Impacts of agricultural produce cess (tax) reform options in Tanzania

Aymeric Ricome, Kamel Louhichi, Sergio Gomez y Paloma

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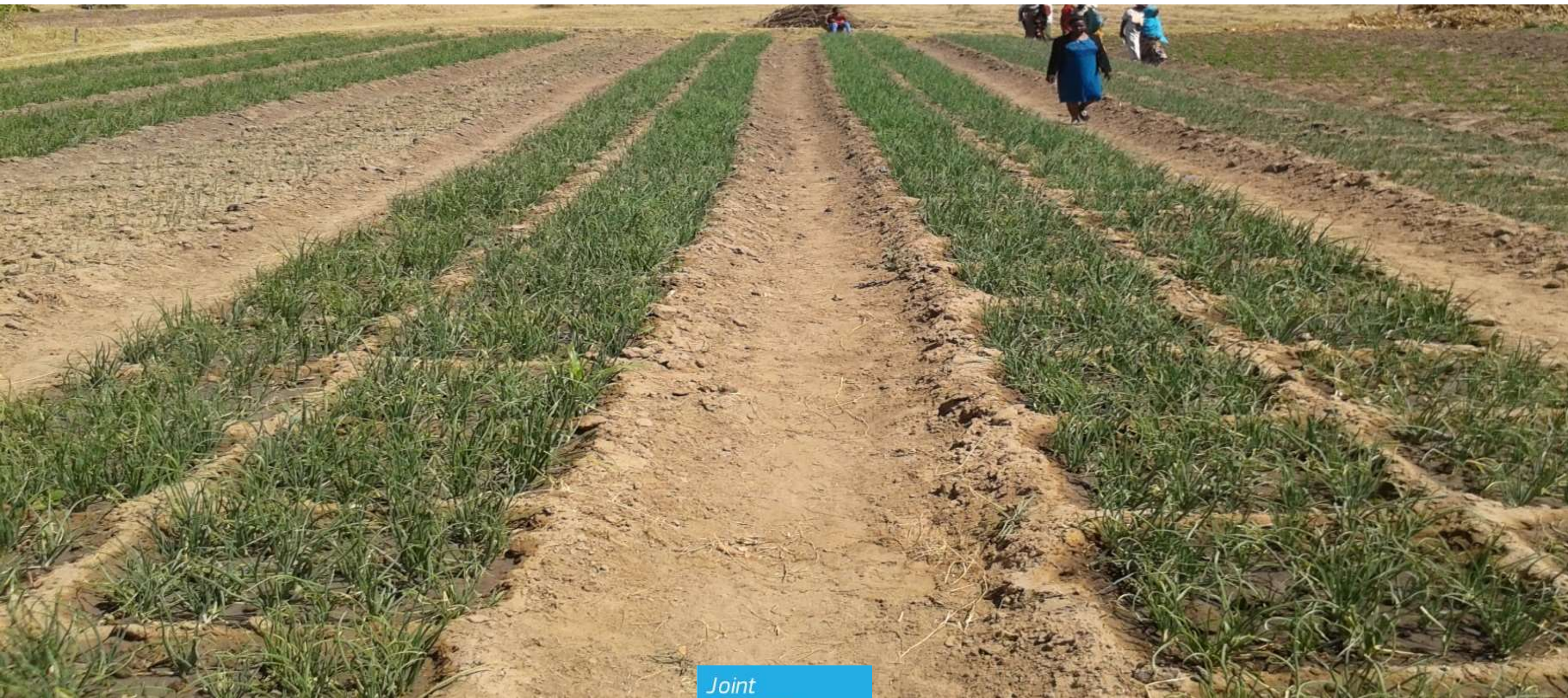

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Summary: This report presents the results of an impact analysis of several reform options of the agricultural produce cess in Tanzania. The produce cess is a levy charged by Local Governments Authorities (LGAs) on the value of the marketed agricultural production. This analysis is achieved using a micro-economic model applied to a representative sample of 3134 farm-households spread out over all the country coming from the World Bank-LSMS-ISA surveys. The potential effects of the simulated reform options on land use, production, input use, farm income, LGAs revenues and some food security related indicators are presented and discussed.

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Contents

Abstract

The government of Tanzania is willing to improve the socio-economic environment for the farming sector to encourage farmers to produce (and sell) more products from their activities. To that end, the central government is reforming the local tax system and particularly the agricultural produce cess, which is a turnover tax on marketed agricultural products charged by local government authorities (LGAs) at a maximum of 5% of the farm-gate price. Although it constitutes a significant source of revenue for many LGAs, this tax restricts an increase in production by farmers, and thus improvement of their livelihoods. In 2017, the government reduced the maximum cess rate from 5% to 3%. However, this reduction seems insufficient according to stakeholders, and several options to further reduce the rate are currently under discussion by the government. This report provides an *ex ante* impact assessment of the main reform options, using a micro-economic simulation model called FSSIM-Dev (Farming System Simulator for Developing Countries). Based on positive mathematical programming, this model was applied to a representative sample of 3,134 farm households spread throughout the country, taken from the World Bank LSMS–ISA surveys. Simulation results show that reduction of the cess rate leads to greater intensification and an increase in farm income, ranging between +2% and +21% depending on options and regions. The largest positive impacts are observed in the Northern and Western highlands. As expected, large farms and farms specialized in cash crops tend to gain more from the reduction in cess. At the individual farm household level, the impact is modest: 95% of the farms will experience an income increase of less than 10%. The impact on food security and rural poverty reduction is quite limited (improvement is less than 2%). Finally, the results show that a uniform cess rate of 1% for all crops seems to be the most efficient policy option.

Foreword

The Joint Research Centre (JRC) is one of the Directorates-General (DGs) of the European Commission (EC); its objective is to provide independent scientific and technical support to EU policy. Since 2014, the JRC has been collaborating with the Directorate-General for International Cooperation and development (DG DEVCO) under the Administrative Arrangement 'Technical and scientific support to agriculture and food and nutrition security sectors in sub-Saharan Africa' (TF4FNS), with the purpose of providing support for: (i) improvement of information systems on agriculture, nutrition and food security; (ii) policy and economic analysis to support the policy decision-making process; and (iii) scientific advice on selected topics concerning sustainable agriculture and food and nutrition security.

Within this framework, the Economics of Agriculture (EoA) Unit of the JRC is committed to provide to the DG DEVCO and to the EU delegations micro-economic analysis in the areas of food and nutrition security and (sustainable) agriculture. This consists of developing quantitative economic tools and models for *ex ante* impact assessment of selected national agricultural policies and EU cooperation policies on food security and rural poverty alleviation in sub-Saharan Africa.

The United Republic of Tanzania is one of the countries selected for running such policy analysis. Extensive discussion with the Delegation of the European Union to Tanzania, the Tanzanian Ministry of Agriculture, Food Security and Cooperatives (MAFSC), as well as researchers from Sokoine University of Agriculture and the Agricultural Sector Policy and Institutional Reform Strengthening (ASPIRES) project, led us to focus our policy analysis on produce cess, the most important rural tax in the country, with the aim of *ex ante* assessing the potential impacts of the main reform options currently under discussion. The preliminary results of this study were presented and discussed at a workshop held in Dodoma on 12 February 2019. This report presents the methodology, the data used and the final results of this impact assessment, and attempts to provide policymakers in Tanzania with some evidence on the potential effects of these reform options, from the perspectives of both farmers and government.

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Disclaimer

1 Introduction

The United Republic of Tanzania, located in East Africa, is the 13th largest country on the African continent, covering over 94.7 million hectares. While the Tanzanian economy was in difficulty in the 1970s and 1980s, several reforms set up in the 1990s and the 2000s allowed the country, over the last 15 years, to reach annual economic growth of 7% per year. This growth had a positive effect, although delayed and limited, on the poverty level (World Bank, 2015). However, the agricultural sector did not benefit from the expansion of the economy (Edwards, 2016). Agricultural productivity has remained low, mainly due to limited use of productivity enhancing factors such as improved seeds and fertilisers (MAFAP, 2013).

With this long-term and steady economic growth, Tanzania is pursuing the goal of becoming a middle income country by 2025 through industrialization of the economy and growth of its agricultural sector. The second phase of the Agricultural Sector Development Programme (ASDP-2), launched in June 2018, mentions that the agricultural sector may actually grow from the current annual rate of 3% to an expected 6% (MAFSC, 2016). To reach this quantitative target, the government of Tanzania has started to implement several policy reforms to improve the 'enabling' environment for stakeholders directly involved in agriculture, such as farmers, input suppliers, cooperatives, traders and retailers. The aim is to create an environment favourable to the development and conduct of commercial activities. These reforms consist of a number of measures, including relaxation of trade restrictions for staples (export ban), abolishment of VAT or import duty on several agricultural technologies such as irrigation equipment, and finally a limitation on local taxes and charges administered by local government authorities (LGAs).

The main local tax that has been modified is the agricultural produce cess.[1] This is a levy charged at a given rate (a percentage of the farm-gate price) on production sold by the farmer to any trader. Even though traders are statutorily obliged to pay this tax, it has been shown that it is actually the farmers who pay most, if not all, of it through an equivalent reduction in the farm-gate price offered by traders.

Local authorities use this tax instrument because it can generate a significant amount of revenue, while being easy and inexpensive to administer as it avoids measuring the actual farm income (Ogada et al., 2018). For this reason, the produce cess is used in several sub-Saharan countries, especially in Eastern Africa. Kenya collects the produce cess on several crops such as maize, sugar cane, tea, coffee, cotton and horticulture. Uganda imposes the produce cess at least on maize and coffee. Zambia, which had suppressed this tax several years ago, reinstated it very recently (Nyange et al., 2015).

Although it constitutes a significant source of revenue for many LGAs, produce cess has been strongly criticised by agricultural stakeholders, for: (i) reducing farmers' revenues and their incentive to produce more commodities; (ii) hindering the competitiveness of Tanzanian agriculture; and (iii) causing market distortion, as the taxation level is not the same across LGAs, ultimately worsening food security and poverty. In 2017, the government of Tanzania decided to reduce the cap for the produce cess rate from 5% to 3%, and plans to go further by decreasing the cess rate even more in 2020 and also by reducing disparities between current rates across crops and LGAs. Nevertheless, the modalities of the new reform are not yet decided; several options are currently under discussion, including:

- total removal of the produce cess,
- uniform cess rate reduction for all crops and all LGAs,
- differential cess rates by crop types (staple vs. non-staple crops).

This report presents the results of the impact assessment, for several options for reform of the agricultural produce cess, on farm household production decisions, farm income and poverty level, as well as on LGA tax revenues. We used a farm household model called FSSIM-Dev (Farming System Simulator for Developing Countries), which is a comparative static Positive Mathematical Programming model that relies on both the general household's utility framework and the farm's technical production constraints, in a non-separable regime. The model is applied to 3,134 representative farm households spread throughout the regions of Tanzania and taken from the 2012/13 Tanzania National Panel Survey, also known as the Tanzania Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA).

The report is organised as follows. Section 2 presents a brief overview of the Tanzanian agricultural sector and the major challenges facing it; section 3 presents the main specifications and mathematical formulation

[1] The term 'cess' is barely used in Europe but it is strictly equivalent to the term 'tax'. We will keep this name in the report as it is the terminology used by Tanzanian officials.

of the FSSIM-Dev model; section 4 provides a short description of the data used and the procedure for processing and cleaning the data; section 5 analyses the results of the model application to produce cess reform; and section 6 summarizes the main conclusions and policy implications.

2 The agricultural sector in Tanzania and its challenges

2.1 The Tanzanian agricultural sector

As in most sub-Saharan countries, agriculture is the most important sector of activity for Tanzania. It contributes to 30% of GDP and about 65% of the country's employment. The secondary sector (energy, manufacturing and construction) represents 23% of GDP and the service sector contributes to 46% of GDP (World Bank, 2019), but these are much less important in terms of employment. Given this situation, development of the agricultural sector would significantly contribute to poverty alleviation and to enhancement of wellbeing for the Tanzanian population.

Tanzania is a vast country. Excluding inland water bodies, the total surface of land in Tanzania is 88.5 million ha. While agricultural land covered 36% of the surface of the country in 2000, the share increased to 45% in 2015 to reach 39.6 million ha, at the expense of forest land (FAO, 2019). This expansion in cultivated land is due to stagnant land productivity while demographic growth is reaching 3% per year, resulting in increasing need for new land. Nevertheless, the stock of land is high because only 25% of the 40 million ha of land classified as arable is actually under cultivation. Also, agriculture is mainly rainfed, with scarce use of irrigation. Despite an estimated total area suitable for irrigation of 29.4 million ha, only 0.36 million ha are currently equipped, representing less than 2% of the Tanzanian potential (FAO, 2019).

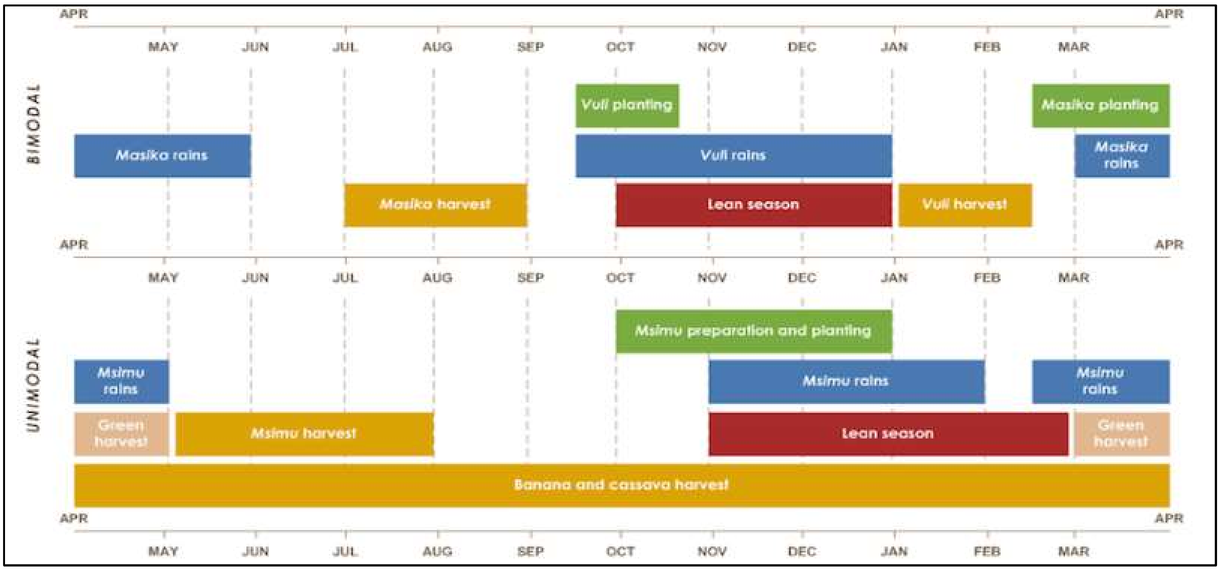
The Tanzanian territory is not only vast but also rich, and encompasses a large diversity of agro-ecological zones (AEZs). This wide variety is enabled firstly by the large variability in topographic conditions, with altitudes ranging from 0 to 5,895 m above sea level. Such topography translates into a rich and complex hydrological profile, with seven watersheds in the country. Rainfall varies greatly too, from 100/250 mm per year to 1,250/2,500 mm per year, although most places receive 750-1,250 mm per year. The pattern of rainfall is also variable, as areas in the north, north-east and north-west receive a bimodal rainfall regime while the rest of the country receives a unimodal rainfall regime (FEWS NET, 2008). Figure 1 gives an overview of the timing of the rains (*msimu* rains for the rain period in the unimodal regime, *vuli* for the short rains and *masika* for the long rains in the bimodal regime) and the resulting agricultural calendar.

Given these characteristics and others such as soil type and temperature, 10 AEZs are identified in Tanzania according to Sokoine University of Agriculture, one of the most renowned education and research centres for agriculture in Tanzania. These are:

- Coastal plains
- Arid land
- Semi-arid land
- Plateau
- Northern highlands
- Southern highlands
- South-western highlands
- Western highlands
- Alluvial plains
- Isolated granitic mountain blocks

The AEZs are plotted on the Tanzanian map in Figure 2, and the farming systems under each of these AEZs are named in Table 1. Each AEZ actually includes several farming systems, due to variations in agro-climatic conditions within an AEZ as well as socio-economic factors (market, employment opportunities, etc.). Within the country, all farming systems are based on a combination of cereals or tubers with legumes. Although maize is the major crop, sorghum and millet can be found in many drier areas such as the centre of the country. Rice is grown in the floodplains and in the lowlands with enough rainfall and adequate soil to retain water.

Figure 1: Agricultural calendar in Tanzania for bimodal and unimodal rainfall regimes

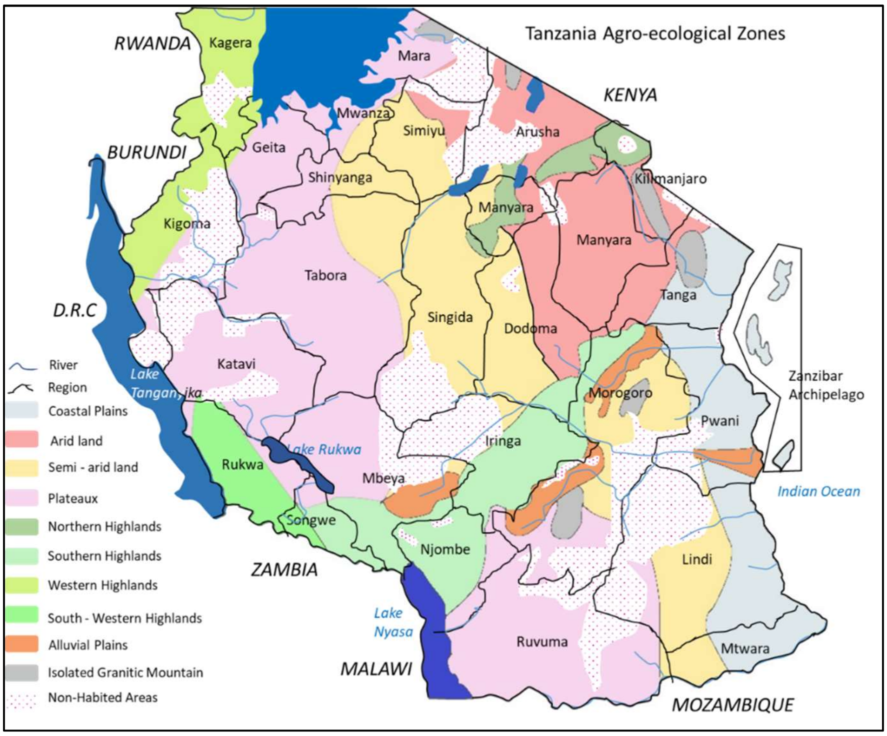


Source: FEWS NET (2008).

The main legume crop cultivated is bean, but pea and groundnut are also common. Certain types of legumes are exported, such as chickpeas. The farming system is generally completed by a cash crop, which may be cashew nut, tobacco, coffee, cotton, tea, sunflower, Irish potato, or fruit trees. When irrigation is available, horticulture is also included in the farming system. In specific areas with high rainfall, farming systems rely on banana and coffee. Permanent crops are also important in Tanzania, as they are grown on about 10% of the land and their value amount to 16% of production. Main permanent crops are banana, plantain, trees and cashew nut. Source: Lelievre and Kilcher (2018).

Figure 3 shows the relative significance of crops cultivated in Tanzania.

Figure 2: The agro-ecological zones of Tanzania



Source: Sokoine University of Agriculture, cited by Lelievre and Kilcher (2018).

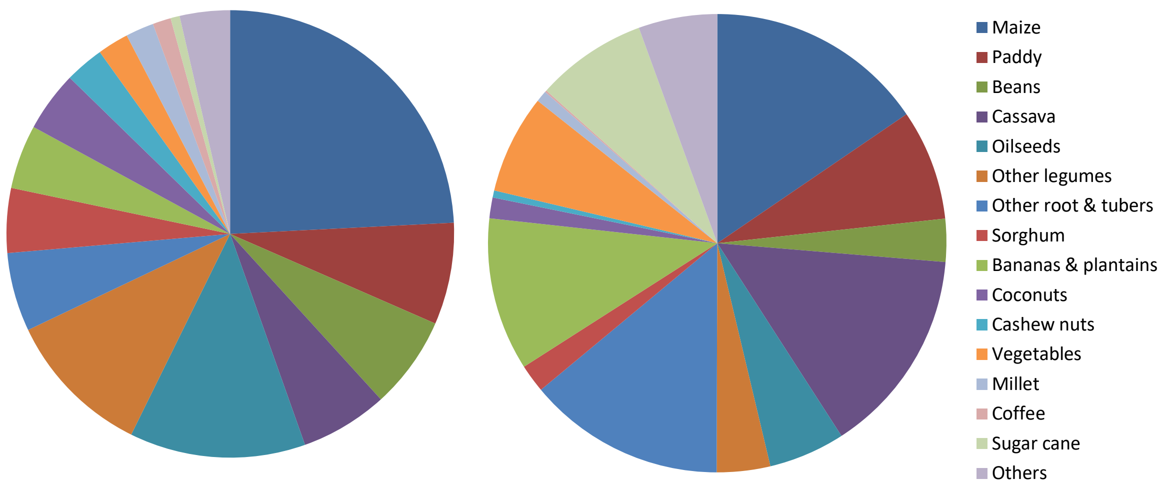
Furthermore, most households possess at least some livestock, such as chickens and goats, and cultivate on average 2 ha of land, which is relatively small (MAFSC, 2016). Nomadic and semi-nomadic pastoralism is found in the driest parts of the country.

Table 1: Summary of the agro-ecological zones and farming systems in Tanzania

AEZ	***Farming System***	***AEZ***	***Farming System***
Coastal Plains	Agro-pastoralism	**Northern Highlands**	Maize, Bean, Livestock +
	Cashew, Maize and Sesame		Maize, Coffee and Bananas
	Maize and Pulses	**Southern Highlands**	Coffee and Banana or Maize
	Tree Crops and Maize		Maize, Bean
Arid Land	Agro-pastoralism (nomadic)		Maize, Bean (and horticulture)
	Maize and Livestock		Maize, Potato
	Maize, Sorghum, Pigeon Pea		Maize, Tea and Timber
	Northern Nomadic Pastoralism		Rice and Cocoa
Semi-Arid Land	Agro-pastoralism	**South-Western Highlands**	Cassava, Rice, Fishing
	Cotton, Upland Rice and Livestock		Maize, Sunflower, Livestock
	Maize and Cashew	**Western Highlands**	Banana, Coffee and Beans
	Maize and Sunflower		Cassava, Beans and Maize
	Sunflower, Sorghum, Millet, Livestock		Livestock, Beans and maize
Plateau	Cassava, Cashew	**Alluvial Plains**	Rice and Maize
	Cotton, Livestock, Cassava, Maize		Rice, Maize and Sugar Cane
	Fishing, Cassava, Sweet Potato, Rice		Large Commercial Farms
	Maize, Bean, Cassava	**Isolated Granitic Mountain Blocks**	Agro-pastoralism
	Maize, Coffee		Banana, Coffee and Beans
	Maize, Paddy, Sunflower, Livestock		Cassava, Fruit trees, Sesame
	Sunflower, Cassava and Groundnuts		Irish Potato, Vegetable, Fruit trees
	Tobacco, Maize, Rice		
	Tobacco, Maize		

Source: Lelievre and Kilcher (2018).

Figure 3: Share of the crops in terms of cultivated land (left) and total production (right) in Tanzania in 2016

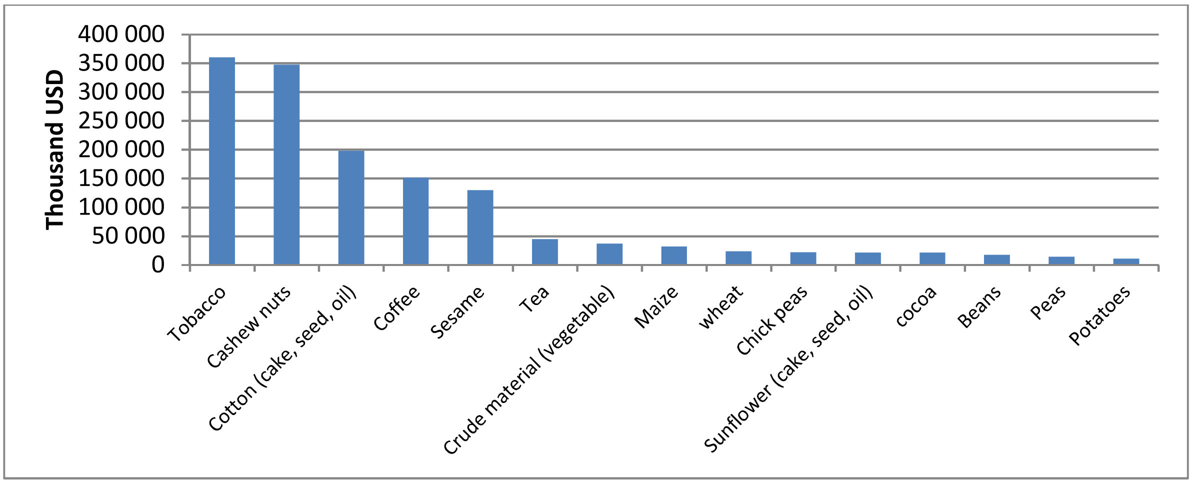


Source: FAO, 2019.

The average yields obtained by farmers are fairly low and far below potential yields (van Dijk et al., 2017). According to data from FAO for the year 2016, average cereal yields were 1,400 kg/ha for maize, 2,400 kg/ha for paddy, 967 kg/ha for sorghum and 917 kg/ha for millet. Yields for beans were 1,035 kg/ha and for groundnuts 705 kg/ha.

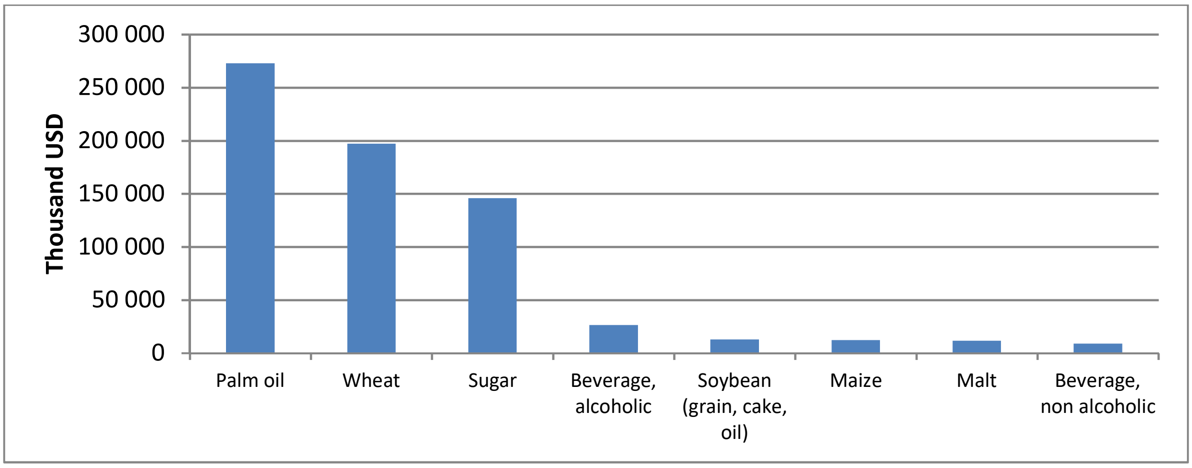
Although staple crops are mainly produced for self-consumption, they are also traded on domestic and regional markets (mainly to neighbouring countries) and represent an important source of income for many farmers across the country. Nevertheless, cash crops are those that bring most liquidity to farmers.**Error! Not a valid bookmark self-reference.** shows the main crops exported in 2016. Tobacco and cashew nut are the most sold crops, with earnings of about USD 350 million, followed by cotton (USD 200 million), coffee (USD 150 million) and sesame (USD 130 million). Those crops are clearly not the most important in terms of area cultivated or level of production, but they are an important source of income for farmers and the country. On the other hand, despite the wish by the authorities to substitute locally produced edible oil for palm oil, the level of importation of the latter is the highest among all imported commodities, with a total value of USD 270 million. Wheat and sugar follow, with import values of over USD 100 million (Figure 5).

Figure 4: Main agricultural products exported in 2016 (thousand USD)



Source: FAO, 2019.

Figure 5: Main agricultural products imported in 2016 (thousand USD)



Source: FAO, 2019.

2.2 Constraints on production and on policy environment

In the late 1990s, President Mkapa formulated the Tanzanian Development Vision 2025 (TDV 2025) to create a global long-term vision for development of the Tanzanian economy. Today, this is still the political foundation from which all programmes and sectorial policies for the country must take inspiration. The overall aim of this national vision is to change the country from a least developed country to a middle-income country by 2025. The way to reach this objective is by achieving good governance and setting up a strong and competitive economy to provide better socio-economic opportunities and better public sector performance (The United Republic of Tanzania, 1997). The structural reforms resulting from the launch of the Tanzanian Development Vision 2025 did in fact lead to the acceleration of growth in Tanzania, with an average growth rate of 7% over the last 15 years (Robinson et al., 2011).[2] Unfortunately, the agricultural sector has lagged behind throughout that period so the economic growth did not translate into a clear-cut reduction in poverty, especially in rural areas.

The stagnation in agricultural production and productivity is the result of strong constraints on production, acknowledged as the following: (i) low public expenditure on agricultural research and development; (ii) limited agricultural financing; (iii) poor production techniques, with limited use of improved seeds and fertilisers and overreliance on unpredictable natural rainfall;[3] (iv) poor rural infrastructure (rural roads, electricity, etc.); and (v) underdeveloped and distorted agricultural markets (MAFAP, 2013). The government of Tanzania admitted that the main constraints to transformation and growth of the agricultural sector are actually the lack of involvement of the private sector, and the current policy environment that is not encouraging farmers to produce more in order to achieve commercial activities with the production of surpluses. To address this problem, in 2006 the government launched the Agricultural Sector Development Programme (ASDP), followed in 2018 by the second phase (ASDP-2). The objective of ASDP-2 is to achieve growth in the sector of 6% per year, by transforming it into a modern, highly productive and competitive sector on both national and international markets (see the strategic priorities under ASDP-2 in Table 2).

Table 2: The strategic priority investment areas under ASDP-2 (2016/17-2025/26)

Components/programme areas	*Strategic priority investments*
Component 1: SUSTAINABLE WATER & LAND USE MANAGEMENT	Sustainable integrated land and water resources use and management and increased resilience (irrigation, charco-dams & boreholes, land use planning, soil fertility management, pasture development, ponds/cages)
Component 2: ENHANCED AGRICULTURAL PRODUCTIVITY and profitability	Increased productivity growth rate for commercial market-oriented agriculture for priority commodities (crops, livestock and fisheries value chains)
Component 3: RURAL COMMERCIALIZATION AND VALUE ADDITION (build competitive CVC)	Expanding farmer access to rural value addition and competitive marketing systems for priority commodity value chains, driven by an inclusive, strengthened and thriving private sector and effective farmer organizations.
Component 4: STRENGTHENING SECTOR ENABLERS at national, regional and local level	Policy and regulatory framework Institutional capacity strengthening, communication & knowledge manag. Food security and nutrition (including early warning and safety nets) Coordination (facilitate planning & implementation at all levels) Monitoring & evaluation (including agricultural statistics)

Source: ASDP-2 official document of the Ministry of Agriculture.

Establishing an enabling environment may, on one hand, encourage farmers to increase their productivity and boost their revenues, and on the other hand, reduce market distortions and failures that occur, for instance, on input markets. Currently, the government and the MAFSC seem to have identified three regulatory aspects to reform in order to improve the policy environment (The United Republic of Tanzania, 2018).

First is a plan to improve governance of the commodity boards that perform regulatory functions on supply, price, quality aspects and marketing of the country's main commodities. Second is a relaxation in trade restriction (storage and release of food stocks, export bans, import permits, exemption of tariffs for imported staple crops) allowed under Tanzania's Food Security Act (1991). Third is a reform of the local tax system.

[2] The first reforms started at the end of the 1980s, with the first Economic Recovery Program (ERP).

[3] In 2015, only 8.8 kg of fertiliser per ha of arable land was used in Tanzania, lower than the average of 15 kg/ha for the whole of sub-Saharan Africa (FAO (2019). FAOSTAT Database. Rome, Italy. retrieved October 2018 from the FAO Website.

The government is actively reforming the local tax system though a reduction in the produce cess (tax). In the following section, we explain in more detail the past reforms and the policy options being discussed for a new reform that may be adopted in 2020.

2.3 Reform of the produce cess (tax) in Tanzania

The produce cess is a turnover tax on agricultural output, charged by LGAs at a given rate (percentage) of the farm-gate price. This tax, established through the Local Government Finance Act in 1982, constitutes the major source of revenue for many LGAs, especially rural ones where on average 43% (and up to 90%) of their own revenue relies on the produce cess (Nyange et al., 2015). Yet this revenue could be much higher if rural LGAs could solve some institutional issues. A large part of the cess revenue in fact goes uncollected, due to 'limited human and institutional capacity at local level and widespread tax evasion, some of it likely featuring the collaboration of some local officials' (Nyange et al., 2015).

Although it constitutes a significant source of revenue for many LGAs, this tax discourages the production of grain and its commercialization, and negatively affects development of the agricultural sector. Even though traders are statutorily obliged to pay this tax, it has been shown that they often pass it back to farmers – who pay most, if not all, of it through a reduction in the farm-gate price offered by traders (i.e. traders internalise the cess tax). This is explained by the fact that, after the harvest, supply to market is much less elastic than demand, which gives the traders far more bargaining power. That is, the inelastic supply and elastic demand tend to push the cost of the tax onto the farmers, through a reduction in farm-gate prices. This is confirmed by a survey conducted by (Nyange et al., 2015) on a sample of traders and farmers, which reveals that farmers end up paying most of the produce cess. The produce cess was implemented by the LGAs in a totally independent way, so it rapidly led to very different taxation rates across the LGAs (with the rate going up to 20% of sale value in some cases). In 2003, the central government decided to reform local taxation to simplify it and reduce the high variability in the cess rate across LGAs, by putting a cap on the cess rate of 5% of the farm-gate price.

Despite this previous reform implemented in 2003, the cess tax was strongly criticised and agricultural stakeholders expressed many concerns, as it: (i) reduces the incentive to the farm to produce and trade; (ii) affects farm profitability; (iii) reduces the competitiveness of Tanzanian agriculture abroad; (iv) creates market distortion, as the level of taxation is not equal between LGAs (creating tax avoidance strategy); (v) worsens food security and poverty level; and (vi) creates uncertainty over the final producer price if there is lack of clarity on the eligibility of the products (e.g. whether crops produced for seeds might be subject to the tax).

Due to stakeholder pressure, the government decided in 2017 to amend the Local Government Finance Act a second time, by reducing the cap of the cess rate from 5% to 3%.

The plan now is to go further by decreasing the cess rate even more in 2020, to continue reducing disparities in current rates across both crops and LGAs. Several options are currently under discussion:

- total removal of the produce cess,
- uniform cess rate reduction for all crops and all LGAs,
- differential cess rates by crop types (food vs non-food crops).

The aim of this study is to evaluate the potential impacts of these reform options on farm household livelihoods, particularly on land use, crop mix, production, farm income and poverty gap (both at the individual and aggregate levels), as well as on LGA tax revenues.

3 FSSIM-Dev model

3.1 General description of the model

In this study, we use an improved version of the FSSIM-Dev model as described in (Louhichi and Gomez y Paloma, 2014). FSSIM-Dev is a micro-simulation tool that is well adapted to assess the impacts of market and policy changes on food security and rural poverty alleviation in the specific context of low-income developing countries. It aims to inform policymakers on how changes in prices, technology, food and agricultural policies could affect the viability and food security of heterogeneous sets of farm households that characterise the agricultural sector, which types of farm households will be the most affected, where these most-affected farms are located, etc.

FSSIM-Dev is designed to be applied to family or peasant agriculture, where farm household production, consumption and labour allocation decisions are non-separable due to market imperfections. Peasants are farm households, with access to a piece of land and utilizing mainly household labour in farm production. They are characterised by partial engagement in markets, which are often imperfect or incomplete due to transaction costs (Ellis, 1992). Peasant farms have a dual character, with both production and consumption sides: a proportion of the agricultural outputs produced on the farm is sold to meet their cash requirements and financial obligations, and the other part is used for self-consumption. If self-produced food is not enough for the family's subsistence, the peasant must use the local market to fill the gap.

The farm household's production decisions depend on their consumption requirement, resource endowment, agro-ecological conditions, socio-economic contexts and policy environments, while their consumption decisions are mainly driven by the income generated from farming activities, off-farm incomes, and the household members and their associated preferences. Also, this dual character of farm households as producers and consumers has the important implication that an increase in commodity prices creates both positive income and negative consumption effects.

Therefore, FSSIM-Dev aims to capture this dual nature of peasant households, as well as other key features of developing countries' agriculture, such as (i) the heterogeneity of farm households with respect to both their consumption baskets and resource endowments; (ii) the inter-linkage between transaction costs and market participation decisions; and (iii) the seasonality of farming activities and resource use.

FSSIM-Dev is a comparative static and (non-linear) positive mathematical programming (PMP) model. Static means that the model optimises an objective function for one period (e.g. one average base year) over which decisions are taken; thus it does not explicitly account for time. Positive means that the model aims to reproduces the real (observed) situation as accurately as possible and to simulate 'what is likely' to happen to this situation when changing external conditions, i.e. exogenous shocks, occur (Howitt, 1995).

In FSSIM-Dev, farm households are assumed to be: (i) rational decision-makers under the given conditions; (ii) full (i.e. farm household) income maximisers; and (iii) price takers (i.e. they have no control over input and output market prices).

FSSIM-Dev was designed to be sufficiently generic and with transparent syntaxes, in order to be applied to many different farming systems across Africa and elsewhere. It has a modular setup to make it re-usable, adaptable and easily extendable to achieve different modelling goals.

The principal outputs generated by FSSIM-Dev for a specific policy scenario are indicators of the crop mix and agricultural production, resources and input uses, food and non-food consumption, farm household income, poverty gap and government expenditure. These indicators are calculated at farm household level, but can easily be aggregated at any scale relevant for policymakers. Moreover, as long as a representative survey is used, the results aggregated for the whole sample (with specific sample weight for each household) can be seen as the impact at the national level. Also, the results can be presented according to a characteristic of the farm households, such as the amount of land cultivated by the household, the specialisation of the farm, or any other relevant criteria that may be relevant to study the redistributive effects of the policy. However, these results may not be considered as projections or forecasts, but as indications of trends triggered by exogenous shocks.

The model's capabilities are illustrated by an analysis of the effects of rice seed policy on the livelihood of farm households in Sierra Leone (Louhichi and Gomez y Paloma, 2014), as well as an *ex post* evaluation of an animal traction programme in Ivory Clast (Tillié et al., 2018).

3.2 Mathematical structure and formulation

FSSIM-Dev is a constrained optimization model which relies on both the general household's utility framework and the farm's technical production constraints, in a non-separable regime. Consequently, for each single farm household, it maximizes the income of the household (R) subject to resource endowments (land and labour) and other constraints covered below.

Farm household income (R) is defined as the income earned from all economic activities of family members of the same household. It has three components: agricultural income, income from marketed factors of production (non-farm wages, rent of land and equipment), and off-agricultural incomes. Agricultural (farm) income is defined as the income earned by households from selling or consuming their own agricultural products. Off-farm incomes are defined exogenously and can originate from different sources such as non-farm wages, self-employed activities (petty trading, craftsmanship, etc.), pensions, transfers (including remittances) and donations.

Agricultural (farm) income is computed as the sum of agricultural gross margin minus a non-linear (quadratic) activity-specific function. Gross margin is the total revenue from agricultural activities, including sales and self-consumption, minus the accounting variable costs of production activities. The accounting costs include costs of seeds, fertilisers, crop protection, and other specific costs. The quadratic activity-specific function is a behavioural function introduced to calibrate the farm model to an observed base year situation, as is usually done in PMP models. The PMP methodology (Howitt, 1995), recently refined by Mérel and Bucaram (2010), intends to reproduce households' production and consumption decisions in a precise way, allowing capture of the effects of factors that are not explicitly included in the model, such as price expectations, risk-adverse behaviour, labour requirements, capital constraints and other unobserved costs (Heckelei, 2002).

A crop-specific quadratic yield response function to nitrogen fertiliser, considered as the most important nutrient in sub-Saharan Africa, was also econometrically estimated and then calibrated to the observed level and embedded in the model, under the assumption that yields are independent of acreage planted. This yield response function allows better representation of the behaviour of the farm household, which could easily adapt its nitrogen fertilizer use to the physical (climatic and soil) and economic (market and policy) context. It also enables recommendations to be made on fertilizer rates under different policy options.

Agricultural commodity prices (i.e. market prices) are exogenously fixed for households participating in markets. We assume that those farm households are price takers on commodity markets. However, the price at which the household values a commodity will be generated by the model, depending on household trading status (net buyer, net seller or self-sufficient), which is in turn related to transaction costs.

FSSIM-Dev involves three blocks of equations for modelling market participation decisions: the first block for upper and lower bounds for commodity prices; the second, known as complementary slackness conditions, to guarantee that a farm household uses its own internal shadow price if, and only if, it does not participate in the market for goods; and the third one to ensure that, for each commodity, a farm household can be either a buyer or a seller but not both (households can also be self-sufficient, i.e. neither buying nor selling goods). It also includes two market clearing conditions. The first ensures commodity balance at household level: the sum of production and market demand for each good must be equal to consumption plus market sales. The second balances demand and supply for goods and tradable factors at regional/village level (i.e. this condition is used to capture interaction among farm households for goods and tradable factors).

The general mathematical formulation of the model for each farm household h is as follows:

(Eq. 1)
$$Max\ R_h = \sum_i \left(s_{h,i} + cs_{h,i}\right) P_{h,i} + \sum_i sb_{h,i} x_{h,i} - \sum_{i,k} a_{h,i,k} x_{h,i} - \sum_i \left(d_{h,i} + 0.5 Q_{h,i,i'} x_{h,i}\right) x_{h,i} + exinc_h$$

s.t.:

(Eq. 2) $\sum_{tf} A_{h,i,tf} x_{h,i} \leq B_{h,tf} \qquad [\rho_{h,tf}]$

(Eq. 3) $c_{h,j} P_{h,j} = \beta_{h,j}\left(R_h - \sum_{j'} \gamma_{h,j'} P_{h,j'}\right) + \gamma_{h,j} P_{h,j}$

(Eq. 4a) $p_j^m t_{h,j}^s \leq p_{h,j} \leq p_j^m t_{h,j}^b$

(Eq. 4b) $p_{tf}^m t_{h,tf}^s \leq p_{h,tf} \leq p_{tf}^m t_{h,tf}^b$

(Eq. 5) $s_{h,j} b_{h,j} = 0$

(Eq. 6a) $s_{h,j}(p_{h,j} - p_j^m t_{h,j}^s) = 0$

(Eq. 6b) $b_{h,j}(p_{h,j} - p_j^m t_{h,j}^b) = 0$

(Eq. 7a) $q_{h,j} = s_{h,j} + cs_{h,j}\ ;\ c_{h,j} = cs_{h,j} + b_{h,j}$

(Eq. 7B) $q_{h,j} + b_{h,j} = s_{h,j} + c_{h,j}$

where indices *i = 1,2,...,I* and *j = 1,2,...,J* denote agricultural activities and products[4] respectively, *k = 1,2,...,K* are intermediate inputs (i.e. fertilizer, seeds, crop protection, etc.) and *tf = 1,2,...,M* are the tradable factors. R_h is the total income of the farm household *h*, **s** is the *(n×1)* vector of sold quantities of goods, **cs** is the *(n×1)* vector of self-consumed quantities of goods, **p** is the *(n×1)* vector of expected prices of the goods, **sb** is the *(n×1)* vector of production subsidies, **x** is the *(n×1)* vector of the non-negative levels of the agricultural activities, **a** is the *(n×k)* matrix of accounting variable costs, **d** is the *(n×1)* vector of the linear part of the activities' behavioural activity function, and **Q** is the *(n×n)* symmetric, (semi)positive matrix of the same function; *exinc* is the off-farm household income.

A is the *(n×m)* vector of resource requirements (land, labour, etc.), **B** is the *(m×1)* vector of initial resource endowments and ρ is the *(m×1)* vector of their corresponding shadow prices. **c** is the *(n×1)* vector of consumed quantity of goods, γ is the uncompressible consumption (interpreted as minimum subsistence or 'committed' quantities below which consumption cannot fall), and **β** is the marginal budget share ($\frac{\partial(c_{h,j}p_{h,j})}{\partial R_h}$). γ and **β** are the unknown parameters to be estimated. $\mathbf{P^m}$ is the *(n×1)* vector of the market price of goods while $\mathbf{t^s}$ and $\mathbf{t^b}$ are *(n×1)* vectors of the transaction costs related to the sales and the purchase respectively, of goods or tradable factors. Finally, **q** is the *(n×1)* vector of production level.

Q and **d** are estimated using a variant of the PMP approach (Louhichi et al., 2020). γ and **β** are estimated simultaneously in each region using the highest posterior density (HPD) estimator (see below) and prior information on income elasticities and Frisch parameters.

While equation 1 is the objective function, equations 2 to 9 are the constraints for the mathematical programming model. These constraints are related to the following.

— The limited resource endowments (Eq. 2)

— The household consumption constraints, through the Linear Expenditure System (LES) (Eq. 3). LES is the most frequently used system in empirical estimation of consumer demand; it is also the easiest in term of parameterization and calibration.

— The existence of transaction costs when the household wants to use the market, which make the actual selling and buying prices respectively lower and higher than the market price (Eq. 4a and 4b).

— The fact that for a given product, the household can be only seller or buyer but not both (Eq. 5).

— The introduction of complementary slackness conditions, stating that the household values a supplied or consumed product at the market price, augmented/reduced by the corresponding transaction costs, if and only if the household is a net buyer/seller for a given product; otherwise (if it does not participate in the market for that product) the household values the commodity at its own internal shadow price (Eq. 6a and 6b).

[4] To simplify mathematical notations, we assume one product per activity so that indices for activity and product are identical.

— The market clearing condition at the household level, assuming that for each product, the sum of production and purchase equals consumption plus sales for this product (Eq. 7a and 7b).

This estimation of the crop yield response function is based on the following equation:

(Eq. 8) $$y_{h,p} = \beta_0 + \beta_1 N_{h,p} + \beta_2 N_{h,p}^2 + \boldsymbol{\beta_3 X}_{h,p} + \boldsymbol{\beta_4 Z}_{h,p} + \boldsymbol{\beta_5 Z}_{h,p}.N + \beta_6 aez_i + \beta_7 aez_i.N + \boldsymbol{\beta_8 W}_h + \varepsilon_{h,p}$$

where indices *h = 1,2,…,H* and *p = 1,2,…,P* denote the farm households and the farm plots respectively. $y_{h,p}$ is the crop yield (kg/ha^{-1}), $N_{h,p}$ is the nitrogen application rate (kg/ha^{-1}), $\boldsymbol{X}_{h,p}$ is the vector of other variable inputs (area, labour use), $\boldsymbol{Z}_{h,p}$ is the vector of dummies for the use of improved seeds and irrigation, aez_i the agro-ecological zone where the household *h* is located, $\boldsymbol{W}$ is the vector of socio-demographic characteristics of the farm households, allowing control for endogeneity, and $\varepsilon_{p,i}$ is the error term with mean assumed equal to 0 and constant variance equal to σ^2. The β coefficients have been estimated for the whole farms using the ordinary least squares (OLS) estimator. With this crop yield specification, the impact of nitrogen will vary according to the seed type used, whether the crop is rainfed or irrigated, and finally the agro-ecological zone. It allows for consideration of technological and soil/climatic heterogeneity. The other fertiliser elements (phosphorus, potassium) are assumed to be applied in fixed proportions to nitrogen, and remaining inputs such as pesticides and labour use are assumed to be independent to nitrogen fertilizer and used at a fixed rate per hectare for each specific crop.

The model calibration was performed using an improved approach based on the HPD estimator with prior information on supply and income elasticities (Louhichi et al., 2017).

The calibration of the supply side of the FSSIM-Dev model aims to replicate the two key observable production decision variables: 'nitrogen fertilizer applied to crop activities at plot level (i.e. by unit of area)' and 'land allocated to production activities at farm level', by taking into account the underlying profit optimization problem. This is performed in two successive steps: first we calibrate the nitrogen fertilizer use, and then the land allocation. Prior information on supply elasticities and on land rental prices is used for the calibration of land allocation. The aim is that the model exactly replicates the observed land allocation crops, as well as the exogenous set of supply elasticities. The calibration to the exogenous supply elasticities is performed in a non-myopic way, i.e. we take into account the effects of changing dual values on the simulation response (Heckelei, 2002; Mérel and Bucaram, 2010). Based on the literature (Alemu et al., 2003) the supply elasticity considered in the model is 0.35. Nevertheless, due to the lack of information regarding permanent crops, we assumed in the model that these were barely reacting to the price, with an assumed elasticity of 0.05.

The parameters of the behavioural function are estimated only for observed activities in each farm household, meaning that the well-known problem of self-selection is not explicitly addressed in this estimation. To cope with this problem, we adopted the following ad hoc modelling decisions in the simulation phase: (i) in each region, the gross margin of the non-observed activities is equal to the farm-type average gross margin; (ii) the activity's quadratic function parameter is equal to the activity's average quadratic function parameter within the farm type; and (iii) the linear term's quadratic function is derived from the difference between the gross margin and the dual values of constraints.

The aim of the calibration consumption module is to ensure that the consumption decisions of the farm households during the base year period are exactly reproduced by the optimal solution of the programming model.

More details on model specification and its equations are supplied in Louhichi et al. (2020) and Louhichi and Gomez y Paloma (2014).

In the following section, we describe the database used to parametrize the model for the Tanzanian case study. We also present the descriptive statistics for the sampled farm households, as well as the results of the farm typology aiming to group farmers into homogeneous groups. Developed on the basis of farms' crop specialisation and economic size, this farm typology allows us to present the model results not only at individual and aggregated (regional and national) levels, but also by farm group (specialization and size).

4 FSSIM-Dev application to Tanzania

4.1 Data

The data used come from the 2012/13 Tanzania National Panel Survey, also known as the Tanzania Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA). This is a representative survey of households living in both rural and urban areas, but with a strong focus on agriculture. It is conducted by the Tanzanian National Bureau of Statistics, in collaboration with the Survey unit of the World Bank in charge of the implementation of LSMS-ISA surveys throughout the world. Up to now, the survey has been implemented every two years since 2008. We used the 2012/13 survey because when data preparation started, the 2014/15 survey was not yet available.

There were 5,015 households surveyed in the 2012/13 survey, among which 3,212 were farmers. The data collection was done over a full year, from October of the first year to September of the following one.

The survey is a two-stage cluster sample design. The primary sampling units are the enumeration areas (EAs), which correspond to a village in the rural area and have been stratified along two dimensions (rural and urban area) and four strata (rural areas, Dar es Salaam, other urban areas on the mainland, and Zanzibar). From this stratification, 410 EAs were randomly drawn from the 2002 Population and Housing Census. The second stage of sampling consisted of random selection of households to be interviewed in each EA, based on a household listing. The sampling design enables reliable estimates of key socio-economic variables for mainland rural areas, Dar es Salaam, other mainland urban areas, and Zanzibar, i.e. at the strata level.

The survey comprises four modules.

(i) A community questionnaire that addresses topics related to the village, such as the physical and economic infrastructure, access to basic services, investment projects and land use.

(ii) A household questionnaire dealing with the socio-demographic characteristics and activities of the household members, food and non-food consumption, and livelihood activities.

(iii) A fishery and livestock questionnaire including a comprehensive description of all types of herds of animals owned by the farmers, the output (sales) and production costs.

(iv) An agriculture questionnaire describing the agricultural activities of the households. This details information on all plots held by the households, land tenure, soil type and agricultural practices. For each plot, data report the crops cultivated and their respective areas, the amount of inputs used, the quantity of family and hired labour used for the main farming operations, production harvested and sold, production costs, and farm implements and machinery. Crop output is collected for each plot and each crop on the plot. Plot size was measured according to farmers' estimates and in some cases by GPS.

Before using the LSMS-ISA data, several steps were performed to screen the data and to convert them into a format compatible with the FSSIM-Dev modelling framework. The variables of interest, such as yields, output and input prices, input quantities, quantity of labour used, etc., were treated for outliers using Tukey's method based on Interquartile Range or winsorizing. Missing values were also identified and replaced by median values.

After cleaning and dropping out the urban households, and rural households having no commitment in any agricultural activities, the total sample used for the FSSIM-Dev model consists of 3,134 farm households.

4.2 FSSIM-Dev sample: descriptive statistics

Table 3 presents some key characteristics of our farm household sample, at both national and regional levels. The average size of the farm households in the sample is around 1.5 ha, which is slightly low but in line with the 2007/08 agricultural census (National Bureau of Statistics, 2012). We observe significant disparities between regions, with the smallest average farm size (0.87 ha) in the Western highlands and the largest (2.24 ha) in the Semi-arid and Arid zone. The latter region is also the one with lower land productivity and higher climatic risk. The table also shows that around 75% of the farms and 80% of the cultivated lands in the sample are concentrated in three main zones: Coastal plain, Plateau/South-western highlands, and Semi-arid/Arid. The remaining three zones together represent less than 25% of the sample farms and less than 20% of the cultivated land. This indicates that some regions are more agriculture-oriented than others, so the number of farm households from these zones – and their corresponding cultivated areas – dominate in the sampling frame.

Table 3: Key sample characteristics

	National	Coastal plain	Northern highlands	Plateau/ South-west highlands	Semi- arid/ Arid	Southern highlands	Western highlands
Number of households surveyed	**3,134**	943 (30.1%)	167 (5.3%)	785 (25%)	638 (20.3%)	346 (11.1%)	255 (8.2%)
Average farm size	**1.47**	1.12	1.07	1.7	2.24	1.09	0.87
Equivalent adult per household	**3.98**	3.7	4.06	4.21	4.4	3.4	3.87
Share of cultivated land, over total sample cultivated land	**100**	22%	4%	29%	31%	8%	5%
Land use in the long rainy season (% total cultivated land in each region)							
annual crop	**85**	67	93	90	91	88	87
perennial crop	**15**	33	7	10	9	12	13
maize	**34.6**	22.9	61.6	36.9	34.9	49.6	28.6
rice	**8.5**	10.5	1.8	10.2	8.1	6.2	3.7
sorghum/millet	**4.3**	2.6	2.2	2.5	8.9	0.6	1.9
cassava	**6.6**	13.2	0.2	8.0	1.3	1.7	13.8
other roots	**3.3**	1.9	1.4	4.7	2.1	3.4	8.1
banana	**3.5**	4.6	3.7	4.6	0.7	6.0	6.0
beans	**6.9**	1.1	16.4	10.0	1.5	14.1	23.2
other legumes	**11**	10.5	3.8	10.1	15.5	6.8	6.2
cashew nut	**5.8**	18.8	0.0	1.0	4.8	0.0	0.0
cotton	**4.7**	0.0	0.0	2.9	12.2	0.0	0.2
other annual crop	**5.3**	4.2	5.9	4.6	6.8	5.8	0.8
other perennial crop	**5.5**	9.8	3.0	4.4	3.3	5.8	7.5

Source: Authors' calculations based on the LSMS-ISA 2012/13 database.

Table 3 also highlights the strong heterogeneity across regions in terms of land use. This is, however, not surprising and fully consistent with the national statistics and also other published studies (FEWS NET, 2008). For example, the Coastal plain region which has low agricultural potential, particularly for cereals, is characterised by a higher presence of perennial crops (coconut, mango, orange in the north and cashew nut in the south) and cassava in comparison to other regions, to the detriment of maize.

In the Semi-arid and Arid zone, sorghum, millet and legumes are quite common in comparison to other regions, while beans remains very low due to the high risk of failure caused by the scarcity of rainfall. Conversely, in the Northern highlands, which is a mountainous zone with abundant rainfall and fertile soils, maize and beans dominate and are intercropped with cash crops such as coffee and fruit trees (banana, avocado, etc.). In the Plateau and South-western highlands, maize, cassava and bean are the main crops, along with rice (north/central part) and cassava (southern part). The Southern highlands is considered one of the most productive area of Tanzania, due to the presence of fertile soils, good altitude and rains. Although several farming systems coexist in the zone, farmers prioritize maize, beans and cash crops (rice, cocoa, coffee, horticulture, etc.). Finally, in the Western highlands, the farming system relies on the combination of banana-beans-coffee in the north, and root and tuber crops with beans and maize in the south. All these regional heterogeneities are well captured by the sample.

The average yields showed in Table 4 are roughly in line with yields published by official statistics (FAO, 2019), except for cassava. The highest yields are obtained in the Northern and Southern highlands, which are known to be the most productive regions for both food and cash crops.

Table 4 also provides average producer prices and average gross margins per ha for the main crops. It appears that rice generates the highest gross margin, followed by maize, cassava and groundnut. The lowest productive crops are millet, sorghum and cashew nut.

Table 4: Average yields (national and agro-ecological level), farm-gate price and gross margin per ha (national level) for the main crops of Tanzania

	Average yields (kg/ha)							Gate price (TZS/kg)	Gross margin (TZS/ha)
	Nat.	Coastal plain	Northern highlands	Plateau/ South-west highlands	Semi-arid/ Arid	Southern highlands	Western highlands	Nat.	Nat.
Maize	**1091**	820	1513	1177	869	1335	948	365	330815
Paddy	**1591**	1125	4878	1703	1500	1896	1762	563	834210
Sorghum	**530**	496	761	473	544	336	550	531	182941
Millet	**724**	150	555	496	771	315	638	321	184214
Cassava	**1095**	1294	5713	1062	1060	1404	831	260	282755
Banana	**1190**	1338	2632	460	1176	1229	2118	223	261395
Beans	**437**	358	598	341	500	470	500	740	238530
Groundnut	**614**	402	195	470	821	528	337	550	270460
Cashew nuts	**161**	173	-	60	149	-	-	983	131819

Source: Authors' calculations based on the LSMS-ISA 2012/13 database.

15% of the sampled farmers use fertiliser on at least one of their plots (see Table 5) but the percentage varies significantly across regions. 40% of farmers use fertiliser in the Southern highlands, 25% and 21% in the Northern highlands and Plateau/South-western highlands respectively, and less than 5% in the Western highlands. The actual amount of fertilisers used is very low, and it is mainly applied to maize and paddy.

Table 5: Percentage of farmers using fertilizers on their plots

	National	Coastal plain	Northern highlands	Plateau/ South-west highlands	Semi-arid/ Arid	Southern highlands	Western highlands
Percentage of farmers using fertilisers	**15.1**	7.3	25.1	21.2	6.7	40.7	3.5

Source: Authors' calculations based on the LSMS-ISA 2012/13 database.

4.3 The farm household classifications

Given the large diversity of farm households and farming systems in Tanzania, we decided to group farm households into homogenous groups, using the following criteria:

- economic size
- crop specialization

This typology will allow us to analyse the differences among farm household groups and also to aggregate the model results by specialization and economic size.

4.3.1 Economic size

The economic size has been defined as the size of the farm in terms of total standard output value (TSOV), where the standard output value (SOV_c) is defined as the product of the national average yield with the national farm-gate price and is given in Tanzanian shillings per hectare (TZS/ha). For the farmer *i* who cultivates the area A_c of a given crop *c*, the $TSOV_i$ (measured in TZS), is defined as follows:

$$\mathrm{TSOV_i} = \sum_{\mathrm{c}} \mathrm{SOV_c} * \mathrm{A_c}$$

Applying the economic size criterion, three different categories are identified, with approximatively the same number of farms in each category. The thresholds selected are given in Table 6.

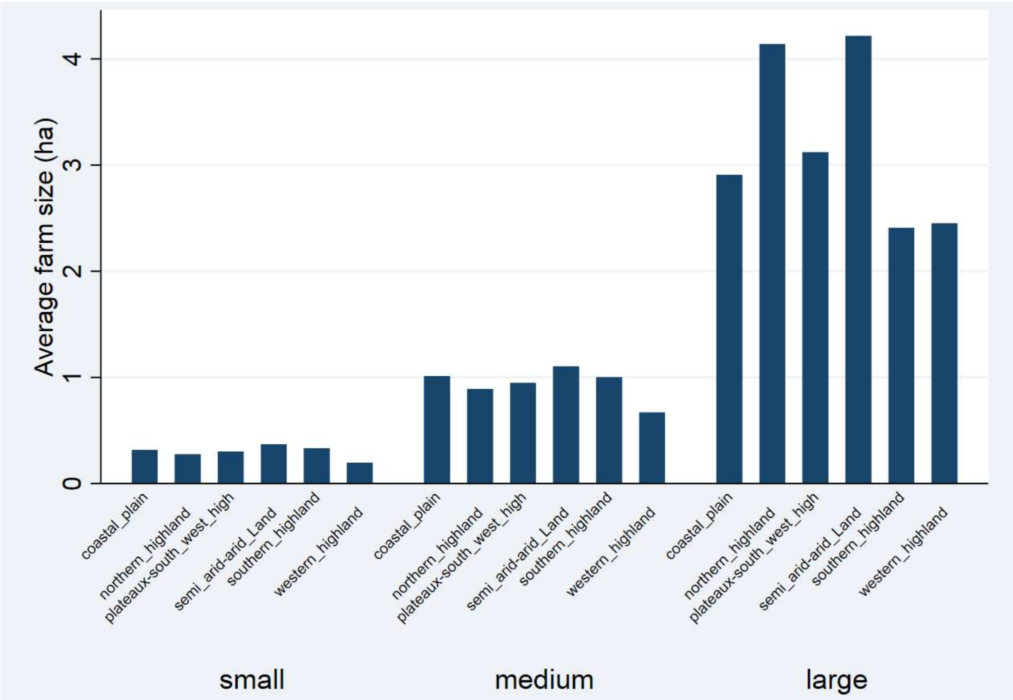
Table 6: ES classification according to total output value thresholds

ES classification	ES thresholds (thousand TZS)	% of farms represented
Small farms	Less than 250	34.3
Medium farms	From 250 to 700	34.7
Large farms	More than 700	31

Source: Authors' calculations.

Figure 6 illustrates the strong correlation between the economic size measure and the physical farm size (in ha). This is also confirmed by the coefficient of correlation of 0.82 for the overall sample.

Figure 6: Average farm size (ha), by economic size class (small, medium or large) and agro-ecological zone



Authors' calculations.

4.3.2 Crop specialization

We also classified the farms according to their level of specialization in a given type of crop production. The classification is based on the following crop types:

- annual staple crops (cereals, roots, tubers, bananas and pulses)
- other annual crops (oilseeds and vegetables)
- permanent crops
- mixed crops.

We assumed that a farm is specialised in one of the first three crop types if at least two thirds of the TSOV comes from this crop type. Otherwise, the farm was considered a mixed crop farm.

Half of the farms are specialised in staple crops, while 12.3% are specialised in other annual crops. Farms specialised in permanent crops are fewer, representing only 10% of the sample. Finally, 26.7% of the farms create value from several crop types (Table 7).

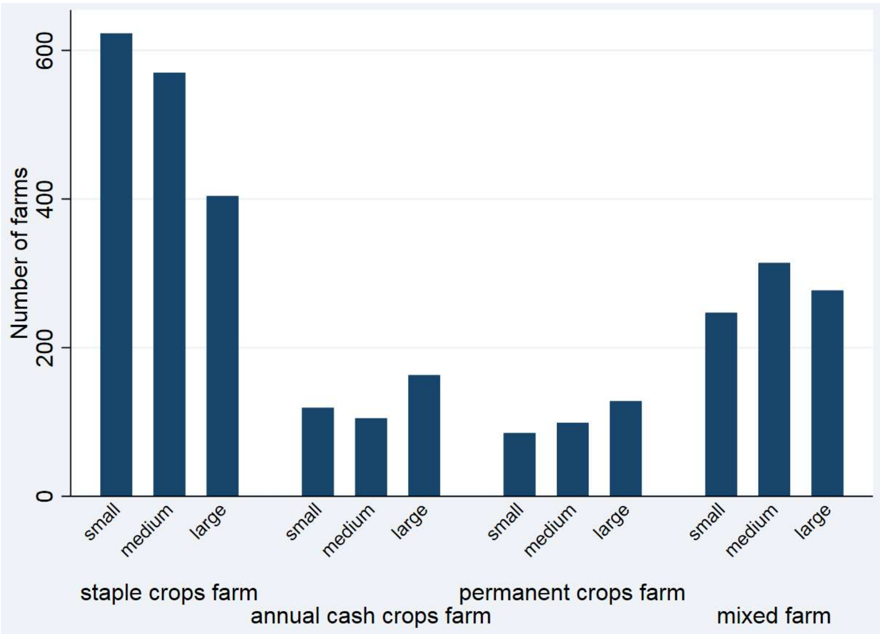
Table 7: Description of the crop specialization categories

Farm specialisation category	Description	Sample share	Average farm size (ha)
Staple crops	Farms specialised in annual staple crops (cereals, roots, tubers, bananas, pulses)	51%	1.2
Annual cash crops	Farms specialised in annual cash crops (oilseeds, vegetables)	12.3%	1.9
Permanent crops	Farms specialised in permanent crops	10%	1.8
Mixed crops	None of the above	26.7%	1.6

Source: Authors' calculations.

Figure 7 shows the distribution of the farm households according to their crop specialization and economic size. On average, farms specialised in staple crops are farms with a smaller economic size. Being constrained as to land, the share of the crops dedicated to staples is necessarily high. Conversely, farms that dedicate their land to annual cash crops or permanent crops have greater representation among large farms.

Figure 7: Number of farm households according to crop specialization and economic size



Farm specialised in staple crops are over-represented (in comparison to the national average) in the Coastal plain and Plateau/South-western highlands, and under-represented in the Western highlands and Northern highlands where mixed farms dominate. There is a much higher proportion of permanent crop growers in the Coastal plain, which is consistent with our expectations (it is the main zone for fruit tree production).

Table 8: Distribution of crop specialization categories across the regions (in %)

	Staple crop specialist	Annual cash crop specialist	Permanent crop specialist	Mixed farming specialist
Sample average	**51.0**	**12.3**	**10.0**	**26.7**
Coastal plain	54.4	6.2	20.1	19.3
Northern highlands	38.3	11.4	8.4	41.9
Plateau/South-western highlands	56.6	13.9	5.0	24.6
Semi-arid/Arid	50.8	18.8	4.1	26.3
Southern highlands	50.3	13.0	6.9	29.8
Western highlands	30.6	14.1	7.5	47.8

Source: Authors' calculations.

4.4 The household consumption typology

To facilitate estimation of the parameters for the consumption function (Eq. 3) which are supposed to be farm household–type dependent, we classify farm households into homogenous groups according to their consumption patterns, using the Agglomerative Hierarchical Clustering (AHC) method.

The following five variables are used to build up the consumption pattern–based typology:

- share of total consumption dedicated to food
- share of food consumption self-consumed (food produced on the farm)
- share of food consumption corresponding to cereal, root or tuber crops
- share of food consumption corresponding to protein (legumes, meat, fish)
- share of food consumption corresponding to vegetables or fruits.

The Euclidean distance has been selected to measure the distance between pairs of observations, and the Ward criteria as the linkage algorithm. Three classes, fairly balanced in terms of observations, are finally selected. According to their characteristics (see Table 9), these classes can be named as follows:

1. diversified consumption households
2. hardly self-sufficient households
3. self-sufficient and slightly diversified households.

The diversified consumption households represent 40.7% of the sample and are the farm households that are less constrained in terms of ability to cover all their food needs. They have the lowest share of expenses allocated to food (72.8%) and the lowest share of food coming from self-consumption (17.7%). They also have the highest share of protein content in their total dietary budget (27.1%). This class includes farm households with the highest off-farm income and located nearest to city centres and agricultural markets. It should be noted that, even if they are not necessarily more integrated to market, they are more specialized in annual cash crops and permanent crops.

The hardly self-sufficient class represents 27.4% of the sample and corresponds to farm households at the other end of the spectrum. This class includes households that dedicate the highest part of their spending to food products (81.3%) and have the lowest level of off-farm income. Furthermore, the percentage of food coming from their own fields (27.5%) is higher than in the first class, but lower than the third class described below (64.5%). Finally, this class contains households that consume more carbohydrates (cereal/tuber/root crops) than proteins. They are also further away from the city centre and the agricultural markets, compared to the other classes. We can assume that this class encompasses the households that are more sensitive to food security issues (undernutrition, malnutrition). This class is also over-represented in the Semi-arid/Arid zone and the Western highlands.

The third class represents 31.9% of the sample and corresponds to the farm households that are somehow in the middle of the two classes described above. They are self-sufficient and have a slightly diversified diet.

They are ranked between the two other classes, based on only three criteria: (i) share of self-consumed goods; (ii) economic size of the farm; and (iii) degree of integration to market. In fact, it appears that this class has both the highest share of self-consumed food products and the highest degree of integration to market, which seems paradoxical. This is because, since they are the largest farms in term of production value, they produce enough food to satisfy household needs and to sell the surplus on the market.

Table 9: Characteristics of the household consumption typology[a]

	Diversified	Hardly self-sufficient	Self-sufficient & slightly diversified
Share of the class over the sample	**40.7%**	**27.4%**	**31.9%**
Share of the class in each agro-ecological zone:			
Coastal plain	54.5%	27.4%	18.1%
Northern highlands	42.7%	20.7%	36.6%
Plateau/South-western highlands	32.6%	26.5%	40.9%
Semi-arid/Arid	36.7%	29.5%	33.8%
Southern highlands	35.7%	26.0%	38.3%
Western highlands	31.3%	30.6%	38.1%
Share of budget allocated to non-food goods	27.1%	18.7%	24.7%
Share of budget allocated to food goods	**72.8%*****	**81.3%*****	**75.2%*****
Share of self-consumed food goods over total food budget	**17.7%*****	**27.5%*****	**64.5%*****
Share of cereal, tuber & root crops consumption value over total food value	**41.8%*****	**61.1%*****	**50%*****
Share of legumes, meat and fish over total food value	**27.1%*****	**12.1%*****	**22.2%*****
Share of vegetable & fruit consumption value over total food value	**9%*****	**9.9%*****	**8.9%*****
Equivalent adult per household	3.8**	4.2	4.1
Average off-farm income (TZS)	1005124***	379309	473445
Distance (in km) to nearest city (> 20,000 inhabitants)	43.7***	53.7***	59.7***
Distance (in km) to nearest agricultural market	77.1***	83.3	85.3
Average economic size value (in TZS)	520908	637509	1184189***
Average market orientation degree (% of total production value sold)	25.8%	25.3%	32.5%***
Crop specialization:			
Staple crops	40.9	26.4	32.8
Annual cash crops	47.7	25.5	26.8
Permanent crops	54.2	28.1	17.6
Mixed crops	32.4	29.7	37.9

[a] Figure in bold are the variables used for the cluster analysis.

5 Layout and implementation of simulated scenarios

As explained in an earlier section, the information for which the model was calibrated stems from the year 2012/2013. By calibration, we mean that the simulated nitrogen application rate and simulated crop acreages for every individual sampled farm are exactly equal to their observed values (from the survey). This phase is called 'base year' and is used as a starting point for generating the 'baseline' scenario, which is considered as a reference point for comparing the effects of the simulated scenarios.

Below, we describe the main assumptions made in setting the produce cess rate under the base year, baseline and simulated scenarios.

It is important to recall that the produce cess rates are quite heterogeneous across districts and crops. Information on these rates is, however, not available either in the World Bank LSMS-ISA survey or in the statistical database. To set the cess rate in the base year, we used data collected by Nyange et al. (2015) on the cess rate applied in Tanzania from 2010 to 2012 by 103 LGAs spread throughout the country. The main findings from their study are that: (i) on average, the cess rate for cash crops was higher than for staple crops; (ii) the average crop cess for staple crops is often about 3%; and (iii) tea was considered an exception to the pattern for cash crops, being charged less tax than other cash crops and sometimes even less than staple crops (Nyange et al., 2014). Based on this information, we made the assumptions that, for the base year, the cess rate for staple crops and tea is equal to 3% and for cash crops (except tea) is equal to 4%. The rationale for these assumptions is that, at that time, only a few cash crops were subject to a tax rate of 5%.

The following crops are considered as staple crops: cereals, roots, tubers, bananas and pulses. Cash crops are tea, oilseeds, vegetables, sugar cane, tobacco, and perennial crops. Note that the distinction between staple and cash crops is not always straightforward, because crops that are in general used for subsistence can, in some areas and some parts of year, be produced for marketing purposes and vice versa. Here, we classify the crops between these two categories according to how the government would make the distinction when setting the cess rate for each crop category.

5.1 Baseline

The baseline is interpreted as a projection over time, covering the most probable future development in terms of technological, structural and market changes. In our case study, a continuation of current agricultural and rural fiscal policies up to 2020, taken as the time horizon for running simulations, is the principal policy assumption in the baseline. Compared to the base year, the main change in terms of produce cess representation is the adoption of a uniform cess rate of 3% for all crops and farms. This rate corresponds to the maximum cess rate adopted by the government in 2017, assuming it will continue to be implemented up to 2020.

All other parameters (e.g. prices, yields, costs, farm resource endowments, farm weighting factors) are assumed to remain unchanged between the base year and the baseline.

The other assumptions adopted are as follows.

1. Traders are assumed to fully transfer the cess to farmers (i.e. farmers pay the tax through a reduction in farm-gate prices). This assumption comes from Nyange et al. (2014), who observed that 'most if not all the cost is passed on to farmers, meaning that they end up paying at least the majority of the cess'. Inelastic supply in the short run and elastic demand tend to push the cost of the tax onto the farmers.
2. The mechanism of tax revenue collection is assumed to be efficient (i.e. we estimate the potential and not the real cess revenue for the LGAs). This assumption is made in order to provide the potential gains/losses for each policy scenario, as it is difficult to know the exact amount of tax evasion.

It also should be noted that livestock activities and large commercial farms are not included in our analysis. Moreover, given that FSSIM-Dev is a price-exogenous model, the market (price) effects of the simulated reform options are not taken into account.

5.2 Produce cess reform scenarios

Based on extensive discussion with stakeholders and researchers from the ASPIRES project and Sokoine University of Agriculture, three reform scenarios (options) in relation to produce cess rate are simulated with FSSIM-Dev and compared to the baseline.

— **NoCess scenario**: a total removal of the produce cess for all crops and districts.

— **1%Cess scenario**: a uniform reduction of the produce cess rate to 1% for all crops and LGAs.

— **NoCess_stap scenario**: a total removal of the produce cess for only staple crops and tea. For cash crops (except tea), the produce cess remains unchanged compared to baseline.

Table 10: Produce cess rate assumed in each simulated reform scenario

	Base year	Baseline	NoCess	1%Cess	NoCess_stap
Staple crops + Tea	3%	3%	0%	1%	0%
Cash crops (except tea)	4%	3%	0%	1%	3%

Once the produce cess rates are defined under each scenario, we reset the farm-gate prices assuming a full transfer of the produce cess to farmers. To illustrate that, let us assume P_c^m is the farm-gate price for crop *c* before cess reduction, and r_c^s is the case rate for the same crop *c* and scenario *s*. The farm-gate price after cess reduction for crop *c* under scenario *s*, P_c^s, can be calculated as follow:

(Eq. 11) $P_c^{BY} = P_c^m * (1 - r_c^{BY})$

(Eq. 12) $P_c^s = P_c^m * (1 - r_c^s)$

Where P_c^{BY} and r_c^{BY} are the observed prices and cess rate under the base year, respectively. From Eq. 11 we have:

$$P_c^m = P_c^{BY} / (1 - r_c^{BY})$$

And substituting in Eq. 12 gives:

$$P_c^s = P_c^{BY} \frac{(1 - r_c^s)}{(1 - r_c^{BY})}$$

As we know P_c^{BY} from the survey and r_c^{BY} and r_c^s from our assumptions (see Table 10), we can easily derive the farm-gate price after cess reduction for each crop *c* under scenario *s* P_c^s.

6 Results: potential effects of produce cess scenarios

The impacts of the simulated scenarios are represented by a set of technical indicators (land use, nitrogen use and production), economic indicators (farm income and LGA revenue) and food security and nutrition indicators (rural poverty and food consumption and intake). These indicators have been computed at both country and regional levels, by farm specialization, farm economic size and for the full distribution across the farm population. In order to make results easily understandable and comparable across scenarios, all impacts were measured as percentage changes in comparison to the baseline. We first show the absolute values for the baseline scenario.

6.1 Baseline scenario

Table 11 reports area, total production and nitrogen use, for both staple and cash crops, under the baseline scenario. From this table, it is clearly apparent that staple crops dominate the agricultural landscape in Tanzania. At the national level, staple crops represent about three quarters of total area and total crop production. In terms of area, the main staple crops are maize, followed by beans, bananas and rice. In terms of production level, the main crop is also maize, followed by bananas, rice and cassava. The main cash crops are cashew nut, followed by groundnut, cotton and tobacco.

The prominence of staple crops is observed in all regions, except for the Coastal plain where staple crops represent less than 60% of the cultivated area. Differences across regions are more obvious regarding the use of fertilizer. While, at the national level, average nitrogen use is around 8.5 kg/ha, it is four times higher in the Southern highlands and ten times lower in the Western highlands.

Table 11: Area, production, and nitrogen use for both staple and cash crops, under baseline scenario in the different regions

	Staple crops			Cash crops		
	Area (ha)	Production (ton)	Nitrogen use (kg/ha)	Area (ha)	Production (ton)	Nitrogen use (kg/ha)
Tanzania	8 377 449	8 656 155	8.3	3 133 825	2 765 162	5.1
Region						
Coastal plain	1 051 040	1 014 893	2.7	860 897	710 719	0.3
Northern highlands	478 080	728 871	14.8	80 742	84 707	2.6
Plateau/ Southwest	2 868 136	2 847 214	7.1	701 805	681 674	11.4
Semi-arid/ Arid	2 295 436	2 147 844	1.8	1 102 711	878 177	3.5
Southern highlands	907 124	1 124 119	37.8	211 219	296 452	16.0
Western highlands	777 634	793 214	0.8	176 452	113 434	0.8

Source: model results.

As expected, the differences across economic size and crop specialization are more pronounced in terms of both area and production. Although the use of fertilizer per ha is fairly similar (slightly lower for the largest economic size), the share of area/production dedicated to staple crops decreases with farm economic size. Moreover, the share of area/production dedicated to staple crops in farms specialized in annual cash crops and in permanent crops (60% and 45%, respectively) is lower than in other farm types (see Table 12).

Table 12: Area, production, and nitrogen use for both staple and cash crops, under baseline scenario according to economic size and crop specialization

	Staple crops			Cash crops		
	Area (ha)	Production (ton)	Nitrogen use (kg/ha)	Area (ha)	Production (ton)	Nitrogen use (kg/ha)
Economic size						
Small	672,183	981 485	10.1	135 117	119 954	3.7
Medium	2 170 076	2 334 470	10.9	636 197	614 270	2.5
Large	5 535 191	5 340 200	6.8	2 362 511	2 030 938	5.8
Crop specialization						
Staple crops	4 157 078	4 593 191	8.9	383 525	421 553	2.2
Annual cash crops	1 121 145	1 165 251	6.9	719 325	772 317	15.3
Permanent crops	564 177	482 898	5.3	916 008	587 043	0.6
Mixed crops	2 535 050	2 414 814	8.5	1 114 966	984 249	3.1

Source: model results.

National average farm income is around TZS 405,000 (around €162), with some discrepancy across regions, economic size and specialization as indicated in Table 13. For example, the larger the economic size of the farms, the higher the income. Furthermore, the average income of farms specialized in staple crops is lower than the income of other farm specializations.

Table 13: Economic and food security indicator values under baseline scenario

	Farm income[1]	Poverty gap (%)	**Energy intake** (Cal/equivalent Adult)	Protein intake (g)
Tanzania	405.3	50.47	1 959	77
Region				
Coastal plain	452.4	32.5	2 238	79
Northern highlands	152.2	31.1	2 172	89
Plateau/South-west highlands	501.7	52.3	1 881	73
Semi-arid/Arid	502.8	54.7	1 980	78
Southern highlands	343.6	43.7	2 109	85
Western highlands	411.5	9.3	1 836	72
Economic size				
Small	116.6	60.6	1 801	73
Medium	312.3	43.9	1 918	76
Large	824.5	48.0	2 133	81
Crop specialization				
Staple crops	323.5	58.7	1 936	75
Annual cash crops	479.5	50.6	1 852	76
Permanent crops	629.3	14.4	2 300	89
Mixed crops	451.2	39.5	2 012	79

Source: model results.

[1] Expressed in thousand TZS, farm income is defined as total revenue from agricultural activities, including sales and self-consumption, minus accounting variable costs for production activities, including costs of seeds, fertilizers, crop protection and other specific costs.

There is also significant disparity among regions and among farm types in poverty level, which ranges from 10% to 55%. However, this disparity dissipates when looking at food intake indicators.

The extreme poverty gap index is defined in FSSIM-Dev as the averaged percentage difference between farm household income per household unit per day and the extreme poverty line of USD 1.90 equivalent per person per day (TZS 4,370). For each farm, the gap is a percentage between 0 and 100% (a value of 0% implies that the household is above the extreme poverty line). The average value at the national level is 50.47%, with large differences across regions. The World Bank gives a value of 15.4% for the year 2011, which is somewhat less than the value calculated from the LSMS-ISA data. However, the latter data do not include in the sample urban households, which on average have a significantly higher income than farm households.

6.2 Land use impacts

Table 14 reports the impacts of the three simulated scenarios on crop acreage, at both national and regional levels, by economic size and by crop specialization. Results show that at national level, the change in staple and cash crop acreage is fairly limited, ranging from -0.86% to 0.32%. The change in staple crops is driven by a slight increase in maize and cassava, and a reduction in beans and other pulses. The reduction in cash crop area is driven by a reduction in groundnut, other vegetables and papaya.

At the regional level, changes are slightly larger, mainly when the tax reduction targets only staple crops (NoCess_stap scenario). This is case in the Semi-arid/Arid region, where a tax cut only for staple crops leads to a decrease in cash crop area of 1.4%, and an increase in staple crop area of 0.7%. It is also interesting to note that an equal tax deduction for both staple and cash crops (NoCess and 1%Cess) would favour staple crops in some regions (e.g. Southern highlands) and cash crops in other regions, depending on the dominance of the crop category in each region.

Regarding farm economic size, the effects tend to be fairly homogenous, although large farms report slightly greater reallocated areas than small and medium-sized farms, especially under the NoCess_stap scenario where the rise in staple crops is about 0.48%. This is because large farms are market-oriented and thus benefit more from the reduction in produce cess, compared to small/medium farms which are more oriented towards providing supplementary food for their families. Table 13 also shows that farms responding most to the reform options, in terms of land reallocation, are those specialized in annual cash crops. The land allocated to staple crops in these farms increases by 1.01%, to the detriment of cash crops which decrease by 1.57% under the NoCess_stap scenario.

Overall, the reallocation of land is fairly limited, especially at aggregated (national and regional) levels, and under the first two scenarios (NoCess and 1%Cess scenarios). This is because, firstly, produce cess reduction is applied to all crops; secondly, the percentage reduction in produce cess is not so big as to lead to a large change in cropping pattern, as could happen for example with the adoption of a new technology; and thirdly, the produce cess reduction seems to stimulate intensification (i.e. an increase in land productivity; see below) rather than land reallocation.

It is important to note that our analysis assumes a fixed farm structure, implying that land extension/expansion in response to produce cess reduction is not considered. This may lead to an underestimation of the simulated impacts of the land effect, mainly for farms without fallow land in the baseline.

Table 14: Land use change under simulated scenarios, by region, economic size and crop specialization (percentage change relative to the baseline)

	Staple crops			Cash crops		
	No Cess	1% Cess	NoCess_stap	No Cess	1% Cess	NoCess_stap
Tanzania	0.037	0.043	0.322	-0.098	-0.116	-0.862
Region						
Coastal plain	-0.173	-0.125	0.107	0.211	0.153	-0.13
Northern highlands	0.037	0.019	0.124	-0.218	-0.112	-0.733
Plateau/ Southwestern highlands	-0.105	-0.0387	0.194	0.43	0.158	-0.794
Semi-arid/ Arid	0.334	0.257	0.704	-0.696	-0.536	-1.47
Southern highlands	0.16	0.122	0.275	-0.686	-0.522	-1.18
Western highlands	-0.18	-0.135	0.138	0.793	0.569	-0.606
Economic size						
Small	-0.075	-0.045	0.009	0.375	0.224	-0.047
Medium	-0.08	-0.052	0.023	0.276	0.177	-0.077
Large	0.096	0.091	0.478	-0.225	-0.214	-1.12
Crop specialization						
Staple crops	-0.01	0.006	0.109	0.011	-0.069	-1.18
Annual cash crops	0.323	0.325	1.01	-0.504	-0.507	-1.57
Permanent crops	-0.142	-0.105	0.182	0.087	0.064	-0.112
Mixed crops	0.026	0.012	0.4	-0.059	-0.027	-0.909

Source: model results.

6.3 Production impacts

Tax reduction is an incentive to sell more, and hence to produce more, through both intensification of the cropping system and reallocation/expansion of land (through bringing fallow land into cultivation). Given the assumed fixed structure of the farm, we expect to capture the intensification effect better than the reallocation/expansion effect, which is probably underestimated as seen above. So, the question is which crop category will gain more from this tax reform, given the set of land, labour, consumption and other constraints faced by farm households. For instance, cash crops are expected to gain more from the tax reform as they are market-oriented, but on the other hand high production of staple crops may also be directly translated into marketable surplus and thus profit from the tax reduction. Moreover, a large increase in cash crop area and production, to the detriment of staple crops, may negatively impact household consumption. Furthermore, the decision to intensify crops will depend on crop response to nitrogen use. For example, we may expect a one unit increase in fertilizer to raise maize yield much more than for another cereal such as millet. This is to say that it is not straightforward to anticipate the whole production effects of tax reduction or removal without a simulation model.

Table 15 shows the changes in production and nitrogen use, under each simulated scenario, at national and regional levels. At national level, a total removal of the cess (NoCess scenario) leads to an increase in production, for both staple and cash crops, of around 5%; meanwhile, a reduction of cess from 3% to 1% (1%Cess scenario) raises production by only 3.5%, which is still not negligible. Furthermore, we observe that the changes are slightly bigger for staple crops. Yield response to nitrogen is, in fact, slightly higher for staple crops than for cash crops, leading to a higher use of nitrogen on the former crop type. As expected, the removal of tax for only staple crops (NoCess_stap scenario) significantly boosts their production through an increase in nitrogen use. On the other hand, the production of cash crops is reduced by 1.23%. Note that production of tea, a cash crop that benefited from the same reduction as staple crops, does not benefit much from it. The increase is only 0.1%, 0.07% and 0.04% for the NoCess, 1%Cess and NoCess_stap, respectively.

To better understand the yield changes provoked by the simulated scenarios, we show in Figure 8 how, at national level, the increase in average nitrogen application is translated into average yield enhancements for the NoCess scenario (only crops with the largest changes are reported). It appears that abolition of the produce cess leads to an increase in fertilizer application of up to 33% for onions, 30% for tomatoes, 26% for paddy and 22% for maize. These increases seem quite large in relative terms, but one should keep in mind that the observed fertilizer application rates in the baseline are fairly low for the majority of the crops. It translates into yield enhancement of 23% for onions, 8% for tomatoes, 3% for paddy and 5% for maize.

At regional level, the effect of the simulated scenarios on production is quite heterogeneous, ranging from 1.2% in the Semi-Arid/Arid zone under the 1%Cess, up to 11.2% in the Coastal plains under the NoCess_stap scenario. The increase in nitrogen application also varies across regions, ranging from 5% in the Southern highlands up to 136% in the Coastal plains in the case of the NoCess_stap scenario (the nitrogen use in the baseline is 2.71 kg/ha, which explains the large increase).

Table 15: Regional production change under simulated scenarios (percentage change relative to the baseline)

		Staple crops			**Cash crops**		
		No Cess	1% Cess	NoCess_stap	No Cess	1% Cess	NoCess_stap
Tanzania	Production	5	3.54	5.38	4.97	3.27	-1.23
	Nitrogen use	24.1	15.5	24.5	18.5	12	-0.69
Region							
Coastal plains	Production	10.09	7.64	11.25	7.32	5.27	-0.05
	Nitrogen use	135.38	85.97	136.98	127.38	90.84	0.06
Northern highlands	Production	9.36	6.13	9.46	1.02	0.72	-0.27
	Nitrogen use	51.74	33.51	52.23	4.33	3.57	-9.56
Plateau/ South-west highlands	Production	4.09	2.92	4.36	8.83	5.45	-1.08
	Nitrogen use	28.44	17.95	28.69	20.84	13.16	-0.50
Semi-arid/ Arid	Production	1.76	1.22	2.08	-0.13	-0.23	-2.73
	Nitrogen use	34.65	22.74	34.60	12.12	8.30	-0.14
Southern highlands	Production	5.35	3.64	5.47	3.41	2.27	-0.34
	Nitrogen use	5.08	3.41	5.47	0.92	0.21	-1.28
Western highlands	Production	6.09	4.25	6.60	13.56	9.31	-0.83
	Nitrogen use	39.39	27.22	39.50	338.53	230.21	-0.70

Source: model results.

The production changes, gathered by economic farm size and crop orientation, are given in Table 16. This shows the extent to which large farms will benefit more from the reform options compared to small ones. This difference in impact is however not surprising, and it is explained by the fact that the volumes sold on the market are definitely not the same across farms, and thus that total savings allowed by the cess reforms are much higher for large farms than small ones.

The direction and magnitude of changes are quite similar across crop specializations. This is because the cess reforms target all crops in the first two scenarios, and a large range of crops in the third one (NoCess_stap), and therefore all farm specializations are affected in some way. The exception is under the NoCess_stap scenario, where farms specialized in annual cash crops seem to be much more negatively affected than the other ones. Also, it is interesting to note that, with a uniform reduction in cess rate for staple and cash crops, farms specialized in staple crops will mainly enhance staple crops (under the NoCess scenario, 5.05% increase in staple crops vs 3.03% increase in cash crops), while farms specialized in annual cash crops will mainly boost cash crops (under the NoCess scenario, 3.74% increase in staple crops vs 4.43% increase in cash crops).

Table 16: Production change under simulated scenarios, by economic size and crop specialization (percentage change relative to the baseline)

		Staple crops			Cash crops		
		No Cess	1% Cess	NoCessst ap	No Cess	1% Cess	NoCess_st ap
Economic size							
Small	Production	1.30	0.85	1.39	2.26	1.34	-0.19
	Nitrogen use	11.22	7.33	11.35	21.81	14.28	-0.46
Medium	Production	4.06	2.73	4.21	4.44	3.09	-0.13
	Nitrogen use	15.98	10.33	16.00	24.13	15.85	-0.40
Large	Production	6.10	4.38	6.63	5.29	3.44	-1.62
	Nitrogen use	31.99	20.50	32.65	17.70	11.52	-0.74
Crop specialization							
Staple crops	Production	5.05	3.62	5.36	3.03	1.81	-0.68
	Nitrogen use	26.42	17.52	26.90	33.78	16.59	-7.20
Annual cash crops	Production	3.74	2.55	4.36	4.43	2.48	-2.74
	Nitrogen use	26.79	16.74	28.37	17.56	11.55	-0.39
Permanent crops	Production	6.71	4.77	7.27	3.64	2.62	-0.23
	Nitrogen use	14.08	8.96	13.99	20.15	13.60	-0.08
Mixed crops	Production	5.19	3.62	5.54	7.02	4.90	-.87
	Nitrogen use	20.69	12.57	20.54	17.45	12.26	-.20

Source: model results.

Figure 8: Changes in nitrogen use and yield for selected crops under the NoCess scenario (percentage change relative to the baseline)

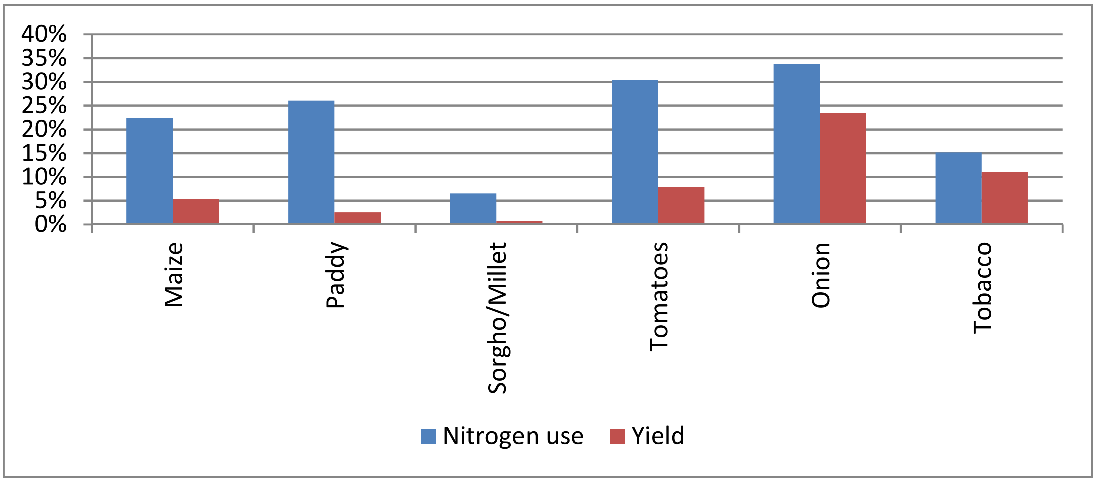
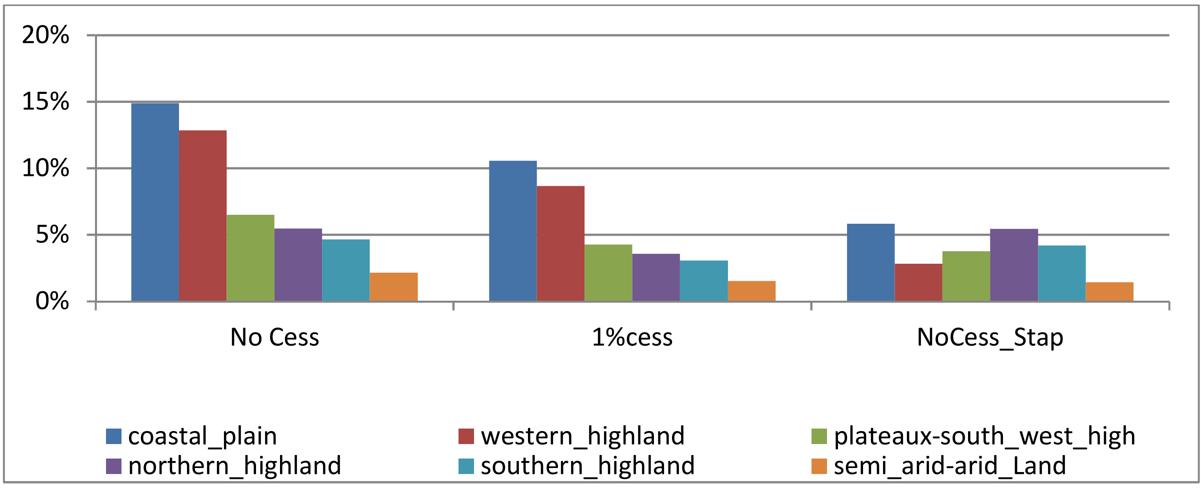


Figure 9 shows the impact of the simulated scenarios on the value of crop production in each region. While for all regions the NoCess scenario has, as expected, the biggest impact, the ranking of the two other scenarios varies across regions. For Coastal plains, Western highlands, and Plateau/South-western highlands, the 1%Cess scenario has a bigger effect on production value (an increase of 10.%, 8.5% and 4%, respectively) than the NoCess_Stap scenario (5.5%, 2.8% and 3.7%). Conversely, for Northern highlands and Southern highlands, the NoCess_Stap scenario has more impact (an increase of 5.5% and 4%, respectively) than the 1%Cess scenario (3.5% and 3%). Those differences are driven by the current regional characteristics, mainly in terms of land use and share of staple/cash crops over total land.

Figure 9: Changes in production value, by region, under simulated scenarios (percentage change relative to the baseline)



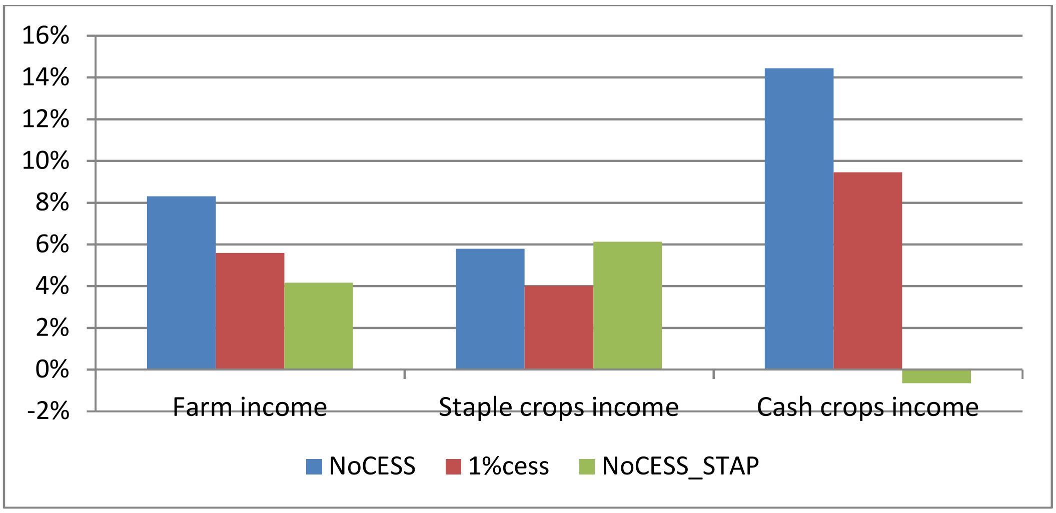
6.4 Economic impacts

One of the main goals of produce cess reform is the enhancement of farm income through increase in marketed production. Therefore, in this section, we attempt to explore whether such a goal was achieved, by assessing the impacts of the simulated scenarios on farm income and its decomposition into staple and cash crop income.

Figure 10 presents income changes at national level under the three simulated scenarios. From this figure it is clearly seen that, firstly, the land use and production effects reported above largely explain the income changes, and secondly, the NoCess scenario engenders the biggest impact, with an 8% increase in farm income, followed successively by the 1%Cess with +5.6% and the NoCess_Stap scenario with +4%. The NoCess_Stap scenario has less impact than the 1%Cess scenario because the share of marketed staple crops is much lower than the share of marketed cash crops. Thus, an increase in production of one unit has more income effect for cash crops than for staple crops, and therefore a reduction or a removal of produce cess provokes a larger increase in income for the former.

The removal of cess only for staple crops, under the NoCess_Stap scenario, leads as expected to an increase in production and income from staple crops, to the detriment of cash crops, which leads to a slight reduction in income from this crop type (around -0.6%).

Figure 10: Farm income changes under simulated scenarios (percentage change relative to the baseline)



When looking at farm income changes by region in Figure 11, the regional impact appears quite marked but heterogeneous, mainly under the NoCess scenario. The biggest positive impact occurs in Northern highlands with +22%, followed by Coastal plains and Western highlands with +13% and +12%, respectively. The dominance of staple crops in these regions explains a large part of this impact. For regions strongly relying on staple crops, such as the Southern_highlands and Northern_highlands regions, the NoCess_Stap scenario generates larger impact than the 1%Cess scenario. For the remaining regions, the ranking of simulated scenario impacts follows the same order observed at national level, with some differences in terms of magnitude.

Figure 11: Farm income changes, by region, under the simulated scenarios (percentage change relative to the baseline)

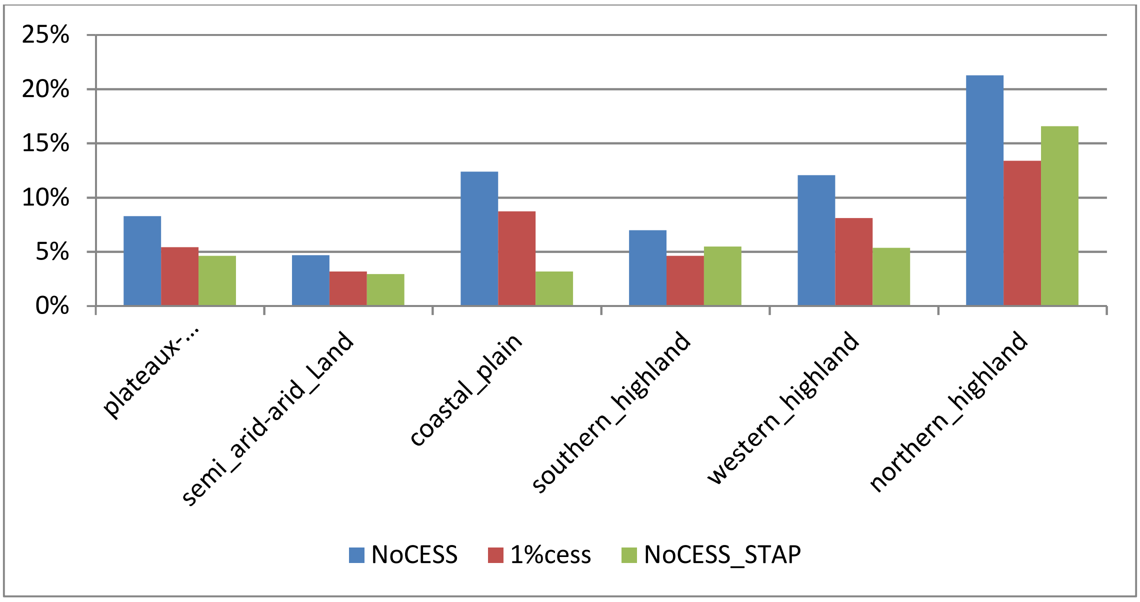
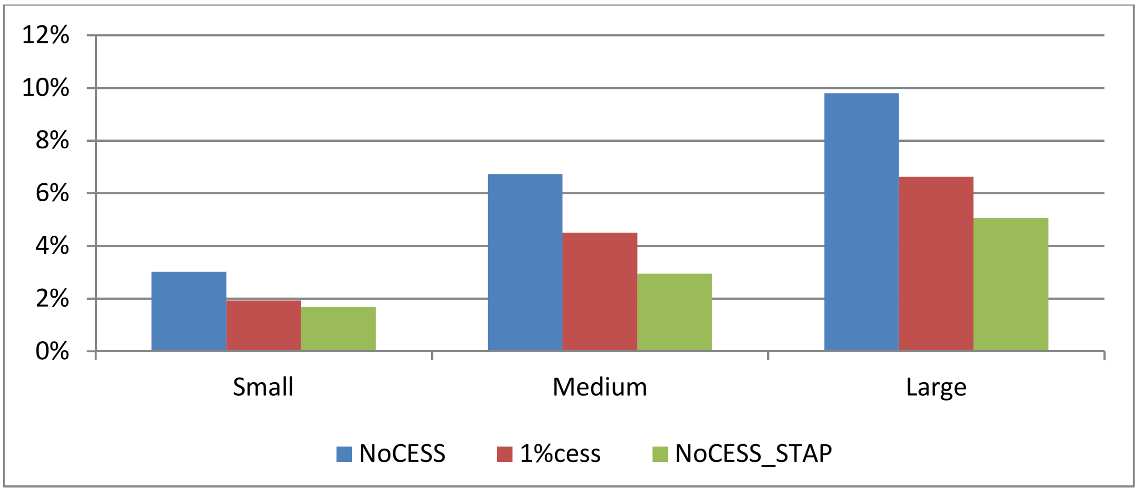


Figure 12 displays the income effects of the simulated scenarios by farm economic size. From this figure, one can observe that: (i) all farm economic sizes benefit from the simulated reform options, to different degrees; (ii) the NoCess scenario engenders the largest farm income increase, as expected, followed by the 1%Cess scenario; and (iii) the larger the economic size, the higher the income increase. In other words, reduction or elimination of produce cess tends to favour large farms (in both absolute and relative terms) and to increase disparity among farms. In fact, for the large farms, the farm income increase ranges from 5% to 9% depending on scenario, while for the small farms this increase is only between 1.5% and 3% despite their lower farm income (see Table 13). This is however not surprising, because large farms are market-oriented and thus benefit more from the reduction in produce cess compared to small farms, which are more oriented toward providing supplementary food for their households. In fact, as the produce cess is a flat tax, it is a regressive taxation that disproportionally burdens small farmers.

Figure 12: Farm income changes, by economic size, under simulated scenarios (percentage change relative to the baseline)

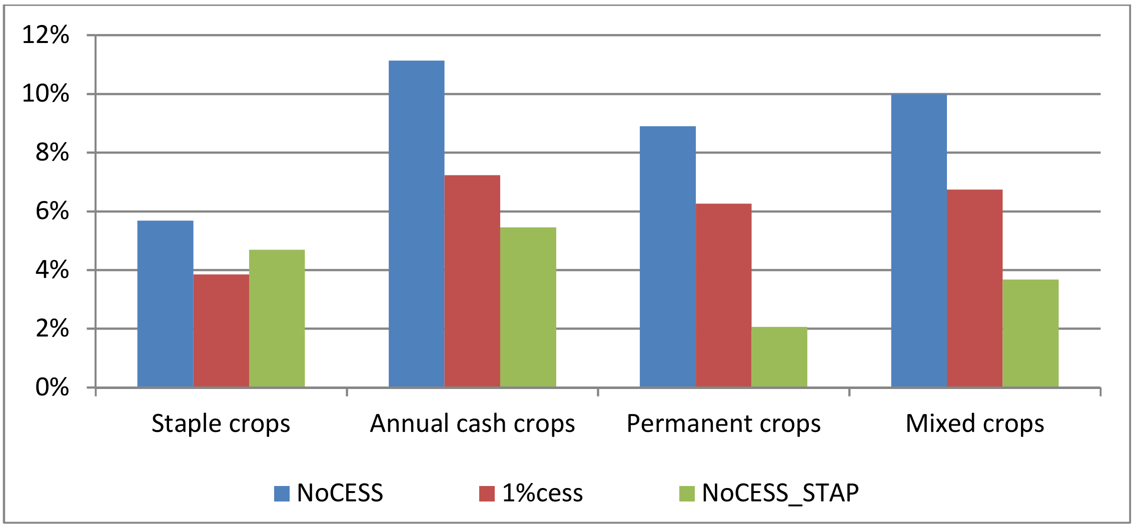


It is also interesting to note that the NoCess_Stap scenario creates less variation among economic sizes in terms of income increase. However, it is also the scenario that causes the lowest income effect, whatever the farm economic size.

Regarding crop specialization (Figure 13), simulation results shows that all farm specializations improve their incomes under the simulated reform options, to different levels. Farms specialized in cash crops and in permanent crops tend to gain more from reduction or removal of the produce cess. This is not unexpected, given that the majority of cash but also permanent crops are market-oriented, and therefore a rise in their prices will directly boost their production and income, contrary to staple crops which are mainly used for self-consumption. Moreover, given that most of the farms produce both staple and cash crops, their income increases even when cess reduction affects only staple crops (NoCess_Stap).

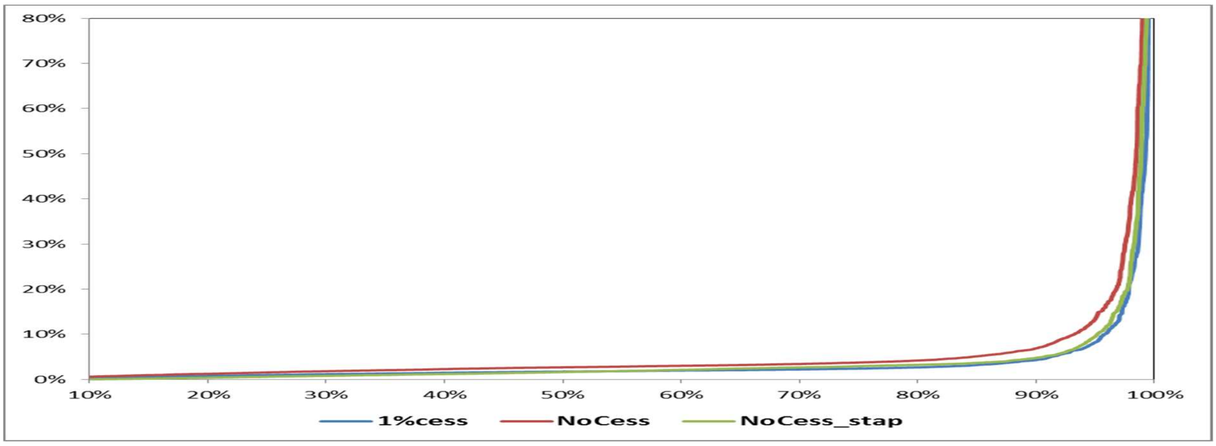
As projected, the NoCess scenario is the best scenario for all farm specializations, followed by the 1%Cess scenario, except for farms specialized in staple crops. For the latter, income raises by 5.6%, 3.8%, and 4.6% under NoCess, 1%Cess and NoCess_Stap scenarios, respectively. This result makes sense, since the NoCess_Stap scenario increases the competitiveness of staple crops. For the other farm types, an equal reduction in cess rate for staple and cash crops (1%Cess scenario) stimulates cash crops more (see Table 166 above), which generate higher incomes and thus engender a bigger income effect. Furthermore, a uniform cess rate of 1% leads to smoother relative income changes among farm specializations, ranging from +4% to +7%.

Figure 13: Farm income changes, by crop specialization, under the simulated scenarios (percentage change relative to baseline)



One of the big advantages of the FSSIM-Dev model is that it runs at individual farm household level. Hence, one can zoom in to see the effects of the simulated scenarios on every single sampled farm household. Figure 14 shows the distribution of the income change relative to the baseline, across the total farm population. Only 5% of the farms experience a substantial increase in income (more than a 25%) with reduction or abolition of produce cess. For the remaining 95% of farmers, income increase is less than 10% or even close to zero, due to low market participation and/or high production costs. This figure also shows that total removal of produce cess (NoCess scenario) has the biggest positive effect on all farms (red line), in comparison to the other two scenarios which have pretty much the same distributional effects.

Figure 14: Distribution of income change caused by the simulated scenarios, across the whole farm sample (percentage change relative to the baseline)



Up to now, we have only discussed the benefits of each simulated scenario, without considering the cost in terms of loss of revenue for the LGAs. Yet this is an important aspect to consider, because whatever the selected reform option, LGAs need to know the amount of revenue they will lose and how to cover it. Hence, it is important to calculate the total 'cost' of each simulated policy and compare it with the total benefit. From a cost–benefit perspective, the most efficient policy option is the one that best achieves the targeted benefit at lowest cost. We measure policy efficiency as the ratio of aggregate change in farm household income (i.e. income gain) to total costs supported by the LGAs (i.e. loss of revenue).

Obviously, the scenario that provides the highest gain is also the most costly (Figure 15). Indeed, the NoCess scenario leads to a total cost of TZS 86 billion and a gain of TZS 214 billion. Interestingly, the costs of the two other scenarios are quite similar: TZS 55 billion for the 1%Cess scenario and TZS 53 billion for the NoCess_Stap scenario. However, the former scenario leads to much higher gains: the 1%Cess scenario produces a total gain of TZS 144 billion, while the NoCess_Stap scenario leads to a total gain of TZS 107 billion.

Therefore, in terms of cost–benefit analysis measured by the income gain/loss of revenue ratio, the 1%Cess scenario has the best ratio (2.61), even better than the NoCess scenario (2.49). With a value close to 2, the ratio of the NoCess_Stap scenario is the lowest (Figure 16). This ratio could be understood as how much farm income increases when reducing produce cess by TZS 1.

Figure 15: Comparison of the policy scenarios in terms of total farmer gains and total LGA losses

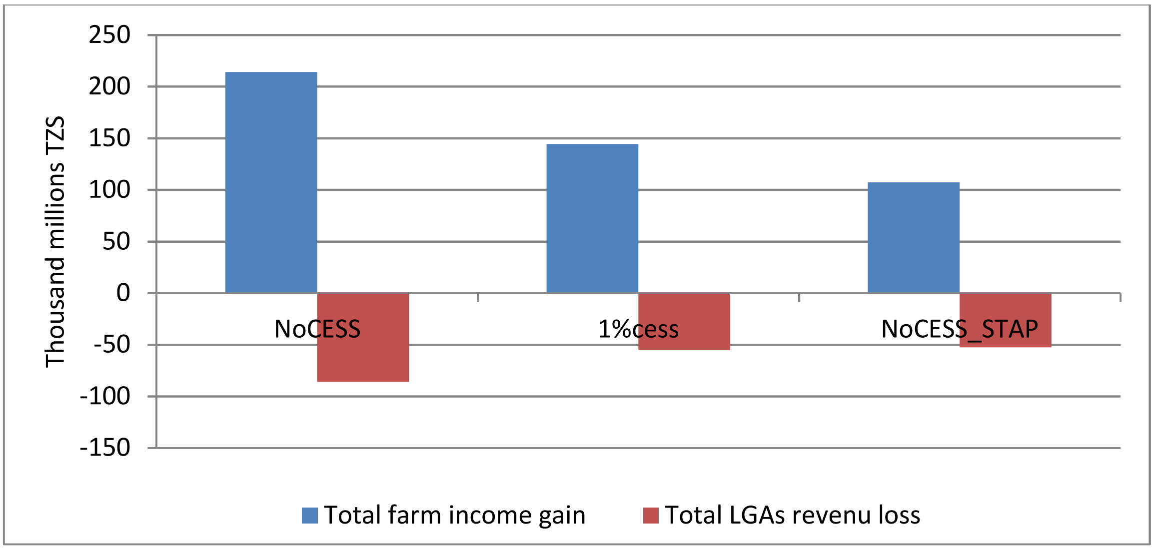
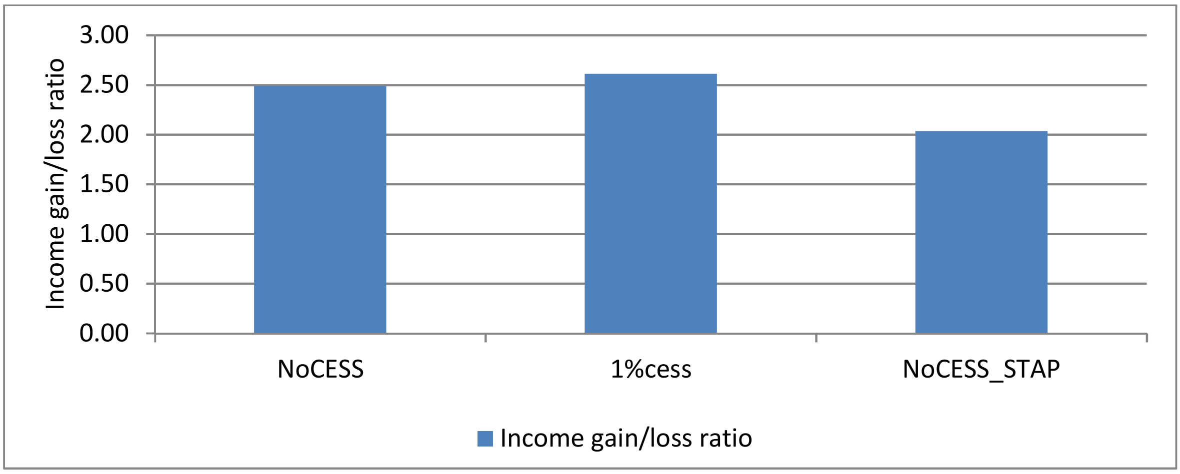


Figure 16: Gain/loss ratio for the simulated policy scenarios



6.5 Food security and poverty impacts

The impacts of the simulated scenarios on rural poverty and on food and nutrition security are assessed using three indicators, calculated at individual household level and then aggregated at regional and country levels: extreme poverty gap index, energy intake, and protein intake.

As explained above, the extreme poverty gap index is measured as the averaged percentage difference between farm household income per household unit per day and the extreme poverty line of USD 1.90 equivalent per person per day (TZS 4,370). Globally, the impact of the simulated scenarios on rural poverty (proxied by the extreme poverty gap index) is strongly correlated to farm income effect, but is quite limited at national level. It ranges from -0.2% under the NoCess_Stap scenario to -0.37% under the NoCess scenario (Figure 17). At regional level, the effects are rather thin. The largest impact is in the Semi-arid/Arid region with a change of -0.4% (Figure 17). Farms specialized in annual cash crops and in permanent crops, as well as large farms, register the highest change in the extreme poverty gap, ranging between -0.2% and -0.7%, because they benefit the most from cess reduction or removal (Figure 18 and Figure 19).

Overall, the impact on poverty is rather limited for the different farm types and for all regions (improvement is than less 1%), confirming that reducing or removing produce cess is not the best policy option for rural poverty reduction. This is also because the scale of the tax reduction is not big enough to observe a significant impact.

Figure 17: Effects of the simulated scenarios on rural poverty, at both national and regional levels

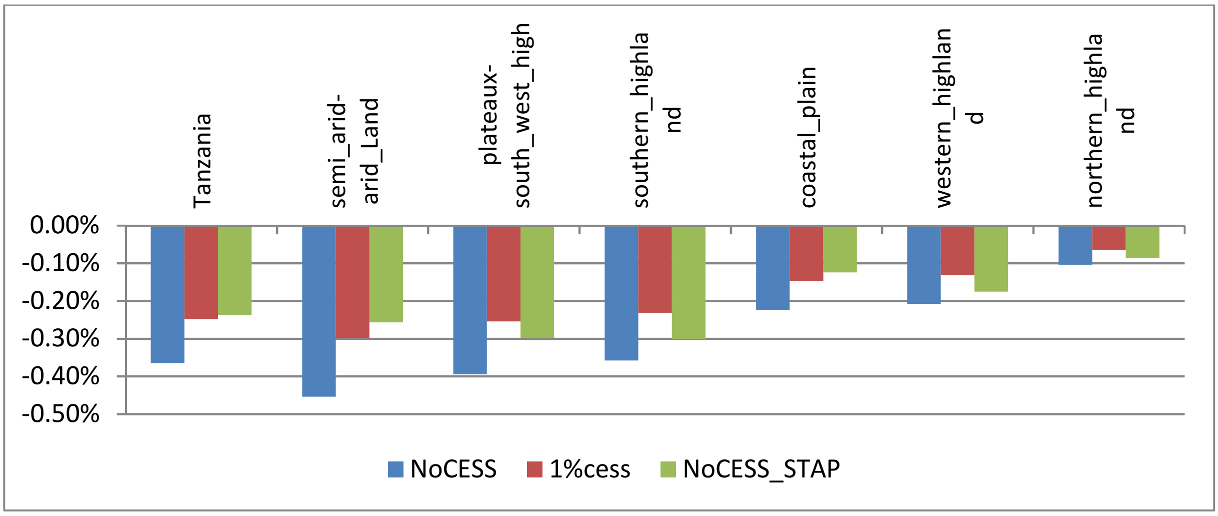


Figure 18: Effects of the simulated scenarios on rural poverty, by farm economic size

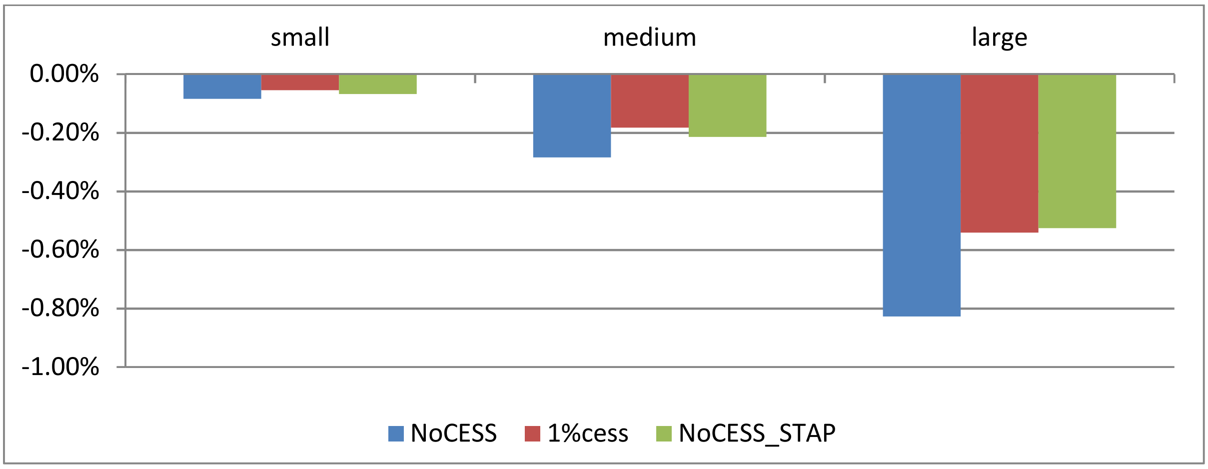
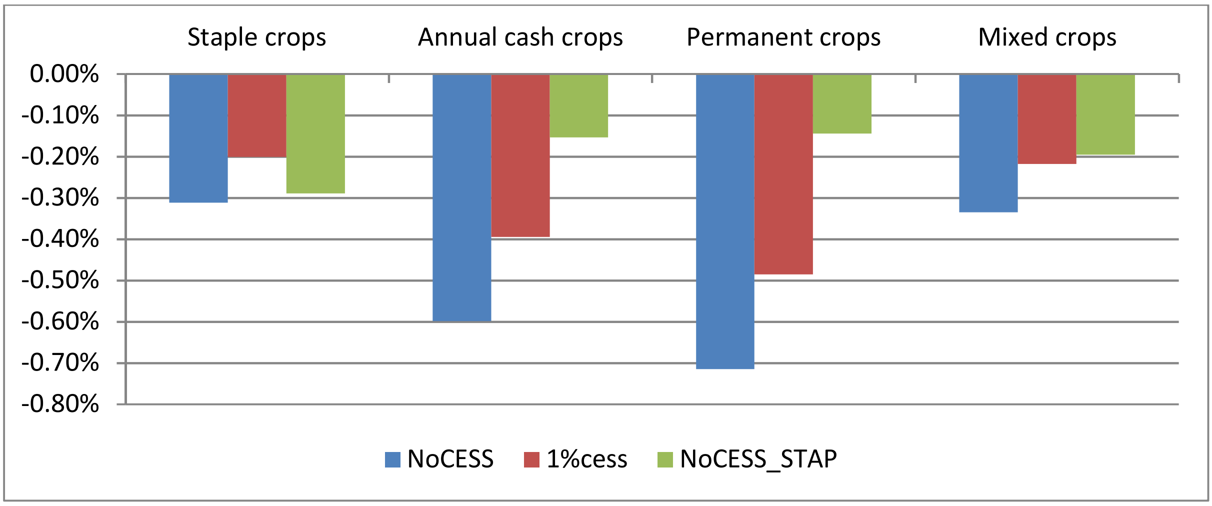


Figure 19: Effects of the simulated scenarios on rural poverty, by crop specialization



The use of the FSSIM-Dev nutrition module allows us to calculate the impact of the scenarios on selected food and nutrition security indicators, such as energy intake and protein intake. The results are given in Table 17.

The production and income effects shown above are expected to have a positive impact on farm household consumption, and thus on food and nutrition indicators. However, looking to simulation results, one can observe that the impact on household food security is quite small, despite some variation by region, economic size and crop specialization. As for the poverty gap index, the largest impacts are experienced under the NoCess scenario, for the Coastal plain region (+2%), for large farms (+2.5%), and for farms specialized in permanent crops (+2%). This leads to the conclusion that reducing or removing produce cess will not be enough to improve food and nutrition security among Tanzanian farm households.

Table 17: Food intake changes under simulated scenarios by region, economic size and crop specialization (percentage change relative to the baseline)

	NoCess		1%Cess		NoCess_stap	
	Energy intake	Protein intake	Energy intake	Protein intake	Energy intake	Protein intake
Tanzania	1.19	1.16	0.6	0.6	0.9	0.8
Coastal plain	2.09	1.92	1.49	1.37	0.63	0.56
Northern highlands	0.19	0.20	0.11	0.12	0.12	0.13
Plateau/South-west highlands	1.35	1.40	0.90	0.97	0.77	0.85
Semi-arid/Arid	0.64	0.62	0.43	0.41	0.39	0.38
Southern highlands	0.88	0.84	0.59	0.56	0.69	0.66
Western highlands	1.73	1.87	1.17	1.26	0.70	0.78
Economic size						
Small	0.17	0.17	0.11	0.11	0.09	0.09
Medium	0.91	0.85	0.61	0.57	0.36	0.35
Large	2.51	2.48	1.74	1.74	1.31	1.34
Crop specialization						
Staple crops specialist	0.67	0.62	0.46	0.43	0.57	0.53
Annual cash crops specialist	1.44	1.39	0.93	0.90	0.60	0.59
Permanent crops specialist	2.03	1.93	1.42	1.35	0.49	0.57
Mixed crops specialist	1.73	1.73	1.19	1.21	0.62	0.70

Source: model results

7 Conclusion and limitation of the study

This report presented the results of a comprehensive analysis aiming to *ex ante* assess the impact of reduction or removal of the agricultural produce cess (tax) in Tanzania, using the farm household model FSSIM-Dev. The produce cess is a levy charged by local government authorities (LGAs) on the value of marketed agricultural production. Even though traders are statutorily obliged to pay this tax, it has been shown that it is actually the farmers who pay most, if not all, of it through an equivalent reduction in the farm-gate price offered by traders. Although it constitutes a significant source of revenue for many LGAs, the produce cess has been strongly criticized by farmers, agribusiness and stakeholders for hindering the competitiveness of Tanzanian agriculture, reducing farmers' incomes and their incentive to produce more commodities, and worsening food insecurity and poverty for consumers.

In 2017, the government of Tanzania amended the Local Government Finance Act (2017/18) to reduce the produce cess from 5% to 3% of the farm-gate price, and now it plans to go even further by reducing the cess rate in 2020 and also by harmonizing it among crops and LGAs. Several options are currently under discussion and this report proposes an *ex ante* impact assessment of the main ones, namely: (i) full removal of the produce cess for all crops and LGAs (NoCess scenario); (ii) removal of the produce cess only for staple crops (NoCess_Stap scenario); and (iii) reduction of the produce cess rate from 3% to 1% on both staple and cash crops (1%Cess scenario). To assess the impact of these different options, we used the farm household model FSSIM-Dev and microdata from the LSMS–ISA survey implemented by the World Bank for 2012/13. 3,134 farm households spread out across all regions of the country are individually modelled and their results are aggregated to quantify the impact of simulated options for the whole country.

Given the nature of the scenarios simulated, we did not expect to find significant impact at the farm level. Yet the main finding of this impact assessment is that reduction or removal of the agricultural produce cess in Tanzania would lead to the following impacts.

(i) At the national level, intensification in the cropping system through an increase in nitrogen use of between 13% and 20% depending on the scenario. This intensification is translated into an increase in crop yields of between 3.5% and 5%. The simulations also show that the intensification occurs mainly for staple crops, whatever the scenario chosen.

(ii) At the regional level, an increase in production of both staple and cash crops, ranging between -1% and 13.5% depending on scenario and region. These regional effects are due to the strong regional specificities that occur in Tanzania.

(iii) The increase is driven by the rise in land productivity (through higher use of nitrogen per ha), rather than area expansion (through bringing fallow land into cultivation) and/or area reallocation. The increase in production also leads to a rise in market participation, manifested by a shift in farm household status from self-sufficient to net seller for some staple crops.

(iv) An improvement in farm income at various levels, from the individual farm household up to regional and national levels. The increase in farm income is assessed to be between 3% and 21% depending on scenario and region. The largest impact at the national level is registered under total removal of the cess, with an average increase of 8%. The regions most positively affected are the Northern highlands and Coastal plain, namely due to the dominance of cash crops in these regions. The largest increase in income is experienced by farms specializing in annual cash crops, and large farms (i.e. farms with economic size > TZS 700,000), because these farms are market-oriented and thus benefit more from the reduction in produce cess than small farms and other specialized farms which are more oriented towards providing supplementary food for their households. At individual farm household level, the income impact could be more pronounced (an increase of more than 25% in farm income), although 95% of the farms will experience an income increase of less than 10%.

(v) A uniform cess rate of 1% for both staple and cash crops (1%Cess scenario) is the most efficient policy option, as it has the highest cost–benefit ratio of 2.61. We measure policy efficiency as the ratio of the aggregate change in farm household income (i.e. income gain) to total costs supported by the LGAs (i.e. loss of revenue).

(vi) A rather limited impact on food security and rural poverty reduction (improvement of less than 1%). This leads to the conclusion that reducing or removing produce cess is not sufficient as a policy option to reduce poverty or improve food and nutrition security among Tanzanian farm households.

These findings confirm the relatively positive effects of produce cess reduction or abolition, in increasing productivity and production for both staple and cash crops and in enhancing farm performance. However, given that the produce cess is levied on marketed products, its reform would yield greater benefit for large farms, which are market-oriented, rather than small farms. Although some small farms may also gain from the reform, by increasing their market participation and their surplus, their gain remains low compared to large farms. Such reform may increase disparities among farms, particularly if a part of the tax collected by the LGAs was used to directly or indirectly support smallholders. Moreover, according to our findings, this reform cannot be considered an appropriate solution to reducing rural poverty and improving food and nutrition for farm households, although one should recognize that this is not one of the objectives of the cess reform.

These findings must however be considered with some caution, on account of the model's assumptions and data limitations. First, the heterogeneity among LGAs in terms of implementation of produce cess is not fully considered. Second, given that FSSIM-Dev is a price-exogenous model, the market (price) effects of the simulated reform options are not taken into account, which could lead to overestimation of the simulated impacts. A third potential caveat to our analysis is that we assume a fixed farm structure, implying that expansion of agricultural land in response to the reduction in produce cess is not considered. This may lead to underestimation of the simulated impacts, mainly for farms faced with binding land constraints. Fourth, the 2012/13 Tanzania National Panel Survey includes only small to medium farms; large commercial farms, which would gain most from the cess reform, are underrepresented in the database. Finally, the poor quality of input data remains a serious limitation. A careful analysis of each of these limitations is therefore needed when analysing the simulation results.

Despite these limitations, our report provides insights into the potential effects of the cess reform options at different levels, from farm to region and up to country level. The simulation results presented here could be useful to policymakers currently developing programmes and policies to enhance competitiveness and sustainability in the farming sector in sub-Saharan African countries.

Beyond analysing the effects of selected policy options, this report highlights the potential of this kind of modelling approach for making finer policy analyses and for providing policymakers with useful insights into how and where policy options may be expected to be most effective.

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List of abbreviations and definitions

AEZ	agro-ecological zone
ASDP	Agricultural Sector Development Programme
ASPIRES	Agriculture Sector Policy and Institutional Reforms Strengthening
DG DEVCO	Directorate General International Cooperation and Development
EA	enumeration area
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FSSIM-Dev	Farming System Simulator for Developing Countries
GDP	gross domestic product
HPD	highest posterior density
JRC	Joint Research Centre of the European Commission
LGA	local government agencies
LSMS-ISA	Living Standards Measurement Study – Integrated Surveys on Agriculture
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
PMP	Positive Mathematical Programming
TSOV	total standard output value
TZS	Tanzanian shilling
USD	US dollar

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