*Environment and Sustainability Feature:*

# Livestock's Role in Land Degradation – A Critical Analysis (Part 1)[1]

*By Bianca Little*[2]

## *Abstract*

Accounting for more than 75% of the Earth's land areas, and increasing at an alarming pace, land degradation is one of the most severe and complex socio-ecological problems currently facing humanity. Driven primarily by the rapid expansion and unsustainable management of croplands and pastures, land degradation contributes to a myriad of other pressing environmental problems that threaten the security, livelihoods and well-being of billions of people worldwide. Although socially, culturally and economically very important, the livestock sector is a significant stressor on virtually all aspects of the environment and plays a major role in land degradation. Under current trends dubbed the 'livestock revolution', unprecedented growth within the sector is further exacerbating environmental degradation. Without adequate regulation, current global trends could bring about unsustainable levels of agricultural expansion and natural resource consumption. The livestock sector should therefore become a major policy focus for tackling land degradation and finding solutions towards sustainable development. Owing to its interlinkages with many of the other sustainable development goals and targets, combatting land degradation is essential to realising the United Nations 2030 Agenda for Sustainable Development, and thus requires urgent attention.

**Keywords**: land degradation, desertification, livestock sector, animal agriculture, sustainable development, UN 2030 Agenda, SDGs, Sustainable Development Goals, Climate Change.

[1] The views in *The Culture Mandala* are those of the author(s) and do not necessarily reflect the views, position or policies of the *Centre for East-West Cultural and Economic Studies* (FSD, Bond University). Bearing in mind the controversial debates now occurring in International Relations and East-West studies, the editors publish diverse, critical and dissenting views so long as these meet ethical and academic criteria.

[2] Bianca Little has a Masters of International Relations from Bond University, QLD, Australia.

## *Introduction*

Occupying over a quarter of the earth's ice-free terrestrial surface, the livestock sector is the world's largest anthropogenic user of land, and a leading contributor to today's most pressing global environmental issues. Worldwide in geographic extent, and increasing at an alarming pace, land degradation is one of the most severe contemporary socio-economic, environmental problems facing humanity. Unprecedented rates of land degradation are the primary cause of biodiversity and ecosystem services losses, pushing the planet towards a sixth mass species extinction and costing the equivalent of 10% of the world's annual gross product. Substantial land degradation currently accounts for more than 75% of the Earth's land areas and its implications on food and water security undermines the well-being of 3.2 billion people. According to a recent and extensively peer-reviewed report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), if current trends continue, more than 90 percent of the Earth's total land surface could become degraded by 2050 (FAO, 2018; IPBES, 2018; UNCCD, 2017).

The livestock sector is a driving force behind land degradation and associated biodiversity loss. Albeit socially, culturally, and politically very significant, livestock production systems are a significant stressor on virtually all aspects of the environment and at every level, from local to global. Both directly, through grazing, and indirectly, through deforestation and feed-crop production, animal agriculture is a key driver of land-use changes that have led to disastrous consequences including, but not limited to: soil degradation; erosion; salination; desertification; and habitat loss. Globally one of the largest sources of greenhouse gases, and a primary source of water pollution, the livestock sector contributes to a myriad of serious environmental problems that exacerbate food and water insecurity along with climate change. The cascading effects of livestock production systems on the environment, are not only large-scale but intensifying (Gerber et al., 2013; Steinfeld et al., 2006; Thornton, 2010).

Due to population growth, rising affluence, rapid urbanisation, changes in consumption patterns, climate change, and an increasingly globalised economy, the livestock sector is growing at an unprecedented rate and represents a major sustainability challenge. The result is increasing developments towards intensification

and industrialisation, which in turn, are having a profound impact on the global environment. By 2050, the global population is projected to reach 9 billion people, and the global production of meat alone is expected to more than double (FAO, 2014; Herrero & Thornton, 2013; IPBES, 2018; UNCCD, 2017).

The global importance of the livestock sector is far-reaching and multifunctional, employing 1.3 billion people, accounting for a global average of 40 percent of agricultural GDP, and providing livelihoods for one billion of the world's poor. The benefits of short-term gains from unsustainable land management, however, do not outweigh the negative implications of its long-term losses. Findings from the FAO reveal that to merely prevent the level of damage from increasing beyond its current level, the environmental impact per unit of livestock must be halved (FAO, 2018; Herrero, Thornton, Gerber, & Reid, 2009; IPBES, 2018; Steinfeld et al., 2006).

This article focuses on the linkages among livestock production, land degradation and global Sustainable Development Goals (SDGs). It argues that the livestock sector is a key driver of extensive land degradation and desertification, which, in turn, has far-reaching global implications on food security, poverty, biodiversity, ecosystems, climate change, forced migration, and human well-being, among other things. The paper further maintains that combatting land degradation through the successful implementation of SDG 15: "Life on Land" and target 15.3 "Land Degradation Neutrality" are essential to meeting other SDGs and realising the United Nations 2030 Agenda for Sustainable Development. The central argument thus stresses that the livestock sector should be a major policy focus when addressing matters of land degradation and the delivery of sustainable development goals and targets, as its potential contribution to the solution to SDG 15 is paramount.

This analysis provides a framework for assessing livestock's impact on land degradation and other global environmental problems hindering progress towards achieving the 2030 Agenda. It does not address solutions and strategies to the problems outlined, as a follow-up article will be dedicated to providing policy recommendations. Instead, it aims to provide a multidimensional perspective to the complex socio-ecological problem of land degradation, within the context of animal agriculture.

In terms of structure, it begins by providing a brief overview of land degradation's history, current status, and trends, before highlighting the complexities of the problem embedded in cascading effects and underlying causes. After

emphasising the relevance of the United Nations 2030 Agenda for Sustainable Development to the discussion, the nexus between land degradation and problems such as food and water insecurity, mass migration, and climate change will be examined. Through highlighting the linkages and integrated nature of the Global goals, the paper will then go on to explore the importance of achieving target 15.3 (on land degradation neutrality) in realising the overall 2030 Agenda. Against this background, the pivotal role of the livestock sector in matters of land degradation, climate change, air pollution, water depletion and pollution, and biodiversity will then be analysed. The article concludes with a review of the global trends that are worsening the environmental crisis by driving unprecedented growth and unfavourable structural transformations within the livestock sector.

## *Desertification and Land Degradation: A Global Problem*

### *Terminology*

Many studies incorrectly use the terms land degradation and desertification interchangeably. Considering the definitions adopted by the Convention to Combat Desertification are now widely regarded to be authoritative, they will be used throughout this paper.

**Desertification** means "land degradation in the arid, semiarid zone and dry sub-humid areas resulting from various factors, including climatic variations and human activities". It is not the natural expansion of existing deserts - an idea that is often linked with the term (UNCCD, 2000, p.12).

**Land** denotes "the terrestrial bio-productive system that comprises soil, vegetation – including crops, other biota, and the ecological and hydrological processes that operate within the system" (UNCCD, 2017, p.23).

**Degradation** implies a decrease in resource potential by one or a combination of processes acting on the land, such as: soil erosion by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation (UNCCD, 2017).

**Sustainable land use** infers the continuation of land use without degrading it. It depends both on the properties of the resource and the way it is managed (UNCCD, 2017).

### *Historical Background*

Land degradation is not a new phenomenon; the international community has long recognised it to be a severe global socio-economic and environmental problem that undermines the well-being of humanity. In the past, drylands generally responded quickly to climatic fluctuations and recovered effortlessly following prolonged droughts and dry periods. Over time, people learned to preserve the land's resources using traditional strategies such as shifting cultivation and nomadic herding. In modern agriculture, however, such strategies have become less widely practised. Nowadays, land is frequently overexploited owing to changes in pricing, subsidy and tax policies, and the use of pesticides and intensive monoculture to achieve increased yields. As a result, under current conditions, the biological and economic productivity of today's land rapidly decreases when it is not sustainably managed (Helden, 1991; Nkonya et al., 2011; UNCCD, 2017).

In the 1970s the global-level assessment of desertification and land degradation began alongside the United Nations Conference on Desertification (UNCOD) adoption of a Plan of Action to Combat Desertification (PACD). However, early global evaluations of land degradation largely focused on the biophysical impact of land degradation and the loss of on-site productivity and paid little attention to the related economic costs or benefits of combatting the problem. While these early studies played a key role in raising global awareness of the gravity of the land degradation, the studies relied upon limited mapping technology for data collection and were therefore prone to subjective judgment and substantial inaccuracies. Rapid technological advancements, however, have improved the monitoring tools that measure the extent and severity of land degradation. Modern-day studies now use data obtained from satellite imagery, rather than expert opinion, to present credible, evidence-based assessment reports. Subsequently, the development of spatial analysis techniques has both, improved accuracy and lowered the costs of global assessments (IPBES, 2018; Nkonya et al., 2011; Steinfeld et al., 2006; Thornton, 2010; UNCCD, 2017).

### *Status and Trends*

In 2018, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) published a report on land degradation and restoration that provided the world's first comprehensive, evidence-based assessment of the global status and trends in land degradation. Involving over 100 international leading experts and drawing upon over 3000 scientific, governmental, indigenous, and local knowledge sources, the report finds that land degradation, through human activities, presently impacts 3.2 billion people, pushing the planet towards a sixth mass species extinction and costing more than 10 per cent of the annual global gross product in loss of biodiversity and ecosystem services. The report maintains that worsening global land degradation has reached 'critical' levels in many parts of the world, with more than 75% of the Earth's total land surface subjected to the substantial impacts of human activity. Findings also revealed that by 2014, more than 1.5 billion hectares of natural ecosystems had been converted to croplands and that wetlands have been hit the hardest, with losses of 87% since the start of the modern era, and 57% lost since 1990 (IPBES, 2018).

The current state of worldwide land degradation poses a serious threat not only to human well-being also may cause mass migration and increase conflict. With deforestation alone accounting for about 10% of all human-induced greenhouse gas emissions, land degradation also emerges as a key contributor to climate change. According to the authors of the IPBES report, land degradation will worsen with population growth, unprecedented consumption, an increasingly globalised economy and climate change. To make matters worse, most future land degradation is predicted to occur in the areas with the largest amount of arable land remaining. If current trends continue, experts estimate that by 2050, more than 90% of the Earth's land areas will be substantially degraded, 4 billion people will live in drylands, 50-700 million people will be forced to migrate, and global crop yields will be reduced by an average of 10% and up to 50% in some regions (Gomiero, 2016; IPBES, 2018; IUCN, 2015; Nachtergaele, Biancalani, & Petri, 2012).

### *Causes of Land Degradation*

Land degradation is a multifaceted phenomenon that can manifest in various ways. Soil degradation, vegetation degradation, water degradation, climate deterioration and losses to urban/industrial development are all constituents of land degradation. Different types of land degradation can be classified according to their physical, biological, and chemical processes. *Physical land degradation processes* include erosion, soil organic carbon loss, and changes in the soil's physical structure such as compaction or waterlogging. *Biological processes*, on the other hand, include deforestation and biodiversity loss including the loss of soil organic matter, flora and fauna populations, and species in the soil. Additionally, changes in the structure and botanical composition of plants can constitute vegetation degradation. *Chemical land degradation processes* refer to salinisation, acidification, leaching, nutrient imbalances, and fertility depletion (FAO, n.d.; FAO, 2015; Gomiero, 2016; Hazell & Wood, 2008; Nkonya et al., 2011; UNCCD, 2017).

Predominantly triggered by unsustainable human activities and climate variability, the causes of land degradation can be divided into direct causes, underlying causes, and natural hazards. Despite the division the direct and indirect causes of land degradation remain linked by a causal nexus - a chain of cause and effect (FAO, n.d.; Nkonya et al., 2011).

#### Natural Hazards

Climatic conditions directly affect the terrestrial ecosystem and land degradation. The biophysical conditions of natural hazards are predisposing factors for land degradation and vary for different types of degradation. For example, naturally occurring wildfires in dry, hot areas can lead to biodiversity loss, soil erosion and the release of carbon; strong rainstorms can lead to flooding and erosion; variable rainfall patterns (such as low and infrequent rainfall or monsoonal rains of high intensity), can lead to low soil-moisture content causing erosion and salinization due to high run-offs and decreased plant productivity; and pests and diseases (such as invasive species) can lead to loss of biodiversity and reduced crop and livestock productivity. In some cases, these natural hazards are severe enough to trigger natural land degradation – without human interference. Most of the time, however, human activities contribute to and exacerbate the problem (FAO, n.d.; FAO 2015; Nkonya et al., 2011; Steinfeld et al., 2006; Young,

Orsini, & Fitzpatrick, 2015).

**Direct Causes**

Unsustainable land use and inappropriate land management practices are the direct causes of land degradation. *Unsuitable land use* is the term used to describe the use of land for purposes for which is bio-physically unsuited on a sustainable basis; for example, the cultivation of annual crops on steep hillsides with shallow soils.

*Inappropriate land management*, on the other hand, is the use of land in ways which could be sustainable if properly managed, but where the necessary practices are not adopted. One example is the failure to replenish soil nutrients removed in harvested products. The reasonably low importance given to environmental protection often results in poor land management decisions. According to the IPBES report (2018), the most extensive global direct driver of land degradation is the rapid expansion and inappropriate management of croplands and grazing lands. The most commonly identified forms of unsustainable land management include: overgrazing, land clearing, over-cultivation, cultivation on steep slopes, deforestation, bush burning, pollution of land and water sources, soil nutrient mining and poor irrigation practices. Such overexploitation is largely attributed to by economic and social pressures, ignorance, war, and drought (FAO, n.d.; IPBES, 2018; Nkonya et al., 2011; Steinfeld et al., 2006; UNCCD, 2015).

**Underlying Causes**

Underlying causes are the reasons why various types of unsuitable land use, and inappropriate land management, are practiced. They generally concern the socio-economic circumstances of the land users and the social, cultural, economic and policy setting in which they operate. The findings of the IPBES report reveals that unprecedented consumption, population growth, an increasingly globalised economy and climate change are the underlying drivers of worldwide land degradation. Policies also have a large impact on land management practices as they can impact land users' behaviour, directly or indirectly. Unregulated access to land resources can lead people to maximise their own gains by exploiting the land at the expense of the whole community. Access to markets can also impact factors affecting land management. Good

market access often creates an incentive to invest in improved land management.

Similarly, insecure land tenure and land rights can lead to the adoption of unsustainable land management practices (FAO, n.d.; Gomiero, 2016; IPBES, 2018; Nkonya et al., 2011; UNCCD, 2015; Young et al., 2015).

The vicious cycle of poverty can also be linked to the downward spiral of low productivity and land degradation. Poor land users often have little alternative but to extract what they can from the scarce resources available to them. Meanwhile, their lack of capital required to invest in land improvement leads to decreased land productivity which, in turn, leads to marginal lands and low yields, further manifested in their lack of financial means and poor health status. Man-made disasters such as wars and national emergencies can also contribute to land degradation by displacing its managers or overburdening an area due to mass human migration. Infrastructure development has been linked to increased production which, in many cases, has contributed to biodiversity loss and irreversibly affected the water cycle due to poor planning and poor infrastructure maintenance (FAO, n.d.; Gomiero, 2016; Nkonya et al., 2011; Steinfeld et al., 2006; UNCCD, 2015; Young et al., 2015).

## *Effects of Land Degradation*

Land degradation has many impacts on the environment, the economy, and society. In the literature related to land degradation, effects are usually categorised into on- and off-site effects.

### *On-Site Effects*

The impacts that directly affect farmers through soil degradation are described as on-site effects of land degradation. For example, loss of crop yield productivity due to erosion is an on-site effect of land degradation. By 2050 crop yields are projected to reduce by an average of 10% globally and up to 50% in certain regions. Water quality and storage reduction are also on-site effects of land degradation due to the nexus between water and land productivity. Socioeconomic on-site effects include the increase of production costs due to the requirement for additional inputs to counteract the adverse physical impacts of land degradation. Income losses due to erosion, soil fertility and nutrient loss, and reduced vegetation can further lead to productivity

losses if farmers are unable to afford to pay for inputs (feedstuff, fertilisers, water, energy etc.). Ecosystem service losses, such as reduced water storage and absorption capacity due to soil erosion, are another on-site effect. All in all, reduced land productivity leads to food insecurity (FAO n.d.; Gomiero, 2016; IPBES, 2018; Nachtergaele et al., 2012; Nkonya et al., 2011; Steinfeld et al., 2006; UNCCD, 2015; UNCCD, 2016; Young et al., 2015).

### *Off-Site Effects*

Off-site effects are externalities, meaning that the consequences are not reflected in market prices, because they do not occur on the degrading land itself and are therefore not considered in people's land use decisions. Examples of off-site effects include: water pollution due to fertiliser use; coral reef pollution due to eutrophication caused by nutrient runoff; food insecurity and poverty due to low productivity and increased production costs; the release of carbon dioxide into the atmosphere contributing to global warming due to the oxidisation of biomass carbon in the soil from soil erosion and biodiversity loss; health problems, such as allergies, respiratory illnesses and eye infections due to air pollution (dust) caused by wind erosion; reduced water storage capacity for irrigation, domestic water supply, industries and hydropower; downstream flooding due to the deposition of large amounts of eroded soil into lake and river systems; and decreased water quality due to increased concentrations of agrochemical, metals and salts (Doreau, Corson, & Wiedemann, 2012; FAO, n.d.; IPBES, 2018; Nkonya et al., 2011; Pimental, 2006; Steinfeld et al., 2006; UNCCD, 2016).

## *The Global Outlook*

Global awareness of natural resource degradation has accelerated because of climate change and rising food and energy prices. Moreover, attention to land degradation has increased significantly over the past three decades, largely due to the rise in the level of international cooperation and the acknowledgement that local changes in land resources have global impacts. Despite this interest, however, land degradation has not been comprehensively addressed at the global level or in developing countries. Although climate change has attracted considerable attention and investment, action to avoid or mitigate land degradation has been low. One main reason for this is policymakers' and decision makers' limited knowledge on the cost of global land

degradation and its underlying causes. As part of the effort to address this gap, this article attempts to draw attention to the livestock sector - the source of the most significant direct and indirect drivers of land degradation (Herrero & Thornton, 2013; Nkonya et al., 2011; Thornton, 2010).

## *The United Nations 2030 Agenda*

In September 2015, world leaders of 193 Member States unanimously adopted a collection of 17 global goals for sustainable development (the SDGs) at the United Nations Summit in New York. The global agenda is a universal and transformative plan of action that aims to eradicate poverty, protect the planet and ensure that all people enjoy peace and prosperity. Building on the principle of "leaving no one behind", the Agenda emphasises an integrated approach to the social, environmental and economic dimensions of sustainable development. The SDGs are a roadmap to restoring a balance between people and the environment. They address global challenges currently facing humanity, including land degradation, along with those related to poverty, hunger, inequality, prosperity, education, health, water scarcity, climate, and peace and justice (Biermann, Kanie, & Kim, 2017; UN, 2015, para. 1).

The major challenge in realising the 2030 Agenda lies in understanding and successfully managing the interlinkages between the various goals and targets. The SDGS are integrated and indivisible - what might be a comprehensive solution for meeting one global goal may involve confronting issues associated with another. The key to achieving the overarching goals lies in harnessing synergies and minimising potential trade-offs and conflicts among the SDGs and targets (Biermann et al., 2017; UN, 2015).

## *Sustainable Development Goal 15: Life on Land*

The case for combatting land degradation is set out under SDG 15 'Life on Land' because human life depends on healthy and productive land. Healthy and productive land is the indispensable foundation of ecosystem services that make up the Earth's life- support system. It is essential to carbon and nutrient sequestration, water

filtration, maintaining soil biodiversity, sustainable plant growth, providing habitat to billions of organisms, and the supply of most of the antibiotics used to fight diseases. Decreased land productivity, particularly in dryland areas, makes societies vulnerable to socioeconomic instability and has been a leading contributor to mass human migration and increased conflict. The core objective of SDG 15 is 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". Achieving the overarching Sustainable Development Goals of the United Nations' 2030 Agenda will depend upon how successful we are in delivering this goal (IPBES, 2018; Steinfeld et al., 2006; UN, 2015, para. 83; UNCCD, 2018).

### *Land and Drought*

Drought is a natural phenomenon; the impacts of which can be intensified by human activities that are not adapted to the local climate. Inappropriate land use and unsustainable land management practices can cause land degradation that can be further aggravated by drought. The UNCCD reasons that water scarcity and drought are the most far-reaching of natural catastrophes. This is, in short, due to the resultant economic and ecological impacts, including both short and long-term losses, together with the extensive and adverse cascading effects that follow. Sustainable solutions to mitigating the impacts of drought depend on healthy land. In order to achieve drought preparedness, the link between water conservation and land conditions must, therefore, be brought to the attention of all stakeholders – including both water users and water providers alike. Given that the restoration of land can increase crop yields and bring back fauna (through raising groundwater levels), large-scale implementation ought to be established as an urgent priority (UNCCD, 2017).

### *Land and Climate Change*

Climate change is expected to exacerbate the impact of many direct drivers of land degradation. This includes, among other things, the acceleration of soil erosion due to increased frequency, duration and severity of extreme weather events, the risk of naturally occurring wildfires, and the altered distribution of pests and diseases. The land use sector currently represents almost 25% of total global emissions.

Consequently, the mitigation potential of the land use sector can make a significant and immediate contribution to reducing the emissions gap. While the commitments in the intended nationally determined contributions (INDCs) are only expected to close the emissions gap by less than 30% of what is needed, according to the UNCCD, improved land use and management could close the remaining emissions gap by up to 25%.

Furthermore, since the world's soils store more carbon than that of the Earth's atmosphere and biomass combined, avoiding, reducing, and reversing land degradation is paramount for meeting the global Sustainable Development Goals and closing the emissions gap (FAO, 2015; Gerber et al., 2013; IPBES, 2018; IUCN, 2015; Nkonya et al., 2011; UNCCD, 2017).

The findings of the IPBES Report (2018) determined that the implementation of more sustainable land use and management, along with land rehabilitation and ecosystem restoration activities, are not only vital to protect life on Earth and ensure human well-being, but also constitute a cost-effective strategy that would see to rapid cutbacks in emissions.

### *Land and Human Security*

Land degradation is a complex socio-ecological problem that can destabilise the security and development of all countries. The impacts of land degradation on resource depletion, environmental degradation and climate change can, alone or in conjunction together with other elements, threaten livelihoods and socio-economic stability. Throughout history, countries have fought over natural resources such as land and water. Decreasing land productivity, among other factors, makes societies vulnerable to socioeconomic instability. According to the IPBES report, ecological stress and social conflict are strongly interconnected. Where local and national institutions lack the governance to resolve disputes, land degradation and resource scarcity can increase the likelihood of violent conflict. In dryland areas, years with exceptionally low precipitation have been associated with violent conflict increases of up to 45%. Furthermore, land degradation is a key aspect of forced migration. According to the IPBES report, by 2050, some 50-700 million people are likely to be displaced as a consequence of land degradation and climate change (Gomiero, 2016; Herrero & Thornton, 2013; IPBES, 2018; Thornton, 2010; UNCCD, 2017).

Poverty and land degradation are also interlinked and may exacerbate one another in a vicious cycle. Increases in the frequency, duration and severity of droughts, accelerates land degradation and desertification which, in turn, can lead to increased rates of poverty and food and water insecurity. At the same time, poverty often forces poor people to engage in unsustainable practices that have adverse effects on the environment as they seek basic provisions to support their livelihood and well-being. With 12 million hectares of arable land lost every year as a result of desertification and drought, land degradation's capacity to undermine land productivity and contribute to food insecurity is very much apparent (Herrero & Thornton, 2013; UNCCD; 2017).

Given the current trends of population growth and rising consumption, combatting land degradation is essential to future yield growth and keeping up with demand. Sustainable land management practices can assist populations adapt to climate change and build resilience to drought, thereby avoiding land degradation and desertification. As a result, the risk of forced migration and resource-related conflict is then minimised. The sustainable management of land is also essential to renewable energy, as its production depends heavily on healthy and functioning ecosystems (FAO, 2108).

## *The Importance of Achieving SDG 15.3: Land Degradation Neutrality*

Under sustainable development goal 15, target 15.3 sets out to "combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" by 2030 (UN, 2015, para. 83).

Land degradation is a cross-sectoral issue impacting everyone at the local, national and global levels. It is strongly related to sustainable development, climate change, biological diversity, water resources, energy sources, food security, and socio- economic factors. The importance of understanding the interactions between these issues and land degradation is essential to the successful implementation of the 2030 Agenda. Achieving land degradation-neutrality will deliver many co-benefits as it will simultaneously accelerate the delivery of many other sustainable

development goals and targets because of the particularly strong interlinkages across-the-board (Gomiero, 2016; Machingura & Lally, 2017; UN, 2015; UNCCD, 2017; UNCCD, 2018).

Combatting land degradation through sustainable land management and restoration of degraded land will protect biodiversity and ecosystem services, which in turn, will lead to an increase in food and water security, employment opportunities, energy provision, improved livelihoods and the subsequent delivery of many SDG targets. At the same it time will contribute to the avoidance of mass migration and resource conflict. In essence, achieving land degradation neutrality is a conduit to greater resilience and security for all (UN, 2015; UNCCD, 2017; UNCCD, 2018).

## *The Role of Livestock in Global Environmental Issues*

The livestock sector is one of the most significant contributors to the world's most pressing environmental problems. It is the world's largest anthropogenic user of land, and rapid expansion and unsustainable management of croplands and grazing lands is currently the most extensive global direct driver of land degradation. Globally, livestock production is also a primary source of water and air pollution and a leading causal factor in resource consumption and loss of biodiversity. Overall, livestock activities have a substantial impact on the earth's natural resources, at every level, from local to global (FAO, 2015; FAO & IWMI, 2017; IPBES, 2018; Steinfeld et al., 2006).

Combatting land degradation is an urgent priority to ensure human well-being and to protect the biodiversity and ecosystem services that are vital to all life on Earth. According to the FAO, to merely prevent the level of damage from increasing beyond its current level, the environmental impact per unit of livestock must be halved. To highlight the very substantial contribution of animal agriculture to climate change, air pollution, land, soil and water degradation, and the reduction of biodiversity, this section will review the various significant impacts of the world's livestock sector on the environment (FAO, 2015; Steinfeld et al., 2006).

### *Livestock's Role in Land Degradation*

The livestock sector is by far the single largest anthropogenic user of land. The total area occupied by grazing is equivalent to one-quarter of the Earth's ice-free land surface

and accounts for 70% of all agricultural land. In addition, approximately one-third of the crops produced globally are used to feed livestock, with feed-crops covering roughly 33% of total arable land. Against this background, animal agriculture has a considerable influence on land degradation mechanisms due to the role it plays in increasing pressure on land. Two areas pose the most pressing problems: the ongoing process of pasture degradation and the issue of pasture expansion into natural ecosystems (FAO, 2018; Gomiero, 2016; IPBES, 2018; Steinfeld et al., 2006).

*Pasture degradation* is generally related to an incongruence between livestock density and the capacity of the pasture to be grazed and trampled. Overgrazing, compaction and erosion from livestock activities are the main drivers of the land degradation, and account for roughly 20% of the world's pastures and rangelands - 70% of the rangelands are in dry areas. Agricultural land degradation in the drylands is of particular concern as livestock are often the only source of livelihood for the people living in these areas and mismanagement is common (IPBES, 2018; Steinfeld et al., 2006; Thornton, 2010).

To maintain preferable land conditions, pastures' land/livestock ratios need to be constantly regulated. However, largely due to population growth and the encroachment of arable farming on grazing lands, such adjustment is rarely practised. While intensified land-management systems have significantly improved crop and livestock yields in many areas of the world, high levels of land degradation can result when inappropriately managed. Furthermore, the separation of production from resources in landless industrial systems often leads to issues surrounding soil degradation and pollution. As a result, additional resources such as lime to neutralise acidity and water to flush out salinity, are often needed to restore the land - in addition to soil erosion and the loss of biodiversity due to habitat changes (Herrero et al., 2009; Steinfeld et al., 2006; Thornton, 2010; Young et al., 2015).

Agricultural land degradation is particularly unfavourable as it decreases productivity which then gives rise to *pasture expansion* including the conversion of forest land into pastures. Deforestation and the expansion of agricultural land into natural habitats are now widely occurring in some of the world's most species-rich ecosystems. Some estimates claim that cattle enterprises have been responsible for 65- 80% of the deforestation of the Amazon - with feedcrops, such as soybeans, accounting for a large part of the remainder. While crop and pasture expansion into natural ecosystems has contributed to livestock production growth, the destruction of

natural habitats has led to a substantial loss of biodiversity. Forest loss from both cattle and feedstock production amounts to roughly 2.4 billion tonnes of $CO_2$ emissions worldwide (Gomiero, 2016; Herrero et al., 2009; IPBES, 2018; Steinfeld et al., 2006; UNCCD, 2017; Weber & Hurst, 2011; Young et al., 2015).

Contamination in peri-urban environments driven by manure and wastewater management is another major mechanism of land degradation related to the livestock sector. The major effects of animal waste mismanagement on the environment include eutrophication of surface water, the leaching of nitrate and transfer of pathogens to groundwater, nutrient overloading and water pollution (Gomiero, 2016; Steinfeld et al., 2006; UNCCD, 2017; Young et al., 2015).

### *Livestock's Role in Climate Change and Air Pollution*

Climate change is one of the greatest challenges currently facing humanity and a growing threat to global security. The effects of climate change such as the melting of ice sheets, rising sea levels, increased surface temperatures, extreme weather conditions, ocean acidification, and the expansion of deserts are attributable to the ongoing emissions of greenhouse gases. The global livestock sector is a significant contributor to climate change, responsible for an estimated 7.1 gigatonnes of $CO_2$ equivalent per annum, which represents 14.5% of all anthropogenic greenhouse gas emissions and 75-80% of the agricultural sector's total emissions. The main types of greenhouse gases associated with livestock systems are carbon dioxide, methane, and nitrous oxide (FAO, 2013; FAO, 2018; Gerber et al., 2013; Steinfeld et al., 2006; UNCCD, 2016).

#### Carbon Dioxide ($CO_2$)

The livestock sector is accountable for nine percent of global anthropogenic carbon dioxide emissions, with the largest source of emissions coming from land-use changes. While deforestation for pasture and feed-crop expansion not only ceases carbon absorption but contributes to the increase of atmospheric $CO_2$ through the burning of wood or the rotting of dead trees, pasture and arable land degradation results in a net loss of soil organic matter, which in turn releases carbon dioxide into the atmosphere. $CO_2$ emissions from burning fossil fuels in the production of feed grains and oilseed crops (i.e. fertiliser production, drying, milling, machinery, and transport), along with

those derived from the processing and refrigerated transport of animal products, are also attributable to the livestock sector (FAO, 2015; FAO, 2018, Gerber et al., 2013; Steinfeld et al., 2006; UNCCD, 2017).

**Methane ($CH_4$)**

Given the significant amount of methane produced by ruminant animals as part of their normal digestive processes, livestock emerges as the primary source of global anthropogenic methane emissions. With the release of approximately 86 million tonnes of methane from enteric fermentation and a further 18 million tonnes from animal manure, the livestock sector accounts for 35 – 40% of total anthropogenic methane emissions. Methane's contribution to global warming is particularly problematic as it has a global warming potential (GWP) 23 times greater than that of carbon dioxide (FAO, 2018; IUCN, 2015; Steinfeld et al., 2006; UNCCD, 2017).

**Nitrous Oxide ($N_2O$)**

Livestock-related nitrous-oxide emissions, released largely from manure, contribute to about 65 percent of global anthropogenic emissions. With the potential to last up to 150 years in the atmosphere, and a GWP 296 times greater than that of $CO_2$, nitrous oxide is the most potent greenhouse gas associated with livestock activities. In addition to its contribution to global warming, $N_2O$ is the leading gas involved in ozone layer depletion. If unregulated, doubling the concentration of atmospheric nitrous oxide, as is projected by 2050, could see a 20% increase of UV radiation reaching the Earth (FAO, 2018; Steinfeld et al., 2006; UNCCD, 2017).

**Ammonia ($NH_3$)**

Although not considered a greenhouse gas, ammonia ($NH_3$) emissions from livestock waste are one of the largest sources of air pollutants, contributing significantly to acid rain and the eutrophication and acidification of ecosystems. It is estimated that livestock account for almost two-thirds of global anthropogenic emissions, equivalent to some 30 million tonnes of $NH_3$. Current trends anticipate the annual atmospheric emissions of air-polluting ammonia to rise to 116 million tonnes by 2050 almost exclusively as a result of food production and animal manure (FAO, 2018; IUCN, 2015; Steinfeld et al., 2006; UNCCD, 2017).

### *Livestock's Role in Water Depletion and Pollution*

Water scarcity is a global challenge that currently undermines the economic growth and physical well-being of billions of people, in both developed and developing countries on every continent. With 2 billion people already living in countries experiencing high water stress, if global water demand exceeds supply by 40% - as projected under current trends - almost half the world's population will live in water- stressed basins by 2030. The livestock sector is one of the largest users of freshwater resources, accounting for over 8% of human water use worldwide. Although issues of water quantity and water-use efficiency and allocation receive the most attention globally, water scarcity is also caused by the progressive degradation of water *quality* as it reduces the *quantity* of water that is safe to use (FAO & IWMI, 2017; FAO, 2018; Steinfeld et al., 2006; UNEP, 2016).

Land degradation within the sector through overgrazing, soil compaction, reduced infiltration, dried up floodplains, and deforestation, among other things, increases run-off and affects the natural replenishment of groundwater resources. Over-extraction and poor water management are the key drivers of lowered groundwater tables, damaged soils and decreased water quality worldwide. The most prominent demands for water-use in animal agriculture are for drinking and servicing, product processing, and feed production. The irrigation for feed-crop production is the primary cause of groundwater overexploitation, although hygiene and quality requirements are also highly water-intensive processes (Doreau et al., 2012; FAO & IWMI, 2017; Herrero et al., 2009; Steinfeld et al., 2006).

Animal agriculture is a major player in the worsening global water-crisis, particularly due to: water pollution from improper management of animal wastes; antibiotics, vaccines and growth hormones; chemicals from tanneries; fertilisers and pesticides from spraying feed-crops; and sediments from eroded pastures, among other things. Livestock's role in groundwater pollution causes eutrophication that affects aquatic ecosystems through its negative impacts on biodiversity and fisheries. While nutrient pollution due to animal waste and fertiliser runoff is a leading source of freshwater contamination, toxins such as chemicals and nutrients that are carried from farms by streams and rivers into the sea cause marine pollution and the degradation of coral reefs. Human health problems and rising antibiotic resistance are also among the

many other consequences that derive from such water pollution. Against this background, livestock is perhaps the most damaging sector to the Earth's diminishing water resources (Doreau et al., 2012; Herrero et al., 2009; Mekonnen & Hoekstra, 2012).

Livestock water productivity (livestock benefits/water input) varies for different animal products and production systems, depending on location, type of feed production, diet diversity, intensification and so forth. While significant variations do exist, regardless of what kind of production system is being used, rearing livestock and processing animal products demands copious amounts of water. The fact that water is generally a free or low-cost resource in most parts of the world, and that much of agricultural expansion is taking place in water-stressed regions, makes matters even worse. Managing the trade-offs in water-use to maintain food security, without further reducing water resources and harming ecosystems, is one of the biggest challenges facing sustainable animal agriculture (Doreau et al., 2012; Herrero et al., 2009; Mekonnen & Hoekstra, 2012).

### *Livestock's Impact on Biodiversity*

The world is facing a global biodiversity crisis, considered by many ecologists and experts to be without precedence since the end of the last ice age. The Earth is currently amid a mass species extinction – the sixth wave of extinctions in the past half-billion years. The rate of species loss is hundreds to thousands of times higher than the background rate. Habitat loss, which involves the destruction, degradation, or fragmentation of habitat to a point in which it becomes incapable of supporting its native species, is the single largest threat to biodiversity (Alkemade, Reid, Van Den Berg, De Leeuw, & Jeuken, 2013; IPBES, 2018).

The damaging effects of livestock on biodiversity and ecosystems services are well studied. Through its substantial role in greenhouse gas emissions, deforestation, over-withdrawal of water resources, eutrophication, overgrazing, and disease transmission, among other things, animal agriculture has modified ecosystems and directly affected biodiversity. Land degradation, primarily through land conversion and unsustainable land management practices, has reached critical levels in many parts of the world and substantially affected ecosystem functions – particularly those of forests, rangelands, and wetlands (Alkemade, et al., 2013; MEA, 2005; IPBES, 2018).

Land-use changes, which lead to processes such as land degradation and loss of

forests, coral reefs and other habitats, are the primary drivers of biodiversity degradation. Climate change, invasive alien species, overexploitation, and pollution, are also among the most important direct drivers of biodiversity and ecosystem services losses. Livestock's extensive contribution to all of these drivers, either directly or indirectly, makes it a key player in the current global biodiversity crisis (IPBES, 2018, Steinfeld et al., 2006).

## *Global Trends and the 'Livestock Revolution'*

Livestock production is socially, culturally, politically and economically very significant. Although only accounting for a global average of 40% of agricultural GDP, the livestock sector it is presently one of the fastest growing agricultural subsectors in developing countries, providing livelihood support, income and employment for over 1 billion of the world's poor (Herrero & Thornton, 2013; Steinfeld et al., 2006). Population growth, rising per capita incomes, high and rising consumption patterns, progressive urbanisation, and an increasingly globalised economy, are driving unprecedented growth in the global demand for animal products. The impact of these trends, dubbed the 'livestock revolution', are changing the face of livestock production and bringing about substantial structural transformations within the sector. Among the changes are increasing developments towards intensification and industrialisation are occurring, a geographical shift from rural to urban and peri-urban areas, and an exponentially growing species shift towards the production of monogastric varieties, i.e. pigs and poultry (FAO, 2018; Gomiero, 2016; IPBES, 2018; Nkonya et al., 2011., Steinfeld et al., 2006).

Increases in consumption bring about new economic opportunities which, in turn, lowers the consumer costs of land-based resources, leading to further increases in demand. New economic opportunities also lead to technological developments which increase production capacity. The extensive negative implications of these trends on the global environment are far-reaching and have cascading socio-economic effects.
Without adequate regulation, these elements could drive unsustainable levels of land degradation through agricultural expansion, natural resource extraction, and urbanisation (Gerber et al., 2013; Gomiero, 2016; Herrero & Thornton, 2013; IPBES, 2018).

## *Conclusion*

The United Nations' 2030 Agenda has brought about heightened global awareness to matters of drought and land degradation as the world's focus on addressing climate change takes centre stage. Despite the increased attention, action towards combatting land degradation and improving drought preparedness has, nevertheless, been inadequate. Previously, inaction was in part due to the limited availability of assessments regarding the off-site costs of land degradation. Recently, however, the launch of a comprehensive evidence-based report by IPBES on land degradation and restoration rectified this problem. Outlining both the on-site and off- site direct and indirect costs of land degradation and ecosystem services losses, the report's experts emphasise that the cost of inaction is much higher than the costs of action (IPBES, 2018; Nkonya et al., 2011; UN, 2015).

Sustainable management and the restoration of degraded land will deliver many co-benefits to the overarching goals of the SDG Agenda. Given the integrated and invisible nature of the sustainable development goals and targets, the key to realising the 2030 Agenda lies in harnessing synergies and minimising potential trade-offs. Combatting land degradation is essential to restoring a balance between humans and the environment as the Earth's life support system is supported by ecosystem services that depend upon healthy and productive land (IPBES, 2018; UNCCD, 2017).

While the global social, cultural, political and economic importance of livestock production is extremely significant, the impact the sector is having on the environment cannot be ignored. Livestock's contribution to land degradation, climate change, air pollution, water scarcity and pollution and the loss of biodiversity and ecosystem services is large-scale and intensifying. With population growth, urbanisation, rising per capita incomes and consumption patterns, and an increasingly globalised economy, unprecedented growth in the livestock sector is bringing about substantial structural changes to the sector that are changing the face of animal agriculture. Increasing developments towards intensification, large-scale agribusinesses and industrialisation, among other changes, are accelerating environmental degradation in many parts of the world (Steinfeld et al., 2006; Thornton, 2010; FAO, 2018).

Due to its linkages with food and water insecurity, mass migration, increased conflict, poverty, biodiversity loss, and climate change, land degradation is one of the

most severe socio-economic, environmental problems currently facing humanity. Fortunately, it is now established that combatting land degradation makes sound economic sense and requires urgent attention. Given that the livestock sector is a driving force behind the unprecedented rates of land degradation that continue to increase at an alarming pace, many solutions to the combatting the problem lie in how the sector is managed (Herrero et al., 2013; IPBES, 2018).

The global trade-offs that arise between livestock production, human well-being and environmental sustainability, require immediate and due consideration as the likely consequences of inaction could destabilise the security and development of all countries. Above all, land degradation must be urgently addressed with strong political will and government action. Achieving land degradation neutrality will provide a natural fix to various other pressing global challenges. The livestock sector must now become a major policy focus, not only for dealing with issues of land degradation but also for addressing matters of climate change, water scarcity and pollution, biodiversity loss and other environmental problems; its potential involvement in sustainable solutions to reducing and reversing environmental damage is paramount. Life on Earth depends on healthy and productive land; failure to address land degradation and the cascading effects of livestock production on the global environment will hinder progress towards achieving the goals for global sustainable development. As demonstrated in this study, the 2030 Agenda will stand or fall depending on how successfully the indivisible and integrated nature of SDGs are understood and how well the interlinkages are managed (FAO, 2018; Herrero, 2009; Steinfeld et al., 2006; UNCCD, 2018).

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