Review of Maize Value Chain Resilience and Sustainability in Ethiopia

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Abstract
Maize is Ethiopia's most important cereal crop both in terms of level of production and area coverage. This review was conducted with the main objective of identify the key negative environmental impacts and externalities of the maize value chain, identify climate change risks in maize value and identify the best practices to overcome these impacts and externalities to make maize value chain resilient and sustainable in Ethiopia. Review of empirical documents indicated that emission of emission of green house gases, soil infertility and nutrient shortages, land clearing and degradation and subsequent loss of wildlife habitat and biodiversity, soil erosion and nutrient shortages were the major negative impacts and externalities of pre-production, production and post-production phase activities of maize value chain in Ethiopia. In addition to this, review of the impact of climate variability in maize value chain indicated that loss of yield, diseases and pest infestation, drought and rainfall shortage were the major climate change risk in maize value chain in Ethiopia. The review of identification of best practices for sustainability and resilience of maize value chain in Ethiopia has indicated that sustainable intensification of agriculture; off-farm diversification and commercialization, on-farm diversification and climate smart agriculture were the best options. Therefore, policies and programs which promote sustainable production and marketing for resilience of maize value chain to climate variability should be formulated.
Keywords*:* Climate Smart Agriculture, Maize Value Chain, Resilience and Sustainability

1. INTRODUCTION

1.1. Background and Rationale

Ethiopia is one of the largest maize producing countries in Africa (FAO, 2013). Maize is Ethiopia's most important cereal crop both in terms of level of production and area coverage. About 9 million farmers, i.e., 70% of the total farmers produced about 6 million tons of maize over two million hectares of land. The farmers grow maize mostly for subsistence, with 75 % of all maize produced is consumed by the farming households (CSA, 2012). Maize is the cheapest source of calorie, providing 16.7 % of per capita calorie intake nationally (Rashid et al., 2010). Maize is thus an important crop for overall food security. Despite, the fluctuations in the percentage changes over the years, maize productivity has revealed a steady growth trend. The productivity of maize in the early 1990s was 1.5 t/ha while in late 2000s, it has grown to 2.2 t/ha, and in 2012, it reached 2.9 tons/ha (CSA 2011, 2012). Moreover, maize plays a central role in Ethiopia's food security and continues to be a significant contributor to the economic and social development of the country (IFPRI, 2010). However, despite all the efforts and progress made so far in development and dissemination of maize technologies for different agro-ecologies, the biotic and abiotic constraints remain the major limiting factors for increasing maize productivity and production compared to the potential (Mosisa, et.al, 2012).

Although Ethiopia has a relatively low per capita footprint, the ecological footprint of the country has increased as a result of population growth and increased consumption. This means that the country's average per capita footprint is rapidly approaching the available bio-capacity within its borders. The challenge is to find sustainable ways to feed a growing population, causing an ever-increasing demand for food, where adequately but sustainably feeding a growing population is extremely pressing. The country is constantly challenged by chronic food deficits, an undernourished population, extreme poverty rates, extremely low crop yields and poor soil quality (UNDP, 2017).

Households are also directly reliant on rain-fed agriculture, as their primary source of income. At the same time, various activities operated in different stages of maize value chain in Ethiopia cause negative environmental impacts and externalities. They bring harm to ecosystems, by causing biodiversity loss, greenhouse gas (GHG) emissions, soil degradation, depletion of water resources, and so on. Moreover, climate change and climate variability will further exacerbate the risks faced by this particular enterprise: it will lead to higher temperatures or extreme weather events such as droughts, affecting the entire value chain system. Moreover, environmental sustainability is under considered in many agricultural value chains like maize. As result of all these practices, environmental sustainability and resilience of the value chain is jeopardize and also the value system makes itself vulnerable to climate variability. Carrying out a careful review on identification of the negative environmental impacts and externalities and the climate change risks in maize value chain is quite important for further development plan and policy initiatives aiming at ensuring sustainability and resilience of the value chain. Moreover, the results obtained from this review also helps further research geared on sustainability dimension of maize value chain and also informs development alliances to design projects which enhance resilience of maize production system. Therefore, this review was done with the main objective of identify the key negative environmental impacts and externalities of the maize value chain, identify climate change risks in maize value and identify the best practices to overcome these impacts and externalities to make maize value chain resilient and sustainable in Ethiopia.

2. Definitions and Concepts of Sustainable Value Chain

Recently, the thinking in terms of a 'Sustainable Food Value Chain' (SFVC) is gaining popularity. SFVC is defined as "the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources. Unlike traditional understanding of the commodity chain or the supply chain, the sustainable food value chain concept emphasizes that value added and sustainability is explicit, multidimensional performance measures, assessed at the aggregated level. The sustainability of the value chain plays out simultaneously along the economic, social and environmental dimensions (FAO, 2014). For this particular commodity, the review will look at three key stages of the maize value chain: the pre-production, production, and post-production stages, thereby taking into account the full range of stakeholders involved in reducing negative impacts and externalities, including civil society organizations (NGOs, farmers' organizations), farmers, citizens, agri-business, and government entities.

2.1. Key Stages of the Maize Value Chain

Gomez et al. (2011) made a useful distinction of three stages of the value chain, thereby discussing the key types of environmental impacts and externalities, resulting from different agricultural practices, at each of these respective stages of the food value chain. Pre-production phase including site and field selection, land clearing, soil tilling, and other land preparation for planting; Production phase including natural and synthetic input for crop production (nutrients, water, agro-chemicals) and the consequences of nutrient and water management and pest control strategies and post-production phase including crop residues and other waste disposal, and pollution attributable to crop transport, processing and storage. At each of these stages, a wide range of negative impacts and externalities is generated which further jeopardize environmental balance and food production process.

2.2. Socio-Economic Importance of Maize in Ethiopia

Agriculture continues to be the dominant sector in Ethiopia's economy, with cereals playing a central role. Grain production and marketing are particularly important: studies show that cereals account for 65 percent of the agricultural value added (Gray, 2008), equivalent to about 30 percent of the national GDP (IFPRI, 2008). Maize is Ethiopia's largest cereal commodity in terms of total production, acreage, and the number of farm holdings. In addition to the highest total production per annum and the highest per-hectare yield, maize is also the single most important crop in terms of number of farmers engaged in cultivation. The vast majority of Ethiopian farmers are small-scale producers – estimates show about 94 percent of Ethiopian farmers rely on less than 5 hectares of land, of which 55 percent cultivate less than 2 hectares (Lirenso, 1994).

3. Environmental Impacts and Externalities of the Maize Value Chain in Ethiopia

In the pre-production phase, the relatively widespread and rising use of synthetic fertilizers in maize systems is responsible for the release of green house gases, both during manufacture of the fertilizer and in its use. However, in SSA countries like Ethiopia, these impacts are only localized because in most areas fertilizers and pesticides are underused (Reay et al. 2012, cited by Reynolds et al., 2015). Maize-related clearing continuing in Ethiopia also leads to green house gas emissions (Fargione et al. 2008; Phalan et al. 2013, cited by Reynolds et al., 2015).

During production phase, mono-cropping of maize, and unsustainable management practices, lead to soil infertility and nutrient shortages. Other environmental impacts and externalities of maize cropping relate to land clearing and degradation and subsequent loss of wildlife habitat and of biodiversity. At the same time, soil erosion and nutrient shortages represent the most severe constraints to maize yields in SSA (Mueller et al. 2012, cited by Reynolds et al., 2015).

Diseases and pests are among the major constraints limited maize productivity in smallholder farming systems in SSA. Diseases include grey leaf spots, common rust and the famous maize streak virus. The latter caused major losses during a huge outbreak in the 1970s in a number of SSA countries.[i]Pests such as downy mildew grey leaf spot, army worm and stem borers also hamper maize production (Pingali and Pandey, 2000).

In the post-production phase, cereal crops such as maize also suffer significant losses in traditional storage from the many pests and diseases (Tefera 2012, cited by Reynolds et al., 2015).

3.1. Climate Change Risks of Maize Value Chain

This is explained by the fact that maize is predominantly grown in smallholder farming systems under rain fed conditions, which makes maize systems highly vulnerable to climate variability and change. Even small changes in rainfall patterns/amounts can lead to huge losses of yields (Reynolds et al., 2015). In addition, general low yields in Ethiopia are largely associated with drought stress, low soil fertility, weeds, pests, diseases, low input availability, low input use and inappropriate seeds (Adger et al., 2007, cited by Cairns et al., 2013). Future climate change is likely to exacerbate these conditions. It will therefore be especially damaging to maize yields in Ethiopia (more than cassava, for instance), leading to the severity of several biotic and abiotic constraints, including high temperatures, drought and pests, and reducing the areas where maize can be grown (Reynolds et al., 2015). In sum, current and future climate change therefore represents a greater challenge because the probable impacts are out of the range of farmers' previous experiences (Adger et al., 2007, cited by Cairns et al., 2013).

3.2. Best Practices to Make Maize Value Resilient and Sustainable

3.2.1. On-Farm Diversification

This refers to maintaining multiple sources of production, and varying what is produced across farming landscape and over time. There is on-farm temporal diversification (e.g. crop rotation) and on-farm spatial diversification (e.g. intercropping, mixed farming). These types of diversification are employed at the plot or farm levels (in contrast with off-farm diversification,. They allow adapting to changing climate and weather variability, whilst farmers can enhance the productivity of their individual livelihood components. Diversified agricultural systems contribute to resilience in a multitude of ways, ranging from pest and disease suppression to increased production and climate change buffering. Agro-ecology is understood as the science of applying ecological concepts and principles to the design and management of sustainable food systems.

Diversified agro-ecological systems' require a transition away from industrial agriculture that is characterized by crop monocultures and a reliance on chemical inputs. Although most maize farming systems in Ethiopia include various forms of smallholder and subsistence farming, the options of diversified agro-ecological systems can work for smallholders as well as industrial farms. More concretely, this means the use of locally adapted varieties and species, more labor-intensive systems, a maximization of multiple outputs and low external inputs. The basic idea is the agricultural systems should be redesigned to maximize biodiversity and stimulate healthy ecosystems and security livelihoods. There is evidence that, in terms of outputs, these systems can actually compete with industrial agriculture (IPES-Food, 2016).

3.2.2. Sustainable Intensification of Agriculture:

Sustainable intensification brings together the practices to optimize production relative to inputs, including land, water, fertilizer, and improving the livelihoods of farmers, while minimizing negative impacts and externalities, such as pollution or deforestation. In other words, it means making more efficient use of the land available, which often requires access to new seeds, varieties and new technologies. In some cases, 'extensification', meaning that farmers acquire land to increase the farm size, is also a viable way out of poverty, but in SSA, there is very limited scope for further expansion without highly detrimental impacts on natural resources (e.g. deforestation) (Liniger et al., 2011).

Although sustainable intensification is a promising pathway to food security, environmental sustainability and resilience, it should go beyond top-down technologies for production and embrace holistic approaches, including indigenous knowledge, practices and solutions (AGRA, 2016). It requires, among others, a better use of improved seeds and fertilizers. Furthermore, in recent work by Rockström et al. (2016), it is argued that there is a need to use sustainable principles as the entry point for generating productivity enhancements, instead of the older paradigm that aimed to enhance agricultural productivity while reducing its environmental impacts. In a nutshell, the authors suggest to add a new dimension to sustainable agricultural development, notably by managing natural capital for long-term productivity and social-ecological resilience at field, watershed, and regional scales, in agricultural systems that operate within planetary boundaries to safeguard Earth system. Based on this approach, intensifying sustainably will require an understanding of the political economy in which food is traded and prices are determined and the business economy along the value chain from field to consumer (Rockström et al., 2016).

3.2.3. Off-farm (livelihood) diversification and commercialisation:

The transition towards environmentally sustainable and resilient food value chains will require more than production-oriented solutions, discussed above in the first two points. A third, important course of action is therefore off-farm diversification (e.g. differentiating income sources through wage employment on other farms), at landscape level. Riisgaard et al. (2010) refer to this as 'functional upgrading defining it as a situation in which producers take on a new function in the value chains, either by performing *downstream* activities (e.g. grading, processing, bulking up, transporting or advertising), or by engaging in *upstream* activities such as the provision of services, inputs or finance. Functional upgrading often leads to vertical integration - when an actor performs more than one value chain function – except when the producer decided to abandon primary production in order to focus on the new function" (Riisgaard et al., 2010, p. 198). In doing so, households can create a buffer for economic as well as environmental or climate shocks. In addition, the surplus of food produced, gained from moving away from subsistence farming due to diversification of activities, should be sold. Therefore, linkages should be set up between input providers, small-scale producers, processors and remunerative markets.

3.3. Approaches and Techniques to Make Maize Value Chain Environmentally Sustainable and Resilient in Ethiopia

There are many labeled approaches and practices towards sustainable and resilient agriculture that can be gathered under the Sustainable Agriculture (SA) umbrella. SA, like sustainable development, encompasses benefits from social, environmental and economic angles. It claims that farming systems must be resource conserving, socially supportive, commercially competitive, and environmentally sound (Ikerd, 1990, cited by Knaepen et al., 2015). Under the SA umbrella, some practices are at the farm level (e.g. sustainable intensification), whereas others relate to comprehensive, holistic approaches (e.g. Integrated Landscape Management, ILM). Some support a more nature-driven agriculture, such as agro-ecology, while some others support a more 'technology driven' agriculture, like precision agriculture.[ii] Most of these practices however are context-specific and they evolve over time, in line with new emerging issues and new scientific knowledge available. The following are some of the approaches and techniques to make maize value chain resilient and environmentally sustainable in Ethiopia.

3.3.1. Sustainable land management (SLM)

Refers to the process of land management for farm production, forests and protected areas in a sustainable and resilient way. SLM across a range of different land management units is necessary in order to achieve sustainable landscapes (GCP et al., 2015). It consists of various practices that can help to preserve and enhance ecosystem services in all land use systems. There is a long list of key interventions that can be broadly grouped into three management techniques:

Improved water management: including proper soil preparation, crop selection and timing of planting to reduce runoff and utilize available water resources even in the absence of irrigation. Efforts to overcome water constraints on maize production in smallholder systems include irrigation and other water management practices and the use of diverse and drought resistant varieties, depending on local contexts;

Improved soil management: including ensuring farmers do not over-use fertilizers, and promoting the use of crop rotations, intercropping with leguminous species, reduced tillage and incorporating agricultural residues. Minimal tillage and the retention of crop residues in particular can often reduce soil erosion, reduce GHGs and support soil fertility, and may raise yields. For many SSA smallholders, cropping systems, implementing rotations and intercrops, along with organic manures and targeted small amounts of synthetic fertilizer all frequently raise crop yields and financial returns from investments in inputs, while also improving food system stability;

improved pest (including disease and weed) management through integrated pest management, but relying primarily on interventions supporting crop health and discouraging pest outbreaks have seen growing effectiveness and acceptance among farmers (Reynolds et al., 2015).

3.3.2. Climate-smart agriculture (CSA)

Is newer concept, with a strong focus on tackling negative climate impacts, whereas SLM and ILM take into account the broader environmental constraints (e.g. pollution impacts). It was developed by FAO in 2010 as a holistic approach that "integrates the three dimensions of sustainable development by jointly addressing food security and climate change challenges. It is composed of three pillars such as sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing and/or removing green house emissions, where possible" (FAO, 2013, as cited by Knaepen et al., 2015).

4. Conclusion and Recommendation

The review of empirical studies in maize sector indicated that maize plays a central role in Ethiopia's food security and continues to be a significant contributor to the economic and social development of the country. However, the studies have further indicated that maize value chain functions during pre-production, production and post-production phases cause certain negative impacts and externalities which put the sustainability and resilience of environment and maize chain continuum in danger. According to the empirical studies, the negative impacts and externalities of maize value chain in environment may be attributed to emission of green house gases, soil infertility and nutrient shortages, land clearing and degradation and subsequent loss of wildlife habitat and biodiversity, soil erosion and nutrient shortages. Moreover, as result of inappropriate production and marketing functions which put aside sustainability aspect, maize value chain systems are highly vulnerable to climate variability and change which is characterized by loss of yield, diseases and pest infestation, drought and rainfall shortage. In order to counter back these negative effects and climate change risks simultaneously, on-farm diversification, off-farm diversification, sustainable land management and climate smart agriculture are the most advisable and best options.

In line with the findings of this review, what is the way forward is policy initiatives aiming at enhancing maize value chain resilience and sustainability in Ethiopia should be designed. Also development efforts geared towards maintaining environmental balance should get more attention so that make the whole maize value chain system resilient and sustainable given the dynamic weather elements.

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