration, sustainability, environmental degradation

1.1 Introduction

Land degradation is a major environmental issue on global basis. It is estimated that the total cost associated with land degradation process includes up to 17% of the gross domestic product (GDP). Thus, ecorestoration approaches have become the need of the hour in order to avoid such economic loss across the globe. The term ecological restoration simply implies the ecosystem recovery process from a degraded situation [1]. The process is very much important when self-regeneration ability of the ecosystem gets impaired. Therefore, the focus of ecological restoration includes restoration of ecosystem services, functions, and processes. Some of the land uses, such as agricultural land use, undergo intensive modification due to higher production of food. Therefore, extensive modification of the land surface usually takes place through altered land use practices. According to one estimate, globally, the land degradation consists of more than 900 million hectare of degraded croplands, and overall up to 6 billion hectare land has degraded due to variable reasons, which are more than half of land surface at the global level [2, 3]. Significant amount of economic loss is associated with altered land use along with various forms of land use change [4]. Ecological restoration is an important process that helps to improve the quality of degraded land to promote crop yields and various other forms of benefits in the form of ecosystem services [4, 5].

Globally, various ecosystems are undergoing several process of ecosystem degeneration due to practices of modernized agricultural systems. Considering the fact of maximizing the yield minimum attention is being given to environmental aspects. Altered land use in the form of conversion forest land for agricultural production and animal husbandry practices has taken place due to benefits in terms of more economic gain. Further, no proper attention has been given to the soil and land resources for their contribution toward agricultural production. No proper sustainable approaches are available toward proper land management and conservation of stock of capital resources that is required for agricultural production. Therefore, various nations across has taken initiatives at global

level to frame policies and regulatory framework to reduce the hazards over land surface. Overall, the process of degradation of land is considered to have huge social and economic costs, which can be mitigated through various ecological restoration processes. Restoration of degenerated lands is a key element toward the various approaches to inhibit the spreading of agricultural land use in place of forested land use. Subsequently, it would also help to fulfill growing energy demands and address the issue of food crisis [6, 7].

Ecorestoration approaches would also bring benefits in terms of improving various forms of ecosystem services along with natural resource conservation [8]. Overall they will bring various forms of tangible and non-tangible benefits (Figure 1.1). It includes conservation of natural resources, biodiversity conservation along with sociocultural and economic benefits to the people [8–10]. According to one research report, ecological restoration of grasslands reflects benefit-cost ratio of 35:1 along with addition benefits [11]. Ecological restoration, to some extent, leads to generation of employment opportunities. In this connection, one report briefs that ecological restoration process in United States has generated more than one lakh twenty five thousand jobs directly along with creation of 95,000 jobs indirectly [12]. Such type of benefits has lead to the promotion of ecorestoration process up to a hundredfold increase [9]. Globally, in various conventions, treaties have been organized as well as UN-Sustainable Development Goals (SDGs) emphasized the importance of ecorestoration for achieving sustainable development [13]. The target of LDN till 2030 can be achieved through massive ecorestoration processes [14]. As per the Paris agreement in 2015, UNFCCC has mentioned the importance of increasing forest cover and stock of soil carbon to combat changing climate. Various policy frameworks have been already implemented worldwide to promote the ecological restoration process [15]. Further promotion of ecorestoration process requires extensive activities, research and extension [15]. The present chapter would address the issue

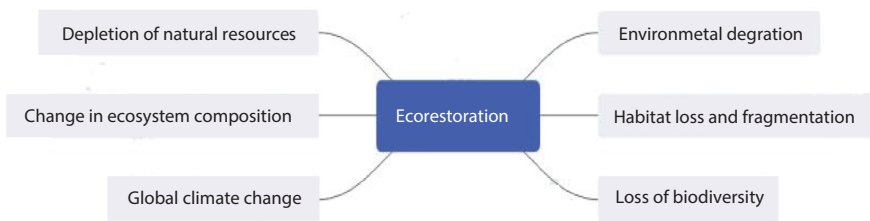


Figure 1.1 Fundamental issues addressed through ecorestoration process.

of ecological restoration on global basis along with recent approaches and advances across various ecosystem services.

1.2 Global Scenario of Ecosystem Types and Their Degradation

Under the changing environmental condition the various ecosystem and habitat types is undergoing severe changes and is under the forefront of rapid degeneration (Table 1.1).

Table 1.1 Global scenario of ecosystem degradation and necessity of ecorestoration approaches.

S. no.	Ecosystem type	Nature of degradation and associated problems	References
1.	Agroecosystem	Unsustainable agricultural practice is causing an economic loss of USD 270 Million on annual basis in Kenya.	[16]
		12 million hectares of agriculture land undergo severe erosion leading to loss of EUR1.25 billion on annual basis.	[17]
		In People's Republic of China only 14% land area is available for cultivation purpose.	[18]
2.	Forest	Across the globe approximately 420 million ha of forest land has been transformed into other forms of land uses since last three or four decades.	[19]
3.	Fresh water	Shrinkage of Aral Sea in Central Asia has taken place at an alarming rate so that its area has been reduced to one tenth of its original area.	[20]

(Continued)

Table 1.1 Global scenario of ecosystem degradation and necessity of ecorestoration approaches. (*Continued*)

S. no.	Ecosystem type	Nature of degradation and associated Problems	References
4.	Grassland habitat	29 million hectares of grassland In western Canada has been converted into agricultural unit causing 25% soil C loss and gradual degeneration of soil quality.	[21]
5.	Mountain ecosystem	Glacier volume of Hindukus Himalaya range has declined by 90% in the 21st century altering the hydrological regime of the South Asian Region.	[22]
6.	Coastal and marine ecosystems	Great barrier reef of Australia has undergone 50% of loss of its coral population due to ocean bleaching.	[23]
7.	Peatlands	Globally 50% of the peatlands has been degenerated due to altered hydrological regime.	[24]
		In Germany 98% of peatland, 95% in Netherland, in Ireland 82%, in Denmark 93% has been drained.	[25]

1.2.1 Agroecosystem

Agroecosystem is the essence of life as it is the main production unit that supports the human consumption as well as provides various forms of tangible and non-tangible benefits [26]. Globally, approximately 2 billion people are directly dependent on the agriculture sector for maintenance of daily livelihood [27] as well as ninety percent of energy and protein input comes from the land surface [27, 28]. Degradation of the agroecosystem not only reduces the crop and livestock yield.

It was observed that degradation of agricultural land reduces the crop and livestock yield. The major impact of such degradation is reflected over the soil [29]; however, the impact spreads in the form of wild species

extinction that has gotten its inherent advantage to provide various forms of ecological services [30]. Various forms of soil problems tend to cause three-fourth of the land problems across the globe. Within a span of 11 years, soil tends to affect 1/5 of the agriculture land over the earth surface and hence shows an increment of 2.5% of the erosion event. The major reason behind such event includes altered land use practices in the form of loss of forest cover and an increase in the agriculture area [31]. According to one estimate the productivity of land ecosystem would show more than 10% decline leading to hike in food prices more than 30% till 2040 [32]. Economic loss associated with such farmland degradation in European Union reflects EUR 1.25 billion associated with loss of 12 million hectares of eroded cropland [17]. Loss of fertility status in USA results in half a billion dollars economic burden on annual basis over the farmers community. The condition is very much worst in case of China reflecting only meagre 14% of land area available for cultivation practice and half of the farmland has already being degraded [18]. In Kenya, under African continent there is significant decline in the crop productivity, livelihoods, and well-being of the local community stakeholders. The loss of soil fertility, known as mining of soil nutrients is reducing the yield and economic loss up to USD 270 million dollars on annual basis. Further, it has got severe impact across various habitat and biodiversity [16].

1.2.2 Forests

Forest ecosystem has an inherent capability of regulating the climate [19] along with carbon absorption from the atmosphere [33] and provide habitat for diverse group of organisms [34]. Further, forest contributes regulating various processes under hydrological cycle [35], and therefore provides water for drinking purpose of 33% of the global cities [36]. Further, forest also helps to create job or employment opportunities in various forms [37, 38].

Within a span of 5 years (2015–2020) deforestation has lead to loss of 10 million hectares of forest [19]. If the current trends of the forest continue then there would be a global loss of 223 million hectares of land area till 2050 [39]. On annual basis 122 million hectares of forest land would be affected by several natural disaster events [40]. Depletion of forest may lead to affect the 1.75 billion people who have been directly and indirectly affected by deforestation. Degradation leads to high incidence of natural hazards, as well as increase human-wildlife conflict [36, 40] as well as epidemic diseases [41], such as animal borne diseases, Ebola virus and COVID-19 virus infection [42, 43]. Further, the combination of such

processes within a span of 18 years has lead to emission of 8.1 ± 2.5 GtCO₂ e per year basis [33].

1.2.3 Freshwater

In the aquatic environment, it was reported that there is occurrence of 33% vertebrate species and one tenth of global species that occurs on the earth surface [44]. The species diversity tends to be higher in the areas of world's wetlands. Further, inland fisheries are the potential source of food in the form of freshwater ecosystems, as well as sources of water for various other economic activities [45]. Inland fisheries ecosystem also tend maintain the water quality and undergoes climatic regulation along with protection from natural hazards. The nexus between forest and water acts as two-third of global water source from the area of forested watershed [35].

On global basis, 1.4 billion people are dependent upon the various forms of water resources and associated industrial activities [46]. However, such ecosystem services are under severe threat at present times. Such incidences has taken place due to overuse of water in last century [47] and according to one estimate this demand would rise further till 2050 [48]. Freshwater utilization for energy production and irrigation activity leads to negative consequences and socio-economic alterations [49]. The most important fact is that more than 90 percent of freshwater footprint accounts from agricultural activity and more than 25% of water resource is used in animal husbandry practices [50]. The scenario of wetland loss was alarming since 19th century onward. Although the developed world has arrested the rate of wetland loss quite a bit but in Asian subcontinent the rate has shown an unprecedented rise due to altered land use practices. Such degradation of freshwater resource has caused half a billion people to face the acute problem of water scarcity per annum globally [51]. The gradual shrinkage of Aral Sea of freshwater habitat is a clear cut example of depletion of freshwater resource worldwide [20]. The main reason behind such shrinkage of water resource includes the diversion of water for crop production and thus leaving the area dry, polluted and gradually salty. The problems such as food crisis, security, loss of employment opportunities become severe on this aspect [20, 52].

1.2.4 Grasslands, Shrub Lands, and Savannahs

Diverse habitats of grasslands and associated biomes are more prevalent in the Asia and African subcontinent [53] and are mostly dry land habitats. It also includes the hyper arid desert areas with low productive nature but

still support a significant amount of global population [54, 55]. According to one report, 250 million people are very much dependent upon on this dry land ecosystem in East African region for maintaining their daily livelihood [56]. Such activities in dry land areas help in carbon sequestration process that helps to combat the changing climate [57]. Such dry land farming system also provides various forms of resource to mankind as well as they act as biodiversity hotspots [19]. Besides performing such valuable ecosystem services such ecosystems are under severe threat of degradation due to agricultural activity globally [58]. In Europe the condition of such grassland habitat is very much worse [59]. Such impacts also cause severe negative consequences over the local community population [60].

1.2.5 Mountains

Mountain ecosystems approximates 50% of the hotspot are in terms of species diversity across the globe [61]. Such ecosystems are pivotal in terms of maintaining daily livelihood of the local people as well as provide various forms of ecosystem services. Mountain ecosystem is also known as “water towers of the world,” and hence fulfills 50% of the fresh water demand of global population [62]. Mountain ecosystem tends to act as food source of 20 plant species that fulfill the food requirements of 80% of the world population [61]. Therefore, degradation of such important ecosystem reduces the productivity in terms of agricultural crop and animal husbandry production. At present times, 50% of people residing in the mountainous region is under the severe threat of land degradation. Also, the problem of food security and crisis has reflected an alarming threat [63].

Natural disturbances have caused several negative consequences over the earth surface and human life. For instance, in last two centuries, incidence of floods due to outbursts of glacial lake has caused several death consequences in Asia, South America, and European countries. This has caused alteration of the hydrological regime impacting the agricultural production and water resources [64].

1.2.6 Oceans and Coasts

Marine ecosystem is the major component of global earth ecosystem, which supports 90% of global life [65], as well as contributes up to 80% of oxygen of the atmosphere [66]. Apart from this ocean ecosystem also plays key role in regulating the climate of the global earth ecosystem as well as