Volume 18 Issue 10
Originally issued as B1

Global Journal of human-social science: B
Geography, Geo-Sciences, Environmental Science & Disaster Management
Volume 18 Issue 1 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-460X & Print ISSN: 0975-587X

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GJHSS-B Classification: FOR Code: 050199



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Hamere Yohannes [α], Teshome Soromessa [σ] & Mekuria Argaw [ρ]

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I. Introduction

Currently, many ecosystems are at risk due to intensive exploitation of resources. This have an impact on the service they provide for human being such as food and fibre production, water provision, climate regulation and wildlife habitat [1]. It is estimated that 86% of the world's population live in countries that require more from nature than their ecosystems can provide [2]. Our consumption rates already exceed the supply of many resources crucial to human health, and few places on Earth do not bear the stamp of human impacts [3]. Over the last 50 years, 60% of worldwide ecosystem services have degraded due to increases in the global population and economic growth [4]. As these impacts increasingly compromise biological diversity, human health and food security. Therefore, policy makers and managers started to push to investment in ecosystem restoration [5].

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Long-term solutions to current environmental problems involve not just conservation of the natural world, but increasingly the restoration of ecologically healthy landscapes and communities [6]. Ecosystem or ecological restoration defined as an intentional activity that initiates or accelerates the recovery of a degraded, damaged, or destroyed ecosystem with respect to its health, integrity, services, and sustainability. The damage may have been caused or aggravated by natural events such as wildfire, floods and storms or, caused as the direct or indirect result of human activities [7].

Ecological restoration is important to enhance ecosystem services and biodiversity, mitigate and adapt climate change, slow biodiversity loss, and contributes to the improvement of human well-being and humanity's relationships within nature [6]. The main goal of restoration is to create self-supporting ecosystem which do not need further assistance to develop mature characteristics [7] [8]. Though, ecosystem based management is powerful and effective, it is costly and time demand action [9]. Ecological restoration requires multiple efforts, long-term commitment, and thoughtful deliberation [10].

In general, the field of ecological restoration has thus received increasing attention worldwide and has experienced tremendous advancement over the past 30 years and is now widely recognized as an essential component of the fields of conservation and sustainability [1].

a) Gaps identified from critically evaluated literatures

Traditional management of ecological systems focuses on specific products or services desired by people, with emphasis on marketable commodities. Resource managers learn just enough about ecosystems to maximize the production of these commodities. As a result, ecosystems are overused and poorly understood [11]. Similarly, Ecological research on restoration has largely focused on community ecology and ecosystem ecology, with particular attention to plants [12]. Nevertheless, an ecosystem perspective on land and resource management means thinking about land-its soils, waters, air, plants, animals, and all their relationships-as whole units that occur in a hierarchy of nested places [13]. Therefore, researches

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and management practices works on restoration of degraded ecosystem should focus in integrated ecological restoration.

Over the last decade, there has been an observation that shows the clear gap between knowledge generated by the researchers and practical application by restoration practitioners in ecological restoration [14] [15]. Though, the need of ecological restoration concept is widely discussed [6] [1], there is still a gap in successful implementation on the ground and report. And this issue is marginally addressed in scientific literatures [11].

In addition, Though, there are different literature, that shows the efforts to explicit integrated ecological restoration by considering different factors for instance the integration of, ecological knowledge, management action and social dimension [16]; multi-functionality, transdisciplinary, participation, complexity, and sustainability [17]; ecological theory with practice and restoration ecology trans-disciplinary framework [18]. Still there is a gap to explore more factors of integrative approaches in ecological restoration in depth. Here in this paper an integrated approach to managing natural resource is not introduced as a new concept, here try to refined through multiple integration such as incorporating landscape perspective; transdisciplinary link, socioeconomics and policy dimension with restoration, scientific based practice and flexible plan and management, because restoration ecology needs to adopt a more integrated approach which will make it a more useful science for sustainability as we progress further in to the twenty-first century. Therefore, this paper shows the possible factors could be integrated in ecological restoration as approach to progression of ecological sustainability. This paper tries to fill the gap by review scientific literatures to overview the current status of ecological theories and principles implementation in ground and the main challenges and propose conceptual framework to apply integrated ecological restoration.

b) Objective of the Review

- Review the experience of ecological restoration practice and main challenges,
- Explore the components of integrated ecological restoration and propose conceptual basis.

c) Review Methodology

This paper is prepared from various review of scientific articles, books, reports published from 1987 up to 2017. The overall process of preparing this paper was done by following the main steps adopted from [19], deine the topic, obejecvtive formulation, select key words for searching, identify the key databese and criricall review the publication. The databases used included Google Scholar, Web of Science, science direct, Scopus and others which were searched in June and July 2017 by using the key searching terms. Accordingly, 118 scientific papers were critically evaluated and included in this seminar review as per to the requirement of the main topic. The main journals reviewed were Ecology and Society, Restoration Ecology and Journal of Ecology. And mostly SER and CBD secretariat reports were used in this paper.

During the review, the focus was collecting concepts and practices for integrated ecological restoration approach to become a paradigm shift for sustainability. Therefore, social, environmental and economic issues were duly incorporated.

II. Review of Related Literatures

a) A Brief History of Ecological Restoration and Paradigm Shifts

The idea of restoring the land dates back centuries, practiced in the different forms, such as erosion control, reforestation, and habitat and range improvement [20], but modern restoration ecology and its practice began in the early 1900s when people such as famous conservationist Aldo Leopold (a forester) began promoting the movement [12]. Restoration ecology is the science on which ecological restoration is based. It emerged as an academic field in the 1980s [16]. Science of restoration ecology has become a strong academic field [20].

Gaining momentum in the latter half of the twentieth century, restoration ecology is now established as a science and studied in many research institutions. International societies and journals, such as the Society for Ecological Restoration (SER) (established in 1988). There has been a strong push to formalize the science and practice of restoration, linking it explicitly with ecological theories [12] [21]. In addition, since the publication of the Millennium Ecosystem Assessment in 2005 there has been a surge of interest in ecological restoration to recover biodiversity, re-establish ecosystem functioning and connectivity, and reactivate the delivery of ecosystem services [22].

As [23] stated "*the next century will, I believe, be the era of restoration in ecology*". Over the last 30 years, ecological restoration has emerged as the central new promise for the reconciliation of societal well-being and biodiversity conservation in a human-dominated world [24]. During this period, many paradigm shifts in restoration ecology develops. The foremost paradigm shift was the emergence of ecosystem based management in 1980's to provide best alternatives for traditional resource management approaches. In 2000, CBD adopted this approach and develop 12 principles for the implementation. [25] [26].Though [27], argue that Ecosystem Based Management cannot be considered as new paradigm shift, because since Leopold's effort of restoration in 1930's there was ecosystem management, although he never actually used the term

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ecosystem management, his career testifies that he recognized the need to protect or restore ecological components, in order to sustain resources. According to [4], By the early 2000s, EBM was the dominant paradigm, at least in theory, for managing natural resources around the world, in both marine and terrestrial systems. [28], identified 17 different criteria that are commonly used to define ecosystem-based management.

In the mid-1980's, there was a paradigm shift with the promotion of more holistic approaches originating from within the conservation community and the emergence of the scientific discipline of landscape ecology [29]. Consequently, since mid-1990's, the paradigm of restoration with landscape perspective thus goes beyond restoring pieces of land or even restoring large area, while ignoring the influence of the landscape structure was raised. Many literatures stated that we need to move from small-scale "environmental gardening" to large scale restoration based on landscape ecology principles [30][17] [31].

The other fundamental paradigm shift was from ''backward-restoration'' to ''forward-restoration'', in which never-seen futuristic designer ecosystems may be the best option to attain self-sustaining ecosystems for the future [32][33]. For the first time, Aldo Leopold, recognized that the practice of ecosystem health required reference points - healthy, intact ecosystems. A reference ecosystem is a model adopted to identify the particular ecosystem that is the target of the restoration project [34]. It can be an actual site (reference site) or a conceptual model synthesised from numerous reference sites, field indicators and historical and predictive records [1]. Restoration of past ecosystems is possible when climatic conditions suit the species that once were present [10]. However, the [35] reported that *global warming of 1.5°C above pre-industrial levels and no sign of temperature reduction. This shows that there is no much chance going back. [36],* also argue that restoration should follow nature's lead, not in order to recreate an 1850's ecosystem, but to restore an ecosystem's ability to respond to change. [10] pointed out historical information is a useful guidance but should not be a 'straight jacket' for projecting restoration goals and trajectories in the future. According to [3], A restored ecosystem will not necessarily recover its former state, however since contemporarily constraints and conditions can cause it to develop along an alternative trajectory [34]. Therefore, we should intervene with an eye to the future and toward managing for future change [37][38]. Therefore, forward restoration become a major paradigm shift.

[18] reported the two recent paradigm shifts in ecological restoration, the first one is moving towards more scientific foundation to unite science with practice and the second is to locate restoration firmly in the transdisciplinary arena. In general, Restoration ecology has historically emphasized the management actions and interventions associated with recovery of damaged ecosystems, sometimes referred to as the "restoration toolbox" [39]. But in recent years, the field has seen a paradigm shift toward stronger scientific foundation and better inclusion of socioeconomic, political, economic, cultural, regulatory frameworks, and taking account of the past and future for sustainability [40]. This could lead as to more holistic and integrated ecological restoration approach.

b) Ecological Restoration in Practice

Through ecological restoration theories are translating to practice. Most countries have suffered degradation and forest loss and have opportunities for restoration. According to [41], rough estimation, more than two billion hectares worldwide offer opportunities for restoration. Most of these lands are in tropical and temperate areas.

From a global perspective, restoration work generally is not taking place in the countries where it is most needed. Most ecological restoration research come out from high income countries classified and the work mostly focuses on forest and aquatic ecosystem [42]. For instance, Vast deforested areas in Europe and North America have regrown forests. In contrary, though, tropical regions have the largest need for restoration efforts, the practice is limited [41]. Ethiopia has 82 million ha of potential for tree based landscape restoration, varying with short and long term [43].

Win-win projects that result in both conservation and economic gains are not easy to implement, although they are a commendable goal [44]. Consequently, according to [28], there are relatively few case studies of successful implementation, and the extent to which the ecosystem based management principles in restoration, for instance Restoration in Kissimmee River, is considered as the most successful project which includes ecological evaluation and adaptive management till date [45].Atlantic Forest Restoration Pac program in Brazil and Sloping land conversation program in China (restoration in Yellow and Yangtze river) also has good progress in ecological restoration. South Korea and Costa Rica have embarked on successful forest restoration strategies [41].

Though, [21], pointed out that the number of empirical evaluations has increased during recent Years, a recent review of restoration in the Nordic countries indicates that ecological restoration projects in the region often completely lack formal evaluation [46]. Other studies also show this to be the case in other parts of the world [47] [48]. In addition, [49], found that from 10 case studies in Northern Hemisphere countries, most evaluations were short-term and only some parts of them were properly documented, which affects adversely the efficiency of restoration process, since inefficient methods were implemented. They suggested

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that perform continues evaluation, disseminate the finding both successes and failures. The case in Ethiopia is the same, there are very few examples of successful implementation of restoration and no proper documentation[50], For instance, Humbo forest restoration landscape and Tigray region restoration experience (Abreha Weatsbeha, Geregera, Mossa and Kihenwatersheds) [51]. There is also ongoing effort in Bale mountain, with Participatory Forest Management (PFM) and the newly launching program to conserve biodiversity and ecosystem functions and services. As compared to the current land degradation status, that is about 33,193,3903.14 ha (30% of total land) of land is degraded in Ethiopia [52], These efforts are not adequate.

On the other hand, [53], reported that Ethiopia is rising as a leader in restoration, though the country passes the long difficult road. In the past, 97% of Ethiopia native forest was lost and 1984-85 famine. Over the last decade, Ethiopia put tremendous effort to rehabilitate and restore degraded lands by using Sustainable Land Management (SLM) tool.

c) Challenges/ Barriers to implement Ecological Restoration

Since ecosystem is more complex process, there might be challenges raised from timing, capacity, communication, and collaboration challenges [53].

i. *Sever land degradation*

In many of severely degraded production landscapes, which loss of habitat and biodiversity, changes in hydrological processes, loss of soil and altered nutrient levels. Restoration to a former state is not viable, and they will be targets of ecosystem repair to improve levels of ecosystem function and services, using native species where possible [37]. According to [54], where the hydrological components like wetland completely drained, soil nutrient and microbial severely degrade, plant and animal communities completely lost and the whole landscape fragmented, restoration become really challenging.

ii. *Cost and Time Constraint*

The areas of degraded land now present in various parts of the world are large. Some systems are severely degraded and will be costly to repair [55]. There is lack of attention to the cost of restoration in research and literatures due to different factors such as economists and ecologists have traditionally approached the cost in different disciplinary perspective; restoration and economics are viewed as opposite force and the consultants who is responsible to guide and publication the whole process may not make the data available. Despite these obstacles, it is essential to integrate ecology and economy in restoration effort [56]. Later, different literatures try to integrate the broad sets of socioeconomics and ecological objectives and criteria when planning and evaluating restoration projects [42][57]. Although progress has been made conceptually, too few practical applications have been achieved during the last 15 years, especially in the crucial areas of valuation and financing [58]. Concurrently, there has been far too little work on how to actually measure and monitor the economic effects of restoration [59], However, Restoration feasibility depends also on restoration costs [60].

In high latitude and high elevation areas, ecosystem often require decades or centuries to recover as a result of short growing season in these areas [61]. Furthermore, in some natural ecosystems require a longer time to develop their mature character. Mostly, it is difficult to determine how long the ecological restoration takes to reach endpoints and even it is hardly to determine the exact time [62]. Typically, if the ecosystem is highly endangered, the responsible bodies fail to commit for the restoration as a result of recovering this kind of ecosystem become time consuming and costly [63].

iii. *The issue of trade-offs in restoration*

Restoration actions focusing on a particular ecosystem service could lead to negative impacts on biodiversity or provision of other services, which will need to be considered during the planning process, leading to conflicts and trade-offs [24]. As restoration of one ecosystem service may come at a cost to another, one particular challenge is how to ensure multi-functionality in both the short and long term. For instance, although planting a few short-lived but fast-growing species is a common approach for carbon offsets, these plantations do not approach the diversity of naturally occurring tropical forests and can have a high rate of failure [64]. [65], also found that vegetation restoration can produce positive effects on Net Primary Productivity, but negative effects on Water Yield. A carefully chosen balance between the aimed biodiversity benefits and the unwanted side-effects is likely to be highly context-specific, where local and national rules and regulations and public opinion provide inputs [66]. The good thing is trade-offs between biodiversity and ecosystem services may change through time after restoration starts [24]. Navigating the trade-offs between provisioning, regulating, cultural, and supporting ecosystem services, as well as maintaining natural capital that is critical to generate future services, is essential for achieving sustainability [67].

iv. *Social Conflict*

Often it may be impossible to choose the optimal sites for restoration due to unwillingness of the land owners [60][57]. Furthermore, it may prove problematic to find areas large enough to host and maintain restoration objectives, especially in densely populated areas characterized by highly fragmented forests and diversified forest ownership. Many of

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degraded ecosystems are still being used by people and many of these people are poor, which could worsen the degradation level [55]. Some research done in Latin America reported that social perceptions towards restoration effort and expectations of several stakeholders could be one of the main challenges of most restoration project in Latin America countries [68][57].[9] also reported that social understanding and need difference could rise to conflict.

v. *Limited Information and Knowledge*

Often, there is little information about the past ecosystem composition and structure, because ecological restoration is relatively recent decade science, in this situation, it become difficult to evaluate the success of restoration [48]. Information access within and among countries still needs improvement. Sometimes, scientific knowledge is not available to practitioners. Much information and knowledge are not produced in scientific arena and are incompletely communicated. In many cases, they are housed in theses, technical publications, forums, and other media products. Knowledge of the whole ecosystem process and function and skill to implement ecological restoration practice also limited [69]. It is necessary to consider and have knowledge about the resilience of the ecosystem, past land use, and the matrix of the surrounding landscape to define restoration approaches in a socioecological perspective [57].

vi. *Lack of Standard Criteria*

There is limited success in many projects due to inappropriate planning and implementation. There has been a growing need for a clear set of standards to establish benchmarks for the technical application of restoration treatments across ecosystem types, and to maximize ecosystem recovery within a framework that engages stakeholders and respects socio-cultural realities and needs. Practitioners, operational personnel, planners, managers, funders, and regulators need standards to help them develop high quality plans and achieve acceptable ecosystem recovery outcomes [69]. [70] reported that there are no standard criteria to assess the restoration success in Ethiopia. Only in recent year (2016), SER release international standard for ecological restoration. These international standards follow pioneering efforts of SER Australasia to develop 'National Standards for the practice of ecological restoration in Australia'. And it became the first such initiative anywhere in the world. Still now no information about its adoption and applicability in local scale in other countries[69]

vii. *Funding*

Most restoration projects lack adequate funding for monitoring [71]. According to [72], Funding for restoration effort and monitoring of its effects is often granted for short periods, and granting is more politically than scientifically motivated. Amount of incentives; amount of resources invested; number of institutions involved; presence or absence of incentives; subsidies or fines to stimulate or discourage restoration activities [60]. Without sufficient funding, the success of our efforts will be difficult to assess, or have the option to revise actions if necessary [66].

d) Integrated Approach in Ecological Restoration

An integrated ecosystem approach is perhaps the only way to tackle the challenges of climate change, habitat loss, and the sustainable use of natural resources. Ecological restoration and biological conservation are the logical pillars upon which we can build an innovative approach to maintaining and restoring the ecosystems that we, and all life, depend on [73]. Restoration ecology is an integrated science, because it adds political engagement, economic basic conditions, education of people, and even cultural aspects [32]. Different authors [18][17][74][16] address integrated ecological restoration by considering different factors, these all efforts revealed that the progress of ecological restoration towards sustainability. According to [53], early integration starting from restoration planning, provides opportunities for efficiency opportunities for improved and productive collaboration and coordination which bring cost-savings in monitoring and adaptive management. Here in this paper, the following components are proposed as a part of integrated ecological approach to meet sustainability, which could increase the success of ecological restoration. These are scientifically based restoration practice, consideration of landscape perspective in restoration, multidisciplinary approach, socioeconomic and policy framework and flexible plan and management actions. Though it is well known in some cases to address all the factors, it is a way of achieving sustainable management.

i. *Combine scientific basis to restoration practice*

The science and practice of ecological restoration have advanced rapidly in the last decade, creating a wealth of guidance, tools and technologies [75]. [10], noted that ecological restoration until recently has been viewed as more of as art rather than science. In addition, [1]) reported that, to date, many of the restoration actions are based on gut feeling rather than on scientific evidence. In fact, the practice of restoration has developed more through trial and error than by the application of any scientific framework [76].According to [18], including scientific basis for restoration practice is one of the paradigm shift. Thus, ecological theory is highly relevant to the practice of restoration ecology. Ecological restoration is applied science and derives from the science of restoration ecology, it means restoration ecology is the science on which ecological restoration is based. Restoration ecology ideally provides clear concepts, models, methodologies and tools for practitioners in support of their practice [34][7].

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Restoration ecology is rooted in ecological principles, such as successional theory, assembly, life histories, recruitment limitation and landscape ecology [77] [8]. [78] stated that ecological restoration should be an acid test of ecological understanding. According to [32], Ecological restoration still can be considered as an acid test, but for our understanding of the interaction of people with their environment, rather than for pure ecology. During this test, restoration ecology can develop new theory specifically to repair damaged ecosystems [7].

Ecological restoration is a knowledge and practice based undertaking [80] [38]. Restoration plans must be based on the best available science [81] with clear goals. Science-based restorations follow: (1) explicitly stated goals, (2) a restoration design informed by ecological knowledge, (3) quantitative assessment and data collection of system responses employing pre- and post-restoration (4) analysis and application of results to inform subsequent efforts, based on adaptive approach [82]. Although, ecological restoration has scientific foundations, the integration of ecological theory and restoration has been uneven, despite recognition that the practice could be enhanced by such integration [20] [1].

ii. *Landscape perspective in ecological restoration*

The first decades of ecological restoration practice were dominated by small-scale initiatives not integrated at the larger scales [30]. In recent year, it is becoming increasingly clear that ecosystems do not function independently from their surroundings and their spatial relations is important [83]. And restoration sites are not isolated compartments; rather they are linked to their surroundings [32]. In addition, the extent of current environmental degradation and the increasing call for large-scale restoration necessitates approaches that can be applied over much larger areas. Ecological restoration can occur at a variety of spatial scales but for maximum benefits should be approached from a landscape perspective [84].

Landscape ecology perspective in restoration mainly consider mosaic ecosystem or the improvement of landscape structure, functions or dynamics, as well as local restoration actions that consider the influence of the surrounding landscape structure on restoration outputs [30]. According to [85], study in Boral forest, Landscape context considerably affects the success of ecological restoration. Similarly, [86], stated that landscape context or surrounding matrix is one of the factor that should be considered during management planning like ecological restoration, because the surrounding land use matrix affects recovery because it serves as an important source of propagules, as well as potential disturbances.

Considering landscape approach is becoming a driving paradigm in the international environmental and development community [17]. [87], also proposed a landscape ecological paradigm shift in resource management design. Thus, Recently, many large-scale restoration programs have arisen across the world. It became induced by other forces such as payments for ecosystem services (PES) schemes [39], the production of timber and non-timber forest products from native species [88], and biodiversity offsetting policies [89]. These programs integration in restoration project could serve as to compensate the highest cost of restoration in landscape scale [86]. But, project that links restoration and these programs are very few [42]. In this context, restoration ecologists and practitioners, as well as policy makers, will certainly have to be prepared to adopt new approaches for inducing, planning and implementing restoration programs. According to [57], Restoration approaches should be based at national levels, but adapted to local-regional levels, in a bottom-up perspective.

iii. *Flexible plan and management actions*

Flexible plan in ecological restoration identifies a probabilistic range of possible outcomes instead of a single reference condition. [90] states that there is a need to identify multiple probabilities and trajectories of outcome to restoration rather than expecting the emergence of a site resembling a single reference system. According to [69], full recovery is not possible or appropriate everywhere. In many cases where restoration has been assumed by some to be impossible (if the system passes its allowable thresholds), it would be sensible to modify the goal.[91] also reported that if the area is highly degraded due to intensive disturbance, creation of new ecosystem (novel) and enhancement will be an option.

The emergence of the novel ecosystems concept is reshaping the field of ecological restoration. In the context of past and ongoing local and global changes, many ecosystems are being transformed into new, non-historical configurations [92], it allows more flexible goal for restoration for the changing environment. Because of these changes, historical restoration targets will often be unsustainable in coming decades [93][37][38] [94].

On the other hand, [80], suggested that the introduction of novel ecosystem together with restoration target may not be important in protected area since some protected areas may be relatively resistant to change and restoration with a focus on historically determined goals will still make sense. According to [93], ecological restoration primary aim is to restores historical ecosystem where possible. Meanwhile, the project need to be ready for the emergence of novel ecosystem. Though the issue is still a debate [95] suggested that in the 21st century the restoration priorities should be broadening the restoration framework to include the emergence of novel ecosystem.

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According to [96], ecosystem management (here restoration) involves decision making within extremely complex natural and social dynamics, the outcomes of management actions are highly unpredictable. In addition, each restoration project has its own uncertainties and surprises, and each requires flexibility. Adaptive management is a way to remain flexible and cope with surprises while making necessary management decisions. It is an approach to ecosystem restoration that recognizes uncertainties, embraces multiple problem-solving strategies, and allows for adjustments to be made along the way in smart way [97]. It promotes flexible decision-making to modify existing activities or create new activities if new circumstances arise or if projects are not meeting their goals [98]. Most literature reported that integrating adaptive management in resource management is very important and useful, however, practical implementation and reporting is still behind, particularly in large scale [99]. Scientific based restoration should include adaptive management, the corrections that are made to the restoration process should be guided by sound theory and experimentation, not just trial and error [82] [100]. Natural resource restoration is complex management systems, we must manage them adaptively and in an integrated manner [101]. In short, flexible adaptive management is one of the general principle ecosystem based restoration [73].

iv. *Socioeconomic and policy dimension in ecological restoration*

During the last few decades, the interest in ecological restoration has increased rapidly [75]. In earlier time, restoration emphasized on ecological sustainability, but in recent past decade, the importance of human benefits from the management become dominantly important through the concept of ecosystem service integrity in restoration efforts, which could bring social sustainability [102]. The practice of ecological restoration seeks to transform humanity's role from agents of degradation to act as conservators and healers of indigenous ecosystems [103]. Although ecological restoration deals with scientifically based practical alterations of ecosystems, it is not only a technical task. Instead, it has an important human element, with strong social and political associations that are increasingly acknowledged in ecological restoration to reach the goal [104]. Therefore, Restoration is carried out to satisfy not only conservation values but also socioeconomic values, without considering these values, particularly relationships between a site and its stakeholders, a restoration project may not gain the social support needed for success and may fail to deliver important benefits to ecosystems and to society [69].

Above all, still there is a gap in addressing practically, all social attributed in restoration effort, for example, [42] did comprehensive review on socioeconomic aspects of ecological restoration, and the most tangible and concrete socioeconomic contributions of restoration to society are underemphasized, or often ignored altogether. [21] also found that very few papers looked at socioeconomic attributes of restoration, but understanding the socioeconomic benefits/impacts of restoration is necessary to support the adoption of ecological restoration in natural resource management. Ecological restoration should also be recognized as an important element of sustainable socioeconomic development particularly for developing countries [42].

Nowadays, there is emphasis on the importance of restoration for addressing global environmental change [105]. It became integrated in global and regional biodiversity policies [75], sustainable policies [58], United Nations Framework Convention on Climate Change (UNFCCC), land degradation neutrality under the United Nations Convention to Combat Desertification, the wise use of wetlands under the Ramsar Convention on Wetlands and Bonn challenge [106].For instance, in achieving the 2020 Biodiversity Targets, the so-called Aichi Targets (including restoration of at least 15 per cent of degraded ecosystems), including by the European Union, UNEP, World Bank. More recently, the United Nations adopted its 2030 Agenda for Sustainable Development, including Sustainable Development Goal (SDG)15 to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" [24][107]These and other international organization also coming to the realization that ecological restoration should receive high priority from society in socioeconomic as well as ecological perspectives [42].

Practically, the two large-scale ecological restoration programs examples are the Atlantic Forest Restoration Pact (AFRP), which aims to restore 15 million ha of degraded lands in the Brazilian Atlantic Forest by 2050 [108], and the Sloping Land Conversion Program (SLCP) in China, in which steeply sloping and marginal land has been retired from agricultural production since 1999 in order to promote forest and grassland cover [109]. These initiatives align with Aichi Targets [110].

In parallel, the Bonn Challenge (2011), which is global commitment to restore 150 million hectares of land around the world by 2020 and the New York Declaration on Forests, which seeks to restore 350 million hectares by 2030 were launched by international organizations such as the World Resources Institute (WRI) and the International Union for Conservation of Nature (IUCN) at a governmental scale. After the Convention of the Parties in Lima, initiative 20x20 is a country-led effort to bring 20 million hectares of land in

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Latin America and the Caribbean into restoration by 2020 [57]. The Bonn Challenge is leading to real progress on the ground. In many countries, restoration opportunity assessment is undertaking and restoration programs stats to be included in national plans and strategies. In general, thought restoration included in many conventions, agreements, policies, strategies and article recommendations, practically, there is no much report on policy impacts or implications of the restoration work [42].

v. *Inter and Trans disciplinary in ecological restoration*

Similar to the broader field of ecology, restoration ecology is an integrative discipline [76]. In current global situation, integrative discipline is essential in ecological restoration, because the goal of restoration is beyond environmental gardening [10]. The broadening of focus of restoration suggests both that ecological aspects need to be considered in a wider socioeconomic context and that an interdisciplinary or even transdisciplinary approach is needed [38]. Interdisciplinary approaches focus more on linking different research disciplines together, such as microbiology, seed science and pollination ecology [10][9]. Biodiversity-Ecosystem Functioning (BEF) experiment is one of interdisciplinary approach which is necessary for better projection and understand of restoration outcomes [10]. It is recent emerging attempt to uniting community and ecosystem by using BEF experiment [111]. According to [112], there is an attempt in forest sector is to adopt the BEF framework in setting up large experiments where the effects of tree species richness on ecosystem functions are evaluated. In the last decade, the relationship between biodiversity and ecosystem function become a central issues and ecologist widely considered it as one of the paradigm shift in ecology science [113][114].

On the other hand, transdisciplinary is about cross-sectoral approaches are based on multi-stakeholder processes relating more to practice [17], such as agronomy, engineering, sociology and landscape architecture, soil science and hydrology [76]. Transdisciplinary restoration thus involves an entirely new type of knowledge, leading to new relationships between researchers, professionals, and practitioners involved. The current transdisciplinary science creates a new way to solve complex biological hydrology and human ecological relationship [115]. It is about broadening our conceptual and methodological scope from the natural sciences to the humanities, from strictly bio ecological issues to much more complex human ecological issues [116]. Similarly, when restoration practice planned to be large, transdisciplinary approach is needed beyond interdisciplinary approach [38]. According to [18], Transdisciplinary arena in restoration is one of the paradigm shifts to unite natural with social science. For example, including political and socioeconomic issues with restoration rather than applying multifaceted aspects of applying ecology to restoration. Though, challenges occur in integrating expertise from various disciplines and multiple, sometimes divergent interests and goals [53], it is important for successful ecological restoration.

e) *Framework of Integrated Ecological Restoration for Sustainability*

Integrated ecosystem approach is the principal method to solve the current climate change, habitat loss and misuse of resources in the world [73]. Thus, Ecological restoration is often a primary component of ecosystem management, conservation, and sustainable development programmes throughout the world. Rehabilitation and restoration are now often a prerequisite to sustainable use [58]. It is now well recognised that science for sustainability will require integrated problem-focussed research [117]. Ecological restoration has as its goal an ecosystem that is resilient and self-sustaining and supporting sustainable livelihoods. A realistic restoration goal has to be ecologically sound, economically feasible and socially acceptable, as any other sustainable practice [32][10]. According to [70], inherently ecological restoration is multidisciplinary, multi-scalar and multi-sectorial activity, so it need good governance. Now, we can see the link of ecological restoration and sustainability issue., even the 17 UN Sustainable Development Goals (SDGs) which come into force in 2016to guide the post-2015 development agenda clearly stated that the importance of restoration to meet their sustainability goal particularly at goal number 15, and many other goals also related to landscape (ecosystem) restoration. These goals explicitly emphasize in the importance of 'holistic and integrated approaches to sustainable development' are required [118]. Furthermore, [117] suggested that landscape ecological restoration as paradigm for sustainability. [109], reported that in sustainability science cannot be addressed through un-coordinated studies of individual components by isolated traditional disciplines; instead, a new kind of interdisciplinary science is needed to build an understanding of social–ecological systems.

Based on the above discussed concepts in this paper the following conceptual basis is proposed to attain sustainability in holistic or integrated ecological restoration. The central idea is when degradation occur in the ecosystem, the whole ecosystem should be assessed to know the problem extent, because there is no single isolated piece, then plan, design and act in integrated fashion to obtain sustainable result. To attain this, by incorporating key elements such as integrate scientific base in restoration practice, consider landscape perspective to boost the restoration outcome, act with flexible plan and management with

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the awareness of the current rapid environmental change, incorporate social and policy framework as integral part of restoration to obtain active community involvement and sustain their livelihood and finally acknowledge multidisciplinary nature of restoration and emphasize on transdisciplinary field of study to produce holistic outcome.

III. Conclusion

Over the last 50 years, ecosystem is highly exploited by human activities globally and ecosystem become unable to provide valuable services including biodiversity maintenance. This has severe impact on human well-being as well as food security. Restoration recognized by the international community as an important way of enhancing both biodiversity and ecosystem services. Recently, ecological restoration gains momentum attention by resource managers, policy makers and researchers and considered as the prime option for the current rapid changing environment, loss of biodiversity and ecosystem fragmentation. It is about restoring the whole ecosystem by using basic principles, realistic plan and adaptive management. In short, it follows holistic or integrated approach to sustain the management.

Though, integrated approach in ecological restoration is important, there is a gap of addressing the issue in literature as well as in practice. Practically, there are few model efforts of ecological restoration in large scale such as Atlantic Forest Restoration Pact in Brazil, Kissimmee river restoration in Florida and Chinese Sloping Land Conversion Program are among the successful projects. Most of the restoration efforts are done in developed countries (Europe and North America), but developing countries are the most severely degraded are in need of restoration still. There are different challenges while restoration implementation such as cost and time constraint, severe level of degradation, social restriction, trade-off issues, limited information and knowledge and lack of standards and funding constraint. These challenges limit the application of restoration widely. These challenges could be also minimized through integrated ecological restoration approach.

Principally, to address Integrated ecological approach, the following conceptual basis is very vital such as restoration practice on the basis of scientific fact; consider the connection of the restoration project with the surrounding matrix; design and manage in flexible manner to tackle any uncertainty; ecological multidisciplinary approach and active community engagement to sustain the restoration practice by providing human health, keep cultural value and economic returns through different incentives such as income generation through different production, at large incentives from PES (CDM, REDD+), biological corridor, in addition, political support through different policy setting also very important to acknowledge the importance of ecological restoration and work to achieve that.

IV. Recommendations

Based on the reviewed paper, the following suggestion are forwarded;

- To tackle current rapid environmental change, integrated ecological restoration should be a priority option.
- Since integrated ecological restoration become widely known as a precondition for sustainability; Therefore, research as well as restoration practice should consider it,
- There are few good examples of ecological restoration, therefore, these efforts should be Adopt to other areas with improvement through Integrated Ecological Restoration.

Acknowledgement

We acknowledge Addis Ababa University for facility support.

Conflict of interest: The authors declare that they have no competing interest.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

References Références Referencias

1. Aerts R, Honnay O (2011). Forest restoration, biodiversity and ecosystem functioning. BMC J. Ecology, 11: 29. http://www.biomedcentral.com/1472-6785/11/29.
2. Andel JV, Aronson J (2006). Restoration Ecology: The New Frontier. Blackwell Science Ltd, a Blackwell Publishing company.
3. Apfelbaum SI, Chapman KA (1997). Ecological Restoration: A Practical Approach. In Ecosystem Management, 301-22. New Haven, Conn: Yale University press.
4. Apfelbaum SI, Chapman KA (2015). Ecological Restoration: A Practical Approach. c:49: 083094. (Available: https://www.researchgate.net/publication/267935089.
5. Aradóttir ÁL, Hagen D (2015). Ecological Restoration: Approaches and Impacts on Vegetation, Soils and Society. Advances in Agronomy (ed), Vol. 120, pp.173-222. DOI:10.1016/b978-0-12-407686-0.00003-8.
6. Aradóttir ÁL, Petursdottir T, Halldorsson G, Svavarsdottir K, Arnalds O (2013). Drivers of ecological restoration: lessons from a century of

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restoration in Iceland. Ecology and Society 18(4):33. http://dx.doi.org/10.5751/ES-05946-180433.
7. Arkema KK, Abramson SC, Dewsbury BM (2006). Marine ecosystem-based management: from characterization to implementation. Front Ecol Environt. 4:525–32.
8. Aronson J, Alexander S (2013). Ecosystem restoration is now a global priority: time to roll up our sleeves. Restoration Ecology. 21:293-296. http://dx.doi.org/10.1111/rec.12011.
9. Aronson J, Blignaut JN, Milton SJ, Maitre D, Esler KJ (2010). Are socioeconomic benefits of restoration adequately quantified? A meta-analysis of recent papers (2000–2008) in Restoration Ecology and 12 other scientific journals. Restoration Ecology 18:143–154.
10. Baker S, Eckerberg K, Zachrisson A (2014). Political science and ecological restoration. Environmental Politics. 23:3, 509-524, DOI:10.1080/09644016.2013.835201.
11. Bernhardt ES, Palmer MA, Allan JD, Alexander G, Barnas K, Brooks S, Carr J, Dahm C, Follstad-Shah J, Galat D, Gloss S, Goodwin P, Hart D, Hassett B, Jenkinson R, Katz S, Kondolf GM, Lake PS, LaveR, Meyer JL, O'Donnell TK, Pagano L, Powell B, Sudduth E (2005). Synthesizing U.S. river restoration. Science. 308: 636-637.
12. Blignaut J, Aronson J, de Wit M (2014). The economics of restoration: looking back and leaping Forward. Ann. N.Y. Acad. Sci. 1322. 35–47. The Year in Ecology and Conservation Biolog. New York Academy of Sciences.
13. Bradshaw AD (1987). Restoration: an acid test for ecology. Pages 24–29 in W. R. Jordan, M. E. Gilpin, and J. D. Aber, editors. Restoration ecology: a synthetic approach to
14. Brancalion PHS, Viani RAG, Strassburg BBN, Rodrigues RR (2012). Finding the money for tropical forest restoration. Unasylva, 63:41-50
15. Bullock JM, Aronson J, Newton AC, Pywell RF, Rey-Benayas JM (2011). Restoration of ecosystem services and biodiversity: conflicts and opportunities. Trends Ecol. Evol. 26, 541–549.
16. Cáceres DM, Tapella E, Quétier F, Díaz S (2015). The social value of biodiversity and ecosystem services from the perspectives of different social actors. Ecology and Society 20:62.
17. Calmon M, Brancalion P, Paese A, Aronson J, Castro P, da Silva S, Rodrigues R (2011). Emerging threats and opportunities for large-scale ecological restoration in the Atlantic forest of Brazil. Restor.
18. Campbell D, Bergeron J (2012). Natural revegetation of winter roads on peatlands in the Hudson Bay lowland, Canada. Arctic, Antarctic, and Alpine Research. 44:155-163. http://dx.doi.org/10.1657/1938-4246-44.2.155
19. Cavender-Bares J, Polasky S, King E, Balvanera P (2015). A sustainability framework for assessing trade-offs in ecosystem services. Ecology and Society 20(1): 17. http://dx.doi.org/10.5751/ES-06917-200117.
20. Caves JK, Bodner GS, SimmsK, FisherLA, Robertson T (2013). Integrating collaboration, adaptive management, and scenario-planning: experiences at Las Cienegas National Conservation Area. Ecology and Society 18(3): 43. http://dx.doi.org/10.5751/ES-05749-180343.
21. Convention on Biological Diversity (CBD) (2000). The Ecosystem Approach. UNEP/CBD/ COP/5/23 Decision V/6, Nairobi, 15-26 May 2000.
22. CBD (2004). The Ecosystem Approach. Secretariat of the Convention on Biological Diversity, ISBN: 92-9225-023-x (.pdf version).
23. CBD (2011). Strategic plan for biodiversity 2011-2020 and the Aichi targets. http://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf.
24. CBD (2012). Strategic Plan for Biodiversity 2011–2020 and the Aichi Targets. www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf.
25. CBD 2016. Recommendation Adopted by the Subsidiary Body on Scientific, Technical and Technological Advice. 20th meeting, Montreal, Canada, Agenda item 10.
26. Choi YD (2007). Restoration ecology to the future: A call for new paradigm. Restor. Ecol. 15: 351– 353.
27. Choi YD, Temperton VM, Allen EB, Grootjans AP. Halassy M, Hobbs RJ, Naeth MA, Torok K (2008). Ecological restoration for future sustainability in a changing environment. Écoscience, 15: 53–64.
28. Czech B (1995). Ecosystem Management is no Paradigm Shift. Journal of Forestory. PP:18-22.
29. Falk DA, Palmer MA, Zedler JB, Hobbs RJ (2006). Foundations of Restoration Ecology. Society for Ecological Restoration International (SER).
30. Federal Democratic Republic of Ethiopia (FDRE) (2015) Ethiopia - Land Degradation Neutrality National Report.
31. Ferraro PJ, Pattanayak SK (2006). Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLoS Biol. 4: e105.
32. Freeman OE, Duguma LA, Minang PA (2015). Operationalizing the integrated landscape approach in practice. Ecology and society.
33. Gann GD, Lamb D (eds) (2006). Ecological restoration: A mean of conserving biodiversity and sustaining livelihoods (version 1.1). Society for Ecological Restoration International, Tucson, Arizona, USA and IUCN, Gland, Switzerland.
34. Guariguata MR, Brancalion PHS (2014). Current Challenges and Perspectives for Governing Forest Restoration. Forests. 5: 3022-3030; doi:10.3390/f5123022.

© 2018 Global Journals

35. Gummew J (2014). 12 Ecologically Sustainable Countries and Why They Should Be Admired. Alternet. http://www.alternet.org/environment/12-ecologically-sustainable-countries-and-why-they-should-be-admired. Accessed on July 2017.
36. Habel JC, Gossner MM, Meyer ST, Eggermont H, Lens L, Dengler J, Weisser WW (2013). Mind the gaps when using science to address conservation concerns. Biodiversity and Conservation. 22: 2413–2427.
37. Hagen (2003). Assisted Recovery of Disturbed Arctic and Alpine Vegetation - an integrated approach. MSc. Thesis. Norwegian University of Science and Technology.
38. Hagen D, Svavarsdottir K, Nilsson C, Tolvanen AK, Raulund-Rasmussen K, Aradóttir Á L, Fosaa A, Halldorsson G (2013). Ecological and social dimensions of ecosystem restoration in the Nordic countries. Ecology and Society 18(4): 34. http://dx.doi.org/10.5751/ES-05891-180434.
39. Halle S (2007). Science, art, or application - the ''Karma'' of restoration ecology. Restoration Ecology. 15: 358–361.
40. Halme P, Allen KA, Auniņš A, Bradshaw RHW, Brūmelis G, Čada V, Clear JL, Eriksson AM, Hannon G, Hyvärinen E, Ikauniece S, Iršėnaitė R, Jonsson BG, Junninen K, Kareksela S, Komonen A, Kotiaho JS, Kouki J, Kuuluvainen T, Mazziotta A, Mönkkönen M, Nyholm K, Oldén A, Shorohova E, Strange N, Toivanen T, Vanha Majamaa I, Wallenius T, Ylisirniö A, Zin E (2013). Challenges of ecological restoration: lessons from forests in northern Europe. Biological Conservation. 167: pp. 248-256.
41. Hilderbrand RH, Watts AC, Randle AM (2005). The myths of restoration ecology. Ecology and Society, 19. (online available at URL: http://www.ecologyandsociety.org/.
42. Hobbs RJ, Hallett LM, Ehrlich PR, Mooney HA, (2011). 'Intervention ecology: applying ecological science in the twenty-first century'. Bio Science 61: 442–450.
43. Hobbs RJ, Higgs E, Harris JA (2009). Novel ecosystems: implications for conservation and restoration. Trends in Ecology and Evolution. Vol. 24(11). 599-605.
44. Holl KD, Howarth RB (2000). Paying for restoration. Restoration Ecology. Vol. 8(3), pp. 200_267.
45. Holla KD, Aide TM (2011). When and where to actively restore ecosystems? Forest Ecology and Management 261 (2011) 1558–1563.
46. Hull RN, Luoma SN, Bayne BA, Iliff J, Larkin DJ, Paschke MW, Victor SL, Ward SE (2016). Opportunities and challenges of integrating ecological restoration into assessment and management of contaminated ecosystems. Integr Environ Assess Manag. 12: 296–305.
47. Intergovernmental Panal on Climate Change (IPCC). (2017). Special report on global warming of 1.5 °C. draft report. Available at http://www.ipcc.ch/report/sr15/.
48. Jackson ST, Hobbs RJ (2009). Ecological restoration in the light of ecological history. Science. 325: 567–569.
49. Johnson GE, Ebberts BD, Thom RM, Ricci NM, Whiting AH, Southard JA, Sutherland GB, Wilcox JD, Berquam, T. (2003). An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary. Pacific Northwest National Laboratory, Columbia River Estuary Study Taskforce, Lower Columbia River Estuary Partnership, Bonneville Power Administration, U. S. Army Corps of Engineers, Portland District.
50. Kareiva P, Marvier M (2012). What is conservation science? Bio Science. Vol. 62: 962–9.
51. Keenleyside KA, Dudley N, Cairns S, HallCM, Stolton S (2012). Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices. Gland, Switzerland: IUCN. x + 120pp.
52. Koebel JW, Bousquin S (2014). The Kissimmee River Restoration Project and Evaluation Program, Florida, U.S.A. Restoration Ecology 22(3): 345-352.
53. Kouki J, Hyvärinen E, Lappalainen H, Martikainen P, Similä M (2012). Landscape context affects success of habitat restoration: Large-scale colonization patterns of saproxylic and fire associated species in boreal forests. Diversity and Distributions 18: 348–355. doi:10.1111/j.1472-4642.2011.00839.
54. Loreau M, Naeem S, Inchausti P, Bengtsson J, Grime JP, Hector A, Hooper D.U., Huston, MA, Raffaelli D, Schmid B, Tilmanm D, Wardle DA (2001). Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges. Review: Ecology. 294.
55. Loreau M (2010). Linking biodiversity and ecosystems: towards a unifying ecological theory. Phil. Trans. R. Soc. B. 365, 49–60. doi:10.1098/rstb.2009.0155.
56. LoSchiavo AJ, Best RG, Burns RE (2013). Lessons learned from the first decade of adaptive management in Comprehensive Everglades Restoration. Ecology and Society 18(4): 70. http://dx.doi.org/10.5751/ES-06065-180470.
57. Maron M, Hobbs RJ, Moilanen A (2012). Faustian bargains? Restoration realities in the context of biodiversity offset policies. Biol. Conserv., 155, 141-148.
58. Martinez ML, Barrera FL (2008). Special issue: Restoring and designing ecosystems for a crowded planet. Ecoscience. 15(1): 1-5.
59. McDonald T, Gann GD, Jonson J, Dixon KW (2016a). International Standards for the Practice of Ecological Restoration – including principles and

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key concepts. SER in collaboration with SER Australasia.
60. McDonald T, Jonson J, Dixon KW (2016b). National standards for the practice of ecological restoration in Australia. Restoration Ecology. 24 (S1): S4–S32. The Society for Ecological Restoration (SERA).
61. Meli P, Herrera FF, Melo F, Pinto S, Aguirre N, Musálem K, Minaverry C, Ramírez W, Brancalion PHS (2017). Four approaches to guide ecological restoration in Latin America. Restoration Ecology. Vol. 25 (2):156–163.
62. Metzger JP, Brancalion PHS (2013). Challenges and Opportunities in Applying a Landscape Ecology Perspective in Ecological Restoration: a Powerful Approach to Shape Neolandscapes. Natureza & Conservação 11(2): 103-107, December 2013 Copyright© 2013 ABECO Handling Editor: Rafael Loyola http://dx.doi.org/10.4322/natcon.2013.018.
63. Millennium Ecosystem Assessment (MEA) (2005) Ecosystems and human well-being: synthesis. Washington, DC: Island Press.
64. Minnemeyer S, Laestadius L, Sizer N, Saint-Laurent C, Potapov P (2011). A World of Opportunity for Forest and Landscape Restoration. World Resource Institute, Washington D.C., USA. http://www.wri.org/sites/default/files/world_of_opportuity_brochure_2011-09. Accessed on June 2017.
65. Minnick A, Woldemariam T, Reij C, Stolle F, Landsberg F, Anderson J (2014). Ethiopia Commits to Restore One-Sixth of its Land. http://www.wri.org/blog/2014/10/ethiopia-commits-restore-one-sixth-its-land. Accessed on July 2017.
66. Naeem S (2002). Ecosystem consequences of biodiversity loss: The evolution of a paradigm. J. Ecology, 83(6): 1537-1552.
67. NassauerJ, Opdam, P (2008). Design in science: extending the landscape ecology paradigm. Landscape Ecol. 23:633–644.
68. Naveh Z (2005). Epilogue: Toward a Transdisciplinary Science of Ecological and Cultural Landscape Restoration. Restoration Ecology. 13 (1). 228–234.
69. Naveh Z (2007). Transdisciplinary Challenges in Landscape Ecology and Restoration Ecology - An Anthology with Forewords by E. Laszlo and M. Antrop and Epilogue by E. Allen. Landscape Series. 7. Published by Springer.
70. Neßhover C, Aronson J, Blignaut JN, Lehr D, Vakrou A, Wittmer H, (2011). The economics of ecosystems and biodiversity in National and International Policy Making. Pages 401 – 448 in P. ten Brink, editor. Investing in ecological infrastructure. Earthscan, London, and Washington.
71. Nilsson C, Aradottir AL, Hagen D, Halldórsson G, Høegh K, Mitchell RJ, Raulund-Rasmussen K, Svavarsdóttir K, Tolvanen A, Wilson, SD (2016). Evaluating the process of ecological restoration. Ecology and Society. 21(1):41. http://dx.doi.org/10.5751/ES-08289-210141.
72. Orsi F, Geneletti D and Newton AC (2011). Towards a common set of criteria and indicators to identify forest restoration priorities: an expert panel-based approach. Ecological Indicators. 11:337–347.
73. Palmer MA, Zedler JB, Falk DA (2016). Foundation of Restoration Ecology, Second Edition. SER. Island Press.
74. Palmer MA (2009). "Reforming Watershed Restoration: Science in Need of Application.
75. Palmer MA, Filoso S (2009). Restoration of ecosystem services for environmental markets. Science. 325:575 –576.
76. Palmer MA, Falk DA, Zedler JB(2006). Ecological Theory and Restoration Ecology. DOI:10.5822/978-1-61091-698-1_1.
77. Pearson DM, Gorman JT (2010). Exploring the relevance of a landscape ecological paradigm for sustainable landscapes and livelihoods: a case-application from the Northern Territory Australia. Landscape Ecology, 25: 1169–1183.
78. Pendleton L (2010). Measuring and Monitoring the Economic Effects of Habitat Restoration: A Summary of a NOAA Blue Ribbon Panel. Durham, NC: Linwood Pendleton Nicholas Institute for Environmental Policy Solutions, Duke University in Partnership with Restore America's Estuaries. [Google Scholar].
79. Perring MP, Audet P, Lamb D (2014). Novel ecosystems in ecological restoration and rehabilitation: Innovative planning or lowering the bar? Ecological Processes. 3: 8.
80. Perring MP, Standish RJ, Price JN, Craig MD, Erickson TE, Ruthrof KX, Whiteley ASE, Valentine L, Hobbs RJ (2015). Advances in restoration ecology: rising to the challenges of the coming decades. Ecosphere. 6(8): 131. http://dx.doi.org/10.1890/ES15-00121.1.
81. Pickering C, Grignon J, Steven R, Guitart D, Byrne J (2015). Publishing not perishing: how research students transition from novice to knowledgeable using systematic quantitative literature reviews. Studies in Higher Education, 40: 1756 –1769.
82. Pistorius T, Carodenuto S, Wathum G (2017). Implementing Forest Landscape Restorationin Ethiopia. Forests. 8(61). doi:10.3390/f8030061. www.mdpi.com/journal/forests.
83. Puettmann KJ, Parrott, L, Messier C (2016). Teaching Complex Adaptive Systems Science in NaturalResource Management: Examples from Forestry. Nat. Sci. Educ. 45. doi:10.4195/nse2016.04.0009.
84. Radford J, Williams JE, Park G(2007). Effective Landscape Restoration for Native Biodiversity in Northern Victoria. North Central Catchment Management Authority, Victoria.

© 2018 Global Journals

85. Reed J, Vianen JV, Deakin EL, Barlow J, Sunderland T (2016). Integrated landscape approaches to managing social and environmental issues in the tropics: learning from thepast to guide the future. Global Change Biology. 22:2540–2554. doi: 10.1111/gcb.13284.
86. Ruiz-Jaen MC, Aide TM (2005). Restoration Success: How Is It Being Measured? Society for Ecological Restoration International. Restoration Ecology. 13(3): 569–577. S194, DOI: 10.1080/1054 9811.2014.884004.
87. Seabrook L, Mcalpine CA, Bowen ME (2011). Restore, repair or reinvent: Options for sustainable landscapes in a changing climate. Landscape and Urban Planning. 100 (4): 407–410.
88. Shackelford N, Hobbs RJ, Burgar JM, Erickson TE, Fontaine JB, Laliberté E, Ramalho CE, Perring MP Standish RJ (2013) Primed for Change: Developing Ecological Restoration for the 21st Century. Restoration Ecology, 21, 297–304.
89. Society for Ecological Restoration (SER) (2002). Science and Policy Working Group. The SER Primer on Ecological Restoration. www.ser.org/.
90. SER (2004). The SER international primer on ecological restoration. Society for Ecological Restoration, Science and Policy Working Group.
91. SER (2008). Opportunities for Integrating Ecological Restoration and Biological Conservation within the Ecosystem Approach. Briefing Note. Society for Ecological Restoration. SER_Briefing_Note_May_ 2008.pdf.
92. SER (2010). International Primer on Ecological Restoration: Note by the Executive Secretary. Information note submitted to the Secretariat of the Conference on Biodiversity, Subsidiary Body on Scientific, Technical and Technological Advice, Fourteenth meeting, Nairobi, 10-21 May 2010, Item 3.4 of the provisional agenda.
93. SER (2016). Best Practice in Restoration, The 10th European Conference on Ecological Restoration Abstract Volume, SER Europe Conference 2016: August 22–26, Freising, Germany.
94. Seyoum Y (2016). Forest Landscape Restoration Experiences of Ethiopia. Ministry of Environment, Forest and Climate Change (MEFCC). Society 20(1): 24. http://dx.doi.org/10.5751/ES-07175-200 124.
95. Suding KN (2011). Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. The Annual Review of Ecology, Evolution, and Systematics is online at ecolsys. annualreviews. org.10.1146/annurev-ecolsys-102710-145115.
96. Suding K, Higgs E, Palmer M, Callicott JB, Anderson CB, Baker M, Gutrich JJ, Hondula KL, La Fevor MC, Larson BMH, Randall A, Ruhl JB, Katrina Z, Schwartz S (2015). Committing to ecological restoration. Science348: 638–640.
97. Tallis H, Kareiva P, Marvier M, Chang A, (2008). An ecosystem services framework to support both practical conservation and economic development. PNAS. vol. 105 (28) 9457–9464. www.pnas.org/cgi/ doi/10.1073/pnas.0705797105.
98. Temperton VM (2007). The Recent Double Paradigm Shift in Restoration Ecology. Restoration Ecology. 15 (2): 344–347. DOI: 10.1111/j.1526-100X. 2007.00222.x.
99. Vaughn KJ, Porensky LM, Wilkerson ML, Balachowski J, Peffer E, Riginos C, Young TP (2010). Restoration Ecology. Nature Education Knowledge. 3(10):66.
100. Villard MA, Jonsson BG (2009). Putting conservation target science to work. In: Villard MA, Jonsson B.G. (Eds.), Setting Conservation Targets for Managed Forest Landscapes. Conservation Biology Series. Cambridge University Press, Cambridge, pp. 393–401.
101. Walker LR, del Moral (2003). Primary Succession and Ecosystem Rehabilitation. Cambridge, United Kingdom: Cambridge University Press.
102. Walker LR, Walker J, del Moral R (2007). "Forging a New Alliance Between Succession and Restoration." Linking Restoration and Ecological Succession. Eds. Walker, Lawrence R., Joe Walker, and Richard J. Hobbs. New York, N.Y.: Springer. 1-18.
103. Wasson K, Suarez B, Akhavan A, McCarthy E, Kildow J, Johnson KS, Fountain, MC, Woolfolk A, Silberstein, M, PendletonL, Feliz D (2015). Lessons learned from an ecosystem-based management approach to restoration of a California estuary. Marine Policy 58:60–70.
104. Watts RJ (2007). Challenges for improving the science underpinning river restoration practices. In: Wilson, A. L., Dehaan, R. L., Watts, R. J., Page, K. J., Bowmer, K. H. and Curtis, A. (eds) Proceedings of the 5th Australian stream management conference. Australian rivers: making a difference. Thurgoona, NSW: Charles Sturt University, pp. 437–442.
105. Wei H, Fan W, Ding Z, BoqiWeng B, Xing K, WangX, Lu N, Ulgiati S, Dong X (2017). Ecosystem Services and Ecological Restoration in the Northern Shaanxi Loess Plateau, China, in Relation to Climate Fluctuation and Investments in Natural Capital. Sustainability. 9:199; doi:10.3390/su9020199. www. mdpi.com/journal/sustainability.
106. Williams BK, Brown ED (2014). Adaptive management: from more talk to real action. Environ. Assess. 53: 465-479.
107. Wilson E. (1992). The diversity of life (Harvard University Press 1992).340.
108. World Agroforestry Centre (ICRAF) (2016). Ethiopia: Landscape Restoration in Ethiopia Brings Watershed to Life. Available at http://allafrica.com/ stories/201707070773.html.

© 2018 Global Journals

109. Wortley L, Hero J, Howes M (2013). Evaluating Ecological Restoration Success: A Review of the Literature. Restoration Ecology. 21 (5). 537–543.
110. Wright J, Symstad A, Bullock JM, Engelhardt K, Jackson L, Bernhardt E (2009). Restoring biodiversity and ecosystem function: will an integrated approach improve results?. Oxford University Press eds S. Naeem, D. E. Bunker, A. Hector, M. Loreau and C. Perrings, pp. 167-177.
111. Wuethrich B (2007). Reconstructing Brazil's Atlantic Rainforest. Science. 315:1070–72.
112. Yin R, Zhao M (2012). Ecological restoration programs and payments for ecosystem services as integrated biophysical and socioeconomic processes China's experience as an example. Ecol. Econ. 73:56–65.
113. Young TP, Petersen DA, Clary JJ (2005). The ecology of restoration: historical links, emerging issues and unexplored realms. Ecology Letters. Vol. 8. Pp. 662–673 doi: 10.1111/j.1461-0248.2005.00764.x.
114. Zedler JB, Callaway JC (2003). Adaptive restoration: A strategic approach for integrating research into restoration projects. Managing for Healthy Ecosystems. D. J. Rapport, W. L. Lasley, D. E. Rolston et al. Boca Raton, FL, Lewis Publishers: 164-174.
115. Zedler JB (2005). Ecological restoration: guidance from theory. San Francisco Estuary Watershed. Sci., issue 2, article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art4.
116. Zedler, J. B., J. M. Doherty, and N. A. Miller. 2012. "Shifting Restoration Policy to Address Landscape Change, Novel Ecosystems, and Monitoring." *Ecology and Society* 17(4): 36. Cross Ref Google Scholar.

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