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THE IMPACTS OF PASTORAL NOMADISM, ON BIODIVERSITY AND CROP PRODUCTION ACROSS THE WORLD – A REVIEW

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Abstract

The contributory impacts of nomadic pastoralism on biodiversity and crop production worldwide today have been so significant and are calling for global attention. This study aims to evaluate the current and future impacts of pastoral nomadism on ecological resources and crop yields worldwide. This study is based on the general concept of ecological resilience and coping with stresses associated with pastoral nomadism practices, which are determined by the local technologies in a community. This involved the assessment of a total of one hundred and eight (108) peer-reviewed publications, both articles and books, that are related to the impacts of pastoral nomadism on ecosystem services and crop production in specific regions. The focus of our study was based on the general impacts of pastoral nomadism on global ecology, ecosystem distribution, and phrenological dynamics change; the ecological and crop yield resilience in the tropics and polar regions were also reviewed. This study found that there are variations in the magnitude and pattern of the impacts of pastoral nomadism on ecosystems and crop yields across the world. However, there are tendencies for continuous increases in the impacts of pastoral nomadism on biophysical components of the environment, particularly crop yields, in the future due to the observed patterns of uncertainties identified in the temperate and polar regions of the world. The study recommends promoting multidisciplinary approaches to the study that will guide the development of the appropriate adaptation and mitigation measures.

Keywords: crop yields, pastoral nomadism, ecosystem services, tropical ecology, temperate and polar regions, impacts

Introduction

The act of feeding cattle with vegetation and water, which involves moving herds of cattle and sheep from one land to another, has been a major concern to scientists for several decades (Nielsen et al., 2022). Both independent scholars and organized international organizations have focused attention on investigating the current and future environmental impacts of pastoral nomadism on the fate of ecosystem resources, particularly crop production (Uchendu, Ihedioha, & Arua, 2015). The Intergovernmental Panel on Climate Change (IPCC), which is the internationally accepted accord for the science of climate change, impacts, adaptation, and mitigations, has been monitoring the activities of pastoral nomadism on crop production for more than three decades. Evidence has shown that the causes and implications of pastoral nomadism are not limited only to the global arena because the cattle-cropland relationship is as old as man's existence on earth (Turner & Schlecht, 2019). Such a relationship has resulted in changes in the quality of soil and water over several decades. Although other factors have been attributed to the changing nature of land and water resources in the past, pastoral nomadism has significantly contributed to the decline in crop production over the last several years (McDowell & Wilcock, 2009).

In recent times, several regions around the world have been facing the negative impacts of pastoral nomadism as the pressure on land is increasing due to urbanization, rapid deforestation, and overpopulation (Wafula, Wasonga, Koech, & Kibet, 2022). This has not only led to infringement on the farmlands but also reduced crop yields. The impacts of pastoral nomadism on ecological resources have been examined in the fields of ecophysiology, phenology, phytogeography, modeling, paleoecology, and vegetation dynamics (Jamil, Zubair, & Endress, 2023). The majority of these studies have identified changes in land use, siltation of river bodies, drying of lakes, an increase in the concentration of carbon dioxide, and low crop yields as the main factors influencing ecological changes worldwide (Njagi et al., 2022). Previous studies have been able to establish intricate links between pastoral nomadism and climate change, in which the loss of crop productivity that accompany extreme climatic events is now considered not only a climate change phenomenon but also the result of pastoral nomadism (Tugjamba, Walkerden, & Miller, 2023b).

Interestingly, certain studies have shown that pastoral mobile herds help to enhance soil fertility under well-managed conditions (Alary, Aboul-Naga, Osman, Daoud, & Vayssières, 2021). For example, recent studies at the western desert edges of the Nile Delta showed that the addition of manure to the croplands may increase the fertility of the farmland. However, recent studies have attributed the increase in the population of soil microorganisms and pests on the farmlands to the effects of pastoral nomadism (Nord, Snapp, & Traore, 2022). The effects of pastoral nomadism were observed by some researchers who investigated the impacts and adaptation strategies of pastoral nomadism (Tugjamba, Walkerden, & Miller, 2023a). The result shows that with current trends on the impacts of pastoral nomadism on crop production across the world, by the year 2050, global biomass production would have declined by close to seventy-five percent (75%) (M. E. Uddin & E. Kebreab, 2020). This has confirmed that the major threats to crop production today are pastoral nomadism, whose impacts

cut across climatic systems including land, water, or ice ecosystems (Stavi et al., 2021). Pastoral nomadism is common, particularly in Sub-Saharan Africa, Central Asia, some parts of Northern Europe, Central South America, and Western North America, which account for approximately 25% of the earth's surface (Holechek, Cibils, Bengaly, & Kinyamario, 2016).

A substantial part of the Brazilian Amazon land has been introduced to pastoral nomadism, which has led to soil degradation, the destruction of fresh water and terrestrial ecosystems, and the reduction of croplands by the crop farmers (M. Uddin & E. Kebreab, 2020). Recent studies have shown that blue water in the Brazilian Amazon region has shrunk by about 90%, thereby making crop production extremely difficult for the region. Similar findings were also recorded in most parts of Africa, Asia, and European countries (Silva, Bressiani, Ebling, & Reichert, 2024). For example, recently, the loss of an entire palm plantation worth about 2.6 million has been reported in the south-eastern part of Nigeria (Ruml et al., 2022). The development has led to the IPCC's recent conclusion that pastoral nomadism has directly and indirectly impacted negatively on crop production in most parts of the world in recent times, and this has caused various degrees of damage to crops across geographical regions (Godde, Mason-D'Croz, Mayberry, Thornton, & Herrero, 2021). Although, depending on the latitude, the most apparent conclusion from the previous studies is that there are many uncertainties regarding the possible effects of pastoral nomadism on ecosystems and soils and their severe biophysical, economic, and sociocultural consequences (Gillin, 2021). These uncertainties may be attributed to associated human and climatic factors and a lack of uniformity in the construction of models, assumptions, and timeframes (Banda, Dzwauro, Singh, & Kanyerere, 2022).

The impacts of pastoral nomadism on both ecosystems and human socio-cultural activities may be worse in the near future. Scholars have generally agreed that there are biophysical, sociocultural, and economic impacts already caused by pastoral nomadism, such as on the ecosystem, biodiversity, and soil (Kerven, Robinson, & Behnke, 2021). Therefore, this exercise aims at reviewing the environmental impacts and adaptation strategies to cope with pastoral nomadism in ecological, socioeconomic, and cultural settings. This is based on the assumption that the ability to cope with the effects of pastoral nomadism in a given community is directly related to social, political, and environmental technologies being enjoyed in a community and the potential for social resilience in light of the ecological resilience concept. This review further examined the existing link between ecology, crop yields, and social resilience as dictated by the economic activities within the ecosystem of a region.

Methodology

A total of one hundred and eight (108) peer-reviewed studies on the general impacts of pastoral nomadism ecology, ecosystem distribution shifts and phenology change, and ecological and social resilience were reviewed across different ecosystems of the world. This involves the compilation of a global dataset of peer-reviewed publications on pastoral nomadism, human factors on the ecosystem in the last three decades, and the effects on crop yields. In this study, the Google engine was used to select the keywords, namely pastoral nomadism, crop yields, and impacts, which provided

acceptable multidisciplinary and integrated research publications on pastoral nomadism and linked content citation metrics from multiple sources and databases for easier access to publications within the same platform. This review was based on understanding how traditional approaches, which include direct observation and proxy measurements, and the latest technological approaches are used in the study of the impacts of pastoral nomadism on ecology and influence the detection of observed responses to pastoral nomadism. Thus, this study presents a methodical review of how pastoral nomadism has changed over the years and projects a long-term perspective of the impacts of these current changes on the ecosystem and crop yields on future impacts in many parts of the world. The meta-synthesis of this study includes an assessment of the effects of pastoral nomadism on the ecosystem in the last decades, the potential impacts of pastoral nomadism in the tropical ecology of Nigeria, the West African Sub-region, and the Polar Regions, and the general impacts of pastoral nomadism on ecological services and crop yields. The review is highly influenced by the cross-disciplinary background knowledge of the relationship between the atmosphere, land, and ocean in different regions of the world.

Nomadic Pastoralism on the Ecosystem in the Past

Nomadic pastoralism received global attention a few years ago because of its potential for ecosystem destruction and reduction of crop yields (M. E. Uddin & E. Kebreab, 2020). The existing studies have highlighted proof of the impacts of nomadic pastoralism on ecological resources using both methods. For example, indigenous knowledge was recently used in some African countries based on a well-established framework to manage rangeland (Manzano et al., 2021). The findings from the modeling approach have revealed that the impacts of pastoral nomadism include a rise in the concentration of atmospheric carbon dioxide and methane, which may have indirectly provoked extreme drought conditions in some parts of the world (Uddin & Kebreab, 2020). The impacts of pastoral nomadism include changes in land use and recently observed changes in the distribution of ecological species across the globe. However, pastoral nomadism alone does not account for these changes; climate change contributed to exacerbating the impacts of pastoral nomadism in the ecological context (Drees, Liehr, Batbuyan, Marg, & Mehring, 2022). For example, the dryness of Lake Chad in the northeastern part of Nigeria was not only caused by the impacts of pastoral nomadism but also due to the negative impacts of climate change (Okpara, Stringer, & Dougill, 2016).

Evidence has shown that the resiliencies of both the terrestrial and aquatic ecosystems may be overwhelmed in the near future (McLeod et al., 2019). This was partly attributed to the poor management of pastoral nomadism in many parts of the world and the attendant negative implications on ecological structures, particularly crop yields (Wulifan, Dordah, & Sumankuuro, 2022). The vegetative belts of the world, particularly forests, grassland, and aquatic ecosystems such as freshwater ecosystems, were important ecosystems for the sustenance of nomadic pastoralism in several parts of the world ("Overview: Pastoralism in the World," 2016). For example, the forest is one of the largest sources of carbon reserves that help mitigate the negative impacts of climate change, of which a larger proportion are found above the ground,

which exists as soil organic carbon (Berryman et al., 2020). Pastoral nomadism, which involves the degradation of vegetative resources, may contribute to the release of carbon dioxide and methane through the mineralization of the soil's organic carbon (Mgalula, Wasonga, Hülsebusch, Richter, & Hensel, 2021). This may lead to climate change, whereas the ecosystem may have contributed to the conservation of biological diversity, maintenance of the integrity of the aquatic ecosystem, sustenance of the productivity of land, and maintenance of crop yields (Sintayehu, 2018).

Unfortunately, the setting of fire on these important ecosystems by the herdsmen, probably for forage and fiber sources for cattle, has further exacerbated extreme events in recent times. This includes drought and flooding, as recently recorded in many parts of the world (Obaisi et al., 2020). These call for the urgent need for environmental conservation to increase the resilience of seedlings and saplings of crops to the global impacts of climate change. However, there were uncertainties in the resiliencies of forests to pastoral nomadism under the global warming condition. Furthermore, the exact risks associated with pastoral nomadism for crop yields require further scientific investigation (Malhi, Kaur, & Kaushik, 2021).

Potential Impacts of Pastoral Nomadism on Tropical Ecology

The ecological resilience to disturbances such as pastoral nomadism constitutes an issue of global concern, considering the global dimension of its impacts on all types of forest distribution across the world (Shekari, Ziaee, Faghihi, & Jomehpour, 2022). Despite the fact that tropical ecology provides one of the most impotent ecological services and other economic values, many scholars have identified pastoral nomadism as one of the most serious environmental problems globally (Djordjević-Milošević & Milovanović, 2019). However, recent studies have shown that pastoral nomadism has strongly influenced the degradation of important ecosystem resources in most regions of the world. Pastoral nomadism may have increased the bulk density of the soil, thereby exerting moisture stress on crop plants (Mousavi, Sarshad, & kKoupaei 2020). Other important implications include alteration in morphology, physiology, plant composition in the tropics. For example, the Amazon forest of Brazil has been highly vulnerable to the influence of pastoral nomadism due to the increased exposure of the area of the forest to the negative impacts of climate change (Fearnside, 2013). The same may be said of the Lake Chad region in the Sahel savannah belt of Nigeria. Several scholars have warned that if current trends of the impacts of pastoral nomadism are not mitigated, most ecosystems of the world are at risk of extreme climatic events that may negatively affect the ability of plants to adapt, thereby leading to biodiversity loss in the tropical region (Obianagwa, Okafor, Adaeze, Gift, & Chinedu, 2023). Scholars have suggested adequate long-term monitoring of vegetation resource responses to future disturbance by pastoral nomadism to assess the findings against real observation in the future. However, there is a need for studies that will integrate climatic parameters with adaptation measures in further studies to reduce uncertainties (McAllister, Gordon, Janssen, & Abel, 2006).

Potential Impacts of Pastoral Nomadism in Nigeria, the West Africa Sub region

As an illustration of tropical ecological studies, several studies have shown that Nigeria, the West African country, has had its own share of the negative impacts of pastoral nomadism on biodiversity and crop production (El Bilali, Dambo, Nanema, Bassolé, & Calabrese, 2022). In the past, studies have shown that this part of the world was characterized by the rich distribution of natural resources for economic productivity, which include tropical forests, water, large stores of carbon in the soil, and wildlife resources (Mayer et al., 2020). This makes the region an important ecological area in terms of the proportionately large distribution of soil flora and fauna. Unfortunately, over three decades of study of the region have shown a decreasing trend in biodiversity and crop production in the region (Chapman et al., 2022). While some scholars attributed the increasing trends of land degradation and lower crop production to climate change impacts, others opined that pastoral nomadism contributed most to the dwindling natural resources. However, several climate scientists agreed that the phenomenon was attributed to nomadic pastoralism, exacerbated by climate change (Kongnso, Buba, & Nfor, 2021). These have clearly shown that the impacts of pastoral nomadism are highly significant in their contribution to the large-scale destruction of biodiversity and crop production over the last three decades (Abbass et al., 2022). The impacts of nomadic pastoralism on vegetal resources include changes in carbon cycling and plant and animal habitats, an increase in temperature due to the destruction of biodiversity, an increase in moisture stress in plant communities, and changes in plant morphology, physiology, and growth (Godde et al., 2021). Studies have also shown that nomadic pastoralism has contributed to the increase in the frequency of new diseases for crops. Recent studies have shown that nomadic pastoralism may contribute to global warming and also worsen the impacts of climate change because of its direct connection to soil, hydrology, and the atmosphere through the biogeochemical cycle (Uddin & E. Kebreab, 2020). This was evidently shown through some studies, which show that some savannah regions of Nigeria are undergoing prolonged drought, partly due to climate change but exacerbated by nomadic pastoralism (Ayanlade & Ojebisi, 2020). The studies also identify changes in the sociocultural and economic environment of the communities, which include farmers' and herders's conflicts, increasing pressure on lands, loss of farmlands, and displacement of indigenous farmers' communities to internally displaced persons (IDP) camps, leading to a reduction in overall crop production and rising costs of crops because of demand, which overshoots supply of crop production in the West Africa sub-region (George & Adelaja, 2021).

Existing studies have shown that governments have been responsive to the sociocultural problems of nomadic pastoralism in the past. This includes the provision of grazing routes for the herdsmen, which cut across the length and breadth of the Nigerian landmass (Ladan, 2018). Some scholars believe that such intervention efforts by the government holistically addressed the socioeconomic way of life of the pastoralists, whose activities are better described as cultural. However, recent scientific studies of nomadic pastoralism have shown that government regulation has failed woefully to address the impacts of nomadic pastoralism on communities and their economic livelihoods (Wulifan et al., 2022). For example, recent studies have

shown that nomadic pastoralism has been characterized by the grazing of crops in the farmlands in several parts of the country, leading to significant economic loss. Recently, some 2.6 million worth of plantation farms were completely destroyed by the herdsmen in some parts of Enugu State, Nigeria, among several other examples. Because of the failure of the grazing routes, successive governments have also recommended the establishment of a Ruga settlement for the herdsmen (Ladan, 2018). Cattle ranching received popularity among some elites in the country, who also began the private establishment of the sedentary system of cattle rearing. However, several scholars have rejected this system of grazing animals because of its failure to acknowledge the nomadic nature of herdsmen, particularly the bush Fulani herdsmen (Ducrotoy et al., 2018). The apparent conclusion from the above measures is that there is a need for the government to devise a more sustainable measure that will holistically address the peculiarities of both farmers and nomadic pastoralists (Krätli & Köhler-Rollefson, 2021). Adequate consultation with all the stakeholders, such as elders among the Fulani communities, the farmer's community, and the community's association, is recommendable for the sustainable utilization of forage resources. Roughly between 18% and 23% of the global land area is covered by Veld grassland, for which about 360 million cattle depend (Ukah et al., 2023). The African continent has the largest component of the veldt ecosystem; however, the veldt ecosystem is under increased pressure from the landscape as a result of pastoral nomadism. Overgrazing of the veldt has led to a sharp decline in forage resources over the past decades (Basupi, Quinn, & Dougill, 2017).

Potential Impacts of Pastoral Nomadism on Ecological Components in the Temperate and Polar Regions

Studies have shown that pastoral nomadism practice is not common in this part of the world, which implies that there is no known direct link between pastoral nomadism and its impacts in the region (Singh, Bhatnagar, Lecomte, Fox, & Yoccoz, 2013). However, most of the literature cited identified many of the impacts attributed to pastoral nomadism, which include global warming due to the average increase in temperature of the ice lands, thawing of permafrost, and mineralization of the soil organic carbon into carbon dioxide and methane. The studies further observed a shift in the distribution of vegetation along the thawed region (Ladan, 2018). This study suggests that climate change impacts may contribute to sea level rise in the future. However, there are uncertainties in the projection of relationships between pastoral nomadism, extreme events in this region, and crop production (Chakraborty, Kambekar, & Arnab, 2021). Despite the fact that little is known about the direct impacts of pastoral nomadism in this part of the world, there are still fears in some quarters about the growing consequences of modifications to the global water cycle and habitat changes in this part of the world (Singh et al., 2013). Most scholars observed that the changes in the habitat of seals, penguins, caribou, walruses, and polar bears from the sea and ocean into the terrestrial habitat may not only pose a danger to humans but also to biodiversity by degrading the terrestrial vegetation of the area in the nearest future (Meltotte, 2013). This position was further strengthened by the IPCC's latest projection of the vulnerability of the temperate and polar regions to the

increasing threats of terrestrial species in the communities, which points to the fact that climate change impacts may also lead to another dimension of the impact of nomadic pastoralism in the near future in the polar regions (Pörtner et al., 2022). The impacts of pastoral nomadism on Steppe ecosystems have been recently reviewed because of the long history of pastoral activities in Mongolia, coupled with the continuous rate of climate change, globalization, and urbanization that have characterized the region (Dorjburegdavaa, Hauck, Dulamsuren, & Tsogtbaatar, 2013). Several scholars from various disciplines have concluded that there is a need to foster further research using multidisciplinary approaches to addressing the impacts of pastoral nomadism in the Steppe ecosystem (Drees et al., 2022).

Impacts of Pastoral Nomadism on Ecological Services and Crop Yields

Studies have shown that the impacts of pastoral nomadism have not only affected ecological services but have also negatively affected crop yields in most parts of the world. For example, Mousavi et al. (2020) recently examined the negative impacts of pastoral nomadism on soil and water and found that the range land has been negatively affected by pastoral nomadism. Pastoral nomadism has exposed the vegetal environment to various hazards, which include the multiplication of insect pests and diseases that attack crops and flowers. Evidence has revealed that there is a direct relationship between deforestation and pests and diseases of crops, whereas vegetal habitat is a rich source of micronutrients for plant intake (Uchendu et al., 2015). This suggests that a multidisciplinary approach is required to understand these important links in future research. Fortunately, there are currently an increasing number of climate scientists and agro-climatological researchers that input climatic elements into pastoral nomadism variables to understand these relationships in more detail (Tofu, Fana, Dilbato, Dirbaba, & Tesso, 2023). The recent projection shows that there is a likelihood for a worsening scenario of global food insecurity in the future. This is based on public health and climate change projections of future threats of extreme events and their impacts on social infrastructure and crop yields in major parts of the world (Mirzabaev et al., 2023).

Conclusion

This review found that there are variations in the magnitude and pattern of the impacts of pastoral nomadism on ecosystems and crop yields across the world. The major finding from tropical ecology is that scientists ought to agree on the standard techniques of collection of historical nomadic pastoralist data, owing to their intrinsic connections with climatic data. This will help to reduce the inconsistencies that characterize responses from different regions of the world. However, the principal results obtained from the temperate and polar regions have further shown that even though pastoral nomadism practices were not common in this region of the world, the region was not excluded from the adverse effects of pastoral nomadism being felt in the tropical ecosystems (Blench, 2001). Further studies confirmed that the impacts being experienced in the region were attributed to climate change, whose albedo effects amplified to all other parts of the world, from which the significant influence of disturbances such as pastoral nomadism is apparent. Because of the variation in the

pattern of responses both from the tropical ecosystems and the temperate ecosystem regions, there is a need to intensify studies to investigate the uncertainties in the study of the impacts of nomadic pastoralism in future studies (Taye, Simula, Tsering, Maru, & Shariff, 2023). Our main finding shows that, because of the complex nature of the variables required for this type of study, there is a need to evolve a multidisciplinary approach in further studies. This may probably need to involve numerical modelers, agroclimatologists, paleoclimatologists, and oceanographers, among others (Burroughs, 2001).

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