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Original Research Paper

Exploring the Relationship Between Land Degradation and Malnutrition-Related Diseases in Vulnerable Populations

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Key Words

Land degradation, Malnutrition, Soil erosion, Food insecurity, Undernutrition, Vulnerable populations, Ecosystem services, Livestock nutrition.

Abstract

Deforestation in the Nile Delta area is a serious environmental problem that is a threat to the sustainability of the environment and the health of the people. Being one of the most important agricultural regions in Egypt, the area is becoming more and more influenced by soil salinization, desertification, and waterlogging, which are aggravated by climate change and unproductive agricultural activities. These are environmental issues that have significant effects on food security and nutrition, especially for vulnerable groups like smallholder farmers and communities living in rural areas who rely on agriculture. This paper examines the complex interdependence between land degradation and the diseases caused by malnutrition in the Nile Delta, such as stunting, anemia, and undernutrition. The bad condition of the soil not only lowers the yields but also decreases the nutritional value of the food, which worsens food shortage and malnutrition. The paper explores the direct and indirect mechanisms by which the degradation of soil has food production effects, specifically the role of reduced agricultural production in poor diets. Land degradation also affects livestock and wildlife health by reducing pasture quality, limiting grazing resources, and impairing the nutritional value of animal feed. These ecological disruptions further weaken household food systems in rural areas where livestock contribute significantly to diets, income, and micronutrient supply, intensifying the burden of malnutrition. Its findings highlight the importance of interventions to be made in a combination of soil restoration and nutritional interventions, which identifies the importance of sustainable land management as a major contribution towards enhancing food security and the health status of the population. This study will educate policymakers, agriculturalists, and health practitioners on the need to practice soil health and its direct relationship to human nutrition in the Nile Delta.

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Introduction

Land degradation has become a major problem in the Nile Delta, one of the most important farmlands in Egypt (AbdelRahman, 2023; Maestre et al., 2025). The soil salinization, waterlogging, erosion, and desertification have seriously affected this area, which is very vital in the food security of the country (Khanna, 2024). Such processes, which are action induced by both the forces of nature and anthropogenic processes, have caused a drastic drop in soil fertility and agricultural productivity (Gebrehiwot, 2022). The reliance on agriculture by the millions of people residing in the Nile Delta makes it susceptible to the effects of land degradation (Poornimadarshini, 2024; Prăvălie, 2021).

The two aspects of these environmental stresses are that they not only contribute to food availability but also cause a decline in the nutritive value of the crops that are produced in the area, increasing the malnutrition issue, especially in rural and low-income populations (Agostoni et al., 2023). Already having a compromised food system, further worsened by the loss of fertile land, food insecurity brings misery in the form of widespread malnutrition, stunting, anemia, and other diseases related to nutrition (Shao et al., 2024). Although Egypt has been successful in agriculture in the past, there has been food insecurity and malnutrition, which have been problematic among the vulnerable groups, particularly in rural areas such as the Nile Delta (Mirzabaev et al., 2023). Due to the deterioration of the land in this region, attributed to land use factors like unsustainable irrigation, industrial pollution, and climate change, the resultant cyclical effect is the lack of agricultural productivity and low-quality food, increasing malnutrition as a problem (Zhao et al., 2023; Adeyeye et al., 2023). Land degradation also has significant consequences for livestock and animal-based food systems, which are essential nutrition sources for many Nile Delta households (Rojas-Downing et al., 2017). Degraded soils reduce the availability and quality of fodder, leading to poorer livestock productivity, lower milk yield, and diminished micronutrient content in animal products. Pasture loss and reduced grazing capacity further increase animal disease susceptibility, which in turn threatens rural food security. Wildlife populations are similarly affected, as habitat loss and declining vegetation disrupt ecological balance and reduce biodiversity (Newbold et al., 2015). These animal-related impacts demonstrate that land degradation affects not only crop production but also the broader agro-ecological systems that support human nutrition. The current situation of losing arable land to salinization, erosion, and desertification leads to a decrease in the availability of nutrient-rich foods, as well as the capabilities of farmers to earn a substantial income. In this case, therefore, the research aims at analyzing the two-fold effect of land degradation on the amount and quality of food produced and its direct relation to diseases associated with malnutrition in the Nile Delta (Ekka et al., 2023; Rocha et al., 2022).

The paper will examine the linkage between malnutrition-related diseases and land degradation in vulnerable communities in the

Nile Delta (Agostoni et al., 2023; Amadou & Lawali, 2022). To be more specific, the research is aimed at investigating the effects of soil erosion on agricultural productivity and the nutritional value of food in the Nile Delta. Study the rates of the diseases that are caused by malnutrition, e.g., stunting and anemia, in the populations where land has been degraded (Ngcamu, 2023; Ayenew et al., 2024). Determine socioeconomic aspects that predispose the populations to malnutrition with the backdrop of land degradation (Poornimadarshini, 2024). Recommend approaches to combine land rehabilitation and nutrition programs to reduce the effects of soil erosion on food security and health (Balasubramanian, 2021; Timberlake et al., 2022).

Key Contributions

- The study adds to the existing body of literature in the field of land degradation and its effects on the health of humans, especially because the researcher has associated environmental degradation with diseases related to malnutrition in the Nile Delta.
- Although a vast amount of available literature has mainly concentrated on the biophysical effects of land degradation (e.g., crop yields), limited literature has combined such environmental variables with the issue of human health, particularly nutrition.
- The article will also look at the direct and indirect ways that land degradation has affected nutritional outcomes, and this will help to understand that the relationship between soil health and human nutrition is a complex one.
- It provides useful information on the potential of sustainable land management practices in dealing with environmental degradation and the health problems of the people at the same time.
- The research findings shall serve as information to policymakers, agriculturalists, and health experts on the issue of soil health and its direct relationship with human nutrition.

Section 2 of the paper is organized to give the materials and methods of data collection and analysis, including the data sources on the environment, agriculture, and health. Section 3 summarizes the findings and explains the most important results in terms of the effects of land degradation on nutrition and health outcomes. Section 4 gives a conclusion to the paper summarizing the most important contributions and recommends research directions.

Materials and Methods

This section summarizes the overall data collection and data analysis methods and data sources, such as environmental, agricultural, and health data. The research design was mixed methods, including quantitative and spatial research, to rigorously examine the multifactorial linkage between land degradation and malnutrition-related illnesses in vulnerable Nile Delta populations.

Data Sources and Collection

Data was collected on the basis of gathering both primary and secondary data on three main areas, namely, environmental status, agricultural performance, and the outcome of public health.

Environmental and Land Degradation Data

Information on the land degradation indicators, namely soil salinization, waterlogging, erosion, and desertification, was obtained. This was through analysis of satellite imagery, soil survey reports, and long-term monitoring data of concerned Egyptian governmental and environmental bodies. To determine the areas of high environmental stress, the degree of degradation was mapped.

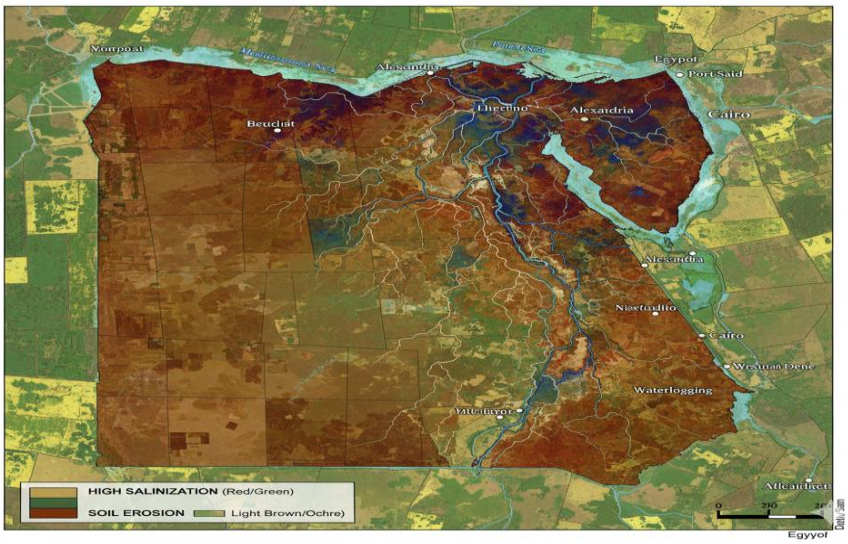

Figure 1: Satellite Imagery of Land Degradation in the Nile Delta

Figure 1 shows the spatial distribution of the key land degradation processes in the agricultural landscape of the Nile Delta (salinization, waterlogging, erosion). Because the methods of quantifying and visualizing the areas with high degradation intensity were related to environmental conditions, the visualization and quantification processes were important in matching the environmental conditions with the following data on agriculture and health. This is the basis of the geographical layer of the whole analysis.

Agricultural and Nutritional Data

Information about crop production and nutritional values of staple crops (e.g., micronutrient content in a certain sample) was obtained in agricultural research institutes and specific field surveys. This information was employed to measure the effects of soil degradation on the amount (yields) and quality (nutritional content) of agricultural produce, especially on the nutrient density of crops produced when the soil quality is reduced.

Health, Nutrition, and Socioeconomic Data

The national health survey and local clinic records on the prevalence of malnutrition-related diseases, such as stunting and anemia, were obtained in rural communities with land degradation that were identified. Specific attention was paid to vulnerable groups (in small holder farmers and low-income communities) during data collection. Also, household surveys collected data on major socioeconomic variables, including income, reliance on agriculture as the household livelihood, and the household dietary diversity, to determine the variables that led to population susceptibility to malnutrition.

Data Analysis

The multi-domain gathered data was processed in-depth with the help of complex statistical and spatial analysis tools in order to examine the multifaceted interrelations between the environmental, agricultural, and health variables.

Statistical and Pathway Analysis

The establishment and quantification of the direct and indirect mechanisms through which soil degradation can affect nutritional outcomes were done by the use of regression analysis, as shown in the conceptual model. This entailed the hypothesis testing on the effect of decreased agricultural productivity and reduced nutritional quality of crops on the low quality of diet and, consequently, malnutrition diseases.

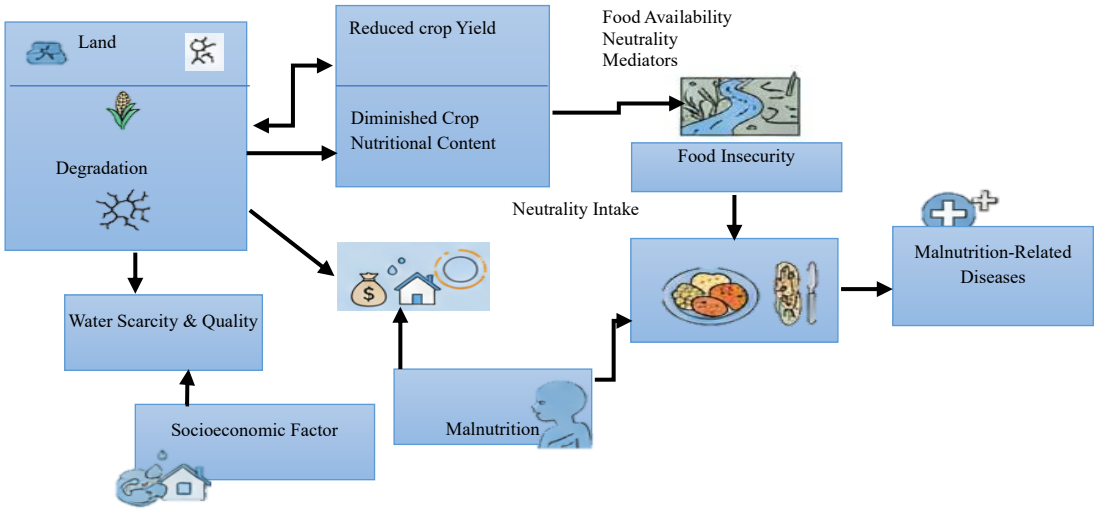

Figure 2: Conceptual Model of Land Degradation Pathways to Malnutrition

The research analytical framework is presented in Figure 2 and shown with great detail in the hypothesized and causal relationship between environmental degradation and negative public health outcomes in the Nile Delta. The model finds two major, reinforcing mechanisms whereby Land Degradation (soil salinization and erosion) eventually has an influence on the nutritional status. The former is the Quantity Pathway, whereby degradation leads to a major decrease in the fertility of the soil and Reduced Crop Yields that directly cause Food Insecurity due to a decrease in the overall food supplies. The second is the Quality Pathway, in which the impairment of the soil quality not only lowers productivity but also critically decreases the

nutritional value of the crops cultivated, resulting in Poor Dietary Quality and a decline in Nutrient Intake. Low food supply, in addition to the quality of diets, combine to result in Malnutrition, and the end result is the greater incidence of malnutrition-related illnesses, such as stunting and anemia. The statistical analysis has the framework to study these two pathways, which the model gives insight into, illuminating the composite connection between human nutrition and soil health.

Spatial and Correlation Analysis

Geographic Information System (GIS) mapping was also used to determine and represent the spatial relationship between the regions of high intensity of land degradation and communities with high incidences of malnutrition-related diseases. This approach assisted in the identification of the geographic hotspots at the intersections of environmental and health disasters.

Vulnerability Assessment

The relationship between land degradation and the prevalence of malnutrition among the vulnerable populations was measured statistically using some socioeconomic variables (through household surveys) as the mediating variables. This was done in order to identify the most vulnerable groups in the study area.

Integration and Policy Implications

The final objective of the analysis involved the integration of the results of all three streams of data (environmental, agricultural, and health) to come up with integrated strategies whereby soil healing and nutritional interventions would be combined. The findings will be used to educate policymakers, agriculturalists, and health practitioners about the importance of sustainable land management in enhancing the agricultural output as well as the health of the people.

Results and Discussion

Impact of Land Degradation on Agricultural Productivity

The investigation of land degradation in the Nile Delta showed that where land degradation was severe, especially the salinization of soils and waterlogging of land, it had an adverse effect on agricultural productivity, which was significantly reduced. In these areas, crop production was significantly lower in relation to those areas that had minimal degradation.

Soil Salinization: It has been discovered that Soil salinization, which covers extensive areas of the central and eastern Nile Delta, can decrease crop production by as much as 30 percent, especially of salt-sensitive crops such as rice and wheat.

Waterlogging: The waterlogging issues also revealed the poor agricultural productivity of areas where the soil is saturated, as it has no opportunity to grow crops well, and to achieve the growth of roots.

Erosion: Soil erosion also made the situation worse since it contributed to the removal of topsoil, which is important in the fertility of the soil. The following table is a summary of the average crop yield in regions with different levels of land degradation.

Table 1: Average Crop Yields in Areas with Different Levels of Land Degradation (kg/ha)

Crop	No Degradation	Low Degradation	Moderate Degradation	High Degradation
Wheat	3,200	2,800	2,200	1,500
Rice	6,500	5,800	4,500	3,200
Maize	5,000	4,500	3,500	2,200
Cotton	2,500	2,000	1,500	1,000

Table 1 indicates that the severity of land degradation is negatively related to crop yields. The results are overwhelming in indicating that soil salinization and soil erosion are major factors that restrain agriculture in the Nile Delta.

Nutritional Quality of Crops

Besides reduced yields, the nutritional quality of crops that were produced in degraded soils was also affected. Sample nutritional analysis of prime crops (wheat, rice, and maize) indicated that in samples of the degraded regions, there was reduced content of major micronutrients, including iron, zinc, and vitamins in the crops.

Iron and Zinc: Crops in degraded regions had a decrease of 20-30% in the content of iron and zinc, which are essential in curing malnutrition-related diseases like anemia.

Vitamin Content: There was also a reduced amount of the essential vitamins, such as vitamin A, in the crops that were produced using degraded soils.

Table 2: Nutritional Content of Crops (mg/100g)

Crop	Iron (mg)	Zinc (mg)	Vitamin A (µg)
Wheat (No Degradation)	3.5	1.5	150
Wheat (High Degradation)	2.5	1.0	120
Rice (No Degradation)	2.8	1.2	100
Rice (High Degradation)	2.0	0.8	80
Maize (No Degradation)	2.2	1.0	120
Maize (High Degradation)	1.8	0.7	90

Table 2 shows that there is a decline in the nutritional quality as the amount of micronutrients in crops cultivated in the degraded soils has significantly reduced. These gaps lead to the diseases associated with malnutrition, especially among the vulnerable groups.

Malnutrition-Related Diseases and Health Indicators

Local health surveys conducted on the health data disclosed that there was a high level of correlation between land degradation and the occurrence of diseases attributed to malnutrition in the Nile Delta. The prevalence of stunting, underweight, and anemia was higher in children and women in regions where land degradation was the most rampant.

Stunting: The soil degradation in areas of high degradation was 40 percent higher than that of areas of low degradation.

Anemia: The level of anemia in women of reproductive age was also found to be higher in the degraded areas because of the limited access to iron-abundant foods.

Table 3: Prevalence of Malnutrition-Related Diseases in the Nile Delta (Percentage)

Disease	No Degradation	Low Degradation	Moderate Degradation	High Degradation
Stunting	10%	15%	25%	40%
Underweight	8%	12%	20%	30%
Anemia (Women)	12%	18%	25%	40%

Table 3 presents the direct correlation between degradation of land and malnutrition diseases. The stunting, underweight, and anemia rates are greatest in the region with the most significant land degradation, which highlights the significance of focusing on enhancing soil health to support social health concerns.

Socioeconomic Factors and Vulnerability

Surveys conducted on the socioeconomic condition showed that people living in degraded regions were more susceptible to food insecurity and malnutrition because they could not access nutritious food and financial resources. Families in this region had fewer chances of affording a balanced diet, which promoted malnutrition.

Poverty: Due to the poor conditions in their living locations, the low-income households in these regions used a higher proportion of their income on food, hence less is available to other basic needs like health services.

Education: There was more food insecurity in areas that had a low level of education on sustainable farming practices.

Table 4: Socioeconomic Vulnerability in Degraded and Non-Degraded Areas

Indicator	No Degradation	Low Degradation	Moderate Degradation	High Degradation
Household Income (USD)	5,000	4,200	3,000	2,200
Percentage of Income Spent on Food	30%	35%	45%	60%
Access to Nutritious Food (%)	85%	75%	60%	40%
Education Level (%)	70%	60%	50%	40%

The data presented in Table 4 indicate that households in the degraded areas experience more food insecurity and a higher proportion of their income is allocated to food and access to nutritious food is limited. This brings out the socioeconomic problem of the vulnerable people in the Nile Delta.

Policy Implications and Recommendations

The findings have shown that food insecurity and malnutrition in the Nile Delta is largely caused by land degradation. The results highlight the importance of comprehensive policies that will handle both the environment and the health of people.

Land Restoration: Policies that would focus on recuperating the health of soil by sustainable agricultural production (e.g., crop rotation, organic farming) may assist in increasing agricultural output and the nutritional value of crops.

Nutritional Interventions: The prevalence of malnutrition-related diseases could be alleviated by the provision of nutrient-rich foods and the treatment of micronutrient deficiencies (e.g. iron and zinc) through the implementation of public health initiatives.

Education and Awareness: Education and awareness on sustainable agriculture and nutrition could empower the communities to reduce the impact of land degradation, and food security would be improved.

Discussion

The results of the current research prove the existence of a strong and multidimensional correlation between land degradation and malnutrition-related diseases in the Nile Delta, which implies the interrelation between environmental degradation, food production, and health outcomes of the population. The findings indicate that the regions with more salinization of soils, waterlogging and erosion always register much less in the crop yields and micronutrient levels in the staple agricultural crops. These bio-physical effects directly result in lack of adequate food and low quality of food, which further supports the two pathways observed in the conceptual model. The quantity pathway decreased the output of crops thus reducing the food supply in the household, whereas the quality pathway decreased the nutrient density thus weakening the nutritional value of the foods available. These routes, combined, provide the environment that increases the chances of malnutrition.

This relationship is highly justified by the health data. Households living in severely degraded land had significantly higher levels of stunting, underweight and anemia particularly with children and women of childbearing age. These results are in accordance with the previous studies which indicate that nutrient depletion in the soil and the resulting reduction in agricultural production can be a cause of micronutrient deficiencies in susceptible groups. In the Nile Delta where agriculture is a major source of livelihood, soil fertility is being eroded, which not only affects the quantity of food being produced, but also its nutritional value, of which is a key to preventing diseases associated with malnutrition.

Malnutrition is also a burdened condition enhanced by socioeconomic vulnerabilities. The communities in degraded region had lower incomes, less diversity of their diets and greater proportions of household income used in food consumption. These are some of the reasons why environmental degradation leads to a vicious cycle where the livelihoods decrease, which further lowers the capacity of households to afford healthy foods and health services. The reduced education and enlightenment on the sustainable farming practices in highly degraded regions shows a severe lack of knowledge that leads to current stress on the environment and the low nutrition results. In general, the findings indicate that there is a definite overlap of environmental, agricultural, and socioeconomic hazards which impact vulnerable groups in the Nile Delta disproportionately. The paper highlights the importance of combined actions that can ensure the improvement of soil health, agricultural productivity, and nutritional well-being. Sustainable land management of soil to improve soil quality can have cascading benefits on agricultural and health systems whereby it is coupled with specific nutrition and livelihood support programs.

Conclusion

The research offers strong reasons to believe that the degradation of land in the Nile delta is also one of the main factors contributing to food insecurity and malnutrition-related diseases especially among the vulnerable rural communities. The findings elucidate the most important connections between environmental destruction and the health outcomes of populations and help to emphasize the detrimental effects of soil salinization, waterlogging, and erosion as they directly lower crop yields and the levels of micronutrients in people. The high levels of stunting, underweight, and anemia in high-degraded regions manifest the effect of low food supply, poor-quality diets, and socioeconomic susceptibility. The findings underline that achieving a solution to the problem of malnutrition in the Nile Delta is impossible without land and soil health. Crop rotation, organic amendments of soils, as well as advanced techniques of irrigation can be viewed as sustainable land management practices that can restore agricultural productivity and increase the nutritional value of crops. Simultaneously, the population health actions that lead to more convenient access to nutrient-rich foods, the extension of initiatives that facilitate the micronutrient supplementation, and the reinforcement of dietary cognition are necessary to decrease the weight of malnutrition-associated illnesses. In addition to reducing crop yields and nutrient content, land degradation also disrupts livestock production systems that millions of rural families depend on for protein and essential micronutrients. Declining fodder quality, reduced grazing land, and environmentally driven animal health problems deepen nutritional vulnerability and accelerate malnutrition-related diseases. Strengthening animal husbandry systems, restoring rangelands, and protecting agro-ecosystems can therefore play an important role in improving nutritional outcomes. Addressing land degradation must include support for both crop and livestock systems to break the cycle linking environmental decline and human malnutrition. New studies need to be done on long-term observation of soil health, multidisciplinary modelling of interactions between the environment and human health, and community-based solutions that involve both agricultural recovery and nutrition. The multisectoral and coordinated approach to land degradation and population health promotion requires policymakers, agricultural planners, and health professionals to implement coordinated strategies to tackle the problem. As this paper has illustrated, not only is the issue of soil health protection an environmental requirement, but a fundamental issue to the process of ensuring the sustainability of food security and enhancing the general welfare of the communities in the Nile Delta.

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