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ASSESSING DIFFERENTIAL GAINS THAT OUTSTANDING AND AVERAGE PERFORMING FARMERS ATTAIN FROM CLIMATE-SMART CASSAVA INNOVATIONS IN NYANDO CLIMATE-SMART VILLAGES, KENYA

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ABSTRACT

In adoption of agricultural innovations, a few farmers attain outstanding outcomes above their peer majority. This reveals a positive deviance behavior in successful deployment of technologies and innovations. Assessing this behavior in climate-smart agriculture (CSA) can reveal the yield gap in triple wins of CSA (adaptation, farm productivity and mitigation). This study investigated differential gains in these CSA triple wins between outstanding (positive deviants) and average (typical) performing farmers who have adopted climate smart cassava innovations in Nyando Climate Smart Villages (CSV). In a household survey, a sample of 150 farmers were reached, which through snowballing approach, peers identified 30 to exhibit positive deviant behaviour. Presenting these in Focus Group Discussion (FGD) with stakeholders further isolated six farmers being those they consider positive deviants (PDs) in climate smart cassava innovations. Data were subjected to cross-tabulation to generate frequencies used to compute weighted index scores. This revealed increasing magnitude and was a preferred fair comparison of a sample of fewer positive deviants (n=6) with large number of typical (n=144) farmers. Results revealed substantial differences in the attained triple win gains from climate smart cassava innovations between typical and positive deviant farmers. The weighted index scores showed that positive deviant farmers had attained higher adaptability, production diversification, farm productivity and intensification, food security and were implementing more mitigation practices for climate change. This empirical evidence demonstrates potential gains from climate smart cassava innovations when deployed effectively. This is because innovative management practices distinguish positive deviant farmers from typical farmers. These typical farmers would benefit more by learning from positive deviant farmers about effective deployment of climate smart cassava innovations. The study recommends strengthening extension services linked to farmer platforms in order to grow capacity for more effective deployment of climate smart cassava innovations for realising the CSA triple wins.

Key words: Adaptability, food security, productivity, production diversification, positive deviants, cassava innovation

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INTRODUCTION

Climate Smart Agriculture (CSA) is a portfolio of innovations developed for responding to persistently changing and variable climate risks. When deployed effectively, CSA delivers multiple benefits which is termed as CSA triple wins: food security (SDG 2), poverty reduction (SDG 1), adaptation and mitigation of climate change (SDG 13) [1]. The CSA is particularly promoted to households vulnerable to impacts of the increasingly variable and changing climate. Deploying CSA in their farming systems is an intervention to increase their adaptability and resilience to climate change, increase farm productivity and incomes while reducing or minimizing greenhouse gas emissions necessary for mitigating climate change. Climate Smart Agriculture (CSA) is mostly promoted to vulnerable households through multi-stakeholder Agricultural Innovation Systems (AIS). This approach capacitates households to test, co-develop and validate a portfolio of CSA innovations with multiple stakeholders.

The farming households of the Nyando Basin in South West Kenya have since 2011 been testing, co-developing and validating a portfolio of CSA innovations with multiple stakeholders. The farming households of Nyando basins are highly vulnerable to the effects of recurring climate change and extreme events [2]. Their agricultural systems are subsistence and rain-fed. This exposes them to extreme droughts, flood events, unpredictable rainfall onset, widespread land degradation from soil erosion, and rising disease and pest incidences prevalent in this basin [2,3]. As a result, agricultural productivity is dismally low, evidenced by average maize yields of 100 kg/ha, a staple food crop in the area [4]. Food insecurity is widespread, with 81% of the households experiencing one to two months of hunger per year, and another 17% experiencing three to four months of food insecurity [2].

Because of high climate change vulnerability of farming households of the Nyando basin, the region has been targeted beneficiary of climate adaptation intervention package, delivered as Climate Smart Village (CSV) with AIS approach. Cassava, a staple food crop and the second most consumed crop after maize, is among the portfolio of CSA innovations in the Nyando CSV. In a multi-stakeholder facilitated AIS, a portfolio of climate smart cassava innovations has been subjected to testing, co-development and validation. These include improved cassava varieties (MH95/0183) with adaptable attributes: mosaic viral disease resistance, high yielding, early maturing, and low cyanide content, tolerance to high water stress, low input demand [3,4,6]. With these attributes, improved cassava varieties are well adapted to the prevalent climate risks and suitable for intercropping with a

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variety of crops, so a promising diversification crop with the other staple food crops - maize and sorghum [3,4,6]. Cassava is a perennial crop, harvestable over a long period of time while still under soil cover that is able to increase soil carbon sequestration and reduce greenhouse gas emissions. Improved cassava is adapted to the prevalent climate risks in the Nyando basin (water stress, and menace of fertilizer, herbicides and pesticides usage). Processing cassava stimulates rural agro-processing with economic opportunities [7].

Adopting improved cassava variety is innovation with the potential to increase productivity for household food security, sell surplus produce to earn income, adapt to variable and changing climate while contributing to mitigation of the climate change [8]. In adoption of agricultural innovations, a few farmers attain outstanding outcomes above their peer majority [9]. This reveals a positive deviance behavior in successful deployment of technologies and innovations. Assessing this behavior in climate-smart agriculture (CSA) can reveal the yield gap in triple wins of CSA. Innovation studies [9] have explained observed individual differences in performance by comparing the social structure of actors, their relationships, and institutions at the macro-level. This ignores those farmers that operate at the micro-level in the midst of collective actions on the AIS platform, transforming themselves into outstanding performers (positive deviants) above the average peer farmers (typical). This study investigated differential gains in CSA triple wins between positive deviants and typical farmers who have adopted climate smart cassava innovations in Nyando Climate Smart Villages (CSV). The empirical evidence is informative in learning to inspire the majority of the farmers performing averagely to deploy their management practices differently. In this study, indicators of CSA triple wins were adaptability, production diversification, farm productivity and intensification, food security and mitigation practices for climate change.

MATERIALS AND METHODS

Study area

The study area was Nyando Climate Smart Villages (CSV) in Nyando Sub-County of Kisumu County, Western region of Kenya. The Nyando CSV was chosen for the study, being one of the climate smart villages established in 2011/2012 by a Research Program on Climate Change Agriculture and Food Security (CCAFS) alongside other stakeholders to test, co-develop and validate a portfolio of climate smart cassava innovations among other CSA portfolios. Nyando CSV is in a region classified hotspot of changing and variable climate, impacting on rural livelihoods. The area (Figure 1) lies between longitude 33° 20' - 35° 20' East and latitude 0° 20' - 0° 50' South. The area covers approximately 163km^2 with population of about

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73,227 persons [9], with a mean annual rainfall of 1000mm and mean annual temperature of 20°C.

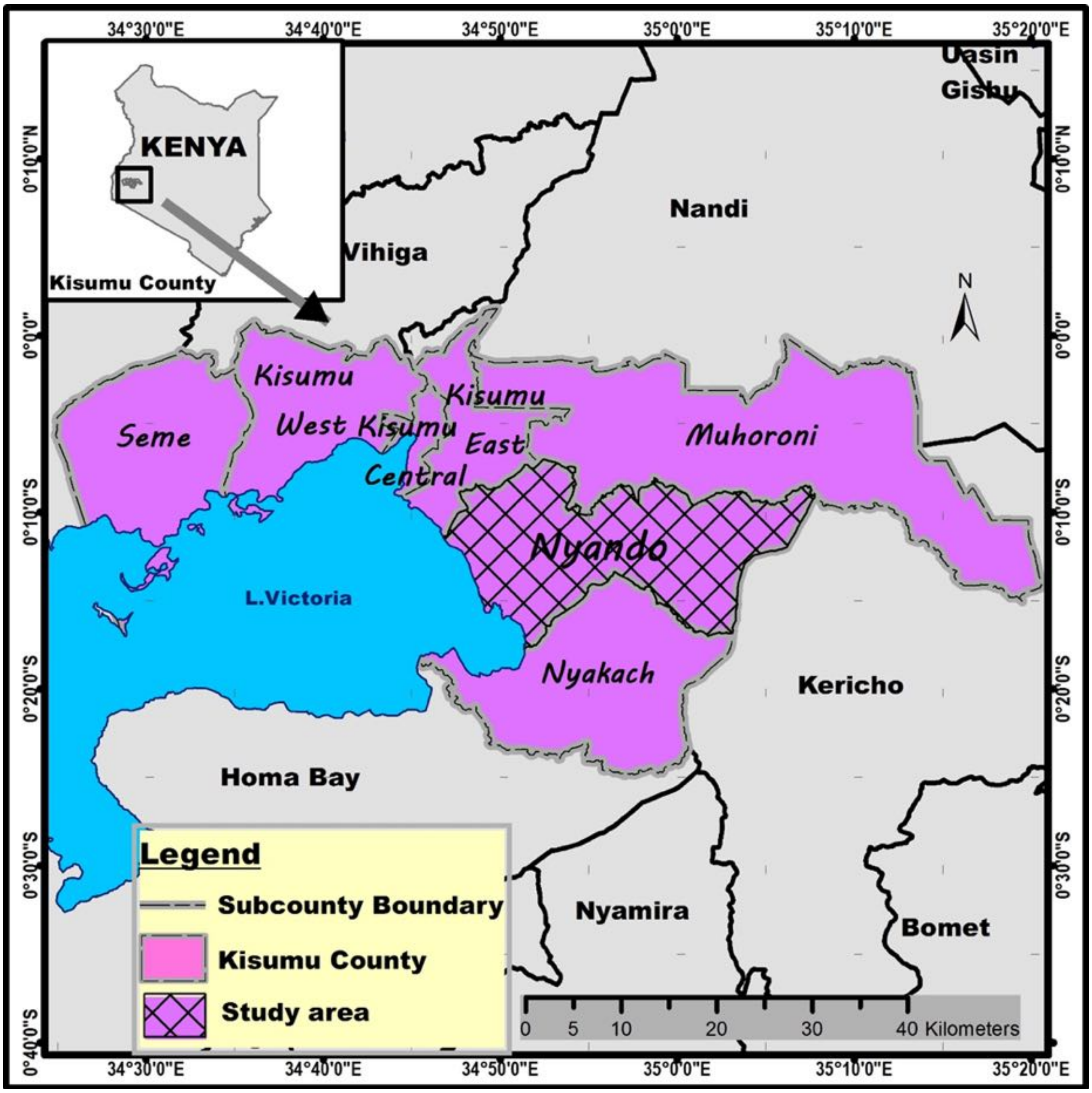

Figure 1: Map of Nyando Sub-County of Kisumu County

Sampling

The target population was households in Jimo location, administratively a Sub-location in Nyando Sub-County consisting of 11 villages with a population of 10,000 households [10]. The study's minimum desired sample size was determined using Fisher's exact formula [11]:

$$n = \frac{(Z_{1-\alpha/2})^2 P(1-P)}{(d)^2} \qquad \text{Equation (1)}$$

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Where;
n = sample size; $Z_{1-\alpha/2}$ = Z statistic for a 95% level of confidence (1.96), P = expected prevalence of cassava farming being 25% based on reported priori estimates [13] and d = allowable margin of error set at 8%. The resulting sample size, was inflated up by 10%, yielding a minimum required sample of 124 farmers. However, the actual number of households sampled 150 farmers because each farmer visited identified three farmers perceived or considered as outstanding in cassava CSA practices and performance outcomes. A detailed explanation of the process is in next sections.

The sample farmers were obtained in a simple random sampling process from the list of farmers participating in the Nyando CSV activities. Kenya Agricultural and Livestock Research Organisation, a lead research institution stakeholder in the Nyando CSV Agriculture Innovation System, provided the list. The selected farmers were visited for interviews.

Data collection
A semi-structured questionnaire administered during a household survey was complemented with Focus Group Discussion (FGD) to capture quantitative and qualitative data [10, 11]. The questionnaire had sections on farmer demographics and use of cassava innovations over the years. For use of cassava innovations, information of interest was about adaptability, production diversification, productivity and intensification, food security and mitigation practices for climate change. Indicators for adaptability were changes in farming practices effected since 2011 when CSV was initiated. For production diversification, a farmer was presented with a list of 13 farm products and 14 cassava products. Out of these, farmers indicated which ones they had been producing in own or rented farms in the last 12 months. Indicator of productivity yield of cassava (Kg/acre) and the proportion of the produce that was home consumed and that was marketed. Cassava intensification was measured from a list of seven (7) possible changes in input to cassava crop that had been made since 2011. A measure of food security was for a typical food year in which a household indicated for each month whether food tended not to be enough for the family food needs. Mitigation practices for climate change were land allocated to tree planting and the number of trees planted.

Identification of positive deviant farmers
In smallholder agriculture, under similar production environment and circumstance, some farmers emerge as outstanding performers above their comparable fellow farmers who achieve just typical average performance. The outstanding

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performers are labelled positive deviants (PDs) while the average performers are labelled typical (TPs) farmers. This phenomenon in CSA practices can be associated with more effective and successful implementation of CSA practices that lead to better performance indicators, in this case, attaining higher CSA triple wins, cassava production, marketing and innovations. This study engaged peer farmers and key informants to identify such PDs in a snowballing and a validation process, as subsequently described.

When administering the questionnaire during the survey, each farmer visited was asked to identify three farmers who grow improved cassava varieties in the village. Of the three farmers growing improved cassava varieties, a respondent was further asked to identify the one that the respondent considered/perceived an outstanding performer with CSA cassava practices, production, and productivity. An open-ended question to the respondent asked each of them to explain the reasons for singling that particular peer farmer, an outstanding performer. Each of the singled outstanding performer was then traced for on-farm visit and interview using the same questionnaire but without disclosing the opinion of their peer fellow farmers. So, each of these outstanding performers also identified three farmers in the village who were growing improved cassava varieties and proceeded to also single out an outstanding performer and gave the reasons for singling the farmer.

At the end of the survey, a list of those singled out as being outstanding performers was constructed then those most frequently mentioned were isolated. With this list, those mentioned at least three times, were a total of 30 and were invited to a follow up FGD of stakeholders. The participants in the FGD session were actors in the value chain, extension staff and researchers from public and private sectors working in the Nyando Climate Smart Villages. The FGD sessions deployed ethnographic interviews through which stakeholders reached a consensus on farmers fitting the description of a positive deviant (PD). Six farmers were characterized as positive deviants, being those who had demonstrated an outstanding performance in uptake of cassava climate smart innovations and were realizing outstanding production and productivity above their peers and comparable farmers in the village.

Data Analysis

Analysis was to establish evidence of differential gains realized between positive deviants and typical farmers in the adoption of climate smart cassava innovations. Specifically, interest was differential magnitude in: adaptability, production diversification, productivity and intensification, food security and mitigation practices for climate change. This was achieved by computing weighted average

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index score because positive deviant farmers were fewer (n=6) as compared to typical (n=144) farmers for a fair comparison.

The weighted average index score for production diversification, food security, adaptability and intensification, was computed adapting the scoring approach used in Climate Change, Agriculture and Food Security (CCAFS) baseline surveys [3]. The CCAFS scoring reflected an increasing magnitude, in five classes of food security which included water, fiber, fats, proteins, and carbohydrates. Specifically, the weighted average index score for production diversification for the entire farm was computed out of 13 possible products while cassava diversification was computed out of 14 possible products, which farmers indicated producing in the last 12 months. Producing one to four (1 to 4) products was classified low production diversification and scored 1, producing five to eight (5 to 8) products was classified intermediate production diversification and scored 2, while producing nine or more (≥ 9) products was classified high production diversification and scored 3. A weighted average index score was then computed from the frequency counts of households. The frequency of those scored 1 were multiplied by 1, frequency of those scored 2 were multiplied by 2 and frequency of those scored 3 were multiplied by 3. The resulting product was divided by the sum of the frequency counts for all the score classes. The weighted average index score (I_i) was for all scores, computed from:

$$I_i = \frac{\text{Score class } (1-5) * \text{Frequency counts for each score class}}{\text{Sum of frequency counts for all the score classes}}$$

The computation of weighted average index scores for adaptability, food security, and intensification followed the same process. For the adaptability of the entire farm and cassava crop only, the index score was computed from the frequency counts of changes in farming practices effected since 2011. If the change in practices was zero or only one (≤ 1), it was categorized as low adaptability and scored 1; if the changes were two to ten (2 to 10), it was categorized as intermediate adaptability and scored 2; if the changes were eleven or more (≥ 11), it was categorized as high adaptability and scored 3.

For food security, the index score was computed for a typical food year, counting the number of months a household tended not to have enough food for the family to eat. These were scored in five classes: hunger for more than 6 months in a year was scored 1, hunger for 5 to 6 months in a year was scored 2, hunger for 3 to 4 months in a year was scored 3, hunger for 1 to 2 months in a year was scored 4, food all year round, no hunger period, was scored 5. The increasing magnitude

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represented a situation of more secure food security in the households. The definition of a household was a unit of people making a family, commonly eating from the same food basket in the same house for the last 12 months before the survey.

For cassava intensification, the index score was computed from seven (7) changes in input in cassava since 2011. A farmer indicating no change in input use was categorized as none intensification and was scored 1, those who had changed one to three (1-3) of the inputs were categorized as low intensification and were scored 2, and those who had changed four to seven (4-7) of the inputs were categorized as high intensification and were scored 3.

Productivity and mitigation indices were computed differently. Productivity index was computed in percentage difference between positive deviants and typical farmers in yield of cassava (Kg/acre) and the proportion of the produce that was home consumed and those that were marketed. Positive difference indicated that positive deviants performed better than typical farmers.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the respondents

The distribution of the respondents (Table 5) revealed that majority were over 35 years of age, with females out-numbering males (57% vs 43%). The majority (82%) had completed at least primary level formal education, and farming was the primary source of income (67%). The same results show that, nine in ten of the sample farmers (88%), had been members of a climate smart group for at least seven years and that growing cassava was a decision made by the head of the household. Group membership is an important pathway for the on-farm testing, co-development, adoption, and promotion of cassava innovation in an AIS platform that Nyando CSV was. Members of a group initiate, import, modify, and disseminate knowledge among the interactively engaged actors that comprise the AIS. Results presented in Table 6 show that nearly half of the farmers (49%) were growing improved cassava varieties or both local and improved varieties (29%), integrated into crops, livestock, vegetable production or tree nursery. Some farmers participated in savings and credit table banking.

Positive deviance behavior in climate smart cassava innovation development
To better understand the role of positive deviance behavior in maximizing benefits from climate smart cassava innovations, peers identified farmers they considered to exhibit outstanding climate smart cassava innovation in practice and productivity

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performance (Table 7). In response, seven out of ten (68.7%) had a farmer whom they considered to exhibit exceptional practice and productivity performance in the use of climate smart cassava innovations. At least eight in ten (82%) of these farmers indicated that they interacted with the outstanding farmers. Interactions with outstanding farmers focused more frequently (27%) on gaining access to improved cassava cuttings.

The results demonstrate that farmers recognize positive deviance behavior amongst their peers and interact with them to access the innovation. Positive deviants are individual farmers who have attained outstanding performance than their average peers under same resources and constraints [4,5]. Results suggest that positive deviants accelerated adoption of climate smart cassava innovations, with nine in ten (91%) of the sample farmers adopting climate smart cassava practices in their cassava farms (Table 8). Growing of improved cassava varieties is a response to climate change and variability induced risks, including more erratic rainfall, soil infertility and frequent droughts, high disease incidences and frequent floods [4]. Cassava has livelihood roles in rural households, which improved variety provides in better yields, and this is important for food security and surplus to sell for income. In supporting adoption of climate smart cassava innovations, positive deviant farmers play important contributory roles in the community towards adaptation, farm productivity and incomes. The successes demonstrated by the positive deviant farmers provide insights that inform development practitioners how to foster cassava innovation and deliver benefits of climate smart cassava innovations. They provide practical proof of the viability of the innovations within the locality, which has local advantage in strengthening response to the persistently changing and variable climate because they innovatively deploy innovations fitted to local farming circumstance [5].

Adaptability

Weighted adaptability index for the entire farm and cassava crop on typical and positive deviant farms is presented in Figure 2. The results show that relative to typical farms, positive deviant farms had attained higher adaptability in both farm adaptability (2.83 vs 2.79) and cassava crop adaptability (2.83 vs 2.72).

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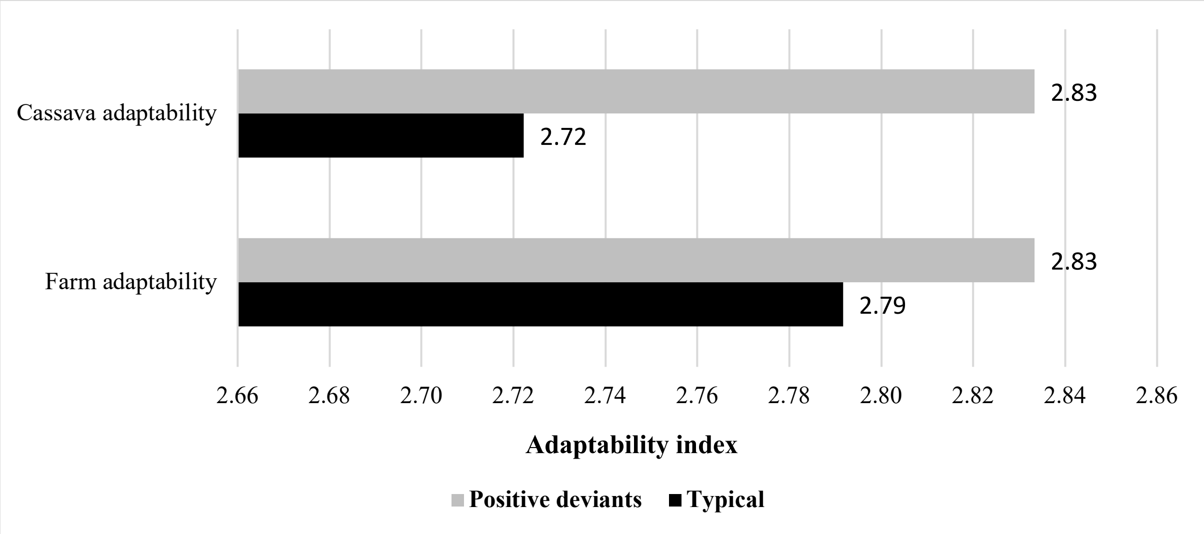

Figure 2: Adaptability index for the entire farm and cassava crop on typical and positive deviant farms

To ensure food security, the majority of smallholder farmers around the world are constantly adapting to climate change by cultivating fewer plots, practicing mixed cropping, farm diversification, and planting improved crops and drought-tolerant crops [18]. In addition, farmers' adoption and adaptability of climate smart crop innovations has been hampered by a lack of information on improved crop varieties and mistrust from input suppliers [18,19]. This is consistent with the findings of this study (Figure 2), which discovered that positive deviants' farmers had higher crop and farm adaptability than typical farmers.

Production diversification

The results reveal that production diversification of the entire farm and of cassava products was relatively higher on positive deviant farms compared to typical farms. These results show that positive deviant farmers were attaining relatively higher production diversification than typical farmers with the use of cassava innovations (Figure 3), whereby they had a farm and cassava diversity of 0.83 and 0.78, respectively.

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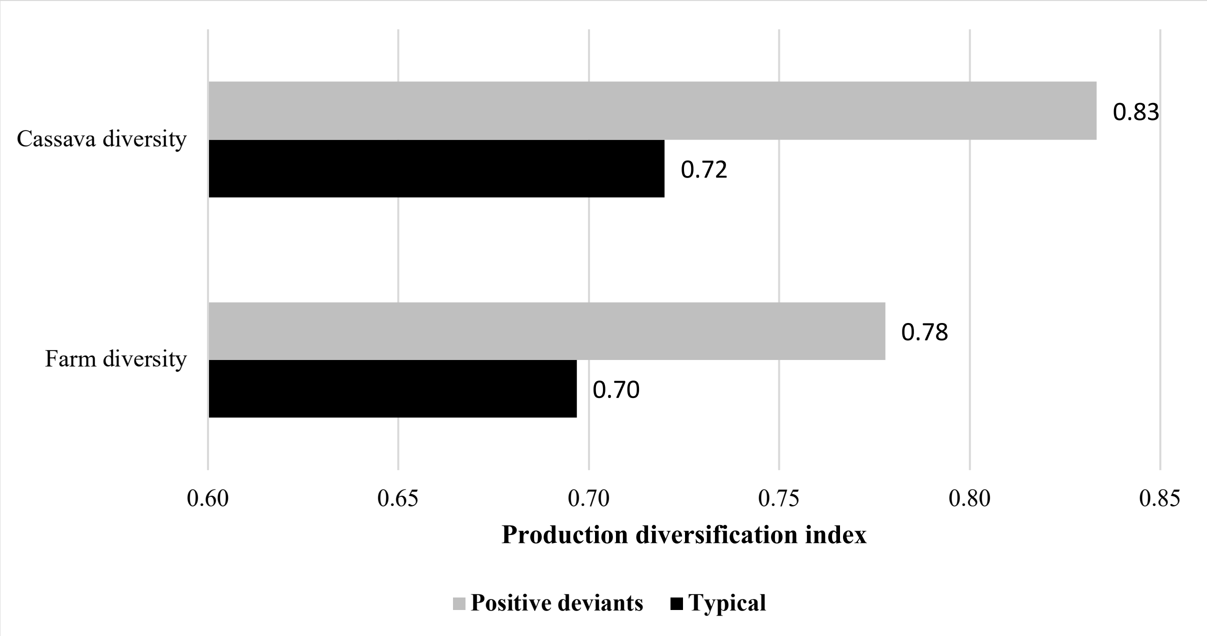

Figure 3: Production diversification index for the entire farm and cassava products produced on typical and positive deviant farms

Positive deviant farmers have lots of stock to consume and sell because of their high production yields. Due to high crop yields, positive deviant farmers must devise strategies for diversifying their crop production in order to meet the needs of their families and communities [15]. These results are in conformity with Charan and Biswas [15], who found that improved innovations lead to farm diversification, which result in high production yields. Farm diversification is critical, especially for resource-constrained farmers who want to increase their production yields. Farmers can improve farm performance by implementing a model-aided farm restructure. It was opined that by optimizing resource allocation, farmers can re-design their farms through various forms of diversification [16]. The positive deviance approach is a technique that can be used effectively to investigate various farm diversities and cassava production diversification. They out-perform typical farmers by being creative in their use of available resources. Following that, the need for whole farm redesign modelling to inform better alternatives for farm diversification was emphasized [17].

Productivity and intensification

Table 8 presents productivity index on positive deviant farms and typical farms. Indicators of productivity in this paper are cassava yield attained in kilograms per acre and the proportion of the yield that is consumed at home and the proportion that is marketed. Cassava yields attained was about 46% higher on positive deviant farms compared to yields attained on typical farms. With higher yields

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attained on positive deviant farms, the households consumed more (1.4%) and sold more (15%) to market, relative to typical farmer households. Input intensification index computed for the typical and positive deviant farms is presented in Figure 5. Positive deviant farms attained higher input intensification index of 2.83 compared to 2.46 of typical farms.

Positive deviant farms had attained higher cassava yield productivity, consumed and marketed more cassava compared to typical farms. One plausible explanation is that farmers who practice innovative cassava farming have received extensive training and are well-versed in the types of inputs to use in their farm production. This translates to high crop yields per acre for them. Furthermore, by doing so, these households benefit from the ability to not only consume more cassava but also market it. Similar findings were documented by Jones *et al.* [18], who established that through embracing climate smart innovations, farmers are able to use improved inputs and achieve higher production yields. Furthermore, they noted that, collaborative learning between various stakeholders is key in the uptake of climate smart innovations.

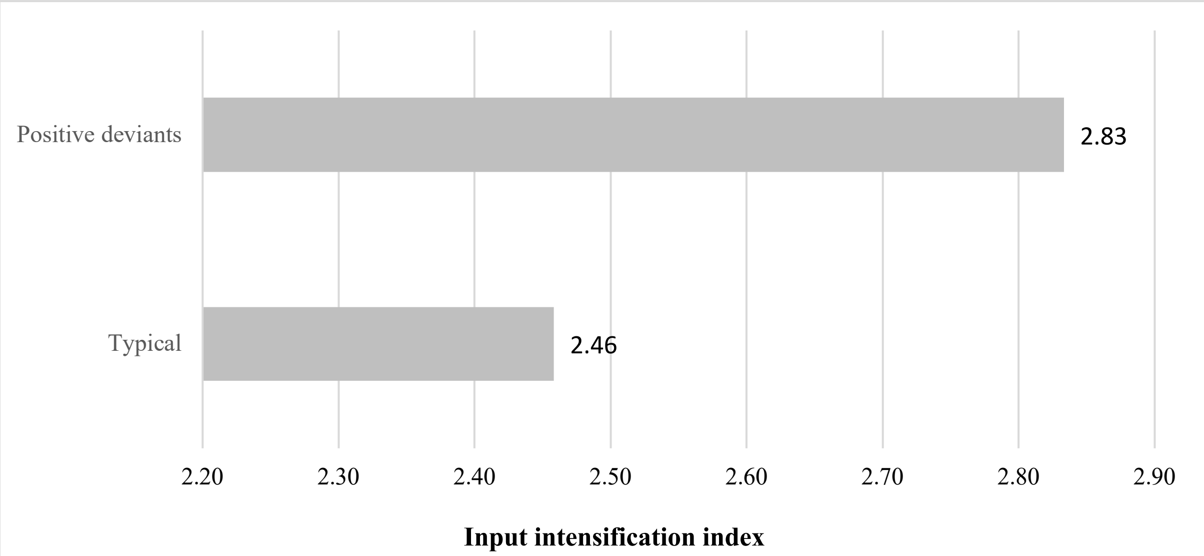

Figure 4: Input intensification index for the typical and positive deviant farms

Food security

Better food security situation was attained in positive deviant households (5.00) compared to that attained in the typical households (3.93) in reference to food availability in the households for the last 12 months before the survey date (Figure 5).

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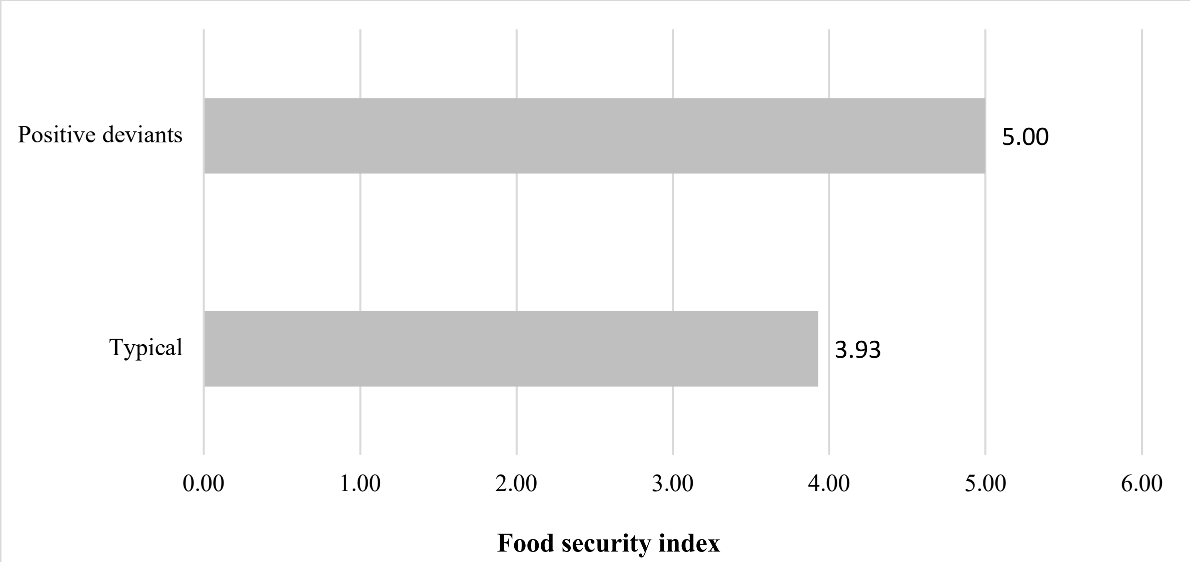

Figure 5: Food security index for the typical and positive deviant farm household

Cassava innovations have also increased food security globally [20]. While it has been highlighted as one of the drought-tolerant crops, there have been numerous discussions about how to make cassava beneficial and sustainable for future food security. Furthermore, cassava has been presented as one of the most easily accessible foods that can be used to overcome food insecurity due to its ability to grow in a wide range of agro-ecological zones, its rich food calorie value, and its affordability [12]. The results in Figure 3 show that positive deviant households had better food security than typical households.

Increased cassava cultivation has a great potential of improving food security based on the interviews, which correlated to other observations [22]. Parmar *et al.* [22], concluded that cassava farming is one of the best strategies of improving food security in Tanzania particularly in the semi-arid region. The findings also alluded to the fact that cassava, as one of the drought-tolerant crops, faces a variety of challenges ranging from infertile soils to community misinformation. However, most farmers in Kenya only know that cassava is a drought-tolerant crop and thus rarely cultivate it. When compared to typical farms, positive deviant farms had higher cassava yield productivity, consumed, and marketed more cassava.
Mitigation actions

Table 9 summarises the tree planting and land management being the mitigation actions that were practiced on positive deviant farms and typical farms. The average land planted with trees was more than twice higher on positive deviant farms than was on typical farms (0.54 vs 0.23 acres), but the proportion of land that was degraded was not different between the two farm groups. On average,

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whether typical or positive deviant farmers, five in ten produced or purchased tree seedlings. Relatively, positive deviant farmers were more likely to seek extension advice on tree management, to practice agroforestry and to introduce cover crops than the typical farmers. With these tree planting and land management practices, eight in ten farmers indicated that they were realising improved land productivity.

Positive deviant farmers planted more trees than typical farmers in an effort to mitigate climate change. However, there was no significant difference between the two farms on land degradation. Similar findings were established that majority of farmers who practiced improved cassava varieties had designed ways of mitigating climate change through mulching, tree planting, and to some extent irrigation to avoid soil degradation and erosion caused by erratic rains or drought seasons [23]. Seeking extension service advice on proper tree management and agroforestry, as well as the introduction of cover crops, was a key characteristic demonstrated by positive deviant farmers. In their study, Githunguri and Njiru [24], noted that agroforestry is indeed important in fostering innovation, particularly among rural households. Because of the enormous rise in technologies and practices in response to various innovations, there is a need for an integrated modern and traditional land use where crops, trees, and livestock can be managed together under one production system to ensure continuous supply of foods, soil nutrient improvement, and climate mitigation.

CONCLUSION

This study computed weighted average index scores to quantify differential gains between positive deviants and typical farmers who have adopted climate smart cassava innovations in Nyando Climate Smart Villages (CSV). The gains represented CSA triple wins, specifically adaptability, production diversification, farm productivity and intensification, food security and mitigation practices for climate change. The weighted index scores showed that positive deviant farmers had attained higher adaptability, production diversification, farm productivity and intensification, and food security. Further, they showed more likelihood to seek extension advisory, introduce good tree and agroforestry management, use cover crops and allocate more land to trees in their farms, which contribute to mitigating climate change. This empirical evidence demonstrates potential gains from climate smart cassava innovations when deployed effectively. Innovative management practices distinguish positive deviant farmers from typical farmers. These typical farmers would benefit more by learning from positive deviant farmers about effective deployment of climate smart cassava innovations. The study recommends strengthening extension services linked to farmer platforms in order

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to grow capacity for more effective deployment of climate smart cassava innovations for realising CSA triple wins.

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Statement of no-conflict of interest

The authors declare that there is no conflict of interest in this work.

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Table 1: Measurement for computing weighted average index score for adaptability

Farming Changes effected	Entire farm (01=yes; 02=No)	Cassava crop (01=yes; 02=No)
1. Introduced a new crop?		
2. Tested new crop?		
3. Stopped growing a crop totally?		
4. Stopped growing a crop in one or more seasons?		
5. Planted disease-resistant variety crop?		
6. Planted drought tolerant variety		
7. Planted higher yielding variety		
8. Planted shorter cycle variety		
9. Planted flood tolerant variety		
10. Expanded area under crop		
11. Reduced area under crop		
12. Started irrigating crop		
13. Introduced intercropping		
14. Mulch during dry spell		
15. Introduced crop cover		
16. Introduced contour ploughing		
17. Introduced rotations		
18. Introduced mechanized farming		
19. Practiced early land preparation		
20. Practiced late planting		
21. Started using or using more mineral/chemical fertilizers		
22. Started using manure/compost		
23. Weeding crops		
24. Started using integrated pest management		
25. Started using integrated crop management		

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Table 2: Measurement for computing weighted index score average of production diversification

Variables	Measurement	Variables	Measurement
Farm production diversification	**(01=No; 02=Yes)**	**Cassava production diversification**	**(01=No; 02=Yes)**
1. Food/cereal crops		1. Local cassava varieties	
2. Cash crops		2. Improved cassava varieties	
3. Fruits		3. Cassava tubers raw	
4. Vegetables		4. Cassava boiled/steamed	
5. Fodder		5. Cassava dried	
6. Large livestock		6. Cassava flour	
7. Small livestock		7. Cassava chips	
8. Livestock products		8. Cassava leaves	
9. Fish		9. Improved Cassava planting materials	
10. Honey		10. 10.Cassava ugali	
11. Timber		11. Cassava porridge	
12. Fuel wood		12. Cassava biscuits/bread	
13. Manure/compost		13. Cassava starch	
14. Agro-forestry tree			

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Table 3: Measurement of productivity index

ID	Crop	Proportion of farm land used allocated to growing this crop'	Quantity harvested	Unit	Was the harvest good or bad last year?	Cropping system 0 = mono 1= intercrop	Proportion of the harvest that you consumed?	Proportio n of the harvest you sold?	Value of sold crop	U va 1= 2= ur
1										
2										
3										
4										
5										

Proportions
1= All or nearly all (87-100%)
2= More than half of it (63-87%)
3= About half of it (38-62%)
4= Less than half of it (13-37%)
5= A small amount (1-12%)

Weight unit
1= Kg,
2= Tonne,
3= Bunch

Harvest
1 = Good harvest
2 = Normal harvest
3 = Bad harvest
4=No harvest

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Table 4: Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access

QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
1. Now I would like to ask you about your household's food supply during different months of the year. When responding to these questions, please think back over the last 12 months, from now to the same time last year. Were there months, in the past 12 months, in which you did not have enough food to meet your family's needs? PLACE A 1 IN THE BOX IF THE RESPONDENT ANSWERS YES. PLACE A 0 IN THE BOX IF THE RESPONSE IS NO.	|__|	IF NO, END HERE
2. If yes, which were the months in the past 12 months during which you did not have enough food to meet your family's needs? This includes any kind of food from any source, such as own production, purchase or exchange, food aid, or borrowing. Do not read the list of months aloud. Place a 1 in the box if the respondent identifies that month as one in which the household did not have enough food to meet their needs. If the respondent does not identify that month, place a 0 in the box. Use a seasonal calendar if needed to help respondent remember the different months. Probe to make sure the respondent has thought about the entire past 12 months. **Months** A January B February C March D April E May F June G July H Aug I Sep J Oct K Nov L Dec	A [ ] B [ ] C [ ] D [ ] E [ ] F [ ] G [ ] H [ ] I [ ] J [ ] K [ ] L [ ]	

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Table 5: Socioeconomic characteristics of respondents by type of farmer

Variable	Pooled (N=150)	TYP (n=144)	PD (n=6)	p
Sex of farmer (%)				
Female	56.67	56.25	66.67	0.698
Male	43.33	43.75	33.33	
Percent of male-headed households	69.33	69.44	66.67	0.885
Mean age of household head	55.01	54.70	62.5	0.156
	(13.17)	(13.13)	(12.86)	
Marital status (1=Married, 0 otherwise)	75.33	75.69	66.67	0.848
Educational attainment (%)				0.371
No formal education	18	18.75	0	
Primary	49.33	47.92	83.33	
Secondary	29.33	29.86	16.67	
Post-secondary	3.33	3.47	0	
Farming as main occupation (%)	66.67	65.97	83.33	0.377
Household size	6.40	6.37	7.17	0.522
	(2.98)	(3.01)	(2.23)	
Farm decision maker (%)				0.013
Head	92.67	93.75	66.67	
Spouse	7.33	6.25	33.33	
Total land size owned by household	3.11	3.06	4.33	0.110
	(1.91)	(1.88)	(2.28)	
Total cropped land	2.52	2.47	3.83	0.035
	(1.58)	(1.40)	(3.76)	
Area under improved cassava	0.50	0.49	0.63	
	(0.44)	(0.30)	(0.21)	
Member of climate smart village (%)	88	87.5	100	0.356
Number of years of group membership	7.48	7.49	7.33	0.905
	3.16	3.16	3.44	

Note: Standard deviation provided in parentheses

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Table 6: Membership to Climate Smart Village Groups and activities of engagement

Membership	Indicators	Local varieties	Improved varieties	Local and improved varieties
Group membership (%)				
	No	22.2	72.2	5.6
	Yes	22.7	48.5	28.8
Group activities (%)				
	Crop production	41.6	31.8	26.6
	Livestock production	40.0	28.7	31.3
	Vegetable production	29.6	34.6	35.8
	Saving and credit	25.1	39.9	35.0
	Nursery/tree planting	24.7	33.1	42.2
Membership	Years	7.3	7.0	8.5

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Table 7: Outstanding farmers growing improved cassava varieties as identified by peer fellow farmers

Engagement with outstanding cassava farmers	Indicators	Frequency	Percentage (%)
Is there a cassava farmer that you consider is outstanding (n=150)			
	No	47	31.3
	Yes	103	68.7
Do you interact with those outstanding farmers (n=103)			
	No	19	18.4
	Yes	84	81.6
Interactions with outstanding farmers is often about (n=84)			
	Accessing improved cassava cuttings	23	27.4
	Using certified planting materials	5	6.0
	Intercropping cassava with other crops	4	4.8
	Mulching and cover cropping	4	4.8
	Cassava marketing	3	3.6
	Using fertilizer	2	2.4
	Other agronomic aspects	32	51.2

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Table 8: Productivity index on positive deviant farms and typical farms

Farmer	Yield (Kg/acre)	Proportion home consumed (%)	Proportion marketed (%)
Typical	1345	20.3	17.9
Positive deviant	1960	21.7	32.5
Percentage difference (%)	45.7	1.4	14.6

Table 9: Mitigation actions practiced on positive deviant farms and typical farms

Mitigation action	statistics	Typical farmers	Positive deviant farmers
Sample (n)	number	144	6
Tree planting last 12 months			
Average land under trees	acres	0.23	0.54
Purchased tree seedlings	%	56.3	50.0
Produced tree seedlings	%	41.0	50.0
Extension advises on tree management	%	31.3	50.0
Land Management			
Land owned that is degraded or unproductive	acres	0.17	0.19
Land productivity improved with CSA practices	%	76.4	83.3
Agroforestry practice	%	54.9	100.0
Introduced cover crops	%	53.5	66.7

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REFERENCES

1. **Steenwerth K L, Hodson A K, Bloom A J, Carter M R, Cattaneo A, Chartres C J and LE Jackson** Climate-smart agriculture global research agenda: scientific basis for action. *Agriculture & Food Security*, 2014;**3(1):** 1-39.

2. **Macoloo C, Recha J W, Radeny M A and J Kinyangi** Empowering a local community to address climate risks and food insecurity in Lower Nyando, Kenya. 2013; CGIAR.

3. **Mango J, Mideva A, Osanya W and A Odhiambo** Summary of baseline household survey results: Lower Nyando, Kenya. Copenhagen, Denmark: 2011; CCAFS. *Retrieved May 5, 2021*, from https://hdl.handle.net/10568/16427

4. **Shija D S, Mwai O A, Migwi P K, Komwihangilo D M and BO Bebe** Identifying positive deviant farms using Pareto-Optimality ranking technique to assess productivity and livelihood benefits in smallholder dairy farming under contrasting stressful environments in Tanzania. 2022a; *World*: **3(3):**639–656. https://doi.org/10.3390/world3030035

5. **Shija D S, Mwai O A, Migwi P K, Mrode R and BO Bebe** Characterizing management practices in high- and average-performing smallholder dairy farms under contrasting environmental stresses in Tanzania. 2022b; *World*; **3(4):**821–839. https://doi.org/10.3390/world3040046

6. **Recha J W, Kimeli P, Atakos V, Radeny M A and C Mungai** Stories of success: climate-smart villages in East Africa. 2017; CGIAR.

7. **Taiwo O, Dayo O S and KO Bolariwa** Technical efficiency analysis of cassava production in Nigeria: Implication for increased productivity and competitiveness. *Research Journal of Agriculture and Environmental Management*, 2014; **3(11):**569-576.

8. **Spielman D J, Ekboir J and K Davis** The art and science of innovation systems inquiry: Applications to Sub-Saharan African agriculture. *Technology in Society*, 2009; **31(4):**399-405.

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9. **Hekkert M P, Suurs R A, Negro S O, Kuhlmann S and RE Smits** Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social change*, 2007;**74(4):**413-432.

10. **Kenya National Bureau of Statistics (KNBS).** Kenya population and housing census. 2019; KNBS.

11. **Fraenkel J R and NE Wallen** How to design and evaluate research in education (4thed.). 2000; San Francisco: McGraw-Hill.

12. **Mapfumo P, Adjei-Nsiah S, Mtambanengwe F, Chikowo R and KE Giller** Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. 2013; Environmental Development, **5**, 6-22.

13. **Okuku OIO** An assessment of the effect of varietal attributes on the adoption of improved cassava in Homa-bay County, Kenya. 2018; [Doctoral dissertation, University of Nairobi].

14. **Yen BY, Khodyhotha K, Toummavong P, Chidvilaphone S, Lee Y, Vorlasan S and LS Sebastian** Summary of baseline household survey results: Phonghong district, Vientiane province, Lao PDR. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); 2015. *Retrieved May 5, 2021*, from https://hdl.handle.net/10568/78491

15. **Charan J and T Biswas** How to calculate sample size for different study designs in medical research? *Indian Journal of Psychological Medicine,* 2013; **35(2):**121-126.

16. **Toorop R A, Ceccarelli V, Bijarniya D, Jat M L, Jat R K, Lopez-Ridaura S and JC Groot** Using a positive deviance approach to inform farming systems redesign: A case study from Bihar, India. *Agricultural Systems,* 2020; **185(2020):**1-15.

17. **Dogliotti S, García M C, Peluffo S, Dieste J P, Pedemonte A J, Bacigalupe G F and WAH Rossing** Co-innovation of family farm systems: A systems approach to sustainable agriculture. *Agricultural Systems,* 2014; **126:**76-86.

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18. **Jones J W, Antle J M, Basso B, Boote K J, Conant R T, Foster I and TR Wheeler** Brief history of agricultural systems modeling. *Agricultural systems,* 2017; **155:**240-254.

19. **Asare-Nuamah P, Mandaza M S and AF Amungwa** Adaptation Strategies and Farmer-led Agricultural Innovations to Climate Change in MbireDistrictof Zimbabwe. *International Journal of Rural Management,* 2022; **18(2):**206-231.

20. **Srinivasan M S, Jongmans C, Bewsell D and G Elley** Research idea to science for impact: Tracing the significant moments in an innovation based irrigation study. *Agricultural Water Management,* 2019; **212:**181-192.

21. **Brüssow K, Faße A and U Grote** Implications of climate-smart strategy adoption by farm households for food security in Tanzania. *Food Security,* 2017;**9(6):**1203–1218.

22. **Parmar A, Fikre A, Sturm B and O Hensel** Post-harvest management and associated food losses and by-products of cassava in southern Ethiopia. *Food security*, 2018; **10(2):**419-435.

23. **Reincke K, Vilvert E, Fasse A, Graef F, Sieber S and MA Lana** Key factors influencing food security of smallholder farmers in Tanzania and the role of cassava as a strategic crop. *Food security,* 2018; **10(4):**911-924.

24. **Githunguri C M and EN Njiru** Role of Cassava and Sweet potato in Mitigating Drought in Semi-Arid Makueni County in Kenya. In: African Handbook of Climate Change Adaptation (pp. 1-19). *Cham:* 2020; Springer International Publishing.

25. **Jewel K N A and M Saifullah** Functional capacity needs assessment for the agroforestry researchers in agricultural innovation systems. *SAARC Journal of Agriculture,* 2021;**19(1):**269-279.

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