

Land Degradation and Human Health

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The land provides vital resources to support life on Earth. Land ecosystems services have social, cultural, and spiritual benefits and promote human health and well-being. However, human activities, particularly ongoing unsustainable land practices, are negatively impacting ecosystems through desertification, land degradation and drought (DLDD).

Land degradation

human health

climate change

ecosystem services

drought

desertification

1. Introduction

The land provides vital resources to support life on Earth. Land ecosystems services have social, cultural, and spiritual benefits and promote human health and well-being. However, human activities, particularly ongoing unsustainable land practices, are negatively impacting ecosystems through desertification, land degradation and drought (DLDD).

Land resources are vital for human health, well-being and, overall, life on earth. Land provides ecosystem services, as well as social, cultural, spiritual and economic benefits that form a life support system for human health and well-being^{[1][2]}. Vital resources provided from ecosystems include food and essential nutrients; clean water and air; shelter; medicines and medicinal compounds; wood; fuel; fiber; energy; climatic constancy; regulation of risks of natural hazards and diseases; pollination; water purification; livelihoods; and cultural, spiritual and recreational enrichment^{[3][4]}. Other benefits are related to biodiversity, which includes diversity within and among ecosystems and species that are essential to ecosystem functions and service delivery, as well as to the sustenance of human health and human well-being^{[5][6]}. Human activities are negatively affecting ecosystem services and biodiversity through land degradation^{[2][4]}. The drivers of land degradation and biodiversity loss are linked to population growth and rising urbanization, increased consumption, the expansion of crop and grazing lands, and unsustainable agricultural and forestry practices; these are within the context of unsustainable economic growth. In addition, climate change can affect the conditions of environmental and human systems, adversely impacting sustainable development^{[2][7][8]}. The degradation of terrestrial and aquatic ecosystems is a problem of global dimensions. It affects every continent, from countries with large landmasses to small island states, from wet and dry regions to cold and warm ones, from wealthy developed countries to poorer developing countries. At least 3.2 billion people worldwide are affected by this complex phenomenon^[8]. The most vulnerable and threatened land areas are the world's drylands, although land degradation is also a large problem outside drylands^[9]. The negative impacts are disproportionately felt by people living in vulnerable conditions. These include poor women, indigenous communities, children, elderly persons, people living in rural, marginal or fragile environments, on land that is particularly vulnerable to degradation, as well as those with a low-income or living in poor areas^{[10][11][12][13]}. This also applies to those without easy access to health care facilities and persons with pre-existing health conditions^{[11][14][15]}. Similarly, DLDD poses multiple risks to livelihoods, and consequently, to human health^{[16][17]}. DLDD reduces food production, freshwater access and ecosystem resources; as a result, health is placed under increasing stress.

2. DLDD Pathways Affecting on Human Health

Land degradation can cause water and food insecurity, unemployment, gender inequality, conflict and migration. All ecosystem consequences from DLDD can affect human health and well-being, directly or indirectly, alone or combined^[18]. Although land degradation is a major contributor to climate change^[8], climate change also can aggravate these impacts, causing substantial costs in the environmental, social, economic and political dimensions, including in the health sector^{[18][19][20][21]}. Climate change can exacerbate impacts on human health associated with DLDD (e.g., impacts from hot temperatures, from intense and prolonged extreme events such as drought and floods, and from declining freshwater resources and food security). Climate change accelerates soil erosion on degraded land through extreme weather events, which can increase the risk of forest fires. It can cause changes in the distribution of invasive species, vectors, pests and pathogens^{[8][20]}, influencing

the occurrence of newly emerging diseases, such as zoonotic infections and vector-borne diseases, in areas without previous exposures^{[22][20][21][23][24][25]}; and airborne pollutants can increase respiratory diseases^[26].

There is a complex relationship between DLDD and health. The causal chain from DLDD through food, water, air and soil quality is mediated by social, economic and other environmental factors and by the response of the health system. Social and economic factors can contribute to vulnerabilities at the local level, especially in poor communities and in cases where the impacts are of long duration. The health outcomes are infectious, parasitic and nutritional diseases; non-communicable diseases; and injuries (unintentional and intentional). Most of the impacts on human health by key DLDD pathways (water security and safety, food security and safety, air quality, and soil quality) are difficult to measure because they are indirect and mediated by global and local environmental, and by social and economic forces, which all are determinants of health. Additionally, the quality of, and access to, health care services also act as mediating factors. Examples of health impacts associated with DLDD drivers are summarized in [Table 1](#).

Table 1. DLDD drivers affecting human health through water security and safety, sanitation and hygiene, food security and safety, and air and soil quality.

DLDD Drivers	Environmental and Social Pathways	Human Health Impacts (Morbidity and Mortality)
Water Security and Safety	Water shortage Consequences of water quality (non-potable water, saline water) Contamination of water by various means, such as toxic algal blooms, bacteria, fungi, virus, toxins, chemical pollutants Damages to health services functioning, with consequences to the provision of some sanitary procedures Consequences on the water supply and distribution system (for piped water, water trucks, cisterns, artesian wells, dams and other alternative sources) Household water collection and storage, which may compromise water quality Water collection and transport (which may cause physical injuries) Change in vectors, hosts and reservoir cycles Effect on irrigation for agricultural production and in livestock and fishing increasing the possibility of food shortages Impaired hygiene (personal, household, food, health service equipment) due to lack of water Consequences of sanitation services, urban cleaning, health services and other basic services	Gastrointestinal infectious diseases (diarrhea, hepatitis A, typhoid fever, and other infections) Parasitic infections (intestinal nematodes infections) Dermatological infectious diseases (scabies) Diseases transmitted by vectors and zoonoses (e.g., dengue, Zika, chikungunya, malaria, leishmaniasis, leptospirosis) Infectious diseases transmitted by viruses, bacteria, fungi (flu, pneumonia, conjunctivitis, trachoma, scabies, and other diseases) Cardiovascular diseases (e.g., hypertension) Kidney diseases Cancers (esophageal cancer) Dehydration Undernutrition Unintentional injuries (poisoning by toxins) Musculoskeletal disorders (bone damage, back and muscle pain) Mental and behavioral disorders (stress, anxiety, depression)
	Food Security and Safety	Nutritional deficiencies (anemia, night blindness, scurvy) Malnutrition and its complications (low physical and cognitive development, deficiency of the immune system, overweight) Fetal growth restriction, neonatal and child deaths Infections from food contaminated by viruses, bacteria, fungi, parasites (diarrhea, cholera, hepatitis A, worms, other infections) Chronic diseases (hypertension, obesity, cancers, diabetes) Renal and kidney damages Mental, behavioral and neurological disorders (stress, anxiety, depression, suicide) Unintentional injuries (poisoning)
Air Quality	Low humidity Increased temperature (heat, warmer conditions)	Acute respiratory diseases (flu, sinusitis, rhinitis, bronchitis, pneumonia) Chronic respiratory diseases (asthma, allergic rhinitis,

and Food Security Information Network (FSIN). Global Report on Food Security: Key Messages for Better Decisions. Food Security Information Network. 2019. Available online:

DLDD Drivers	Environmental and Social Pathways	Human Health Impacts (Morbidity and Mortality)
	Dust storms, dust particles Air contamination by particles from fires (wildfires, agricultural practices) and toxins accumulated in air, soil and water Accidents caused by reduced visibility Release of airborne allergens (fungal spores and plant pollen)	chronic obstructive pulmonary disease) Cardiovascular diseases (stroke, ischemic heart disease, hypertensive heart disease) Cancer (lung, bronchus, trachea, liver, kidney) Neurodegenerative disorders Skin irritations (dermatitis) and eye infection (conjunctivitis) Meningococcal meningitis Diseases caused by fungi, viruses, algae, bacteria, allergens Valley fever Premature births and low birth weight Unintentional injuries by road accidents
1	Soil Quality Loss of productive soil leads to lower food production, from decreasing agricultural yields and livestock, causing food shortages Soil contamination from chemical products Soil contamination from animal and human excreta Air contamination through contaminated dust	Infections from food contaminated by viruses, bacteria, fungi, parasites (diarrhea, cholera, hepatitis A, worms, other infections) Non-communicable diseases (types of cancers, neurological damage, lung and kidney diseases, skeletal and bone diseases, sterility and reproductive disorders, immune suppression) Respiratory infections (e.g., pneumonia) Skin and eye irritation and allergies or infections Nutritional deficiencies Unintentional injuries (poisonings)

[http://www.greengrowthknowledge.org/sites/default/files/Barbier,%20Edward%20-%20Poverty,%20development%20and%20environment%20\(2010\).pdf](http://www.greengrowthknowledge.org/sites/default/files/Barbier,%20Edward%20-%20Poverty,%20development%20and%20environment%20(2010).pdf) (accessed on 25 December 2020).

14. World Health Organization (WHO). **Operational Framework for Building Climate-Resilient Health Systems**. Geneva, Switzerland, 2015. Available online: <https://www.who.int/publications-detail/operational-framework-for-building-climate-resilient-health-systems> (not shown). Note: each pathway can have multiple health impacts

3 Challenges and Directions to Improve Human Livelihoods

Complex and intermingled environmental and social challenges of DLDD affect communities and population health. Four of the many challenges were highlighted in the UNCCD Strategic Framework 2018–2030: poverty and forced migration (key challenges); and lack of water security and lack of food security (key environmental challenges). <https://www.unccd.int/sites/default/files/2018/05/strategic-framework-2018-2030.pdf> (accessed on 17 October 2020).

13. Berman, J.D.; Ebisu, K.; Peng, R.D.; Dominici, F.; Bell, M.L. Drought and the risk of hospital admissions and mortality in older adults in western USA from 2000 to 2013: A retrospective study. *Lancet Planet. Health* 2017, 1, e17–e25. Available online: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5646697/> (accessed on 17 October 2020). Lower-income groups are more dependent on the agricultural sector, as compared to the general population and have access to land with lower productivity, intensifying poverty and income inequality [6][20][45]. The outcome of the analysis in selected low- and middle-income countries showed that people living on fragile lands presented a higher overall proportion of rural poverty [49]. By 2050, four billion people are projected to live in dryland areas with decreased land productivity. This, coupled with poverty and other social stresses, can make people more vulnerable to socioeconomic instability and violent conflict [56]. Poverty and lack of access to health care form a complex vicious cycle. Poverty leads to ill health that can maintain poverty [46][47].

14. Ebi, K.; Bowen, K. Extreme events as sources of health vulnerability: Drought as an example. *Weather Clim. Extrem.* 2016, 11, 95–102. Available online: <https://www.sciencedirect.com/science/article/pii/S221209471530030X> (accessed on 17 October 2020). Poverty and lack of access to health care form a complex vicious cycle. Poverty leads to ill health that can maintain poverty [46][47].

15. Berrán, O.; Cuesta, J.C.; Flores, M.; Haweed, O.; Cherseda, S.; van Loenhout, J.A.F.; Guna-Spir, D. Delays in arrival and treatment in emergency and disaster incidents: women, children and low-income populations at the most at risk for human trafficking. *PLoS ONE* 2019, 14, e0233362. Available online: <https://doi.org/10.1371/journal.pone.0233362> (accessed on 17 October 2020). The temporal dimensions vary, which can be temporary or permanent [14][46].

16. International Panel on Climate Change (IPCC). Climate change and land. In An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. Summary for Policymakers. Approved Draft. *International Panel on Climate Change; WMO and UNEP* 2019. Available online: <https://www.ipcc.ch/site/assets/uploads/2019/08/4-SPM-Approved-Microsite-FINAL.pdf> (accessed on 25 December 2020). DLDD has a complex and frequent association with population migration. Annually, tens of millions of people, many living in rural areas of low- and middle-income countries, migrate for reasons related to land degradation (e.g., food scarcity), extreme weather and climate events (e.g., drought, floods), and the effects of climate change on food security (depletion of natural resources due to environmental degradation also poses risks for rural people's subsistence, especially those depending on agricultural production, livestock, fisheries, and forest-based livelihoods). Intervening mediating factors include social, economic, political, infrastructure, and demographic factors [50][45]. International migration occurs mainly from low- and middle-income to high-income countries. The most common internal migration pattern occurs from rural to urban areas, and also within rural areas and between cities (inter-urban migration). The temporal dimensions vary, which can be temporary or permanent [14][46].

17. Warner, K.; Ennart, C.; de Sherbinn, A.; Adams, S.; Chai-Ohn, T. In Search of Shelter: Mapping the Effects of Climate Change on Human Migration and Displacement. Bonn, Germany: United Nations University, CARE, and CESIN Colombia University and in Close Collaboration with the European Commission; 2019. Available online: <https://www.unu.edu/publications/In-Search-of-Shelter-Mapping-the-Effects-of-Climate-Change-on-Human-Migration-and-Displacement> (accessed on 17 October 2020). The temporal dimensions vary, which can be temporary or permanent [14][46].

19. **Water Governance Panel on Climate Change (IPCC).** Climate change 2007: Impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani, O.P., Palutikof, J.P., van der Linden, P.S., Hanson, C.E., Eds., Cambridge University Press: Cambridge, UK, 2007; 976p. Available online: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_wg2_ii_report.pdf (accessed on 17 October 2020).

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21. Haines, A.; Ebi, K. The Imperative for Climate Action to Protect Health. *N. Engl. J. Med.* **2019**, *380*, 263–273. Available online: <https://www.nejm.org/doi/full/10.1056/NEJMra1807873> (accessed on 17 October 2020).

One of humanity's greatest challenges is to ensure healthy diets for a growing world population while ensuring healthy and sustainable food systems. Globally, more than 820 million people have insufficient food, leading to malnutrition and the risk of infectious diseases. An even larger number of people consume a unhealthy diet that contributes to premature death and morbidity from non-communicable diseases. These extremes occur while pressures on food systems increase ¹. As populations increase and standards of living and nutrition improve, the demand for food will continue to rise. The current world

[illegible]

24. Lima-Camara, T.N. Emerging arboviruses and public health challenges in Brazil. *Rev. Saude Publica* 2016, **50**, 50. Available online: <http://www.scielo.br/pnsp/v50/0034-8910-rsp-S1518-87872016050006791.pdf> (accessed on 25 December 2020).

The current state of DLDD calls for urgent actions to protect human health and wellbeing. Lack of awareness of DLDD and its adverse impacts are a barrier to sound raising and a neglected environment obstructs determining forces on health consequences in the social, economic and environmental domains. The current DLDD challenge needs to be implemented at a global level. Actions across jurisdictions and at a global level are needed to address the challenges of DLDD. The current DLDD challenges will need a global effort. Governments, communities, civil society and

26. Smith, L.F.; Aragao, L.E.; Sabe, C.E.; Nakaya, T. Drought impacts on children's respiratory health in the Simultaneously, the social determinants of health need to be addressed, such as poverty reduction, water and food security, livelihood support, capacity building, and overall building resilience and human development. A better understanding of the

relationship between ecosystem sustainability and health benefits would be an important contribution to decision-making (Patz, J., Cryan, C., Horwitz, P., Campbell-Lendrum, D., Our Planet, Our Health, Our Future: Human Health and the Rio Conventions: Biological Diversity, Climate Change and Desertification; World Health Organization: Geneva, Switzerland, 2012. Available online: https://www.who.int/globalchange/publications/reports/health_rioconventions.pdf?ua=1 (accessed on 17 October 2020).

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