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An economic assessment of the impact of climate change on the Gambia's agriculture sector: a CGE approach

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Abstract

Purpose – Climate change and its imminent threat to human survival adversely impact the agriculture sector. In an impoverished country like The Gambia, economic costs of climate change are colossal. This study aims to establish a computable general equilibrium (CGE) model for The Gambia's agriculture sector to examine the effects of climate change on crops, livestock and sea-level rise.

Design/methodology/approach – This study used a CGE model with other climate change impact models to compute the impacts of climate change on The Gambia's agriculture sector. The social accounting matrix calibrates the results from the various models, thereby generating the baseline results which exemplify a "steady-state" and policy shock results illustrating the medium- and long-term effects of climate change on the country's agriculture sector.

Findings – The baseline results indicate the status quo showing the neglect of the agriculture sector due to limited investment in the sector. Hence, the sector is the "hardest hit" sector as a result of climate change. When the model factored in climate change in the medium term (2055) and long term (2085), the macroeconomic indicators of gross domestic product, national savings, wages, disposable income and consumer price index deteriorated, elucidating the vulnerability of the economy to climate change. The consumption of groundnuts, cattle and fish will decline by 5%, 5% and 4%, respectively, in the long term. However, the production of all agricultural commodities will decline by an average of 35% for the same period. The results for international trade show that exportation would decline while importation will increase

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over time. The general price level for agricultural commodities would increase by 3% in 2055 and 5% in 2085. Generally, the results manifest the severity of climate change in the agriculture sector which will have a multiplier effect on the economy. The impact of climate change would result in agriculture and economic decline causing hunger, poverty and human misery.

Originality/value – The caveat of this study revealed the nuances not captured by previous Gambian climate change studies, thus the novelty of the study.

Keywords Climate change, CGE, Economic performance, Agriculture sector, The Gambia

Paper type Research paper

1. Introduction

1.1 Study objective and scope

The objective of the paper is to empirically assess the economic impact of climate change on The Gambia's agriculture sector. Furthermore, the study attempted to establish a computable general equilibrium (CGE) model for the country's agriculture sector to examine the effects of climate change on crops, livestock and sea-level rise, thus proffering sound policy suggestions and recommendations on how to economically manage the impacts of climate change in The Gambia.

The paper's focus is exclusively and exhaustively on the agriculture sector's trends and performance over time. The paper uses a novel constructed social accounting matrix (SAM) to provide a meticulous account of economic and agricultural output given the impact of climate change. The study also uses mathematical approaches essential for GCE computation. These approaches were necessary because the study involved quantitative and monetary impacts thus estimating the costs of climate change on The Gambia's agriculture sector. There exist limited studies on climate change's impact on agriculture in the country. The approach of the existing studies are not scientifically rigorous and robust, hence their inadequacy and inaccuracy in providing a holistic scientific prediction of the effect of climate change in the country as in the case of Kutir *et al.* (2015), Ampomah *et al.* (2012), Bagagnan *et al.* (2019), Amuzu *et al.* (2018), Sanneh *et al.* (2014).

1.2 Location and topography of The Gambia

The Gambia is at the western end of West Africa, located at 13° 28.02' North 16° 34.02' West. The total territory area of the country is approximately 11,300 km^2, which is divided into landmass and water surface areas of approximately 1,300 km^2 and 10,000 km^2, respectively, thus making the country one of the smallest in mainland Africa (Ampomah *et al.*, 2012).

The Gambia is divided into north and south banks by the River Gambia, one of the navigable rivers in West Africa. The country is enclosed on three sides (north, east and south) by Senegal which is the only country it shares a border with, and on the fourth side (west) is the Atlantic Ocean (Republic of The Gambia, 2003; Jarrett, 1950).

The topography of The Gambia can broadly be characterized by two geomorphologies:

(1) Upland plateau – whose feature is mainly poor water retention capability and low soil fertility, leading to a decline in the productivity of crops and livestock thus negatively impacting human survival in those areas (Odunuga and Badru, 2015; Xing *et al.*, 2022).

(2) Lowland plateaus are floodplains of the River Gambia, which demarcates the area into lower, central and upper valleys.

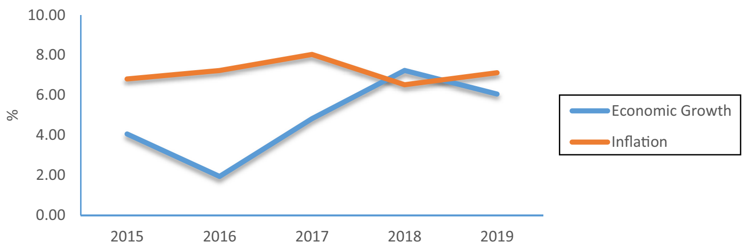
The topography of the lowland plateau is characterized by flat land, fine soil texture and poor soil drainage, affected by high acid sulphate. The soil's acidic content is poisonous to both plants and aquatic creatures. Thus, the effects of variation in climate would have consequences on the survival of both animals and plants and, by extension, human survival (Food and Agriculture Organization, 2005; Michael, 2013; Dhanya and Gladis, 2017).

1.3 Economy of The Gambia

The Gambia's economy is one of the smallest undiversified economies in Africa and is prone to external shocks of the global economy. The economy is mainly driven by the services sector followed by the agriculture sector which is heavily dependent on rain-fed agriculture. In 2019, the economy grew by 6.2%, following a slow growth in previous years. The rebound was principally due to tourism and agriculture (Republic of The Gambia, 2020b). Figure 1 illustrates average economic growth and inflation for the period 2015–2019 at 4.82% and 7.14%, respectively, thus demonstrating modest gains in the economy (World Bank, 2021). These economic gains were negatively affected by the COVID-19 pandemic health shock. As a result of the pandemic, the government introduced lockdown measures by limiting the work hours of employees coupled with social distance measures, which significantly limited economic activities and individuals' incomes. The government, in its estimate of the economic impact of the pandemic, projected a loss of revenue of GMD [1] 2.5bn (US$ [2] 63.2m) which will contract the economy by approximately 3%. The consequence of the contraction will increase the government's fiscal deficits, thus limiting its ability to finance development projects and on the micro-level, household poverty is expected to rise (United Nations Development Programme, 2020).

1.4 Climate change impact on hydro-meteorological

Climate change in Africa is causing havoc; some African counties depend on rain-fed agriculture. However, the recent trend shows that the water demand in Africa by far surpasses its availability, causing a threat to the lives and livelihoods of dwellers of the continent who depend directly and indirectly on agriculture for survival (Castells-Quintana *et al.*, 2018; Tadesse, 2010; Serdeczny *et al.*, 2016). A related study Nhemachena *et al.* (2020), Mtintsilana *et al.* (2021), stressed that southern Africa will experience a decline in rainfall and irrigated water supply. The aforesaid situation will adversely affect food security in that region, thus leading to drought, water stress, reduced yields and, consequently, a food crisis. Studies have shown that the projected rainfall pattern in the Sahel is indeterminate using the various climate models with some degree of uncertainty (Lewis and Buontempo, 2016). However, Desanker (2002) elucidated that the Sahel would experience a decline in rainfall along the semi-arid region south of the Sahara given that the foresaid the region



Source: World bank, world development indicators (2021)

Figure 1. Gambia's economic and inflation trends from 2015 to 2019

would be prone to extreme weather conditions and sea-level rise. In sub-Saharan Africa (SSA), crops and livestock production are primarily dependent on rainfall. Therefore, the erratic nature of rainfall patterns will negatively impact agricultural productivity in SSA over time (MacDevette *et al.*, 2012; Ofoegbu and New, 2021; Dinar *et al.*, 2012).

Studies have shown that climate models can predict future temperatures more accurately than rainfall in SSA. An increase in temperature by 1°C in developing countries will translate to a 2.66% decline in agricultural productivity, thus reducing exports by 2.0%–5.6% ultimately, economic growth will decline by about 1.3%. The foregoing illustrates how the warming of SSA will have serious consequences for economic growth (Serdeczny *et al.*, 2016). However, Alagidede *et al.* (2016) also show that a percentage increase in temperature will affect growth by 0.13%. Therefore, various studies show there is a negative association between temperature and growth, thus the looming climate threat will adversely affect economies in SSA. In the Sahel, where The Gambia is situated data is even grimmer. It is projected that due to climate change that region will become warmer to the point of 1.5°C–6.5°C. Given the projected increase in temperature with time, the Sahel region is expected to experience sluggish growth which will be of grave consequences (Sylla *et al.*, 2016; Musah-Surugu *et al.*, 2018; Ezeife, 2014).

1.5 Climate change impact on crops and livestock

Defrance *et al.* (2020) show that local crop production in West Africa is expected to decline on average by 50 kg per capita by 2050 as a result of climate variability in the sub-region, which is anticipated to experience an increase in importation due to a decline in domestic production. Janssens *et al.* (2020), Sultan *et al.* (2017), File and Derbile, (2020), Menghistu *et al.* (2020) further explained that climate change in the western Sahel region will experience a decrease in yields of crops by 2050 due to climate impact and rapid population growth thus leading to hunger, starvation and malnourishment among dwellers of the region. Zougmoré *et al.* (2014); Rhodes *et al.* (2014), Saxena *et al.* (2018); Rosenzweig *et al.* (2001), Hassan, (2010) have elaborated that crop losses as a result of climate change between the period 2000 and 2009 in the same region were colossal. Two crops in the region-millet and sorghum-average regional yield losses amounted to US$2.33–4.02bn and USD 0.73–2.17bn, respectively, representing 10%–20% and 5%–15% crop yield losses. The foregoing demonstrates the exorbitant costs of climate change for the West Africa sub-region (Sultan *et al.*, 2019).

The looming threat of climate variability will adversely affect livestock species, thus leading to an increase in animal diseases, low fertility, reduced milk production, reduced longevity and a high rate of animal death (Desmidt *et al.*, 2021; Ministry of Foreign Affairs of The Netherlands, 2018). However, small ruminants that consume limited water and food can thrive in the Sahel region given its hotter and direr nature (Zougmoré *et al.*, 2016). In Africa, grassland cultivation is projected to decline by 40% by 2050, which will have undesirable consequences on rangeland production. The aforementioned will result in a decrease in livestock production by 7.5%–9.6% which will cause an estimated economic loss of US$9.7–12.6bn. The multiplier effect of the foregoing will lead to an increase in livestock prices, a decrease in production and reduced income for those who depend on livestock farming for their sustenance and livelihoods (Simpkin *et al.*, 2020; Menghistu *et al.*, 2021).

2. Materials and methods

2.1 The roadmap

Figure 2 shows the modelling sequencing of the study which constitutes the use of various models, thus illustrating an economy-wide framework connecting a CGE model with a range

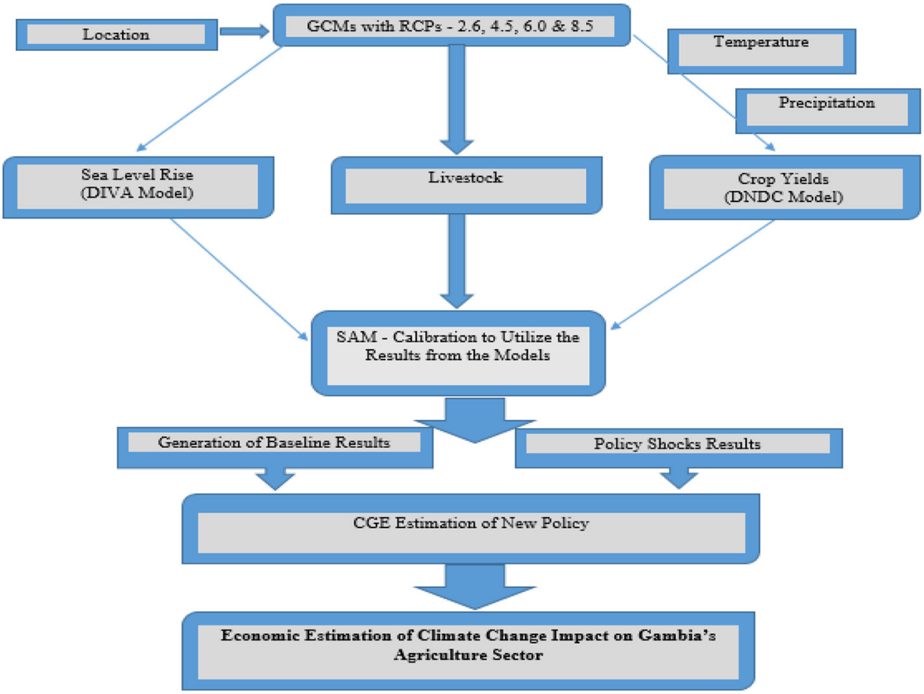


Figure 2.
Flow chart of model sequencing

Source: Authors' iteration (2021)

of climate change impact models – general circulation models (GCMs) with representative concentration pathways (RCPs), the DeNitrification–DeComposition (DNDC) model, livestock and dynamic interactive vulnerability assessment (DIVA) models to estimate the impacts of climate change on The Gambia's agriculture sector. The SAM calibrates the results from the various models and, subsequently, the SAM generates baseline results. The GCMs model then takes into account the policy shocks given the impact of the new policy against the baseline results to compute the effects of the policy changes. Finally, the CGE model aids the analysis of the results to attain the study objectives.

2.2 Global circulation models (GCMs) and representative concentration pathways (RCPs)
The GCMs are vital tools used in simulating and comprehending the future temperature and precipitation for a given location (Weart, 2010). In this case of The Gambia, these locations are the five agricultural regions. Given four RCPs scenarios, with different quantities of greenhouse gas emission over a period, thus contrasting current near future and distant future conditions (Makino *et al.*, 2015). The foregoing commenced the study simulation. The GCMs constitute various models which are simulated simultaneously to generate results for a location's atmosphere, land surface, central coupler component, etc. Thus, the GCMs avail scientists of the opportunity to research the earth's climate variation over time (Community Earth System Model, 2020).

The crop model used for this study is DNDC software as indicated in Figure 2, which can use temperature and precipitation results from GCMs to forecast crop yields for the five agricultural regions. The DNDC model converts climate parameters to actual crop yield outcomes (University of New Hampshire, 2012). Next, on the model sequencing is the sea-level rise model. In this study, the DIVA model is used to simulate atmospheric carbon dioxide (CO_2) concentration and sea-level rise. The study is also able to estimate potential landmass inundation in the coastal zone of a country attributed to accelerated sea-level rise. The DIVA model is a powerful software tool with the ability to evaluate the biophysical and socio-economic effects of coastal sea-level rise. Given the strength of the model, it can be used to simulate various adaptation options and strategies (Hinkel *et al.*, 2010).

The 5th Assessment Report expatiates how Intergovernmental Panel on Climate Change (IPCC), economic modelling could use the various route to attain four distinct radioactive forces that correspond to diverse concentration pathways of greenhouse gas emission, referred to as RCPs. The four distinct RCPs (2.6, 4.5, 6.0 and 8.5) possesses the following radioactive forces 2.6 Wm^2, 4.5 Wm^2, 6.0 Wm^2 and 8.5 Wm^2, respectively. The last RCP is the most pessimistic, thus resulting in average global warming of 4°C at the end of the 21st century, whereas the first RCP is the most optimistic scenario resulting in average global warming of 1°C (IPCC, 2013). The four RCPs generated from the integrated assessment models were chosen from the published academic literature and used in the current IPCC assessment as a basis for the climate predictions and projections presented in Working Group 5th Assessment Report (Van Vuuren *et al.*, 2007; Clarke *et al.*, 2007; Fujino *et al.*, 2006).

2.3 Crop model

The DNDC model is a process-based model of carbon (C) and nitrogen (N) biogeochemistry in agricultural ecosystems used to estimate the impact of climate change on the yield of rain-fed and irrigated crops in different agricultural regions of a study area. The model can accommodate both site and regional modes simulations with input data on soil contents, crop area, flooding, fertilization, manure amendment, residual management, tillage, temperature, precipitation, etc. The first component of the DNDC model consists of the soil climate, crop growth and decomposition sub-models used for predicting soil temperature, moisture, pH, redox potential (Eh) and substrate concentration profiles driven by ecological drivers (e.g. climate, soil, vegetation and anthropogenic activity). The second component of the DNDC model consists of the nitrification, denitrification and fermentation sub-models, which predicts emissions of carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3), nitric oxide (NO), nitrous oxide (N_2O) and dinitrogen (N_2) from the plant–soil systems (University of New Hampshire, 2012).

2.4 Sea-level rise model

The DIVA model is an integrated, global model of coastal systems that calculates, the biophysical and socio-economic consequences of sea-level rise and socio-economic development. It takes into consideration the following coastal impacts: erosion (direct and indirect), flooding (rivers), wetland change and salinity intrusion into deltas and estuaries (Hinkel and Klein, 2009). The DIVA model also has an additional advantage of assessing sea-level rise effects, vulnerability and adaptation strategies in the form of building dikes and reclaiming beaches (Vafeidis *et al.*, 2017). The DIVA model can estimate the economic and adaptation costs of climate change given different scenarios over a period (Hinkel *et al.*, 2015). Jevrejeva *et al.* (2018) further buttress that apart from estimating adaptation cost the DIVA model can be used for projecting flooding damage costs, given the various RCPs' scenarios.

2.5 Computable general equilibrium model

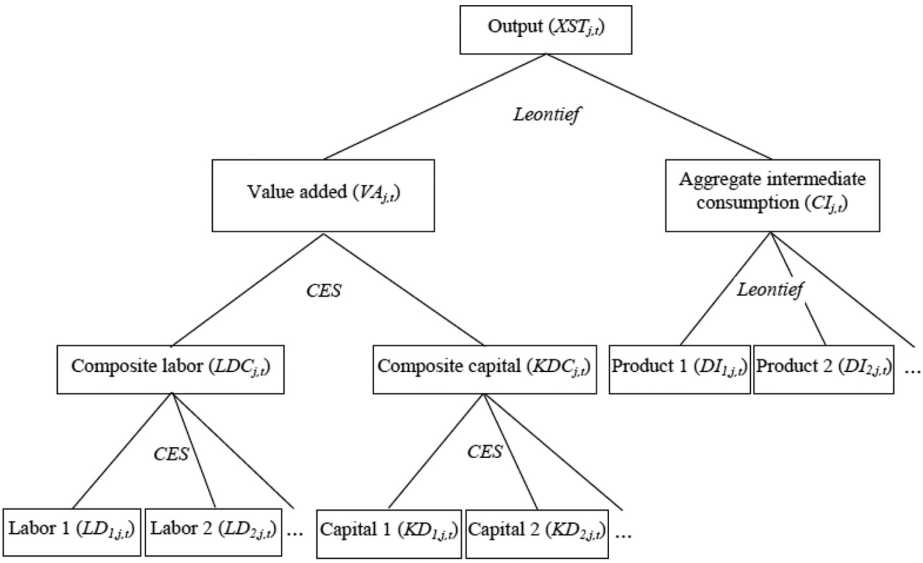
The model uses the Partnership for Economic Policy PEP-1-t a single country CGE dynamic model, which is identical to PEP-1–1, except that the representation of the production function bears the time subscript. The set below encapsulates the production activities:

$$j, jj \in J = \{j_1 \ldots\ldots., j_2 \ldots\ldots. \} \tag{1}$$

It is assumed that firms operate in a perfectly competitive business environment. The motive of firms is to maximize profit, subject to the production technology while considering the prices of goods and services (price-taking behaviour). Figure 3 illustrates the nested structure of the production function. Such nested structures are common in CGE models. The elasticity of substitution is greater at the lower level of the hierarchy (factor inputs). Numerous specifications can be used for this study. Therefore, the study uses the combination that best fits the scenarios of the study. At the top of the model is the sectoral output of each productive activity *j* which combines value-added and total intermediate consumption in fixed shares. The two aggregate inputs (labour and capital) are considered to be strictly complementary, without the possibility of substitution, given the model adoption of the Leontief production function (Decaluwé *et al.*, 2013).

2.6 The social accounting matrix

This CGE study on the economic assessment of the impact of climate change on The Gambia's agriculture sector uses a SAM (SAM that is representative of the entire agricultural economic transaction of the country as of 2015/2016). Hitherto the SAM for The Gambia were rudimentary or unrepresentative. The SAM, therefore, serves as the data for the General Algebraic Modelling System (GAMS) CGE model, hence when the SAM is calibrated into the CGE model, it generates plausible results. The figures in the SAM



Source: Authors' iteration (2021)

Figure 3.
A nested structure of the production

represent the values (price times quantity) of economic transactions at a point in time (2015/16). When calibrating a CGE model, all prices are normalized to one. SAM is a useful instrument in CGE policy analysis, as it allows for the analysis of the structural interdependences at the macro and meso levels and at the inter-sectoral linkages within an economic system (Bellù and Pansini, 2009; Scandizzo and Ferrarese, 2015).

Table A1 in Appendix 1 illustrates the Gambian SAM in the form of a square matrix with rows and columns indicating the same accounts (activities, commodities, factors, institutions, households, government, savings and investment and the rest of the world [ROW]). Incomings are designated as receipts for the row accounts while outgoings are designated as expenditures for the column accounts. The totals for equivalent rows (receipts) and columns (expenditures) are equal for all the SAM accounts, as obtained from macroeconomic and agriculture data sources listed in Table A2 in Appendix 2. The use of supplementary data sources and satellite accounts improves the versatility of the SAM, thus rendering it beneficial for the modification and analysis of various subjects (Mainar-Causapé *et al.*, 2018).

The constituents of the SAM are shown in Appendix 1. A detailed elucidation is done for the numerous accounts. *Activities and Commodities*: domestically supplied commodities are in [Row (R)1 and Column (C)2], while imports [R9 C2], indirect taxes and import tariffs paid on goods and services minus subsidies on goods and services paid by the government to support the production of some goods and services [R7 C2]. The value of commodities is in market prices. These commodities are procured by different economic entities. Intermediate inputs [R^2 C1] are used to produce final commodities. Households' consumption spending [R^2 C5] on final demand for goods and services, government consumption/recurrent expenditures [R^2 C6], investment [R^2 C8] and finally exports demand [R^2 C9] of commodities are found in their respective SAM rows and columns accounts.

Activities generate goods and services using factors of production complemented with intermediate inputs/resources. As factors of production are used in the production process, thus resulting in activities rewarding factors of production wages, rents and profits for their use in the production stages, i.e. value addition. The entry of value-added [R3 C1] is payment received from activities to factors. It can be computed as (value-added = domestic supply – intermediate demand). Intermediate demand [R^2 C1] from activities to commodities. Hence, a summation of value-added and intermediate demand yields domestic output.

2.6.1 Domestic institution. Households are proprietors of factors of production, hence they receive income from factor payments [R5 C3]. Households receive payments from the government [R5 C6]. Such payments are social security and pension funds. From the ROW, remittances are received by family members working overseas. Households pay income taxes to the government via taxes account [R7 C5]. Households buy goods and services from the commodity account [R^2 C5]. Households and enterprises transfer payments to ROW [R9 C5] and [R9 C4], respectively, and surpluses of enterprises are transferred to the government [R6 C4].

The remaining income from households and enterprises is either saved or dis-saved if expenditures are greater than incomes as demonstrated in [R8 C5] and [R8 C4], respectively. As explained earlier, the government receives transfer surpluses from enterprises [R6 C4] and ROW [R6 C9] in the form of overseas development assistance (ODA). The government also receives income such as indirect taxes, customs duties and income taxes [R6 C7]. Those receipts put together are referred to as total government revenue. Conversely, the government makes payments in the form of recurrent consumption expenditures/spending [R^2 C6], transfers to households and financial and non-financial sectors [R5 C6] and transfers to ROW [R9 C6]. Finally, the difference between total revenue and expenditures is the fiscal surplus or deficit contingent on whether revenues exceed expenditures [R8 C5].

2.6.2 Savings, investment and the foreign account. From national accounting identity, investment or gross capital account must be equivalent to total savings. It can be recalled, that the SAM process accounted for enterprise savings and household savings [R8 C4] and [R8 C5], respectively. It also accounts for government savings [R8 C6]. The difference between total domestic savings and the total investment is accounted for in "foreign savings", otherwise referred to as current account balance [R8 C9]. Illustrated below is the computation of gross domestic product (GDP) using the Gambian SAM, which yields GMD4,131,784,915.06 (USD104,469,909.36):

$$\text{GDP} = \text{Consumption Spending} + \text{Recurrent Spending} + \text{Investment Demand} + \text{Net Exports}$$

$$\text{GDP} = \text{C} + \text{G} + \text{I} + [\text{X} - \text{N}]$$

$$= [\text{R2 C5}] + [\text{R2 C6}] + [\text{R2 C8}] + [\text{R2 C9} - \text{R9 C2}] \quad (2)$$

3. Results

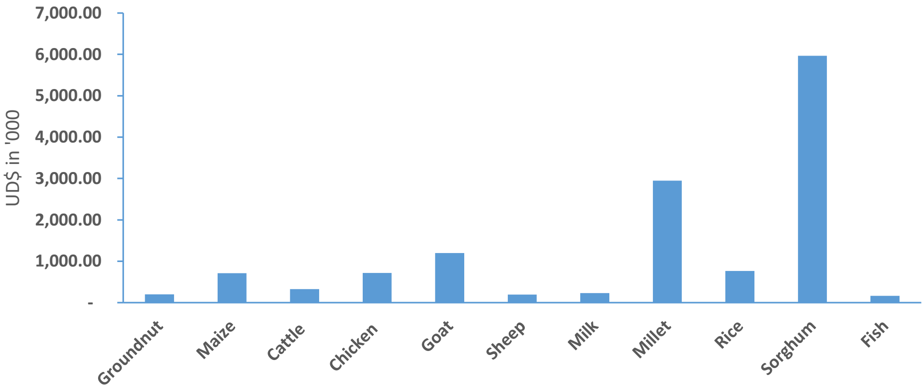
3.1 Baseline simulation

The model creation is premised on the economic estimation of future climate change impact on the agriculture sector in The Gambia. The model incorporates the RCP scenarios to project temperature and precipitation fluctuations in the country over time. Factored in the CGE model is the crop model (DNDC model) indicating crop yields in the five agricultural regions of The Gambia over time, likewise the sea-level rise (DIVA model) and livestock impact. The results of all the aforesaid models were calibrated into the CGE model to generate plausible results to give a true and fair indication of the climate impact on The Gambia's agriculture sector.

The model adopted a baseline scenario wherein it is assumed that there exists "no climate change" impact on the agriculture sector and that the growth rate of the economy is at 4.1% with macroeconomic stability; at baseline the economy experiences minimal domestic and/or external shocks. Subsequently, by 2055 (medium-term), the impact of climate change is experienced and by 2085 (long-term), the impact of climate change becomes more severe on the sector. The results portray the pending economic and food security challenges The Gambia will be exposed to as a consequence of climate change.

3.2 Baseline results

Figure 4 shows the baseline result of the consumption of agriculture commodities by households before climate change impact. It is observed that sorghum and millet are predominantly consumed by households in The Gambia. The foregoing is corroborated by the result generated by the DNDC crop model, showing a high yield of millet and sorghum. Those crops are vastly consumed at a subsistence level (Mungai and Agbe, 2019). Goat and chicken are the major sources of protein. Most households consume chicken in their diet, given its relative affordability. The results show that rice and maize are also highly consumed in the household. This is not astonishing since rice is the country's main staple food. It is observed that in the absence of climate change, the cost of the six major



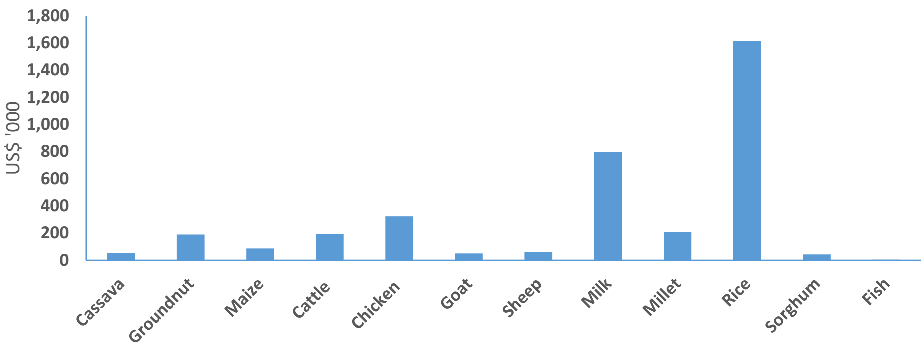
Source: Dynamic CGE simulation result (2021)

Figure 4. Consumption of agricultural commodities by households

agricultural commodities (sorghum, millet, goat, rice, chicken and maize) consumed by households is US$12,311,000 (GMD486,900,050). This demonstrates the exorbitant cost of consumption even in the absence of climate change.

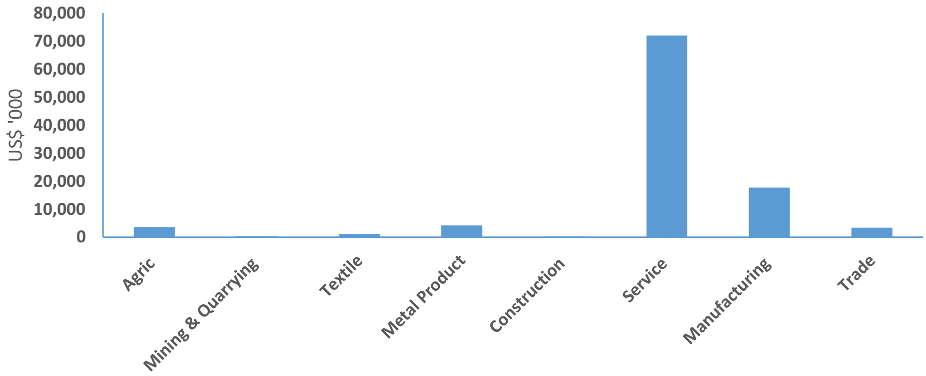
Figure 5 is an illustration of government expenditures on agricultural commodities, given that all conditions remain constant and there exists no climate change in the short term, it is observed that public expenditures on rice are the highest, followed by milk and chicken. It should be noted the government has introduced various projects, including the Rice Value Chain Transformation Project to support rice production by reducing harvest and post-harvest losses. The National Seed Secretariat in collaboration with the Nema Project has embarked on dry season certified rice seed production and distribution of rice seeds to farming groups. These efforts by the government are geared towards mitigating the effects of late rains and poor rice crop performance. The high expenditure on rice by the government is necessary to stabilize its price and ensure adequacy, given that rice is the staple food for Gambians (Republic of The Gambia, 2020a, 2020b, 2021a, 2021b).

Figure 6 illustrates government expenditures in the agriculture and non-agriculture sectors. It is vividly demonstrated that expenditure/consumption is heavily biased in favour



Source: Dynamic CGE simulation result (2021)

Figure 5. Government expenditures on agricultural commodities



Source: Dynamic CGE simulation result (2021)

Figure 6. Government expenditures on agriculture and non-agriculture sectors

of the non-agriculture sectors when compared with the agriculture sector. Expenditures in the services, manufacturing and metal sectors surpass the agriculture sector. This trend is consistent with the investment as illustrated in Figure 9, Panel (B). The country has witnessed neglect of the agriculture sector. Should the trend persist coupled with anticipated climate change impact, the agriculture sector would be the "hardest hit", given its direct link to the effects of climate variability.

Figure 7 shows the domestic demand for commodities. Panel (A) shows the domestic demand for agriculture commodities while Panel (B) domestic demand for agriculture versus non-agriculture sectors. Panel (A) demonstrates that groundnut, millet, rice, maize and sorghum are the crops predominantly consumed in the country. In rural households, consumption are at a subsistence level while in the urban communities they are consumed by purchasers from markets (Gajigo and Saine, 2011). Panel (B) shows that the domestic demand in the non-agriculture sectors is substantially greater than in the agriculture sector,

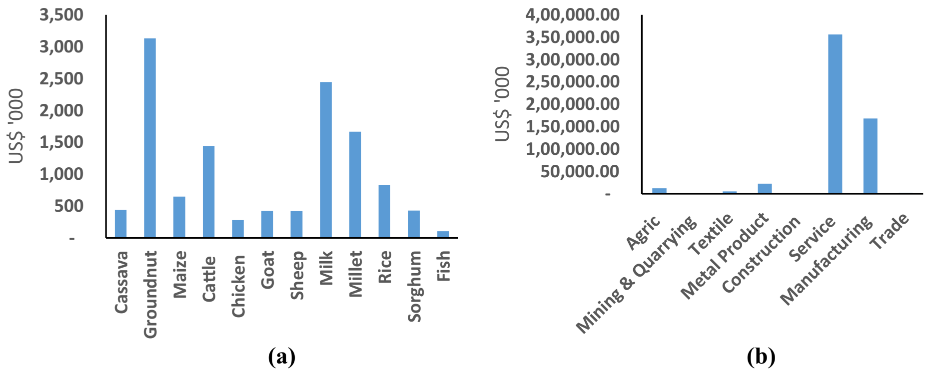


Figure 7. Domestic demand for commodities

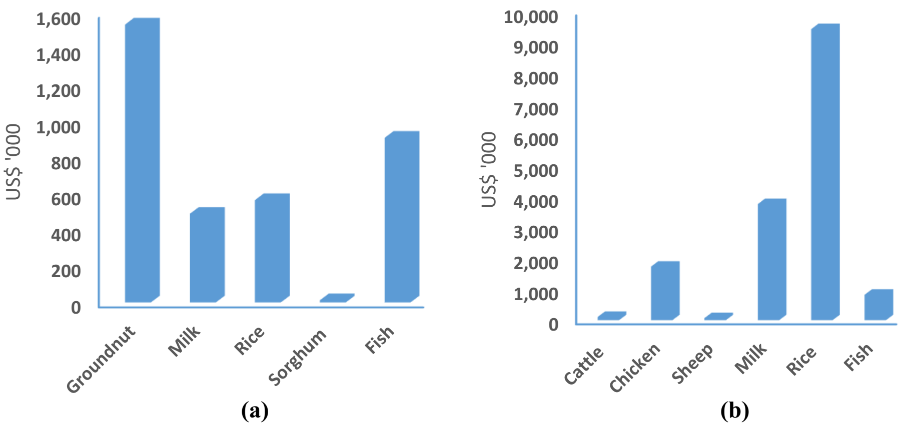
Source: Dynamic CGE simulation result (2021)
Notes: (a) Demand for agricultural commodities; (b) demand for agriculture versus non-agriculture sectors

thus buttressing the significance of the growth of the services and light manufacturing sectors.

Figure 8 shows the exportation and importation of The Gambia's major agricultural commodities before the effects of climate change. On the export side, it is observed that groundnuts are the country's main export, which is a true reflection of the country's situation, given that groundnuts are The Gambia's semi-intensive cash crop (Food and Agriculture Organization, 2021a). The second-largest export of agricultural commodity of the country is fish. It must be pointed out that The Gambia is blessed with aquatic resources, thus fish constitutes a significant portion of the country's exports to the European Union and Asia (Ministry of Trade, 2019). Other agricultural commodities exported are rice, milk and sorghum. Rice is both an exported and imported commodity.

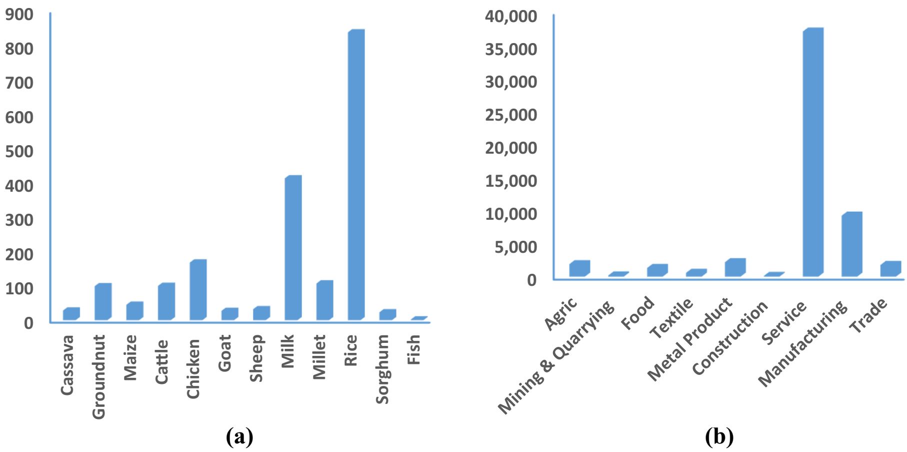
Panel (B) illustrates The Gambia's importation of agricultural commodities. Rice is the country's main import commodity. It is also the country's main staple food as mentioned earlier. The other high-volume imports are milk, chicken and fish. Those other food commodities are a major source of protein and form part of the daily food intake for the residents of the country. It could be seen that the import bills are far higher than the export earnings which results in high trade deficits and dependency on basic food necessities. The aforesaid, coupled with the economic cost of climate change in the medium and long term, will have an enormous impact on the government's ability to fund the country's development programmes.

Figure 9 demonstrates domestic investment in the agriculture sector versus non-agriculture sectors before the impact of climate change on the agriculture sector. Agriculture is an important sector in The Gambia's economy. Over the past decades, it has been overtaken by the services and light manufacturing sectors. Owing to the neglect of the sector, which is characterized by subsistence rain-fed, limited diversification and high food dependency ratio, about 75% of households depend on agriculture for their income and daily sustenance. The crop sub-sector accounts for 40% of the country's foreign exchange income. It also uses 70% of the workforce and accounts for approximately 30% of GDP (Food and Agriculture Organization, 2021b). This explains the significance of the sector for the survival of many who directly or indirectly depend on the sector for their livelihoods.



Source: Dynamic CGE simulation result (2021)
Notes: (a) Exports of agricultural commodities; (b) imports of agricultural commodities

Figure 8. Exports and imports of agricultural commodities



Source: Dynamic CGE simulation result (2021)
Notes: (a) Investment in agriculture; (b) investment in agriculture versus non- agriculture sectors

Figure 9. Investment in agriculture compared with non-agriculture sectors

The Gambia National Agriculture Investment Plan (GNAIP) 2010–2015 stipulates the huge investment costs for the period and the estimated funding gap, thus signifying that the sector requires huge capital investment to transform agriculture from subsistence "slash and burn" agriculture to commercial agriculture that will serve the country's food requirements (Republic of The Gambia, 2010). It is observed in Panel (A) that investment in the agriculture sector is predominately in rice, milk, chicken, millet, groundnuts and maize production. These are all vital agricultural commodities domestically produced or imported for consumption. Panel (B) shows the comparison between the agriculture sector and non-agriculture sectors, thus illustrating the poor investment in the agriculture sector compared with other sectors. It must be noted that the government's budgetary allocation to the agriculture sector under GNAIP 2010–2015 cited above falls short of the 10% requirements stipulated in the Maputo Declaration. Investment via donor-funded programmes could not also fill the funding gap. Loans granted to agricultural project were less than 5% for the period (Republic of The Gambia, 2019).

3.3 Policy simulation scenario

The policy simulation adopted two scenarios, i.e. policy scenario one (S1), which is the medium-term impact of climate change which will occur by 2055 and policy scenario two (S2), which will occur by 2085, representing the long-term impact of climate change on the agriculture sector. Both scenarios were used to compare deviations from the baseline growth path. It must be noted that the baseline represented the absence of climate change impact on the sector. S1 illustrates the adverse effects of climate variation on the productivity of crops, fisheries and livestock which negatively impact the economy in the medium term. Subsequently, by 2085, given S2 the impact of climate change would severely affect the agriculture sector which accounts for about 30% of GDP and, by extension, affects the country's economic performance.

3.4 Policy simulation principle

A GAMS CGE model simulation principle commenced with the development of a baseline scenario as stated earlier. The baseline assumes that there exists "no climate change" impact on the agriculture sector and that the economic growth rate is 4.1%. Hence, at baseline, the economy is exposed to minimal domestic and/or external shocks. The baseline scenario equilibrium condition occurs prior to policy intervention. Thus, the policy scenario is the new equilibrium condition given the policy intervention. Given the policy scenario(s) simulation, it was observed that the baseline equilibrium conditions for various economic and agricultural variables changed over time to a new equilibrium condition. The policy impact measures the deviation between the policy intervention equilibrium condition and the baseline equilibrium condition, which demonstrates how the effectiveness of the policy is.

3.5 Policy results

Table 1 shows the climate change impact on five key macroeconomic variables compared with the baseline growth path. It is observed that a decrease in productivity of crops, livestock and fisheries will cause GDP to reduce by 4.2% in the medium term and by 6.9% in the long term. This phenomenon will cause a decline in productivity, leading to an economic recession, high unemployment and a decline in consumer spending. It is also observed that national savings will decline, given S1 and S2 by 3% and 6%, respectively. A decline in national savings will emanate from a decline in private and government savings. The decline in national savings will reduce both domestic and foreign investment because of the positive relationship between national savings and national investment. Hence, climate impact will negatively affect investment in the agriculture sector, thus adversely affecting other essential sectors, such as education and health.

Wages will moderately decline over the medium and long term, considering S1 and S2 by 2% and 2.5% respectively when compared with the baseline growth path. The decline in wages will result in low disposable income, a decrease in the welfare of workers, leading to a low employment rate and low labour participation rate, thus culminating in sluggish economic growth over time. Disposable income will increase by 4% in the medium term but only increase by 3% in the long term when compared with the baseline scenario. The slow growth in disposable income will reduce consumption and private savings. Finally, in Table 1, the consumer price index (CPI) for S1 and S2 will increase by 3% and 5%, respectively, compared with the baseline growth path. Over time prices of commodities will become more costly given the impact of climate change on the agriculture sector which will trickle down, affecting the entire economy.

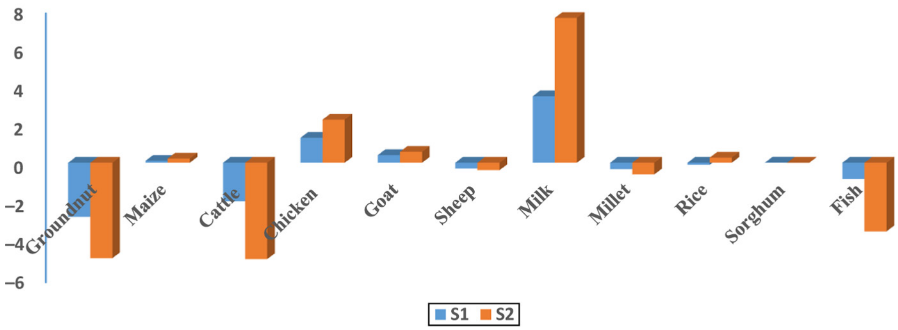
Figure 10 shows the percentage change in the consumption of crops, livestock and fish by households in The Gambia, given the impact of climate in both the medium term and

Table 1. Climate change impact of macroeconomic indications in percentage (deviations from baseline growth path)

Macroeconomic indicator	S1	S2
GDP	−4.2	−6.9
National savings	−3.0	−6.0
Wages	−2.0	−2.5
Disposable income	4.0	3.0
CPI	3	5

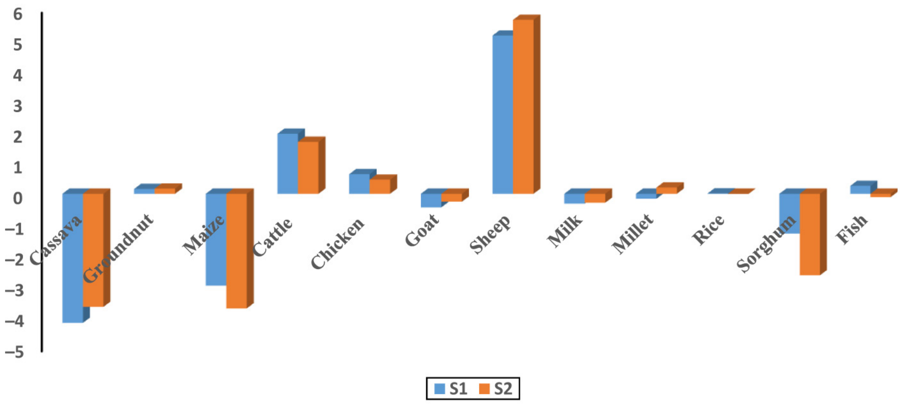
Source: Dynamic CGE simulation result (2021) long term. These food items are necessities for daily survival in rural and urban households, hence their availability in adequate quantities will ensure food sufficiency in the household and reduce food deprivation. It is observed that groundnuts, cattle and fish consumption will decline over time comparing the baseline scenario with S1 by 3%, 2% and 1%, respectively. As the incident of climate change becomes more acute to S2, the decline will further be aggravated, thus the decline will be by 5%, 5% and 4%, respectively, when compared with the baseline growth path. It is observed that households' consumption of chicken and milk will increase considering both S1 and S2. Household consumption for the rest of the food items will remain constant.

Figure 11 represents the percentage change in government expenditures on crops, livestock and fish. It is seen that public expenditures on cassava, groundnuts and sorghum will decline when the model factors climate change, given scenarios S1 and S2. Maize and sorghum as illustrated from the DNDC (crop model) results are vastly consumed predominantly in the rural communities. A reduction in government expenditures on these crops will result in food deprivation if households cannot effectively demand for those crops,



Source: Dynamic CGE simulation result (2021)

Figure 10.
Percentage change in consumption of agricultural commodities by households (deviation from baseline growth path)



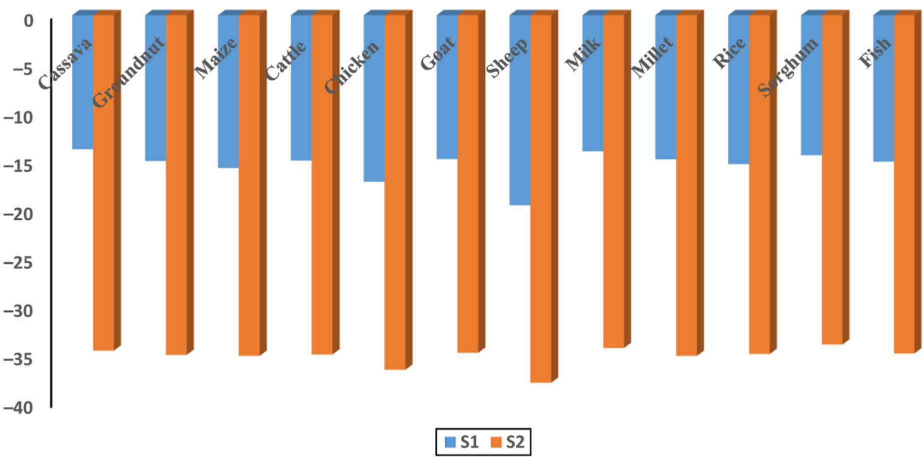
Source: Dynamic CGE simulation result (2021)

Figure 11.
Percentage change in government expenditures on agricultural commodities (deviation from baseline growth path)

thus causing hunger in the rural communities. It should be noted that government expenditures on livestock, especially sheep and cattle, will increase when compared with the baseline for both S1 and S2. In The Gambia, the demand for sheep is high during the Muslim festival of Eid al-Adha given that the inhabitants of the country are predominantly of the Muslim faith.

Figure 12 shows the percentage change in the supply of agricultural commodities to the domestic market, given the impact of climate change on both S1 and S2. The results for the supply of agricultural commodities to the domestic market reveal the severe nature of climate change's impact on the sector in the long term. S1 shows that there would be a decline in the supply of agricultural commodities compared with the baseline growth path. It is observed that the reduction in supply will range from 14% to 20%. The county's staple food crop will reduce by 15%, and other food crops such as maize, millet and sorghum would experience a similar reduction of 16%, 15% and 14%, respectively. Livestock supply would also reduce significantly; cattle and goats will reduce by 15% and sheep by 20%. Chicken supply will reduce by 17%. As climate change becomes more severe given S2, the situation worsens. Rice will further reduce by 35%, whereas other food crops such as maize and millet would reduce by 35% and sorghum by 34%. Livestock supply would decline as manifested by cattle and goat supply declining by 35%, whereas sheep supply will reduce by 38%. Chicken supply will reduce by 37%. With regard to fish availability given S1 and S2, the supply will reduce by 15% and 35%, respectively. The impact of this food crisis will lead to food deprivation, malnutrition, increase health-care costs, food aid dependency, poverty, etc. Hence, the foregoing will have far-reaching social, political and economic ramifications in both medium term and long term.

Figure 13 shows the international trade of major agricultural commodities exports and imports for both S1 and S2. Panel (A) demonstrates that the country will experience a decline in exports when climate change is factored in the model using both scenarios compared with the baseline. In the medium term, S1 demonstrates a decline in all major crop exports. Groundnuts, the country's major export cash crop, will decline by 10%, followed by a decline in the exports of fish and milk by 8%, while rice exports will be reduced by 6%. As the climate change impact intensifies, S2 shows that exports of agricultural commodities



Source: Dynamic CGE simulation result (2021)

Figure 12. Percentage change in the supply of agricultural commodities to the domestic market (deviation from baseline growth path)

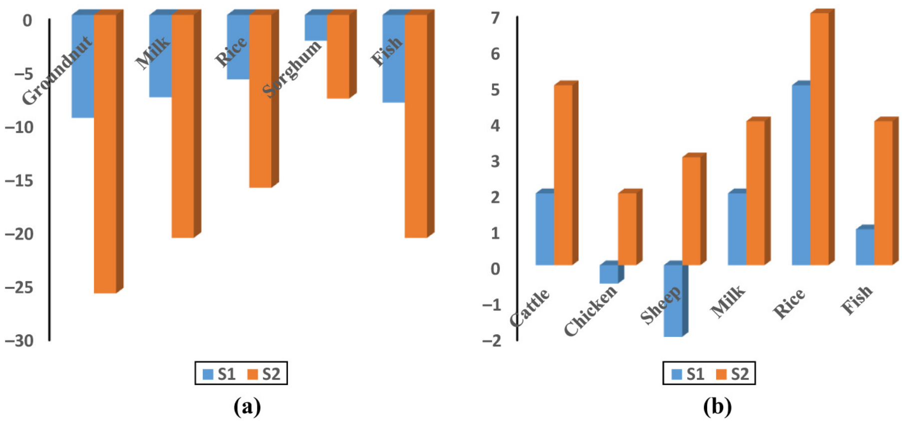


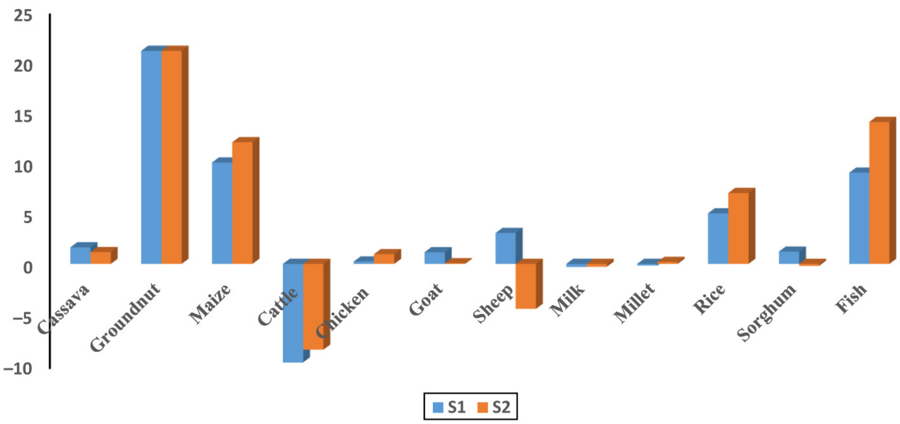
Figure 13. Percentage change in exports and imports of agriculture commodities (deviation from baseline growth path)

Source: Dynamic CGE simulation result (2021)
Notes: Exports of agricultural commodities; (B) imports of agricultural commodities

will further decline as manifested in Panel (A). It is observed that the country's main cash crop exports will be reduced by 26%, followed by a significant decline in fish and milk by 21% and rice exports will decline by 16%. The decline in exports would have a multiplier effect on the economy, leading to declining productivity, high unemployment, trade deficit and sluggish economic growth. Panel (B) shows the importation of agricultural commodities into The Gambia. Given S1, the country's staple food will witness an increase in imports by 5% compared with the baseline. The importation of cattle and milk will also increase by 2% while fish will increase by 1%. However, chicken and sheep importation will reduce by 1% and 2%, respectively. When S2 is considered, all agriculture commodities will experience an increase in importation. The importation of rice will increase by 7% when compared with the absence of climate change. It is observed that cattle, milk, fish, sheep and chicken imports will increase compared with the baseline growth path. The rising level of imports will increase the country's trade deficits, dependency on imported food and negatively impact the country's exchange rate. Thus, the imminent climate crisis will pose a challenge to the Gambian economy.

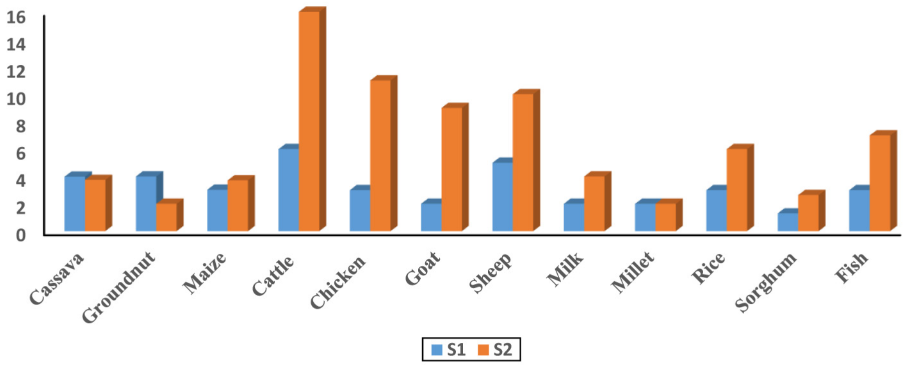
Figure 14 shows the percentage change in investment in the crops, livestock and fish sub-sectors. When the CGE model factors climate change attributable to S1, it is observed that investment will be highest in the production of groundnuts and groundnut-related products. This is not astonishing because groundnuts are the country's main cash crop. Investment will be high in the production of maize and fish. When the effect of climate change is severe as in S2 in the long term, investment in groundnuts will remain constant as in S1 at 22% compared with the baseline. Investment in maize, fish and rice production activities will increase. It is observed that as the impact of climate becomes more acute, given S2, investment in cattle and sheep production will decline by 9% and 4%, respectively. A decline in investment in the sector will affect the performance of the sector, thus gradually causing a drag on the economy in the long term.

Figure 15 illustrates the percentage change in the price of agricultural commodities for both S1 and S2. It is observed that in the medium-term given S1, market prices increase at an average of 3% with the prices of cattle, sheep and groundnuts being above the average. This is consistent with the CPI results found in Table 1. In the short term, moderate inflation is



Source: Dynamic CGE simulation result (2021)

Figure 14.
Percentage change in investment in agriculture (deviation from baseline growth path)



Source: Dynamic CGE simulation result (2021)

Figure 15.
Percentage change in prices of agricultural commodities (deviation from baseline growth path)

good for growth since moderate inflation will boost spending and investment which are prerequisites for economic growth. As the impact of climate change becomes more severe, given S2, it is anticipated that the market prices of agricultural commodities will further increase. The prices of cattle, chicken, goat, sheep, fish and rice will increase rapidly. This phenomenon will erode the purchasing power of the dalasi, thus weakening its value, increasing the costs of production, reducing national savings and an increase in interest rates.

Figure 16 shows the percentage change in the value-added activities for agricultural commodities for both S1 and S2. When the model factors in climate change, it is observed that both S1 and S2 will result in limited value-added activities. This shows that the country's agriculture will remain rudimentary with insufficient value-added activities to augment the market value of agricultural commodities, thus limiting the country's ability to effectively compete in the global market. The pending effects of climate change impact on the agriculture sector are presently manifested in The Gambia. Between 2008 and 2017,

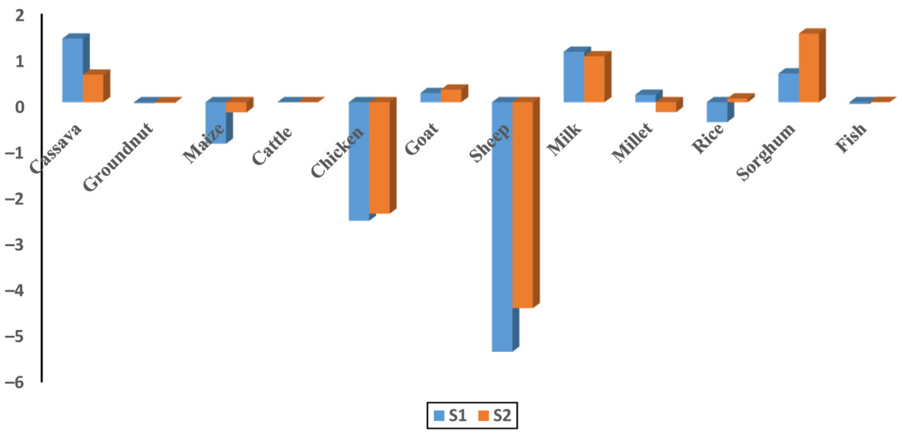


Figure 16.
Percentage change in value-added activities for agricultural commodities (deviation from baseline growth path)

Source: Dynamic CGE simulation result (2021)

average annual growth in agricultural value-added activities were just 2.4%, which was comparably lower when compared with the neighbouring countries in the sub-region (WB, 2019). Thus, the study the results illustrate that the looming climate variability will further aggravate the country's inability to add value to its agricultural commodities both in the medium term and long term.

4. Discussion

4.1 Baseline discussion

The baseline is indicative of the agriculture sector's performance before the consideration of climate change's impact on the sector. The agriculture sector approximately contributes about a third to GDP and two-thirds of the labour force, who are predominantly informally employed by the sector. Over the years, the sector has remained one of the poor performing sectors of the economy. Thus, investment in the agriculture sector compared with other sectors is significantly low, whereas investments in the services and light manufacturing are comparatively much greater as demonstrated by the study and corroborated by Bjornlund *et al.* (2020a); Rich *et al.* (2020). The consequences of low public and private investments in the agriculture sector are responsible for The Gambia's high-level poverty, food deprivation and insecurity, low-level value-added agricultural activities and productivity over time. Thus, the reason why the country's agriculture is subsistence (Mogues *et al.*, 2015; Sahan and Mikhail, 2012; Bathla, 2014; Post *et al.*, 2021).

There are initiatives to increase and improve the investment conditions in the agriculture sector to transform and reform agriculture from subsistence to commercial activities. These initiatives are geared towards progressively reducing the country's dependence on food importation and increasing the domestic production of rice, groundnuts, beans, sorghum, poultry and aquaculture to enhance food security (African Development Bank Group, 2021). The result of this CGE study confirms that some of the aforesaid production would increase due to investments in the agriculture sector. This study shows that sorghum, millet, maize and rice are the crops predominately consumed at the household level, whereas goat and chicken are the major sources of protein consumed in the household, thus buttressing the finding of other publications (U.S. Department of Commerce, 2020; Mungai and Agbe, 2019;

World Food Programme, 2016). Finally, investments in the agriculture sector would augment capital stock for the production of processed agricultural produce to increase future consumption leading to stimulated economic growth and employment.

The baseline shows that The Gambia is experiencing a food deficit thus to make up for the deficit the country imports some of its food requirements. Some of The Gambia's major importing trading partners are the Ivory Coast, Senegal, China, the UK and the USA, while some of its exporting trading partners are France, Vietnam, the UK, India and China. The Gambia's food importation by far exceeds its exportation leading to food deficits. As explained, the consumption of agricultural commodities by households shows a high demand for food commodities that surpasses the supply. If the status quo remains, the consequences are a high rate of hunger, poor health (immune deficiencies, diseases, malnutrition and mortality), an increase in the government budget for social protection programmes and food banks and food aid from development and international partners (Republic of The Gambia, 2019, 2013; Gillson and Fouad, 2014; World Integrated Trade Solution, 2022; GBoS, 2015).

4.2 Policy discussion

The policy simulation shows the impact of the policy intervention, given Scenarios 1 and 2, which represent the medium- and long-term impact of climate change by 2055 and 2085, respectively. The deviation of the policy intervention away from the baseline is an indication of its efficacy. By 2055, the impact of climate change would be adverse on the agriculture sector, while by 2085, climate change would severely affect the sector and, by extension, the economy as a whole. The macroeconomic indicators of the GDP, national savings, wages, disposal income and CPI illustrated a negative effect on the economy when compared with the baseline. Consequently, the policy intervention both in the medium and long term would lead to sluggish growth, a decrease in investment, high unemployment due to low wages, slow growth in disposable income which would result in a decline in consumer demand and low consumer confidence overtime and finally inflation will erode the purchasing power of the dalasi. The resultant effects of climate change on the Gambian economy would be manifested by diminishing wages, low labour participation rate, high unemployment, a reduction in income, wealth and welfare and an increase in the national debt-to-aid mitigation and adaptation to climate variation, thus resulting in greater economic uncertainty. Studies that validate the forgoing economic arguments (Watkiss, 2009; Florent and Schaeffer, 2019; Ezeife, 2014; Zeufack *et al.*, 2021; Abidoye and Odusola, 2015).

Climate variation would have an impact on the consumption demand of agricultural commodities by households, given the supply of those agricultural commodities in the domestic market. The effects of climate change on agriculture production will severely diminish the supply of commodities by 2055 and 2085; supply will decline by an average of 15% and 35% respectively. The effects of such acute decline would be caused by rising temperature, a decline in precipitation, water scarcity, an increased incidence of pests and diseases, environmental degradation, etc. Over time the disequilibrium between food supply (production) and demand (consumption) would continue to worsen, leading to hunger, diseases, deprivation, malnutrition, starvation, misery and poverty (Hollinger and Staatz, 2015; Wiebe *et al.*, 2017; Bjornlund *et al.*, 2020b).

As a result of the pending food deficit, the study shows that food importation would increase both in the medium and long term except for chicken and sheep in the medium term. The importation of rice as the country's staple food would continue to increase, thus the reliance on foreign markets to feed the rapidly growing population. In the event of negative external shocks in the supply of rice, the consequences would be detrimental. The caveat to the foregoing problem is to boost domestic production in the long run by producing crops and rearing livestock that are resilient to climate variation. Publications on the projected increase in the importation of rice and other agricultural commodities in The Gambia validate the results of the study (Mungai and Agbe, 2019; Republic of The Gambia and World Food Programme, 2021). Exportation is projected to decline by 2055 and by 2085 it would significantly decline. Groundnuts being The Gambia's main export cash crop would witness a decline of 26% by 2085. This anticipated decline in the main cash crop and other agricultural commodities would narrow the productive base of the Gambian economy, leading to high unemployment, trade deficit, slow growth and an economic slump.

Investment projection for agricultural commodities indicates an increase in investment for groundnuts, maize, rice and fish both in the medium and long term, given the effects of climate change. The reason for the projected increase is because of donor support in climate change financing, which is aimed at supporting the government in limiting greenhouse gas emissions, cultivating crops that are resilient to the effect of climate variation, reforestation projects, reclaiming fishing coastal land, etc. The objectives of these initiatives are geared towards poverty reduction and improvement in the livelihoods of those who depend directly and indirectly on agriculture for survival. Finally, climate change finance is also meant to ensure that the Gambian economy is resilient to the challenges of climate change (Urquhart, 2017; Camara and Kaur, 2014; Republic of The Gambia, 2021a, 2021b).

Inflation, as measured by CPI, would increase both in the medium and long term, given the effect of climate. The project inflation for agricultural commodities would be acute for cattle, chicken, goats, sheep and rice. This situation was expected, given the result of the macroeconomic indicator CPI. Owing to inflationary pressure, the purchasing power of the dalasi will be eroded, thus creating uncertainties in the domestic food market. If remedial measures are not taken to address the phenomenon, it would have a spillover effect, thus inflation would affect the entire domestic market. This would negatively affect the lives and livelihoods of inhabitants in The Gambia. According to Republic of The Gambia and GBoS, (2021), currently, the inflation rate is 7.5% while the inflation for food and non-alcoholic beverages is 8.8%. The aforesaid corroborates the CPI results because after factoring in climate change, the rate of inflation would exceed its current rate. Finally, Gambian agriculture is characterized as being rudimentary with limited value-added activities which would further be exacerbated by climate impact. Value-added activities in agricultural production would have resulted in generating employment opportunities along the value chain, minimizing wastage and post-harvest losses and increasing the market value of agricultural produce. As a result, the country's agricultural commodities would be competitive on the international market.

5. Conclusion and policy recommendations

The baseline results indicate the state of the Gambian economy in the absence of climate change impact on the agriculture sector. The results show that the economy will underperform showing signs of malaise during the short term. The government expenditure's in the agriculture sector will be in favour of the country's staple crop rice. This was not astonishing, given the numerous project interventions in encouraging a reduction in harvest and post-harvest losses and the drive towards the distribution of viable rice seeds to farming groups. The baseline results vividly manifested that the services and light manufacturing sectors are the dominant sectors of the economy, thus demonstrating the slow pace of development and neglect of the agriculture sector. With regard to international trade, it is seen the country's import bills are by far more than its export earnings which result in a balance of trade deficits. Finally, the baseline results show a huge finance gap in funding agricultural development, the finance gap is below the required Maputo declaration, hence the poor state of the sector over the years.

The policy results were insightful in portraying the impact of climate change in both the medium term and long term on the agriculture sector and by extension of the economy. The five key macroeconomic indicators tested revealed that climate change would have a significant negative impact on GDP, national savings, wages, disposable income and CPI, thus demonstrating the high costs of climate change on the Gambian economy. The supply of agricultural commodities in the domestic market would decline by an average of 15% and 35% in the medium term and long term, respectively. The consequences of diminishing food availability would lead to food deprivation, food aid dependency, malnutrition and food crisis which will have socio-economic ramifications. Climate impact on the exports of agricultural commodities would decline agricultural commodities exports by an average of 7% and 18% in the medium term and long term, respectively. The decrease in exports will limit The Gambia's "much needed" foreign earnings to fund the government's development budget. On the import side by 2085 average imports would increase by 4%, thus increasing the country's dependency on imports. The climate change crisis would also impact the general price level of agricultural commodities, prices would increase by an average of 3% and 5% in the medium term and long term, respectively. Thus, inflation will erode the purchasing power of the Dalasi. Finally, the results for value-added activities show that the country's agriculture is still and would remain rudimentary with limited value-added activities to augment the value of its produce, thereby rendering them competitive in the global market.

The imminent threat of climate change would severely impact the agriculture sector of The Gambia, thus negatively affecting the economy in the medium and long term. The study has catalogued the extent of the exorbitant costs of climate change on an impoverished nation like The Gambia. The climate crisis would exacerbate hunger, food deprivation, starvation, misery and poverty in The Gambia which would translate into sluggish growth and stifle economic development. The study further demonstrates how climate change would severely impact crop, livestock and fisheries sub-sectors, thus having an economy-wide multiplier effect. In light of the foregoing, the study now proffers the following policy recommendations:

- Policymakers need to formulate coherent climate change mitigation and adaptation policies that are aimed at preserving the agricultural ecosystem of The Gambia for sustainable economic growth and development.
- There is a need to understand the linkage of the agriculture sector to the broader economy and how climate factors will translate into poor agriculture and economic performance both in the medium and long term.
- Given the projected decline in precipitation generated by the GCMs with the RCP scenarios which resulted in an unimpressive crop yields in some of the agriculture regions as generated by the DNDC model thus the need for a shift strategy from rain-fed to modernized irrigated agricultural system.
- Given the anticipated decline in the supply of agriculture commodities over the years, policymakers must articulate sound policies that would avert the pending food crisis.
- The government must prioritize the agriculture sector as one of the key drivers of economic growth by creating an enabling and conducive environment to foster public and private investment in the sector. This must be done in cognizance of the long-term climate impact on the sector.

- As a stimulant to the agriculture sector and in a bid to boost agricultural commodities exports, the government should encourage value-addition to agriculture commodities, thus increasing the competitiveness of The Gambia on the global market.
- The government, through the department of agriculture, should encourage farmers to migrate from the production of cereals in ecologies that are prone to climate change. Consequently, the department of agriculture should promote the cultivation of climate-resilient crops.
- Given the significance of the study and the results generated for The Gambia, it would be useful and insightful for similar studies to be conducted in the neighbouring counties. That could serve as a synergistic effort in combating climate change in the West Africa sub-region.

Notes

1. GMD – Dalasi, national currency of The Gambia.
2. US$ – Dollar, national currency of the USA.

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Appendix 1

Table A1. Structure of the Gambian SAM 2015/16

	1 Activities	2 Commodities	3 Factors	4 Enterprise	5 Households	6 Govt.	7 Taxes	8 Saving/ Investment	9 ROW	10 Total
1 Activities		Domestic supply								Activity Income
2 Commodities	Intermediate demand				Consumption spending (C)	Recurrent spending (G)		Investment Demand (I)	Exports	Total demand
3 Factors	Value added								Factor income from abroad	Total Factor Income
4 Enterprise			Capital income to enterprises							Enterprises Income
5 Households			Factor payments			Transfers			Worker's remittances	Income of households and other domestic institutions
6 Govt.				Transfers from enterprise to govt.			Net indirect and income tax custom duties		Foreign grants and loans	Total govt. tax revenue
7 Taxes		Net indirect taxes and custom duties		Income taxes on the enterprise	Personal income tax					Total net tax revenue
8 Saving/ Investment				Savings of enterprises	Private savings	Fiscal balance			Current accounting Balance	Total savings
9 ROW		Imports (M)	Factor income to the ROW	Transfers from enterprises to the ROW	Transfer payment from households	Transfer from govt.				Foreign exchange outflow
10 Total	Gross output	Total supply	Total factors spending	Total spending of enterprise	Total household spending	Total govt. spending	Total net tax	Total investment spending	Foreign exchange inflow	

Source: Authors' iteration

Appendix 2

Entries	Nomenclature	Data source	Comments
1	Domestic supply	1. Food Agricultural Organization (FAO) Database 2. Eora National Input–Output (IO) Table	The supply of domestic products was calculated from FAO and Eora IO Table using producers price
2	Value added	1. FAO 2. Eora IO Table 3. Gambia Bureau of Statistics (GBoS) – Gambia Data Portal	Data on value-added economic activities were calculated from The Gambia Data Portal
3	Intermediate demand	Self-computation	Computed using Intermediate demand = Domestic supply minus Value added
4	Imports	Gambia's Ministry of Trade, Industry, Regional Integration and Employment	
5	Exports	Gambia's Ministry of Trade, Industry, Regional Integration and Employment	
6	Worker's remittances	Central Bank of The Gambia (CBG)	Computed from inflows remittances account
7	Current account balance	CBG	Computed from current account
8	Private savings	CBG	Computed from savings account
9	Fiscal balance	African Statistical Year Book 2018	Computed from public finance records
10	Personal income tax	Gambia's Ministry of Finance and Economic Affairs Statement of Government Operations (SGO)	
11	Income taxes on enterprise	SGO	
12	Net indirect tax and custom duties	SGO	
13	Consumption spending	African Statistical Year Book 2018	Computed using private final consumption
14	Recurrent spending	1. African Statistical Year Book 2018 2. SGO	Computed using government final consumption
15	Investment demand	African Statistical Year Book 2018	Computed using gross fixed capital formation
16	Transfer from government to ROW	SGO	Computed using transfers to international organization and external interest payments
17	Transfers from government to households	SGO	Computed using social benefits and pension payments
18	Transfer payments from households to ROW	CBG	Computed from outflows remittances account

(*continued*)

Table A2.
Data sources

Entries	Nomenclature	Data source	Comments
19	Foreign grants and loans	SGO	Calculated from loans and grants accounts
20	Net indirect and income taxes and custom duties	SGO	Calculated from non-tax revenue income tax and custom accounts
21	Savings of enterprises	(GBoS) – Gambia Data Portal	Computed from the value of enterprises savings
22	Factor payments to households	SGO	Computed from wages, salaries and allowances account and interest account
23	Factor income from ROW	(GBoS) – Gambia Data Portal	Calculated using income and investment portfolios from abroad
24	Transfers from enterprise to ROW	(GBoS) – Gambia Data Portal	Calculated from investment payment abroad and foreign investment accounts
25	Capital income to enterprises	(GBoS) – Gambia Data Portal	Calculated from capital account
26	Transfers from enterprises to government	SGO	Computed from tax, business fines, fees and licenses accounts
27	Factor income to ROW	SGO	Calculated from remunerations for capital ownership abroad

Table A2.

Source: Authors' iteration

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