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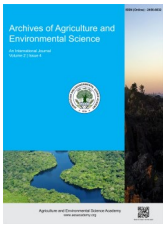

CASE STUDY

Adapting agriculture to climate change: A case study of women vegetable producers in rural communities of the Gambia

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ABSTRACT

In Gambia, fruits and vegetable are the principal source of vitamins and minerals plays an important role in food, nutrition and income security of producers. Over the years' climate change had an adverse effect on production and productivity of vegetables. The aim of the study was to address the problems faced by vegetable producers in relation to change using the climate smart agricultural technologies. The methodology of the study was random sampling administering semi-structure questionnaire, key informant interviews, and focus group discussion among producers. The finding showed that, onion registered 4000kg generating a net income of D196,000.00 followed by sweet pepper with net return of D112,000.00, however cabbage and bitter tomato there was no significant difference. Onion production was found to be the most outstanding commodity grown by women producer based on its comparative advantage. In addition, the second highest income earned was Gengi wollof's with a net return of D707,616.00 thousand from vegetable production. Based, on the research findings I conclude that, crop diversification and intensification is the most effective and efficient resilient approach to mitigate the effects of climate change while increasing nutrition and income of vegetable producers. Therefore, recommends to government, partners, CSOs, and private sector to strengthening the capacity of women in the process of adapting and mitigating climate change related issues practicing climate smart agriculture.

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INTRODUCTION

In the Gambia agriculture plays a critical role in boosting socio-economic development of smallhodler farmers particularly women vegetable producers in the rural communities. Agriculture contributes 28% to GDP of the economy and seventy (70%) of the population are actively engaged in agriculture. The driving force of the economy is being propel by agriculture with active participation of women farmers to attain food and nutritional security. Horticulture is one of the government's policy development priorities in addressing food insecurity, income and ameliorate nutrient deficiencies while creating employment opportunities in rural communities (Parajuli, 2018). In the Gambia, adoption of high yielding and diversification of production activities under diversified cropping systems would help to increase food production and productivity. In addition, vegetables are primary source of vitamins, protein, and carbohydrates with numerous bioactive compounds (Paudel *et al.*, 2017). Growth in the agricultural sector was determined largely by factors that led to increased productivity, including access to agricultural inputs mainly improved seeds and fertilizers, research and extension, and irrigation facilities increasing resilience to the effects of climate change. Irrigation provides reliable access to water, protect farmers from periodic shocks

of crop failure, poor soil fertility caused by climatic variability (Poudel, 2020).

The agricultural sector in most developing countries for the past years suffered immensely as a result of climate variability exacerbating drastic reduction in yield of crops (G.C.A., 2015). However, low rainfalls and high temperatures over the years affects the availability of enough fodders for grazing animals resulting to poor quality meat, and low intake of milk. Therefore, the government and Food and Agriculture Organization (FAO) initiated a project, adapting agriculture to climate change to address the issues of climate vulgarizes in the rural communities of The Gambia. Importantly, the overall objective of the project is to promote sustainable and diversified livelihood strategies for reducing the impacts of climate variability changing production pattern of crops and livestock. The Gambia has semi-arid climatic conditions marked by long dry season with minimal droughts and rising temperatures, changing rainfall patterns and extreme weather events affects production and productivity. These affects crop performance, low soil fertility and prevalence of pests and diseases down grading the quality of feed supply and water (Rijal and Rijal, 2019). The smallholder farmers are neither crops nor livestock producers instead, of having common understanding of diversifying their activities to be more resilient to climate change boosting production and productivity of agricultural commodities (Shirsath *et al.*, 2017).

Primarily, it is important to mark the efforts of practicing farmers with their continuous improvements to changing climate change conditions i.e., market price fluctuations, increasing input costs, labor shortages, pest invasions, and adverse weather conditions. Adapting agriculture to climate change would help to reduce the risk of climate change, increase resilience and mitigation measures. According (Tal, 2018) climate change is affecting smallholder farmers in many areas such as changes in rainfall pattern, unsteadily rising temperatures, inadequate production capacity, infestation of pests and diseases. The food security must be regarded as one of the main criteria for the effectiveness of adaptation at national and local level through the process of awareness creation of policy-makers in promoting resilient food production systems (Abewoy, 2018). Adaptation to climate change must also occur through the prevention of inappropriate adaptive practices that would increase vulnerability rather than reducing its impacts crops and livestock. The risk transfer mechanisms should be included in adaptation strategies from the national to households' level. According to (FAO, 2016) crop insurance or diversified livelihoods such as integrated agriculture systems in response to changes in the suitability of land and availability of quality water to produce vegetables. The process of diversification and intensification of vegetable production at rural communities in response to climate change and variability differs in location (Altieri *et al.*, 2015). The adaptation measures can simultaneously provide co-benefits towards obtaining multiple goals, such as soil health improvement, water quality conservation, and bio-diversity management. Ultimately, adaption of effective and efficient measures was pathway to mitigate the adverse impact of climate change on productivity, quality produce, income and yield. In addition, conservation techniques and organic farming as mitigation measures on annual cultivars that do not have any carbon sequestration potential, hence reducing carbon emissions minimally (Azumah *et al.*, 2019). The production and productivity of smallholder farmers' experiences had serious setback over the years as a result of climate change variability and other related factors. Importantly, climate change has registered negative impact on vegetable production on women producers due to high temperatures (Bisbis *et al.*, 2018). This can cause significant losses on tomato and onion yield due to un-timely planting and inadequate practicing of best agronomy practices causing fruit damage, poor quality fruits, and immature bulbs, plummeting the earning capacity of farmers (Dhakal, 2019).

Ultimately, vegetables are highly sensitive to water inundation, especially shallow rooted crops, and under water-logged conditions, the roots strive for oxygen as soil air is replaced by inundating water, hampering roots respiration to maintain their usual activities of nutrient and water uptake. In hot and dry environment, high evapotranspiration results in substantial water loss from soil, thus leaving salt around the plant roots which interferes with the plant's ability to uptake water. The livestock production system is based on extensive grazing, a decline in fodder supply expected to translate into loss of animal production, low milk content and poor-quality meat resulting to protein deficiency (Gairhe, 2018). Furthermore, unprecedented higher temperatures and humidity had adverse impacts on small ruminants such as sheep and goats, as well as poultry production which makes significant contributions to household sustance in terms of food and nutritional security. The effects of climate change on livestock serve an asset to poor resource farmers, bridging the multiple economic, social and risk management functions. The impact of climate change on livestock affects its production capacity, in terms of rising demand for feed, water and conflict over scarce resources (Climate-Smart Agriculture in Nepal, 2017). The economic importance of rural communities losing livestock assets could trigger a collapse into chronic poverty with lasting impact on livelihoods of women farmers. Cropland mitigation measures remain unexplored although many adaptation options also contribute to mitigation and measures are soil management practices that reduces application of synthetic fertilizer, crop diversification, crop rotations, biodiversity, quality seeds, integrated crop and livestock systems; control of bushfires and to avoid burning of crop residues (Verma *et al.*, 2020).

There is enormous potential for agricultural technologies to achieve benefits of environmental health, and nutrient management to improve farm household income and food security, saving input cost, and reducing emissions. Furthermore, increasing forest cover and agroforestry practices can build resilience, improve environmental health, and mitigation benefits as priority areas of adapting agriculture to climate change (Dhital and Joshi, 2016). However, increasing bush fires at local communities adversely affects the eco-system, reduce soil fertility,

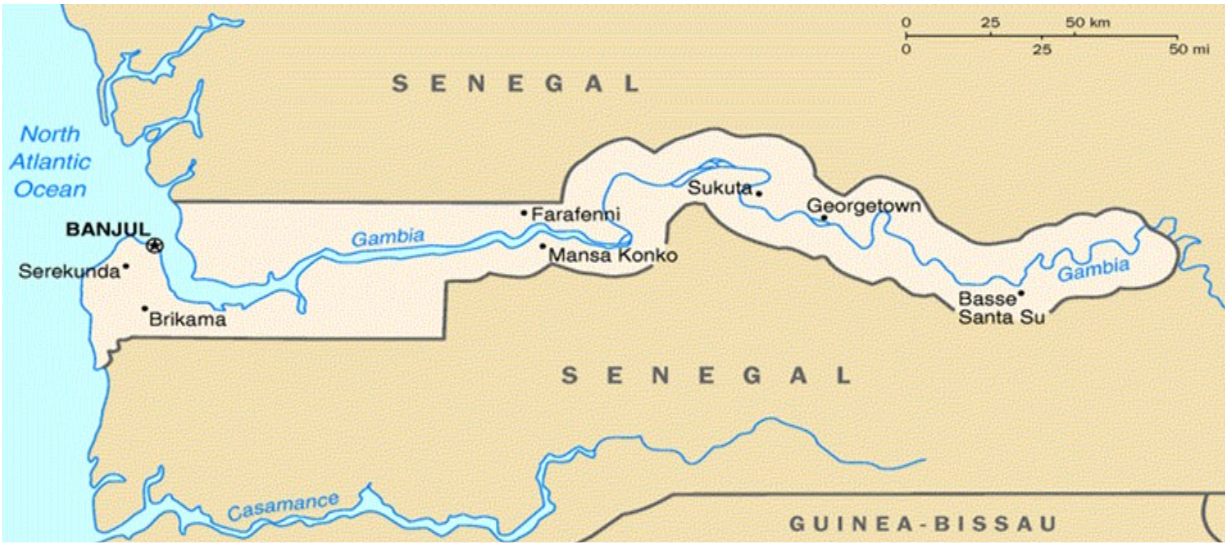

Figure 1. *Map of the Gambia showing study area.*

reduce activities of organisms and animal feed to attain sustainable livelihood. Hence, adapting agriculture to climate change had developed strategies and programmes to combat the negative impact of climate change on livestock and vegetable production to increase productivity. The significance of the study was to adapt the resilient and mitigation methods to climate-smart agriculture, aiming to secure to increase productivity, income security and ensuring environmental sustainability.

MATERIALS AND METHODS

In any scientific research the process of developing research methodology is to arrive at empirical results which is vital for social research. Research methodology is a guide to follow the steps in order to achieve research objectives, draw conclusions and recommendations. The research work was conducted in three (3) regions namely North Bank Region, Central River Region and Upper River Region respectively. The methodology was random sampling to avoid biasness and give chance to all respondents. A total of ten (10) vegetable gardens was established and out of the ten gardens, six (6) were randomly sampled. Primary data was collected by administering questionnaire through interview, focus group discussion, key informants' interview and secondary data from other research work. The data analysis and interpretation were done using the Statistical Package for Social Sciences software (SPSS).

RESULTS AND DISCUSSION

The vegetable production is gaining momentum in the agricultural system of The Gambia's. The women and youth folk are actively engaged in vegetable production as their main source of income to sustain their lives and livelihood. Adapting agriculture to climate change under Food and Agriculture organization gave immense support to women and youth in the rural communities of the Gambia. The research finding reveal the results from six (6) women vegetable gardens with the support from Food and Agriculture Organization. In any research, data collection, analysis and interpretation is fundamental for decisive planning, take inform decisions on policies and programmes and other related development issues. The result given in table 1, shows that, onion obtained 4000kg with a net income of D196,000.00 followed by sweet pepper with a net return of112,000.00, however cabbage and bitter tomato indicate no significant difference of income earned. Primarily, bitter tomato was widely grown by women farmers due to favourable climatic conditions with high potentials of income generation. The net return from onion as a commodity was US$ 3,843, while the lowest income earned was cabbage amounting to US$1,640. According to research finding, the rate of return from vegetable production outweighs the rate of return from field crops. However, women producers find it difficult to eat fresh vegetables as way of improving their dietary health. Therefore, to change this perception would need massive sensitization of women producers about the benefits of eating fresh vegetable particularly for reproductive women.

The vegetable production has multiplied effects on the lives and livelihood of smallhodler women farmers. The results in table 2, indicates a total income earned from onion was D717,750.00 followed by bitter tomato with the earning capacity of D515,625.00, while the lowest income earned was egg-plant with a total amount of D33,000.00 respectively. According to (Poudel, 2020) market-oriented production is the best approach if farmers would adapt the best practices and apply the knowledge and skills to obtain better yield. Vegetable production is one of the most potential windows of opportunity for income generation targeting the consumers on time, set better price and supply quality produce to achieve better returns.

Producers diversify the cultivation of different vegetable varieties that can enhance income security. Crop diversification and intensification in a form of block design is one of key extension messages filtered down to farmers for adaptation and mitigation measures (Kumar *et al.*, 2017). Onion is widely grown by women and youth farmers having comparative advantage on other crops because every household in the Gambia consumed

Table 1. Kunjo women vegetable garden.

Crop	Bed size (m^2)	Average Yield/bed (kg)	Price/kg (Dalasi)	Quantity (kg)	Gross-return (Dalasi)	Net-return (Dalasi)	Net-return (US$)
Onion	1 x 10m^2	330	50	4000	200,000.00	196,000.00	3,843.00
Cabbage	1 x 10m^2	70	35	2,460	86,100.00	83,640.00	1,640.00
B/tomato	1 x 10m^2	25	36	2631	92,085.00	89.454.00	1,754.00
S/pepper	1 x 10m^2	17	65	1,750	113,750.00	112.000.00	2,196.00

Table 2. Kerewan Nyakoi women vegetable garden.

Crop	Bed size (m^2)	Average yield / bed/kg	Price/kg (yield Dalasi)	Quantity (kg)	Gross-return (Dalasi)	Net-return (Dalasi)	Net-return (US$)
Onion	1 x 10m^2	29	30	23,925	717,750.00	693.825.00	13,604.00
Tomato	1 x 10m^2	20	25	16,500	412,500.00	396,000.00	7,764.00
B/tomato	1 x 10m^2	25	25	20,625	515,625.00	495,000.00	9,706.00
Cabbage	1 x 10m^2	13	14	10,725	150,150.00	139,425.00	2,733.00
Egg plant	1 x 10m^2	10	10	33,300	33,000.00	29,700.00	582.00
Okra	1 x 10m^2	25	25	20,625	515,625.00	495,000.00	9,705.00

Table 3. Kuntaur Wassu women vegetable garden.

Crop	Bed size (m^2)	Average yield/ bed/kg	Price/kg (Dalasi)	Quantity (kg)	Gross-income (Dalasi)	Net Income (Dalasi)	Net-income (US$)
Onion	1 x 10m^2	40	24	29,120	698,880.00	669,760.00	13,132,00
Cabbage	1 x 10m^2	71	26	11,275	293,150.00	281,875.00	5,526.00
Tomato	1 x 10m^2	34	30	4,726	141,600.00	137,054.00	2,687.00
B/tomato	1 x 10m^2	47	48	3,325	159,600.00	156,275.00	3,064.00
Pepper	1 x 10m^2	30	100	600	60,000.00	59,400.00	1,164.00
Okra	1 x 10m^2	49	50	1,323	66,150.00	64,827.00	1,271.00

Table 4. Lamin Koto women vegetable garden.

Crop	Bed size (m^2)	Average yield/ bed/kg	Price/kg (Dalasi)	Quantity (kg)	Gross-return (Dalasi)	Net-return (Dalasi)	Net-return (US$)
Onion	1 x 10m^2	14	30	9,282	278,460.00	269,178.00	5,278.00
Tomato	1 x 10m^2	19	30	2,470	74,100.00	71,630.00	1,404.00
B/tomato	1 x 10m^2	21	20	1,911	38,220.00	36,309.00	712.00
Cabbage	1 x 10m^2	16	25	1,376	34,.400.00	33,024.00	648.00
Okra	1 x 10m^2	9	40	585	23,400.00	22,815.00	447.00

onions. The results in table 3, 10m^2 bed of onion scored a quantity of 29,120kg followed by cabbage and tomato while the lowest score was pepper of 11,275kg, 4,726kg and 600kg respectively. Furthermore, price is a determining indicator for profit or revenue as a result pepper scored better premium price/kg of one-hundred-dalasi (100) and bitter tomato of fourty seven-dalasi (47)/kg. In terms of monetary value onion scored D669,760.00 while cabbage scored D281,875. respectively. The value of return on vegetable production was calculated based on the direct monetary value incurred at the local level.

The instability in the marketing system, price fluctuation, influence of local market and poor marketing channels posed a serious threat in selling vegetables. The women producers are faced with serious problem of marketing agricultural commodities particularly tomato which has short shelf life as a result of high temperatures (Kunwar *et al.*, 2015). In table 4, the result indicates that, the income earned by farmers different from onion, was tomato with a quantity of 2,470kg valued at D71,630.00. Furthermore, net return of income was totally different from scheme to scheme by women producers, due to different management practices and adaptation of agricultural technologies by farmers proves to be difficult (Azumah *et al.*, 2019).

In the process of collecting data producers agreed by accepting remarkable changes in terms of yields which resulted to the combined effects of unfavourable climate conditions and variability. The result in table 5 shows that, Jamal's women producers have comparative advantage of producing egg-plant than other vegetable crops due to minimal production cost, product choice, better price and proximity to local markets. In comparison, egg-plants were the choice of producers resulting to a net return of D406,667.00 against other vegetable producers whose choice of crop was onion, bearing the same comparative advantage. In addition, bitter tomato was another crop where women farmers have fetched better income of D218,518.00. It was attributed to better production and marketing plan especially wet season when the demand for such crops is high with better premium prices (Adhikary *et al.*, 2015).

The innovative idea of harnessing women's wide-range of knowledge and skills to attain sustainability and nutritional value of vegetables is paramount to vegetable production. The risk of crop failure was high in producing single crop but the scenario was totally different for women engaged in vegetable

Table 5. Jamal's women vegetable garden.

Crop	Bed size (m^2)	Average yield/ bed/kg	Price/kg (Dalasi)	Quantity (kg)	Gross-return (Dalasi)	Net-return (Dalasi)	Net-return (US$)
Onion	1 x $10m^2$	30	28	4,500	126,000.00	121,500.00	2,382.00
Tomato	1 x $10m^2$	30	25	1,200	30,000.00	28,800.00	565.00
B/tomato	1 x $10m^2$	41	35	6,427	224,952.00	218,518.00	4,284.00
Egg-plant	1 x $10m^2$	87	30	14,023	420,690.00	406,667.00	7,973.00
Okra	1 x $10m^2$	35	50	2,698	134,900.00	132,202.00	2,592.00

Table 6. Gengi Wollof women vegetable garden.

Crop	Bed size (m^2)	Average yield/ bed/(kg)	Price (kg) (Dalasi)	Quantity (kg)	Gross-return (Dalasi)	Net return (Dalasi)	Net return (US$)
Onion	1 x $10m^2$	36	40	18,144	725,760.00	707,616.00	13,874.00
Cabbage	1 x $10m^2$	68	30	4,920	147,600.00	142,680.00	2,797.00
Hot pepper	1 x $10m^2$	25	100	4,200	420,000.00	415,800.00	8,152.00
Egg-plant	1 x $10m^2$	40	25	4,536	113,400.00	108,864.00	2,134.00
Tomato	1 x $10m^2$	32	30	3,076	92,280.00	89,204.00	1,809.00
B/ tomato	1 x $10m^2$	45	25	5,376	134,400.00	129,024.00	2,529.00
Okra	1 x$10m^2$	18	50	3,076	153,800.00	150,724.00	2,955,00

Table 7. Production and income.

Vegetable garden	District	# of beds	Quantity (kg)	Gross-return (Dalasi)	Net-return (Dalasi)	Net- return (US$)
Kunjo	Sanjal	1,177	19,137	1,309,200.00	1,290,063.00	25,295.00
Kerewan	Wuli	21	95,700	2,524,500.00	43,946.00	861.00
Kuntaur	Niani	1,184	50,774	1,402,905.00	27,508.00	500.00
Lamin Koto	Sami	1,071	16,200	468,740.00	9,188.00	180.00
Jamal	Sami		41,760	1,711,145.00	33,550.00	657.00

production as climate smart agriculture is being practice both women and men (FAO, 2016). In table 6, the results show that, hot pepper was regarded as another high value crop where producers can fetch better income against onion, a crop preferably grown by women farmers in rural communities of the Gambia. In monetary value, pepper registered a net return of D415,800 bearing in mind that the demand is high because of its medicinal effects during cold season. Primarily, the price index in table 5, better price was D100/kg compare to other crops, with proper production and marketing plan, pepper production can boost income capacity of women.

Production cost, gross return and net returns, were considered as economic variables to evaluate the comparative analysis of major vegetables grown adopting climate smart agriculture. Production system of crop diversification and intensification can help women producers to improve farm incomes and reduce vulnerability to climate change (Abewoy, 2018). In table 7, the result shows that, the total quantity of crops produced and marketed by vegetable producers was registered by Kunjo women vegetable garden with a gross return of D1,309,200.00 and net return of 1,290,063.00US$ while the lowest net-return registered was Lamin Koto women vegetable garden of D9,188.00 respectively. Crop diversification and intensification is a vital approach for women vegetable producers as it will reduce the risk of crop failure thus increasing food security, nutritional values and income of farmers (Pandey *et al.*, 2019).

However, during the time of interaction with producers at field level many of women alluded to the fact that, market and marketing of vegetables was challenging. This was attributed to the size of local markets, poor marketing channels, in adequate supply chain, post-harvest loss, poor quality and low price affecting the profit margin (Dhakal *et al.*, 2019). In relation to markets 75% of women producers in the rural communities, encounter problem of selling their vegetables to the markets. The initiative of market-oriented produce to sell idea should be practiced by women producers to solve their problem of marketing (Laosutsan *et al.*, 2019). Therefore, the government, partners, civil society organization and agricultural projects should create many horticultural gardens in the rural communities as this will increase food and nutritional security, reduce poverty and increase income. In addition, concentrating on vegetable production at grass-roots level will have multiplier effect on gross domestic product while propelling the growth of local economy.

Conclusion

The agriculture-sector contribution to the GDP is significant to the socio-economic development of smallholder farmers and the government entirely depend on agriculture for economic growth to enhance foreign exchange earnings. The National Development Plan (NDP) which is the blue of government development priorities put emphasis on commercialization of agriculture through value-addition processes. The horticulture sub-sector on average contributes four (4%) to GDP with many programmes to boost production and marketing of vegetables

in the communities. The production system of horticulture can be handled as more of diversification and intensification in order to increase productivity and income of vegetable producers. The most predominantly vegetable crop widely grown in the six (6) vegetable schemes was onion, having the highest net rate of return against other crops. The simple reason of onion been widely grown in the rural communities was that, each household consume onion on a daily basis and the market demand is always at vintage point by consumers. Vegetable production is a viable and vibrant enterprise in rural communities as it provides food and nutritional security, income and reduce poverty. However, one can say that climate change poses a great threat to the livelihoods of the farming communities causing loss of crops, forage and poor quality of meat and milk. In this perspective, adapting agriculture to climate change under Food and Agriculture Organization formulated adaptation and mitigation strategies that would reduce risk the effect on agriculture ensuring sustainable livelihood activities in rural communities. Furthermore, when women producers adapt conservation practices by the use of organic manure, synthetic fertilizer, and application of bio-pesticides would reduce the effects of climate variability. In conclusion, the application climate smart agriculture tools enhance better yields, increase income and profitability of women vegetable producers. Therefore, recommending, institutional strengthening of the extension systems to develop appropriate agricultural technologies and disseminate technologies to farmers to boost production. The government should develop policy and strategy that would address the risk factors associated to climate change in terms of adaptation and mitigation measures.

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