Journal of HyoJeong Academia

*Article*

# Potential and Actual Economic Gains of Restoring Degraded Lands: A Review

**Haileselassie Ghebremariam Araya[1,*], Oliver Vivian Wasonga[1], Stephen Mureithi[1] and Emiru Berhane[2]**

[1] Department of Land Resources Management and Agricultural Technology (LARMAT) University of Nairobi, Nairobi, Kenya
[2] Department of Land Resources Management, Mekelle University, Mekelle, Ethiopia
*Correspondence: hailish746990@gmail.com

**Abstract:** Land degradation is a major challenge to human beings agricultural production and sustainable development. Proven strategies for the rehabilitation of degraded areas are urgently needed before conditions become irreversible. Diverse forms of restorations have been widely practiced to rehabilitate and restore degraded lands and other environmental problems. The aim of this review was to examine the perceived and actual socio-economic benefits and challenges of restoring degraded lands. Rehabilitation interventions have had a positive impact on livelihoods by providing more forage for animals, wood products, and cash income through small-scale and microenterprises sale of forest products as well as avoiding of economic losses due to soil degradation. However, biophysical and institutional challenges, lack of clear and negotiated benefit-sharing mechanisms are the main constraints for sustainability. These constraints highlight the need to have practical and interactive community participation and involvement of the private sector involvement in restoration projects. Many examples in Africa, China, Australia, Europe and South Korea demonstrate the power to enhance or deter development when restoration of degraded lands is taken seriously or not. Effective restoration strategies accompanied by the active involvement of the local communities and strengthening of their subsequent management system are therefore essential. Sustaining the positive impacts of restoration requires negotiating goals among stakeholders, developing contextualized management plan, enhancing economic returns beyond the restoration phase, and defining clear and negotiated by-laws.

**Keywords:** Rehabilitation, restoration practices, socio-economic challenges, benefit, land degradation

**Citation:** Haileselassie Ghebremariam Araya, Oliver Vivian Wasonga, Stephen Mureithi and Emiru Berhane. Potential and Actual Economic Gains of Restoring Degraded Lands: A Review. *JHJA* **2023**, 2.

Received: 6 March 2023
Accepted: 10 March 2024
Published: 13 March 2024

**Publisher's Note:** JHJA stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



## 1. Introduction

Land degradation is a worldwide phenomenon defined as the reduction or loss of the biological or economic productivity [1, 2]. It leads to reduced food production, poor water storage and loss of biodiversity, soil organic carbon and ecosystem services [1]. It affects an estimated 23% of the world's terrestrial area and is increasing at an rate of 5–10 million ha per year [3]. The costs of land degradation affect everyone directly or indirectly resulting in a global economic loss of ecosystem services estimated at US$ 6.3–10.6 trillion [4]. The underlying drivers of land degradation include expansion of crop and grazing lands into native vegetation, unsustainable agricultural and forestry practices, global consumption patterns and climate change [5, 6]. Other contributing factors include urbanization, infrastructure development corridors and extractive industries, which are often associated with landscape change [5]. In an attempt to reverse this trend and reap the benefits, many efforts have been made in which the rehabilitation of degraded lands can take many different forms depending on the localities. Restoring degraded lands offer numerous environmental, social and economic benefits, from biodiversity conservation to job creation

and improved agricultural productivity. Every US$ 1 invested in restoring degraded forests generates US$ 7-30 in economic benefits [7]. This study aimed to review the status of land restoration, its associated potential and actual economic benefits and challenges. Such information can serve as a key input for the development of scaling up programmes responsive to specific socio-economic and ecological settings.

## 2. Methods

To find the most relevant papers the Boolean operators AND, OR and NOT were employed used in Google Scholar with key words specified in the title. After the selection of key literature, the 'Connected Papers' search engine was used to comprehensively fill up the reference library. To account for the multidisciplinary nature of the review sought, the authors attempted to extend the search to scientific papers in other fields using the same search mechanisms. A series of searches across links and sub-links were exhausted until the authors were satisfied with the reference list generated. This method enabled the researchers to provide the review with relevant, up-to-date and global coverage of to help the scholastic community understand the issue.

## 3. Results, Discussions, and Conclusions

### *3.1 Significance of Restoring Degraded Lands*

A quarter of the world's land (2 billion ha), on which about 1.5 billion people depend directly, and two-thirds of African land is already degraded to some extent, the later affecting at least 485 million Africans [8]. Severely degraded and damaged land cannot achieve ecosystem function or provide standard ecosystem services to society [9]. In developing countries, degradation is often associated with chronic poverty [10] as it has enormous negative social and economic dimensions [11] exposing people to serious food security risks and conflicts in Ethiopia [12], Kenya [13] and globally [14]. Moreover, degradation of drylands is associated with a loss of land productivity and high costs of restoration resulting in a loss of income of farmers and pastoralists [15], human migration and politico-economic instability [16]. Combined with biodiversity loss, it represents a major threat to the wealth of the indigenous communities and cultures [8, 17]. It is therefore, important to reverse the degraded lands through integrated and sustainable land management taking into account all ecological and socioeconomic aspects [11]. At the local or village level there is a lack of watershed based integrated planning and implementation due to fragmentation and lack of hydrological linkages [18]. At the global level there is a need to consider the complex social and ecological interactions that operate to establish a common roadmap for the shared goal of saving the planet. However, by balancing ecological, social and economic priorities at landscape level [19], additive and reinforcing global goals can be achieved. Science, technology and finance are sufficiently mature to address the challenges [8, 18, 20-24]. The emerging opportunity to establish damage and loss fund from COP27 [25, 26] and COP28, particularly to the developing countries [27, 28] reaffirms the financial sourcing possibility. Meanwhile, increasing environmental policy education, awareness [29], and initiatives [19, 30, 31] is positively benefiting restoration.

When restoration schemes are established at larger scales and with clear natural, agricultural and economic zones the overall livelihoods of the local people can be dramatically improved as evidenced from Abraha Weatsebaha in Ethiopia [18], Loess plateau in China, Rugezi Wetland in Rwanda [8], Baekdu Daegan protected area and the four major rivers [32, 33] and Cheonggyecheon urban restoration [34] in South Korea. For example, South Korea's dense forest was destroyed during the Korea war to supply wood and fuel [35] which challenged the foundations for rapid economic growth and national development [24]. Another good example of land restoration is Bamburi Haller Park in Mombasa [36]. The Bamburi Ecological and Ecotourism Showcase stands as a testament to the transformative power of ecological restoration, where a once-degraded Bamburi quarry wasteland has been meticulously rehabilitated into a thriving and biodiverse tropical ecosystem. The restoration land enabled generation of $330, 745 per year collected from more than 180, 000 visitors [37] This remarkable achievement showcases the successful application of scientific principles in environmental conservation and sustainable tourism [37]. In order to protect the national land, four types of restoration and preservation plans were developed: the revision of road slope design criteria, the promotion of rooftop re-vegetation and enhancement of green space in urban areas, the revision of National Environmental Conservation Law, and the employment for the first time of environmental specialists [24]. As a result, Baekdu Daegan protected area [24] became the centre of biodiversity of plants and animals and safe place of endemic and endangered species [32]. The key success factors of reforestation in South Korea include the pan-national campaign, efficient governance for social resource mobilization, development of the alternative energy industry, food production enhancement and great international support [38, 39]. Moreover, the highly diverse urban green corridor biosphere reserve of Cheonggyecheon was

internationally recognized as an example of successful urban regeneration [34]. Such large scale restoration projects connecting different villages and administrative regions can further enhance integration of the natural, agricultural and economic zones, by avoiding restoration failures noted by [18].

However, the time required to achieve the intended goals varies greatly depending on the method of restoration and the severity of land degradation [40, 41]. Many restoration projects either take conservation as the final objective, or fail to consider the severity of degradation which is crucial in designing effective methods of restoration and accurately predicting the return period [42]. The long gap before a local community gets benefits from the restored lands has a high level of socioeconomic significance and requires careful planning and the imple2mentation of interim support schemes. For example, benefits such as Carbon Credits often require strict and long processes, only being accrued after successful restoration of degraded lands. The long time lag between the start of the project and delivery of benefits to the local community can result in demoralization of both the local community and experts involved in project delivery. Therefore, there must be an interim solutions to support communities to bridge gaps prior to attainment of successful restoration and payment of Carbon Credits [43, 44]. The good news is that there are restoration projects that have delivered the desired outcomes within the planned time frame. The Loess plateau in China, met its objective in 10 years [8]. In Tigray, northern Ethiopia, both Abraha Weatsbaha [18] and the Merere projects, delivered the desired outcomes within 5 and 10 years, respectively. At a global level, Ethiopia, Rwanda and El Salvador were mentioned as having leaders who have understood that restoration of ecosystem functions restores the economy [8]. These are concrete evidences that Africa can move out of poverty and aid dependence by restoring its degraded lands.

### *3.2 Global Movement to Restore Degraded Lands*

There are doubts, concerns and uncertainties about the ability of future food production to keep pace with the projected increase in global population [45] which is expected to increase to 8.6, 9.8 and 11.2 billion head by 2030, 2050 and 2100 respectively [45]. Land degradation and climate change could reduce the overall global crop yields by 10%, with declines of up to 50% expected in certain regions [47, 19]. This implies increasing production will not be easier due to more stressed and scarcer water resources, soil degradation, salinization of irrigated areas, biofuel production and climate change [45]. The impact of unsustainable over-exploitation of natural resources [48] is also severe. It is recognized that the world entered the Anthropocene era, in which human activities have the dominant influence on climate and the environment. Whilst enthusiasts celebrate this human role in shaping the biosphere, with plans for managing, and even reengineering the planet [49], four of the nine so-called planetary boundaries, namely climate change, bio-sphere integrity, biogeochemical flows, and land-system change have already been crossed [50, 51]. The planetary boundaries are the limits under which human being can thrive and prosper [49]. Extinction rate (one of two indicators for biosphere integrity), deforestation, atmospheric carbon dioxide (an indicator for climate change), and the flow of nitrogen and phosphorus sit at the forefront of the problem [50]. These are global problems [52] that require global solutions [53] and demand local actions (Defensive environmentalism) to achieve collective global effects (Altruistic environmentalism) [54]. Accordingly, there is an increasing trend to restore degraded lands globally [8,18]. Dramatic positive changes have been observed following well-structured restoration projects which contribute to solving the ecological problems and improving the livelihoods of the local people [8, 18, 55]. There are ambitious national and regional initiatives that aim to restore of a significant share of the total global land area by 2030. Outstanding commitments pledged include, The US Forest Service (15M ha); Ethiopia (15M ha); The Democratic Republic of Congo (18M ha); Guatemala (3.9M ha); Uganda (2.5M ha) and Rwanda (2M ha) as well as the Brazil Mata Atlantic Restoration Pact; El Salvador; Costa Rica; Colombia and Niger with 1M hectares each [8]. Moreover, there are regional initiatives like the 'Initiative 20 x 20' that aspired to bring 20M hectares of degraded land in Latin America and the Caribbean into restoration by 2020 in response to the Bonn Challenge [56]. Other initiatives include AFR100, a country-led effort to bring 100 million hectares of degraded land across Africa into restoration by 2030 [19]. In line with global goals, work is ongoing in Europe towards attaining the forest economic, social and ecological pillars [57, 58], and in Australasia. In New Zealand there is the Reconnecting Northland, Banks Peninsula Conservation Trust and Trees That Count initiatives which targets one tree to be planted for every New Zealander increasing by 15% per year to reach 200 million trees being planted annually by 2030 [40]. These restoration programs are all motivated by their actual benefits through enhancement of biodiversity, carbon sequestration, and agricultural productivity on top of the direct economic benefits of the restored lands themselves. Both academic researchers and program advocates emphasize the importance of holistic planning in such initiatives taking into account both ecological and economic factors [8, 19, 22, 47, 59, 60]. Unless conservation programs specifically target the integration of

socioeconomic benefits [8, 59] in general and changing the lives of the poor in particular, then such programs undertaken to conserve biodiversity will have already failed [49].

### *3.3 Economic implications of Restoration on the Local Communities*

#### 3.3.1. Potential Economic Benefits of Restoration

The potential gains of land restoration include income and capital gains [56] and community empowerment [61]. In general, studies have shown that the economic benefits of restoration can far exceed the costs [7, 22] estimates the annual financial benefits from global restoration of degraded lands to be $84 Billion. Analysis by [7] suggested that achieving the Bonn Challenge would generate a net global benefit between U.S.$0.7 and U.S.$9 trillion. According to [22], a successful effort to restore Latin America and the Caribbean's degraded forests, savannas, and agricultural landscapes—one with the scope and character of Initiative 20x20—would result in substantial net economic benefits by yielding an estimated net present value (NPV) of about $23 billion over a 50-year period. For every single dollar invested in meeting the AFR100 initiative, a net income of $35 is expected.

Additionally, benefits may accrue indirectly as the project progresses such as provision of a scenic environment, recreational pursuits and the provision of clean air [62]. Significant achievements in vegetation cover and biomass productivity [55, 63-65], soil physical and chemical improvement [18, 66], protection of downstream farmland, grazing land and water reservoirs [67] are all well recognized benefits of restorations that can be valued in monetary terms. Land restoration has the potential to contribute to improved agricultural yields in degraded lands, mitigate biodiversity loss, increase carbon stocks, and secure gains in soil and water quality all of which can generate financial and economic benefits [56]. This is because landscape restoration, management techniques, and low-carbon and sustainable agriculture all offer opportunities to mitigate and reverse the losses associated with land degradation. WRI [52, 56] estimated an annual NPV of 1140 USD/ha from restoring 20 million hectares by 2020 in Latin America and the Caribbean in terms of income from ecotourism, agricultural production, avoided food security costs and carbon storage.

#### 3.3.2. Actual Economic Returns from Restoration

A study in Degua Tembien Woreda of Tigray (The winner of Future Policy Award as the World's Best Land Restoration Policies), Northern Ethiopia, valued restoration of degraded marginal lands at NPV of 5620 ETB (200USD) per hectare [68]. Their comparative study showed a 50% increase when a project was established in areas with a higher proportion of degraded lands against less degraded land. This provides significant support for establishing of restoration projects in highly denuded lands to become a source of income and thus poverty reduction. [9] reported that rehabilitation interventions affected livelihoods positively by producing more forage, wood products and cash income through small-scale microenterprises and sale of forest products. Similarly restoration in the Sikkim Himalaya watershed, India, showed a positive NPV [69] and ensure economic sustainability for the resident community. Systemic ecosystem management in Tigray, helped recharge groundwater levels in downstream valleys which increased the irrigation by a factor of six from almost 5,000 hectares in 2000 to 30,000 hectares in 2008 thereby helping to expand agricultural production even in drought years, providing food security and steady incomes [8].

#### 3.3.3. Tradeoffs and Challenges Encountered in Establishing Restoration of Degraded Lands

Firstly, restoration of degraded lands has a varying degrees of immediate negative impact on local communities by limiting their actual benefits from grazing, firewood collection, harvesting of available edible wild fruits, harvesting of construction materials, and other goods and services [65, 70] in areas they previously had free access to [71]. This can affect the livelihoods of poor household dependent on natural resources [72-74]. Poorer communities are less likely to adopt the ecological and socioeconomic changes associated with restoration, thereby leading to lower levels of sustainability [75]. Secondly, restoration programs are challenged by other negative attitudes of the local people [17, 76] such as the failure to make significant contribution to household income [77], and low community participation in the establishment and subsequent benefit sharing [78]. As a result, people may refrain from supporting their expansion [79] and become involved in illegal animal grazing [79]. Thirdly, even successful restorations of degraded lands have not always been economically beneficial to local communities. For example, monoculture plantation of eucalyptus trees in Vietnam failed to earn returns to local people, and even triggered outbreak of pests and diseases [8]. In Tigray, Ethiopia, it remains illegal to harvest any part of a tree for wood from lands exclosed 36 years ago, limiting the ability of local people to maximize the potential benefits of exclosures [80]. Biophysical and institutional challenges as well as a, lack of clear and negotiated benefit-sharing mechanisms are the main limiting factors for restoration sustainability [81]. Fourthly, the business sector is not yet involved in restoration programs [7, 58, 78, 82], although Action 2020 was launched in 2013 by

the World Business Council on Sustainable Development with 200 companies as members [8] whose actions are not yet widespread. Fifthly, the untapped potential of religion in terms of its impact on its followers and preservation and reverence of sacred trees [83,84] remains largely unexplored.

## 4. Conclusion

Restoring degraded lands is socio-economically beneficial and can serve as a way out of poverty. The restoration approaches adopted depend on a number of factors especially the level of degradation and socioeconomic context. It is imperative that the restoration projects must encompass the objectives of the local communities and maximize their potential and actual benefits. Failure of the private sector to contribute to restoration projects will have a negative impact both in terms of prolonging the restoration period and affecting its sustainability. Moreover, an equitable benefits distribution of benefits taking into account the poor households is essential. Tradeoffs include pressure and overexploitation on the remaining grazing lands, restrictions on the immediate use of restored areas by the local communities, low contribution of restoration projects to the household income and low adoption rate of restoration initiatives by communities due to the long time lag before transformative benefits accrue.

## Acknowledgement

We would like to thank Dr. D. H. Grove for proof reading and language editing. Our sincere appreciation to those scholars who provided different materials required for the study.

## References

1. Gilbey, J., Davies, G., Metternicht, G. and Magero, C. Taking Land Degradation Neutrality from concept to practice: Early reflections on LDN target setting and planning. *Environ. Sci. Policy 100*, 230–237 (2019).
2. Land Degradation Neutrality Target Setting. In *a Technical Guide Draft for consultation during the Land Degradation Neutrality Target Setting Program inception phase* (United Nations, 2016).
3. Stavi, I. and Lal, R. Achieving Zero Net Land Degradation: Challenges and opportunities. *J. Arid Environ. 112*, 44–51 (2015).
4. Economics of Land Degradation Initiative: Report for policy and decision makers: Reaping economic and environmental benefits from sustainable land management 26. https://www.eld-initiative.org
5. Esch, S.V.D. et al. *Exploring the impact of changes in land use and land condition on food, water, climate change mitigation and biodiversity: Scenarios for the UNCCD Global Land Outlook* (The Hague, 2017).
6. Sutton, P., Anderson, S., Costanza, R. and Kubiszewski, I. The ecological economics of land degradation: Impacts on ecosystem service values. *Ecol. Econ.129*, 182–192 (2016).
7. Verdone, M. and Seidl, A. Time, space, place, and the Bonn Challenge global forest restoration target. *Restor. Ecol. 25*(6), 903–911 (2017).
8. Brasser, A. and Ferwerda, W. 4 Returns From Landscape Restoration. *Commonland Foundation 1*, 59 (2015).
9. Yirdaw, E. and Tigabu, M. Rehabilitation of degraded dryland ecosystems – review. *Silva Fenn. 51*(1B), 1673 (2017). https://doi.org/10.14214/sf.1673
10. Dasgupta, P. and Maler, K. Poverty, Institutions and the environmental resource base. In *World Bank Environment paper 9* (World Bank, 1994).
11. Gilmour, D. *Forty years of community-based forestry* (FAO, 2016).
12. Klein, J., Jochaud, P. and Richter, H. *Green Economy in Sub-Saharan Africa: Lessons from Benin, Ethiopia, Ghana, Namibia and Nigeria* (GIZ, 2013).
13. Wasonga, O. V. Linkages between Land-use , Land Degradation and Poverty in Semi-Arid Rangelands of Kenya : The Case of Baringo District. *Ph.D. thesis* **2009,** University of Nairobi, Nairobi, Kenya.
14. Sunderlin, W. D. et al. Livelihoods, forests, and conservation in developing countries: An overview. *World Dev. 33*(9), 1383–1402 (2005).
15. Zika, M. and Erb, K. H. The global loss of net primary production resulting from human-induced soil degradation in drylands. *Ecol. Econ. 69*(2), 310–318 (2009).
16. Duraiappah, A. K. et al. Millennium Ecosystem Assessment. In *Ecosystems and human well-being: Opportunities and Challenges for Business and Industry* (World Resources Institute, 2005).
17. Birhane, E., Teketay, D. and Barklund, P. Actual and potential contribution of exclosures to enhance biodiversity of woody species in the drylands of Eastern Tigray. *J. DRYLANDS 1*(2), 134–147 (2006).
18. Gebregziabher, G., Abera, D. A., Gebresamuel, G., Giordano, M. and Langan, S. An assessment of integrated watershed management in Ethiopia (2016). https://doi.org/10.5337/2016.214
19. Besseau, P., Graham, S. and Christophersen, T. RESTORING FORESTS AND LANDSCAPES : THE KEY TO A SUSTAINABLE FORESTS AND LANDSCAPES (2018). https://afr100.org
20. Kalhoro, S. et al. Effects of Different Land-Use Systems on Soil Aggregates: A Case Study of the Loess Plateau (Northern China). *Sustainability 9*(8), 1349 (2017).

21. Mekuria, W. et al. Exclosures for ecosystem restoration and economic benefits in Ethiopia: a catalogue of management options. Colombo, Sri Lanka (2017). https://doi.org/10.5337/2017.204
22. World resources institute. The economic case for Landscape in Latin America (2016). https://doi.org/10.13140/RG.2.2.13264.10243
23. Lebedys, A. and Li, Y. Contribution of the Forestry Sector to National Economies, 1990-2011. In *FAO report 168* (FAO, 2014).
24. Kim, N. Ecological restoration and revegetation works in Korea. *Landsc. Ecol. Eng. 1*(1), 77–83 (2005).
25. Pötner, H. Impacts, Adaptation, and Vulnerability. In *Working Group II Contribution to the IPCC Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC, 2023).
26. Climate Change 2022. In *Mitigation of Climate Change - Full Report, no. 1* (IPCC, 2022).
27. Pflieger, G. COP27: One step on loss and damage for the most vulnerable countries, no step for the fight against climate change. *PLOS Clim. 2*(1), e0000136 (2023).
28. Tietjen, B. and Gopalakrishnan, T. Loss and Damage Funding in the UN Climate Negotiations: From Dialogue to Reality. *Environment 65*(3), 18–28 (2023).
29. Stevenson, R. B. Schooling and environmental/sustainability education: from discourses of policy and practice to discourses of professional learning. *Environ. Educ. Res. 13*(2), 265–285 (2007).
30. *Pioneering proposals to restore Europe's nature by 2050* (European Commission, 2022).
31. Romijn, E. et al. Land restoration in Latin America and the Caribbean: An overview of recent, ongoing and planned restoration initiatives and their potential for climate change mitigation. *Forests 10*(6), 510 (2019).
32. Chung, M. Y. et al. The Korean Baekdudaegan Mountains: A Glacial Refugium and a Biodiversity Hotspot That Needs to Be Conserved. *Front. Genet. 9*, 1–4 (2018).
33. Shin, J. H. and Chung, J. Y. The four major rivers restoration project in South Korea. *Proc. Inst. Civ. Eng. Civ. Eng. 164*(1), 19–26 (2011).
34. Yoon, Y. Cheonggyecheon Restoration Project: The politics and implications of globalization and gentrification. *Dartmouth Undergrad. J. Polit. Econ. World Aff. 1*(1), 8 (2018).
35. Choi, G., Jeong, Y. and Kim, S. Success factors of national-scale forest restorations in South Korea, Vietnam, and China. *Sustain. 11*(12), 1–17 (2019).
36. Festin, E. S., Tigabu, M., Chileshe, M. N., Syampungani, S. and Odén, P. Progresses in restoration of post-mining landscape in Africa. *J. For. Res. 30*(2), 381–396 (2019).
37. Siachoono, S. M. Land reclamation efforts in Haller Park, Mombasa. *Int. J. Biodivers. Conserv. 2*(2), 19–25 (2010).
38. Ji, S., Shin, S. and Lee, Y. Forest Restoration Policy in the North Korea Based on the Reforestation Experience in South Korea. *Int. For. Rev. 24*(4), 560–572 (2022).
39. Oh, S., Kim, E. H., Kim, K. M. and Kim, M. K. A study on the application of successful forest greening experience for forest and landscape restoration: A comparative study of two Koreas. *Sustain. 12*(20), 1–19 (2020).
40. Norton, D., Butt, J. and Bergin, D. O. Upscaling restoration of native biodiversity: A New Zealand perspective. *Ecol. Manag. Restor. 19*(0), 26–35 (2018).
41. Ishiwatari, M. et al. *Promoting Green Growth Through Water Resources Management: The Case of Republic of Korea* (World Bank, 2016).
42. Mekuria, W., Barron, J., Dessalegn, M. and Adimassu, Z. Exclosures for Ecosystem Restoration and Economic Benefits in Ethiopia . In *a Catalogue of Management Options* (International Water, 2017).
43. Barata, P. M. *Carbon Credits and Additionality: Past, Present, and Future* (World Bank, 2016)**.**
44. O'Connor, R. and Gaertner, K. Forest Carbon Credits. In *a Guidebook To Selling Your Credits On The Carbon Market* (Boston University, 2018).
45. Alexandratos, N. and Bruinsma, J. World agriculture towards 2030/2050: the 2012 revision. In *ESA Working paper 12*(3) (FAO, 2012).
46. The World Population Prospects: The 2017 Revision, vol. 91 (United Nations, 2017).
47. Cardinale, B. et al. Biodiversity loss and its impact on humanity. *Nature 486*(7401), 59–67 (2012).
48. Iwuji, C., Okeke, O., Ezenwoke, B., Amadi, C. and Nwachukwu, H. Earth Resources Exploitation and Sustainable Development: Geological and Engineering Perspectives. *Engineering 08*(01), 21–33 (2016).
49. Rolston, H. *Endangered Species and Biodiversity* (Elsevier, 2018).
50. Jaramillo, F. and Destouni, G. Comment on 'planetary boundaries: Guiding human development on a changing planet. *Science 348*(6240), 1217–c (2015).
51. RockstrÖm, J. et al. A safe operating space for humanity. *Nature 461*(24), 472–475 (2009).
52. Bhargava, V. *Global Issues for Global Citizens: An Introduction to Key Development Challenges* (World Bank, 2006).
53. Sweeney, J. Climate change: A new contract. *OECD Obs. 3430*(267), 43–44 (2008).
54. Rudel, T. Local actions, global effects? Understanding the circumstances in which locally beneficial environmental actions cumulate to have global effects. *Ecol. Soc. 16*(2), 19 (2011).
55. Le Houerou, H. Restoration and rehabilitation of arid and semiarid mediterranean ecosystems in north africa and west asia: A review. *Arid Soil Res. Rehabil. 14*(1), 3–14 (2000).
56. World Resources Institute *The economic case for Landscaoe Restoration in Latin America* (WRI, 2016).
57. European Commission *Multi-annual implementation plan of the new EU Forest Strategy SWD* (EC, 2015).

58. A new EU Forest Strategy: for forests and the forest-based sector, SWD(2013) 342 final, SWD(2013) 343 final. https://scholar.google.com.
59. Yin, R. and Zhao, M. 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 (2012).
60. Mekuria, W., Langan, S., Noble, A. and Johnston, R. Soil Restoration after seven Years of Exclosure Management in Northwestern Ethiopia. *L. Degrad. Dev. 28*(4), 1287–1297 (2017).
61. Nelson, F. and Sandbrook, C. *Community management of natural resources in Africa: Impacts , experiences and future directions* (Intl Inst for Environment, 2009).
62. Mitchell, J. *Criteria and Indicators of Sustainable Rangeland Management* (Univ. of Wyoming Extension Publication, 2010).
63. Mekuria, W. Conversion of Communal Grazing Lands into Exclosures Restored Soil Properties in the Semi-Arid Lowlands of Northern Ethiopia. *Arid L. Res. Manag. 27*(2), 153–166 (2013).
64. Mekuria, W. and Yami, M. Changes in woody species composition following establishing exclosures on grazing lands in the lowlands of Northern Ethiopia. *African J. Environ. Sci. Technol. 7*(1), 30–40 (2013).
65. Yayneshet, T. Restoration of Degraded Semi-Arid Communal Grazing Land Vegetation Using the Exclosure Model. *Int. J. Water Resour. Arid Environ. 1*(5), 382–386 (2011).
66. Yimer, F., Alemu, G. and Abdelkadir, A. Soil property variations in relation to exclosure and open grazing land use types in the Central Rift Valley area of Ethiopia. *Environ. Syst. Res. 4*(1), 17 (2015).
67. Haregeweyn, N. et al. Reservoirs in Tigray (Northern Ethiopia): Characteristics and sediment deposition problems. *L. Degrad. Dev. 17*(2), 211–230 (2006).
68. Balana, B. et al. Cost-benefit analysis of soil and water conservation measure: The case of exclosures in northern Ethiopia. *For. Policy Econ. 15*, 27–36 (2012).
69. Prabuddh, K. and Suresh, C. A Cost – Benefit Analysis of Indigenous Soil and Water Conservation Measures in Sikkim Himalaya, India. *Mt. Res. Dev. 34*(1), 27–35 (2013).
70. Nedessa, B., Ali, J. and Nyborg, I. *Exploring Ecological and Socio-Economic Issues for the Improvement of Area Enclosure Management: A Case Study from Ethiopia* (DCG, 2005).
71. Börner, J. et al. Environmental Income and Rural Livelihoods: A Global-Comparative Analysis. *World Dev. 64*, S12–S28 (2014).
72. Ethiopia's Progress Towards Eradicating Poverty. In *an Interim Report on Poverty Analysis Study (2010/11)* (FDRE, 2012).
73. *Tigray regional state Five Years(2010/11-2014/15)* (FDRE, 2010).
74. Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E. and Berg, G. Forest environmental incomes and the rural poor. *For. Policy Econ. 9*(7), 869–879 (2007).
75. Fox, E. et al. An Integrated Social, Economic, and Ecologic Conceptual (ISEEC) framework for considering rangeland sustainability. *Society and Nautral Resources 22*(7), 593-606 (2009). http://doi.org/10.1080/08941920802247894
76. Tekalign M., The Role of Area Exclosures for Biodiversity Conservation and its Contribution to LocalLivelihoods. *MSc. Thesis* 2010, Adis Ababa University, Adis Ababa, Ethiopia.
77. Getachew, A. Contribution of exclosure for environmental conservation and community livelihoods in the central rift valley area of Ethiopia. *Int. J. Curr. Res. 9*(6), 51652–51658 (2017).
78. Lemenih, M. and Kassa, H. Re-greening Ethiopia: History, challenges and lessons. *Forests 5*(8), 1896–1909 (2014).
79. Getachew, M. and Malke, A. Socio-economic challenges of area exclosure practices: a case of Gonder Zuria woreda, Amhara Region, Ethiopia. *J. Nat. Sci. Res. 5*(13), 123–132 (2015).
80. Ubuy, M., Eid, T., Bollandsås, O. and Birhane, E. Aboveground biomass models for trees and shrubs of exclosures in the drylands of Tigray, northern Ethiopia. *J. Arid Environ. 156*, 9–18 (2018).
81. Birhane, E. et al. Exclosures as forest and landscape restoration tools : lessons from Tigray Region , Ethiopia. *International Forestry Review 19*(4), 37-50 (2017).
82. Cornell, A. et al. *Economics of Land Degradation Initiative - Report for the Private Sector* (ELD, 2016).
83. Sadowski, R. Religious motivations for the protection of forest ecosystems. *Folia Oecologica 39*(2), 139–146 (2012).
84. Anderson, D., Salick, J., Moseley, R. and Xiaokun, O. Conserving the sacred medicine mountains: A vegetation analysis of Tibetan sacred sites in northwest Yunnan. *Biodivers. Conserv. 14*(13), 3065–3091 (2005).