

**Review Article**

# Effect of Mono Cropping on Soil Health and Fertility Management for Sustainable Agriculture Practices: A Review

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**Abstract:** Mono cropping is a common practice in agriculture, and usually causes serious economic losses due to soil degeneration, decreased crop yield and quality, and increased disease incidence, and pest occurrence. It mainly due to changes in soil microbial communities, nutrient availability, and allelopathy effect. Recently, progressive studies have illustrated the mechanisms of mono cropping obstacles, and valid strategies to overcome them. Crop rotation and inter-cropping, choosing resistant cultivars, and biological management are only a few strategies for overcoming the drawbacks of mono cropping. Crop rotation is the most established and traditional agronomic technique for maintaining water and nutrient balance; avoiding disease; insect, pest, and weed control; and boosting crop production. Intercropping has been proven to increase yield and plant development, and it can help with serious issues, including small crop production, buildup of pests and diseases, soil deterioration, and environmental contamination. Numerous investigations have demonstrated that the major Benefits of intercropping include the reduction of pests and diseases, the improvement of the efficiency of soil resource use, and the improvement of soil nutrient absorption. Overall, a multi-pronged approach that incorporates soil amendments, crop rotation, and intercropping, along with a deeper understanding of plant-microbe relations and stress responses, may help us to overcome the obstacles associated with mono cropping. Therefore, Crop rotation, intercropping, and soil amendments to maintain soil fertility and promote healthy plant growth, so that they can develop sustainable cropping practices to minimize these effects. By improving soil health, farmers can maintain high crop yields and ensure the viable crop production.

**Keywords:** Crop Rotation, Intercropping, Mono Cropping, Soil Fertility

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## 1. Introduction

Mono cropping is the practice of growing the same crop on the same plot of land, year after year. This practice depletes the soil of nutrients (making the soil less productive over time), reduces organic matter in soil, cause significant erosion and finally decline in crop productivity. Mono-cropping system is varied from place to place due to a large share of farmers in cropping system is resource poor, with limited access to off-farm income, and has been pushed into maize mono-cropping in an effort to meet household's staple food consumption requirements [28]. Farmers, however, may also be pulled in mono cropping by the presence of public demand

for maize and tef, as in the case of marketing boards and food reserves in Ethiopia, Zambia or Malawi, as well as input subsidy programmers that support input access for maize [23].

Mono cropping decline in yield production due to nutrient depletion of the soil as a result of continuous absorption of similar nutrients from the same soil root zones by the same crop that is not supported with fertilizer application or soil organic matter management [25]. Monoculture and intensive cultivation of crops can significantly decrease the nutrient level of the soil and its total fertility for particular crop under cultivation; which, finally leading to a decrease in yield of the crops. A study made on maize crop in the Oxysols of Brazil indicated that the yield of maize crop declined considerable when it was mono-cropped on the same field for 60 years [25].

Other impact of mono cropping on the environment are severe when pesticides and fertilizers make their way into ground water or become airborne, creating pollution, damages the soil ecology (including depletion or reduction in diversity of soil nutrients). Organic Farming, the Alternative Approach Monoculture problems can be avoided altogether if organic farming methods are employed. When diverse plant species are planted, crops are better able to withstand attacks from both insects and pests, thus eliminating the need for pesticides. Organic farmers focus on developing healthy, rich soil that provides all the nutrients that plants need to thrive and produce an abundant harvest. The more ecosystem conserved with an decreased dependency on pesticides and artificial fertilizers.

In Ethiopian highlands where about 90% of the arable land is situated, people cultivate their lands with similar types of crops without application of fertilizers until recently [14]. According to Bojo and Cassells [2] reported that continentally soil nutrient depletion arising from continuous cropping together with removal of crop residues, low external inputs and absence of adequate soil nutrient saving and recycling technologies results to land degradation. The aggregated national scale nutrient imbalances due to continuous cropping were 41kg ha<sup>-1</sup>year<sup>-1</sup> for N, 6kg for P and 26kg for K [24]. It has long been known that SOM and other soil properties decline rapidly following tropical forest clearance, burning and subsequent cultivation [18].

In the some research it was found that the nitrogen removed from the soil by crops is 44kg ha<sup>-1</sup> and the nitrogen applied to the field is 35kg ha<sup>-1</sup> in the locality [17]. According to Mulugeta [17] reported that the Highlands of Ethiopia in the Munessa-shashement forest, which is located in the eastern escarpment of the central Ethiopia Rift Vally indicates that, there is soil nutrient depletion as a result of land use change from a forest state to subsequent cultivation of the land, where the depletion was plotted again chronosequence of farm field converted from a tropical Agromontane forest. At the first phase of the land use change that is up to 26 years there was no decline of the organic carbon as well as nitrogen and different cation, however with long period of field cultivation there happened a decline in the organic carbon, nitrogen, available phosphorous, exchangeable potassium, calcium, magnesium [17].

The concentrated presence of a single cultivar, genetically adapted with a single resistance strategy, presents a situation in which an entire crop can be wiped out very quickly by a single opportunistic species. Therefore, depletion of nutrient or land degradation by continuous cropping can now be understood when organic management and application of nutrients is lower.

#### Objective

To review effect of Mono-cropping on Soil health and Fertility Management for Sustainable Agriculture Practices.

## 2. Literature Review

### 2.1. Effect of Mono-Cropping

Continuously growing the same crop in the same field leads to a low diversity of functional soil microbial community,

accumulation of some host-specific soil-borne pathogens, and an imbalance of soil nutrient contents [1, 18]. Effect of Monoculture Farming Planting the same crop in the same place each year zaps nutrients from the earth and leaves soil weak and unable to support healthy plant growth. Because soil structure and quality is so poor, farmers are forced to use chemical fertilizers to encourage plant growth and fruit production [21]. These fertilizers, in turn, disrupt the natural makeup of the soil and contribute further to nutrient depletion. Mono cropping also creates the spread of pests and diseases, which must be treated with yet more chemicals. Soil scientists have also discovered that mono cropping alters the microbial landscape of soil, decreasing beneficial microbes and causing poor plant growth over time. However, monoculture agriculture has significant negative impacts, impacts that must be alleviated if the ecological systems of the earth are not to be irreversibly damaged.

#### 2.1.1. Decreases Biodiversity

When other plants and animals are removed, and narrow down biodiversity, it need to artificially substitute for functions and services biodiversity ecosystems would perform naturally. It is because almost entirely remove biological controls of the system by removing also beneficial insects and plants that would act as a defense against pests and diseases. Due to the loss of this natural resistance, farmers must closely monitor and frequently apply synthetically-created substances to their monocultures. Hence, increased input of fertilizers, pesticides, antibiotics, hormones, water and myriad of other 'growth enhancers' to monocultures. According to a study of the German Nature and Biodiversity Union from 2017, 15 percent of the total bird population has disappeared from rural areas in just 12 years. This includes lovely birds like sparrows, finches and skylarks. Insects are doing even worse. Insect populations have declined by 76 percent over the past 27 years. Both problems are connected to each other, because many birds eat insects, and to intensive agriculture with the overuse of insecticides and destruction of natural environments that provide shelter and food variety for birds and insects. Dröschmeister and Sukopp [8] reported that strong changes in trend direction (a switch from overall decline to overall increase) were only observed for omnivorous birds.

#### 2.1.2. More Synthetic Material Use

Having eliminated the natural checks and balances that a diverse ecosystem provides, monoculture production has to find ways to replicate some of them in order to protect the crop (and the profits from it). This inevitably means the use of large quantities of synthetic herbicides, insecticides, bactericides and fertilizers. In attempting to prevent damage to crops by weeds, insects and bacteria; and to provide sufficient nutrients in the soil for the plants to grow, farmers use synthetic chemicals. Not only do these chemicals leave traces on plants that are intended for human consumption and so can enter the food chain, they are also routinely over-used so that a large proportion of the synthetic material remains in the soil, even after the crop has been harvested. Because of its inorganic nature, this material is not processed into organic matter by

microorganisms. Rather it leaches through the soil, eventually polluting groundwater supplies, having the knock-on effect of altering ecosystems that may be at great distance from the original location where the chemicals were used. For instance, inorganic fertilizer runoff has contributed greatly to algal blooms in oceans and lakes, the growth of which starves water bodies and the organisms that live in them, of oxygen. Longer the same monoculture grows on the same land, more fertilizers are needed because soils get more tired and damaged. According to Food and Agriculture Organization (FAO) reported that the global demand and usage of fertilizers has increased from roughly 162 million tons to 200 million tons in the last decade [9, 10].

### **2.1.3. Creates Pesticide Resistance**

When crops are infested by pests, farmers apply pesticides to kill these unwanted organisms. But some pests always manage to survive. It is those survivors who slowly develop resistance to applied pesticides and then pass it on their progeny. New generations of pests are born with the pesticide resistance and are ready to face new challenges of further improving their survival techniques and smartly evolving according to our land management decisions. This leads to more and more pests surviving every new pesticide application. Farmer's reaction in most cases is to increase the frequency and amount of the pesticide application on the field. According to the International Survey of Herbicide Resistant Weeds, 256 species of weeds have been reported to have developed resistance to 167 different herbicide solutions (weedsscience.org). Based on the farmers' observation, this weed has already developed resistance to 13 different herbicides by now [13].

### **2.1.4. Soil Degradation**

Besides the negative impact the overuse of chemical fertilizers has on the soil, monocultures are detrimental to soil health in other ways. Ground cover crops are eliminated, meaning there is no natural protection for the soil from erosion by wind and rain. No plants provide leaf litter mulch to replenish the topsoil, which would be eroded anyway. All of this combines to continually degrade the soil, often meaning that it becomes useable for agriculture. In some countries this means that forests are then cleared to provide new agricultural land, starting the damaging cycle all over again. According to the United Nation's backed study from 2017, one third of the planet's soils are degraded due to inconsiderate methods used in the modern agriculture and unfortunately, monocultures top the list of causes to be blamed for the global destruction of soils [26].

### **2.1.5. Pollutes the Environment and Contributes to Climate Change**

Increased runoff from monocultures is the main cause of excessive algal blooms in water bodies that pollute drinking water supplies, kill sensitive aquatic species and in the worst-case results in the creation of zones with such a low oxygen content (hypoxic) in water that animals cannot survive in this habitat. Water pollution linked to intensive

monoculture farming is well known, but did you know that it is also responsible for air pollution and increased greenhouse gas emissions. In the air ammonia combines with other pollutants, like nitrogen oxides and sulfates coming from other industries, like transport or energy production, and together they form dangerous particulate matter that easily enters lungs and bloodstream. According to the Intergovernmental Panel on Climate Change [12] agriculture is the largest emitter of greenhouse gases other than carbon dioxide. Big part of these emissions comes from large cattle farms and processes connected with altered nitrogen cycle in soils, which is affected by the overuse of nitrogen rich fertilizers in modern agriculture.

## **2.2. Soil Health**

Soil health and soil quality can be used interchangeably. The capacity of a soil to function, within land use and ecosystem boundaries, to sustain biological productivity, maintain environmental quality, and promote plant, animal, and human health [7]. Fertile soil provides essential nutrients to plants. Important physical characteristics of soil-like structures and aggregation allow water and air to infiltrate, roots to explore, and biota to thrive. Diverse and active biological communities help soil resist physical degradation and cycle nutrients at rates to meet plant needs. A study [7] of soil health describes soils that are not only fertile but also possess adequate physical and biological properties to sustain productivity, maintain environmental quality and promote plant and animal health. Soil health management program is to balance nutrient inputs and outputs and ensure a good balance of nutrients for the crop. This balance requires a complex mix of soil management activities including proper tillage, irrigation, crop residue management, weed management, and crop rotation planning. Neglecting any of these components can compromise soil health and quality, affect crop performance, and create potential pollution problems due to erosion, nutrient runoff or leaching.

## **2.3. Soil Fertility Management**

Soil fertility management can also affect the susceptibility of crops to pests and diseases. For example, the relationship between mineral-nutrient content of crops and pest susceptibility is well documented [3]. Phelan *et al.* [20] demonstrated for the first time that soil organic matter management history was related to the susceptibility of crops to the above ground pest *Ostrinia nubilalis* (European corn borer). Growing a range of crops with different physiological attributes, sowing and harvest dates offers opportunities for cultivation and mechanical weed controlling operations to be undertaken at different times helping to prevent particular species from becoming a problem [15]. The proportion of ley within the rotation has also been shown to affect weed populations and the weed seed bank with weed problems declining as proportion of ley increases [5]. Roots of some plants exude chemicals that deter potential competitors from growing in their vicinity through inhibition of

germination and/or growth and the effects can continue after the incorporation of the inhibitive plant. This effect, known as allelopathy, is exhibited by both crop plants such as rye, vetch and triticale and weed species. Although there may potentially be negative effects of allelopathy on crop production, e.g. when there is inhibition of the germination of crop seedlings, there is a need to understand allelopathy effects in more detail as they can potentially be manipulated to advantage in organic systems [19].

The sustainable farming practices described above, including crop rotations, soil amending and fertilizing, tillage, and irrigation techniques, should be used in concert to improve and maintain the quality and health of agricultural soils. Soil quality in turn affects crop performance (yield) and the resistance and resilience of crop plants to pests and pathogens. Successful management of soil fertility must meet the objectives of increasing production, being economically profitable and protecting the environment to enable the sustainable development of agriculture. The rational input of chemical fertilizer and manure must be emphasized for high yield. The management of soil fertility requires the rational application of fertilizer. This depends on the type of soil and the pattern of nutrient cycling in a particular agro ecosystem.

### **2.3.1. Use of Organic Inputs**

Organic inputs used in soil fertility management commonly consist of livestock manures (farmyard manure), crop residues, woodland litter, household organic refuse, composted plant materials (compost), and any plant biomass harvested from within or outside the farm environment for purposes of improving soil productivity. In urban and peri-urban areas, organic inputs can also be made up of industrial organic waste and sewage sludge. Organic resources have multiple functions in soil, ranging from their influence on nutrient availability to modification of the soil environment in which plants grow. Organic inputs derived from plant remains provide most of the essential nutrient elements, but usually insufficient quantities. Because of their richness in carbon, organic resources provide an energy source for soil microorganisms which drive the various soil biological processes that enhance nutrient transformation and other quality parameters of soil. As these organic materials undergo the process of decomposition (or breakdown) in soil, they contribute to the formation of soil organic matter (SOM), which is generally considered to be the backbone of soil fertility. Most of the lasting impacts of organic inputs on soils are related to the functions of SOM. During decomposition, the organic materials interact with soil minerals forming complex substances that influence nutrient availability (e.g. binding of otherwise toxic chemical substances such as aluminium or leading to better release of phosphorus bound to soil mineral surfaces).

### **2.3.2. Organics as Sources of Nutrients**

The role of organic materials as nutrient sources is underpinned by the biological processes of decomposition, which involve the biochemical breakdown of dead organic tissue into its inorganic constituent forms, primarily through the action of microorganisms. The process by which essential

nutrient elements in unavailable organic forms are converted into their inorganic forms that are available for use by growing plants is known as mineralization. It is during decomposition of organic materials in soils that SOM is formed and nutrients are released. SOM can therefore be said to be made up of organic materials of diverse origin that are at various stages of decomposition through the action of soil microorganisms. Soil microorganisms also grow, multiply and die during the process of decomposition and, in turn, contribute to the dynamic changes in SOM formation and mineralization (nutrient release). The amounts of SOM formed as well as quantities of nutrients released depend on the amount and frequency of organic inputs applied to the soil. Under undisturbed natural vegetation such as permanent forests or grasslands, there is usually an equilibrium between the organic materials added to the soil in the form of plant litter and the SOM status because nutrients are tightly recycled and not removed in crop products.

When the soil is used to cultivate crops, however, the rate of SOM formation and nutrient release is less than the demand for nutrients by crops, particularly when farmers aim for commercial yields. Extra effort is therefore required to add more organic materials to the soil, necessitating the use of mineral fertilizer to increase the amount of organic resources available for use in crop production. Soil organic matter is a significant source of nitrogen (N), phosphorus (P) and sulfur (S) in crop production. Soil microorganisms (microbes) consume carbon (C) as an energy source and N for synthesis of protein and population growth. The ratio of these two chemical elements in a given organic material, termed the C:N ratio, therefore determines the rate of mineralization. As a general rule, organic inputs with a N content of >2.5% or a C:N ratio 16 immobilize (literally lock up) nutrients for prolonged periods. This effectively means that when an organic material with a very wide C:N ratio like straw is added to the soil it will immobilize N for a long time because soil microbes out-compete growing plants and lock up the scarce N from the decomposing organic input and the soil into their own tissue production.

### **2.4. Enhancing Sustainable Agriculture**

Monoculture or rice–wheat and rice–rice systems has resulted in various disadvantages, for example, degradation of natural resources, build up of diseases and pests, and decline in factor of productivity [22]. The most productive zones of India endangered the on sustainability production [22]. Crop-animal systems in Asian agriculture display a wide diversity in cropping patterns, livestock species and use of the resource base. There is evidence of positive and economic benefits from crop–animal interactions that promote sustainable agriculture and environmental protection.

Under the stress of intensive agriculture, environmental degradation has been reported in many economically developed countries from excessive use of high energy inputs such as fertilizers and pesticides. Use and recycling of locally available inputs and integrating them with the minimum needed quantities of external inputs would enhance the

sustainability of the farming process. Use of locally available inputs besides being environmentally friendly can keep production costs within the affordable reach of the peasant farmers. Indigenous technological knowledge has a substantial stake in this process. IFS are useful owing to increased diversification, intensification, improved natural resource efficiency, and increased productivity, as well as increased sustainability [16, 6, 4].

### 3. Summary and Conclusions

Mono cropping has lead to soil erosion, poor soil fertility and finally decline in crop productivity. It leave the same nutrients from the earth and leaves soil weak and unable to support healthy plant growth. This may farmers are forced to use chemical fertilizers to encourage plant growth and fruit production. These fertilizers, in turn, disrupt the natural makeup of the soil and contribute further to nutrient depletion. Mono crops also provide a friendly home for pests that happen to like that crop, since it shows up reliably, every spring. Organic Farming, the Alternative Approach Monoculture problems can be avoided altogether if organic farming methods are employed. Maintaining soil health is the central tenet of organic farming, but it never met a farmer, organic or conventional, who wasn't concerned about it. Crop rotation, even if it's just the two crops, is one way farmers of commodity crops are balancing the need to keep their farms healthy with the need to grow the plants they can sell. No-till systems, which help prevent soil erosion and nutrient runoff, are on the rise, and about a quarter of corn acres, and almost half of soy acres, are farmed that way. There is evidence of positive and economic benefits from crop-animal interactions that promote sustainable agriculture and environmental protection. Under the stress of intensive agriculture, environmental degradation has been reported in many economically developed countries from excessive use of high energy inputs such as fertilizers and pesticides. Use and recycling of locally available inputs and integrating them with the minimum needed quantities of external inputs would enhance the sustainability of the farming process. Use of locally available inputs besides being environmentally friendly can keep production costs within the affordable reach of the peasant farmers. Indigenous technological knowledge has a substantial stake in this process.

### Conflicts of Interest

The authors declare no conflicts of interest.

### References

- [1] Bai, T., Xu, S., Rupp, F., Fan, H., Yin, K., Guo, Z., Zhang, L., Yang, B., Huang, Y., Li, Y. and Li, X., 2019. Temporal variations of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 population in a heavily infected banana field in Southwest China. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science*, 69(7), pp. 641-648.
- [2] Bojo, J. and Cassells, D., 1995. Land degradation and rehabilitation in Ethiopia. *A Reassessment. // World Bank. Washington DC.*
- [3] Dale, P. F. and McLaughlin, J. D., 1988. Land information management: an introduction with special reference to cadastral problems in Third World countries.
- [4] Dalsgaard, J. P. T. and Prein, M., 1999. Integrated smallholder agriculture-aquaculture in Asia: optimizing trophic flows. *Nutrient Disequilibria in Agro ecosystems: Concepts and Case Studies. CAB International, Wallingford*, pp. 141-155.
- [5] Davies, S. W., Turmaine, M., Cozens, B. A., DiFiglia, M., Sharp, A. H., Ross, C. A., Scherzinger, E., Wanker, E. E., Mangiarini, L. and Bates, G. P., 1997. Formation of neuronal intranuclear inclusions underlies the neurological dysfunction in mice transgenic for the HD mutation. *Cell*, 90(3), pp. 537-548.
- [6] Devendra, C. and Thomas, D., 2002. Smallholder farming systems in Asia. *Agricultural systems*, 71(1-2), pp. 17-25.
- [7] Doran, J. W. and Parkin, T. B., 1994. Defining and assessing soil quality. *Defining soil quality for a sustainable environment*, (defining soil qua), pp. 1-21.
- [8] Dröschmeister, R. A. I. N. E. R. and Sukopp, U. L. R. I. C. H., 2009. Indicators and conservation policy: the German Sustainability Indicator for Species Diversity as an example. *Avocetta*, 33(2), pp. 149-156.
- [9] Food and Agriculture Organization of the United Nations (FAO), 2008. An international technical workshop Investing in sustainable crop 602 intensification The case for improving soil health. Integrated Crop Management 603 (Vol. 6). Rome: FAO.
- [10] Food and Agriculture Organization of the United Nations (FAO), 2018. Food outlook. Available at <http://www.fao.org/worldfoodsituation/en/> (verified 1 December 2019).
- [11] German environmental organization Nature And Biodiversity Conservation Union (NABU), 2017. PLOS ONE | <https://doi.org/10.1371/journal.pone.0185809> October 18, 2017.
- [12] Geneva, S., 2013. Intergovernmental Panel on Climate Change, 2014. *Working Group I Contribution to the IPCC Fifth Assessment Report. Climate Change*, 8.
- [13] Heap, I., 2019. The international survey of herbicide resistant weeds. Weed Science. org. Accessed: March, 27, p. 2019.
- [14] Hurni, H., 1988. Degradation and conservation of the resources in the Ethiopian highlands. *Mountain research and development*, pp. 123-130.
- [15] Liebman, M. and Davis, A. S., 2000. Integration of soil, crop and weed management in low-external-input farming systems. *WEED RESEARCH-OXFORD-*, 40(1), pp. 27-48.
- [16] Lightfoot, C. and Noble, R., 1993. *A participatory experiment in sustainable agriculture.*
- [17] Mulugeta, L., 2004. Effects of land use changes on soil quality and native flora degradation and restoration in the highlands of Ethiopia: Implication for sustainable land management. *Uppsala, Sweden: Swedish University of Agricultural Science.*

- [18] Nye, P. H. and Greenland, D. J., 1960. The soil under shifting cultivation Technical Communication no. 51. *Commonwealth Agricultural Bureaux, Harpenden, Royaume-Uni*.
- [19] Olofsdotter, M., Navarez, D., Rebulanan, M. and Streibig, J. C., 1999. Weed-suppressing rice cultivars--does allelopathy play a role?. *Weed research*, 39(6), pp. 441-454.
- [20] Phelan, K. M., Black and Decker Inc, 1995. *Hand-held vacuum cleaner*. U. S. Patent Application 29/009, 939.
- [21] Ryszkowski, L., Szajdak, L. and Karg, J., 1998. Effects of continuous cropping of rye on soil biota and biochemistry. *Critical reviews in plant sciences*, 17(2), pp. 225-244.
- [22] Singh, M. P., 2015, June. Norms as a basis for governing sociotechnical systems. In *Twenty-Fourth International Joint Conference on Artificial Intelligence*.
- [23] Sitko, K., Rusinowski, S., Kalaji, H. M., Szopiński, M. and Małkowski, E., 2017. Photosynthetic efficiency as bioindicator of environmental pressure in *A. halleri*. *Plant physiology*, 175(1), pp. 290-302.
- [24] Stoorvogel, J. J. and Smaling, E. M. A., 1990. *Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000. Vol. 1: Main report* (No. 28). SC-DLO.
- [25] Thornton, T., 1997. Attitudes towards the relevance of biological, behavioural and social sciences in nursing education. *Journal of Advanced Nursing*, 26(1), pp. 180-186.
- [26] United Nations General Assembly, 2017. "Report of the Special Reporter on the Right to Food." Human Rights Council, 34th Session. January 24, 1–24. <https://documents-dds-ny.un.org/doc/UNDOC/GEN/G17/017/85/PDF/G1701785.pdf?OpenElement>.
- [27] Wang, F., Chen, S., Wang, Y., Zhang, Y., Hu, C. and Liu, B., 2018. Long-term nitrogen fertilization elevates the activity and abundance of nitrifying and denitrifying microbial communities in an upland soil: implications for nitrogen loss from intensive agricultural systems. *Frontiers in microbiology*, 9, p. 2424.
- [28] Nielson, H. H., 2009. The role of cassava in smallholder maize marketing in Zambia and Mozambique. Michigan State University.