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Vulnerability and Resilience: The Farmers of Sagara Village

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SIT Study Abroad

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Abstract

Agriculture is a large part of the economy and society of Tanzania, equating to 28% of the country's GDP. Up to 80% of these farms are owned and worked by 19 million smallholder agriculturalists (FAO, 2015). Smallholder farmers are an inherently vulnerable demographic, due to their high reliance on agriculture for food and income in addition to their limited financial, technological, and labor resources (Morton, 2007). Simultaneously, these farmers are often uniquely adapted for the challenges they face, having developed strategies of addressing and mitigating risks over many generations. This study investigates the adaptative capacity of smallholder farmers in Sagara Village, Lushoto District, Tanga Region, Tanzania. Through interviews with farmers (n = 41) and key informants (n = 2), this study assesses farmers' perceptions of previous and present climatic changes, the various coping and adaptative strategies they employ in response, and relevant socioeconomic and institutional factors at play which act to diminish or increase the adaptative capacity of the smallholder community. This study found that the majority of the interviewed farmers had perceived significant climatic changes in rainfall and temperature in previous years. The farmers used many strategies to mitigate the challenges of these climatic changes, but were inhibited by low access to agricultural education, as well as economic difficulties such as low demand for crops and low selling prices.

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Introduction

Agriculture is a significant part of the economy and society of Tanzania. While agriculture contributes 28% of the country's GDP, about 80% of these farms are smallholder farms which are smaller than 2.2 hectares in size (FAO, 2015). These smallholder farms account for the employment of about 19 million Tanzanians, a large portion of the country's total population of 52 million (ibid). While the FAO definition of smallholder farming is useful in quantifying smallholder farming, Morton more specifically describes smallholder farmers as ones who use mainly family labor and for whom their farm provides most of their income (Morton 2007). This definition is more useful as it begins to hint at some of the inherent vulnerabilities smallholder farmers face. While agriculture is vulnerable to both environmental and non-environmental factors, smallholder agriculture is especially so. Because of the limited financial, technological, and labor resources many smallholder farmers possess, as well as the importance agriculture provides for the smallholder's income, negative shocks from outside factors can often seriously impede family and community development through their effects on agricultural success (ibid).

Simultaneously, these farmers and their communities have often adapted strategies of resilience to address the challenges of unfavorable conditions. These strategies are often location-specific and stem from a community's historical agricultural practice in a place for many years (Paavola 2004). Both environmental and non-environmental challenges are nothing new for smallholder agriculturalists. These communities have over time developed and adopted strategies of resilience against such challenges. Previous studies on this phenomenon have largely divided such strategies into coping and adaptative strategies. Coping strategies are short-term responses to a certain challenge at hand, while adaptative strategies are longer-term responses to recurring issues (Pauline et al., 2017). These strategies of resilience, together with institutional, communal, and individual safety measures used as insurance against negative shocks, create the adaptative capacity of a community (Smit and Wandel, 2006). This adaptive capacity can increase or decrease as specific environmental, social, political, and economic conditions change for the community on multiple scales. For example, the development of a sustainable irrigation system, a cooperative system of farming among members of a community, and a government created national crop insurance program would all amount to factors increasing the adaptative capacity of a community.

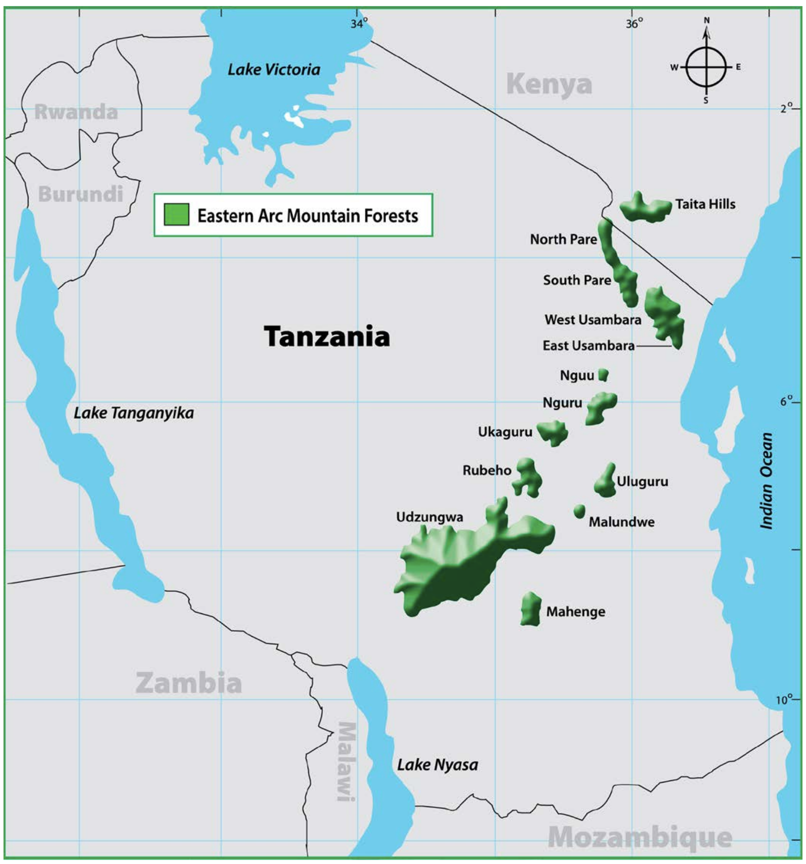
Anthropogenic climate change is a new and increasing challenge for many smallholder farmers globally. Tanzanian agriculturalists have already been grappling with the adverse effects of climate stress, as shifting rainfall distribution patterns, growing intra-season and inter-seasonal dry periods, and extended and more frequent droughts are changing established and expected climatic patterns (Pauline et al., 2017). The burdens of climate change are not shared equally, and changing and worsening climatic conditions will act to exacerbate the risks already disproportionately shouldered by more disadvantaged and vulnerable peoples (IPCC 2014). Predicted climate trends for Tanzania show a likely increase in average national temperature and rainfall. One projection predicts the average national temperature will increase by 1.3°C by 2050 and by 2.2°C by 2100. Annual precipitation of the entire country was projected to increase by 10% by 2100, amounting to season declines of 6% the dry months and increases of 16.7% for the wet months (Agrawala et al., 2003). Crop yield projections for Sub-Saharan Africa for the mid-21st century suggest significant losses. Maize, a staple food crop in many countries including Tanzania, is projected to be one of the hardest hit crops. While these are only projections, increased climactic variability and change of any sort will present new challenges to smallholder farming communities. Changes in temperature can impact crop growth, the prevalence of pests and of diseases. Increased rainfall, especially in the wet months, can cause dangerous flooding that has the potential to destroy both crops and infrastructure, as well as spread disease (ibid).

These climatic changes will add new and sometimes severe challenges to smallholder farming communities. The adaptative capacities of these communities will be extremely important in allowing them to mitigate or adapt to new climatic challenges. Studying the capacities of individual agrarian communities to adapt to such changes allows for a deeper understanding of the consequences of climate change for these communities. This knowledge can also create an increased potential for effective initiatives on larger scales or from outside actors to assist such communities in reducing their vulnerability and increasing their adaptative capacity (Smit and Wandel, 2006).

Study Site Description

The Usambara Mountains are a mountain range approximately 90 km long found in the Tanga region in northeastern Tanzania. They are a part of the larger Eastern Arc Mountains, a mountain range found mostly in eastern Tanzania that includes one smaller chain in southeastern Kenya, known globally for its high levels of endemic biodiversity. The Usambara Mountains are often split into two subdivisions, the Eastern and Western Usambara, which are split by the Lwengera Valley. The climate is characterized by cool temperatures (significantly cooler than similar altitudes found more inland) and a bimodal precipitation pattern. There are long rains from March to May and short rains from September to December, with little precipitation in the other dry months (Hamilton and Bensted-Smith, 1989). Though there are large swaths of protected primary rainforest, there has been significant and very visible forest clearing for agriculture. The area is made of a mix of soil types, some of which are relatively good for agriculture. The higher slopes are composed of lateric and red loams, while lower on the mountains soil composition is mostly grey loamy mineral soils which are more advantageous for cultivation. The valley is composed of colluvial soils that make it ideal for agriculture. There are many streams and rivers, some of which flow year-round. (Jambiya 1998). However, numerous farmers in Sagara communicated that last year, in the height of a drought where the short rains never came, even the most consistent rivers had run dry.

The Western Usambara, where Sagara Village is found, are historically known as the home of the WaShambaa ethnic group (Jambiya, 1998). The main sources of income in the region are farming, livestock keeping and business. The most popular crops grown are maize, banana, yams, paddy, Irish potatoes, sweet potatoes, cassava, legumes. Popular cash crops are tea, coffee, cardamom, vegetables, fruits, and a currently diminishing cultivation of quinine (Shemnga, 2015). High levels of erosion and deforestation in the mid- to late-20th century were partially addressed under government and NGO education, reforesting, and agroforestry programs, with some success (Jambiya 1998). Though the area is known for its climactic variability, a general trend in the data suggests an increasing number of exceptionally wet years and exceptionally dry years. The increasing rainfall variability recorded is consistent with regional weather data, suggesting that the change is regional and is not entirely caused by local factors, such as deforestation (Hamilton and Bensted-Smith, 1998). The resilience of the smallholder farmers of Sagara, their strategies for coping with and adapting to these changes, and the education and support they receive from government and non-government actors, will be crucial in determining how these climactic changes will impact the people of Sagara Village in the years to come.



Source: EAMCEF

Red arrow points to approximate location of Sagara Village in the West Usambara Mountains.

Source: Kanaani Resthouse

North is directly up on this map.
Image taken from Google Maps, April 2017

Methods

Interviews for this study were conducted in Sagara, Mgwashi, and Kizanda Villages in Lushoto District, Tanga Region, Tanzania from April 3 to April 21st, 2017. Interviews were semi-structured, nonrandom, and open-ended, and were conducted with farmers in Sagara Village, as well as one key informant in Kizanda Village and one key informant in Mgwashi Village. Interviews were conducted over 16 days for approximately four hours daily, for a total data collection time of approximately 64 hours. Interviews were conducted with the assistance of a translator, Fatuma, who was fluent in Kiswahili, Kisambaa and English. Interviews were conducted in either Kiswahili or Kisambaa, depending on the preference of the participant, and both my questions and participant responses were translated by Fatuma. Written consent was obtained at the start of each interview, with the additional option of consenting to being quoted in the study by name. All participants consented both to participation and to being quoted. Each participant was asked the same questions in the same order, however, some unique or interesting responses would warrant further questioning. The two key informants interviewed were Peter Mgonja, the Agricultural and Livestock Extension Officer for Mgwashi Ward, as well as Leonard Mshaka-Ngoto, the chairman of the non-governmental organization Tanzania Forest Conservation Group. These interviews necessitated entirely different sets of questions, and were conducted towards the end of the study period to allow time for establishing which issues needed to be discussed.

Interview questions for farmers were divided into four sections based on the category of questioning (Appendix 1). Initially, in Section 1, basic data on the participant and their farming experience and practices was established. Secondly, in Section 2, the participant was questioned about their perceptions of changes in wet season and dry season rainfall since they began to farm, as well as changes of annual temperature in the same time period. If participants replied with a positive answer (they had perceived some type of change over time), they were asked how these changes affected their crops, as well as how they personally responded to the changes through their agriculture. Participants were asked where or from whom they had learned of these agricultural techniques, specifically the ones they had mentioned, as an attempt to deduce the origin of agricultural resilience techniques in the community.

Third, in Section 3, interviewees were asked for predictions for future climatic changes in terms of both rainfall (overall, not broken up by season) and temperature. These questions were designed to investigate farmers' perceptions of the causes and patterns of climatic changes, however, the questions proved confusing for many participants and results were inconclusive. The data from these questions was not included in the study. Participants were then given a hypothetical future climate to see how they would adapt their farming. The hypothetical offered depicted a future climate where the wet months had more rain than currently, the dry months less than currently, the warmest months had higher temperatures than currently, and the colder months had lower temperatures than currently. Participants were asked how they would change their farming in response to these changes, as well as how the changes would affect their lives other than in their agriculture. This question was focused on differences between a farmer's past and present strategies of resilience and the future strategies they mentioned. The aim of this question was to gain a glimpse into which strategies farmers may want to use and may be unable to use currently. The question was also designed to ask participants about the effect climatic changes have on their lives, both indirectly through effects on their farming and otherwise. This question was followed up with an inquiry into the obstacles farmers face individually that keep them from being better able to adapt to climatic changes. Lastly, in a brief Section 4, participants were asked about obstacles to more successful agriculture on the village level. The final question of each interview was if the participant had any questions for either me or the translator, which they were also asked at the start of the interview.

The results of these 41 interviews were a mix of quantitative and qualitative responses. Both because the sample group was non-random and non-representative, and also because some of the data was so visibly significant (e.g. 37 out of 38 participants noting a change in dry season rainfall amounts over time) statistical tests were not used. Quantitative answers were analyzed simply through finding the mean of all responses. Qualitative answers were first grouped into categories of responses equivalent in meaning. The number of responses grouped into each category were summed, then all sums were compared. The number of times a response was given was the metric of measuring these responses due to many participants replying to questions with more than one unique response. This analysis allowed a comparison of the popularity of various responses in the sample group.

Interviews with the two key informants were designed prior to meeting but after the majority of interviews with the farmers of Sagara. This allowed preliminary findings to be assessed to better shape the latter key informant interviews. Peter Mgonja, the Agriculture and Livestock Extension Officer of Mgwashi Ward, was asked about his own perceptions of climatic changes, problems in the village for agriculture, and solutions (both current and potential future) he was using to attempt to address these problems. Leonard Mshaka-Ngoto, the chairman of the NGO Tanzania Forest Conservation Group, was interviewed on similar topics. Both interviews were semi-structured and were much more discussion based than the interviews with farmers, which necessitated a stricter adherence to the pre-planned interview template for the sake of efficiency and consistency. The responses of these interviews were qualitative in nature and unique in context to each individual, and thus were not analyzed in any numerical way.

Results

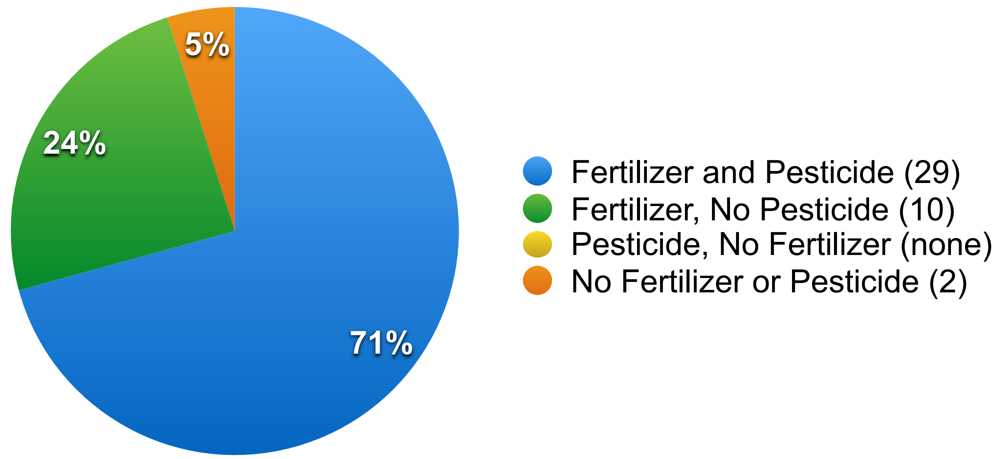


Figure 1. Breakdown of fertilizer and pesticide use - Question 1E

Numbers in the key are the numbers of individuals that gave each response. Sample size for this question was 41 out of 41 participants.

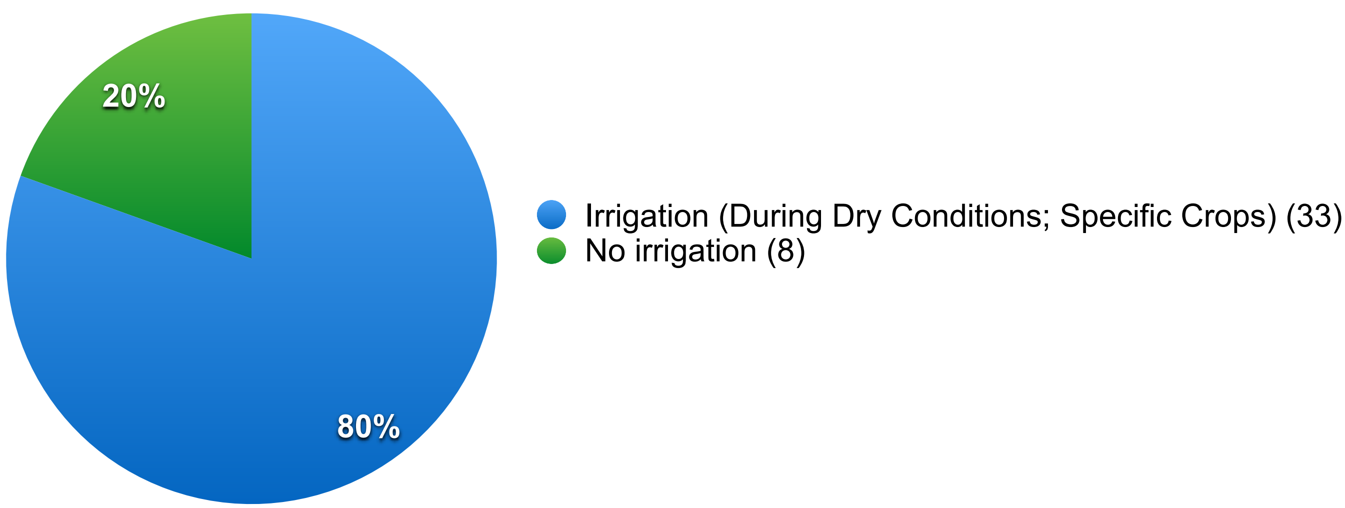


Figure 2. Breakdown of irrigation use - Question 1F

Sample size for this question was 41 out of 41 participants. All 33 participants which noted using irrigation specified use only during dry conditions, and only for specific crops. The most common crops irrigated were tomato, hot tomato, cabbage, carrot, and onion, though others were also sometimes mentioned.

Table 1. Different Inputs Used by Participants - Question 1E

Input	Type of Input	Use	# of Participants Using (41 respondents)
Natural Manure	Fertilizer	General fertilizer, usually cow manure	37
Booster	Fertilizer	Liquid foliar fertilizer, used for all crops*	28
Silicon	Fertilizer	Used for all crops†	9
Urea	Fertilizer	Nitrogen based fertilizer, mostly for maize, rice, wheat, potatoes, & sugarcane**	2
DAP	Fertilizer	Phosphate + Nitrogen, mainly for maize, rice, wheat, potatoes, & sugarcane**	1
No Fertilizer	n/a	n/a	3
DDT	Pesticide	General insecticide	27
Farmerzeb	Pesticide	Fungicide, mainly used for tomatoes and potatoes*	19
Profecron	Pesticide	Insecticide for vegetables, legumes, fruits, cereals, sugarcane, & banana*	1
No Pesticides	n/a	n/a	11

* Kikiwete, J., Garang, M.G., Membe, Y. (2015). Evaluation of farming practices and environmental pollution in Manyara Basin, Tanzania. International Journal of Agricultural Sciences, 5(6), 864-877.
** Premium Agro Chem Ltd. (2010). Products. Premium Agro Chem Ltd. Accessed 23, April 2017.
† Peter Mgonja, personal communication, April 2017

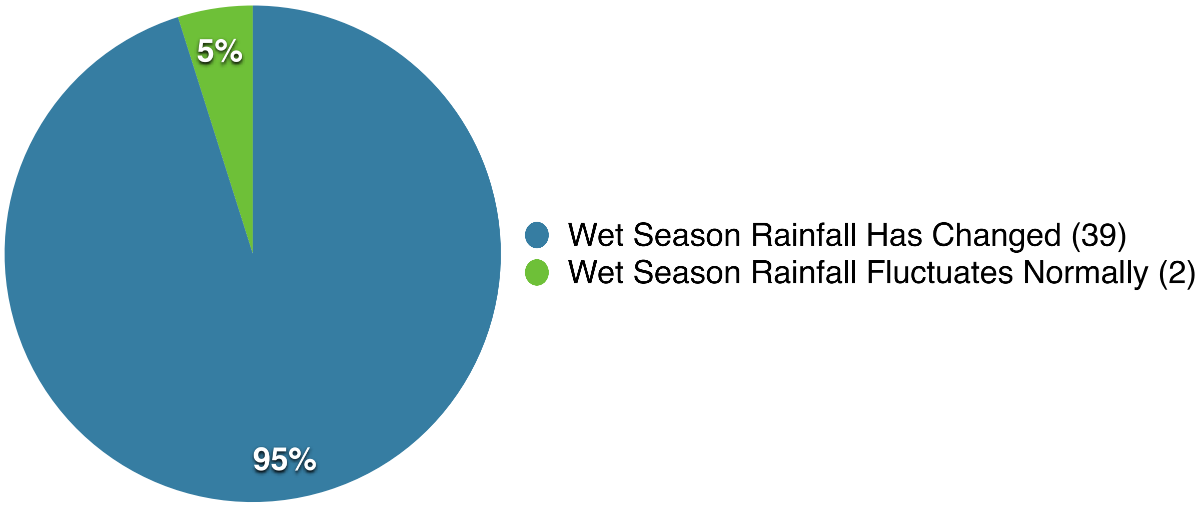


Figure 3. Perceptions of wet season rainfall patterns over time - Question 2A

Sample size was all 41 out of 41 participants. Two participants noted that rainfall is variable in the area and is always changing, but that it has not changed in a pattern over the time they have been farming.

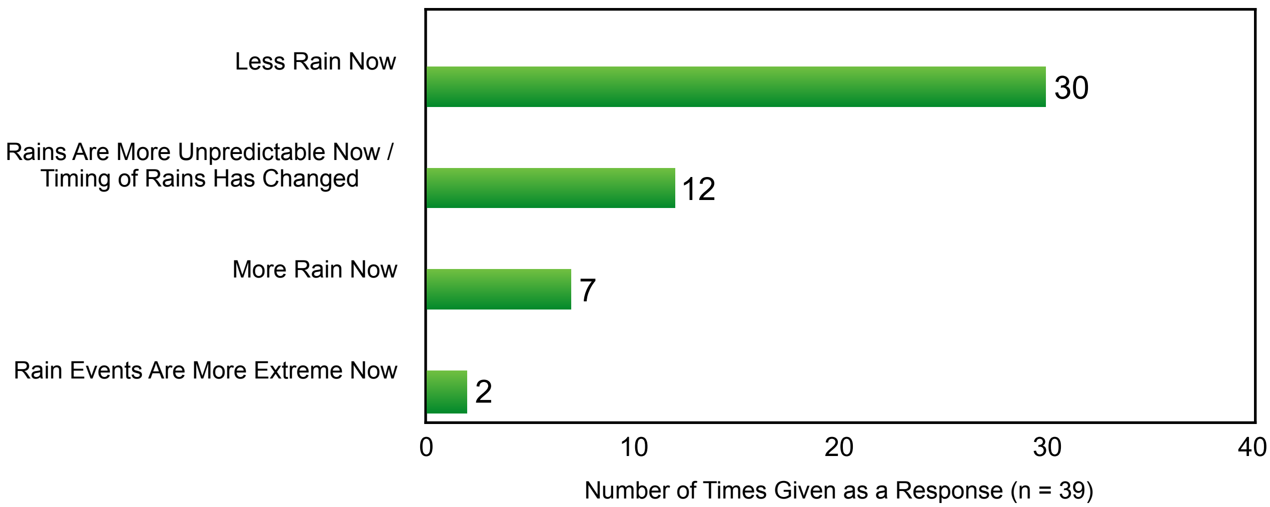


Figure 4. Perceptions of specific changes to wet season rainfall pattern - Question 2A

Only the 39 participants who noted a change in wet season rainfall patterns over time are included.

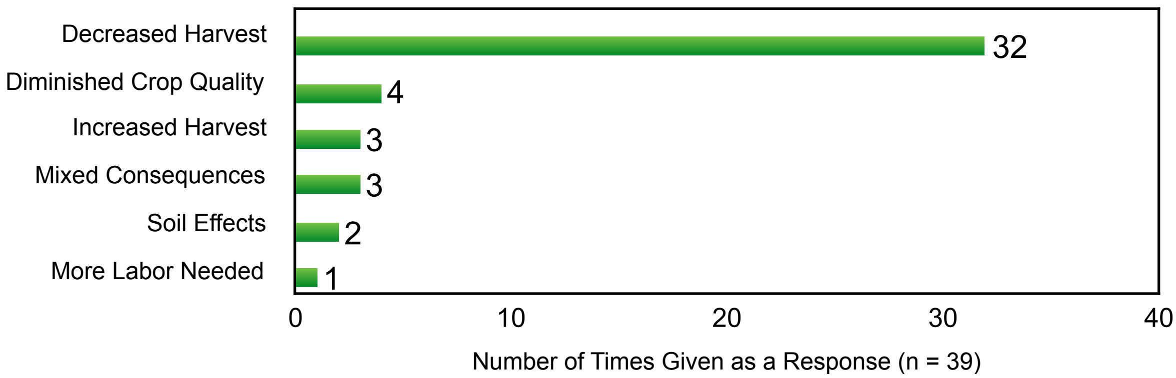


Figure 5. Perceived effects of wet season rainfall change on crops - Question 2A-1

Only the 39 participants who noted a change in wet season rainfall patterns over time are included. Some participants who perceived an increase in wet season rainfall reported either increased harvests, or increased harvests in only some crops (mixed consequences). The two respondents who described soil effects separately noted increased soil erosion (perceived increase in rainfall) and decreased soil fertility (perceived decrease in rainfall). One respondent who perceived a decrease in wet season rainfall only noted that more labor was needed now that the rains had decreased.

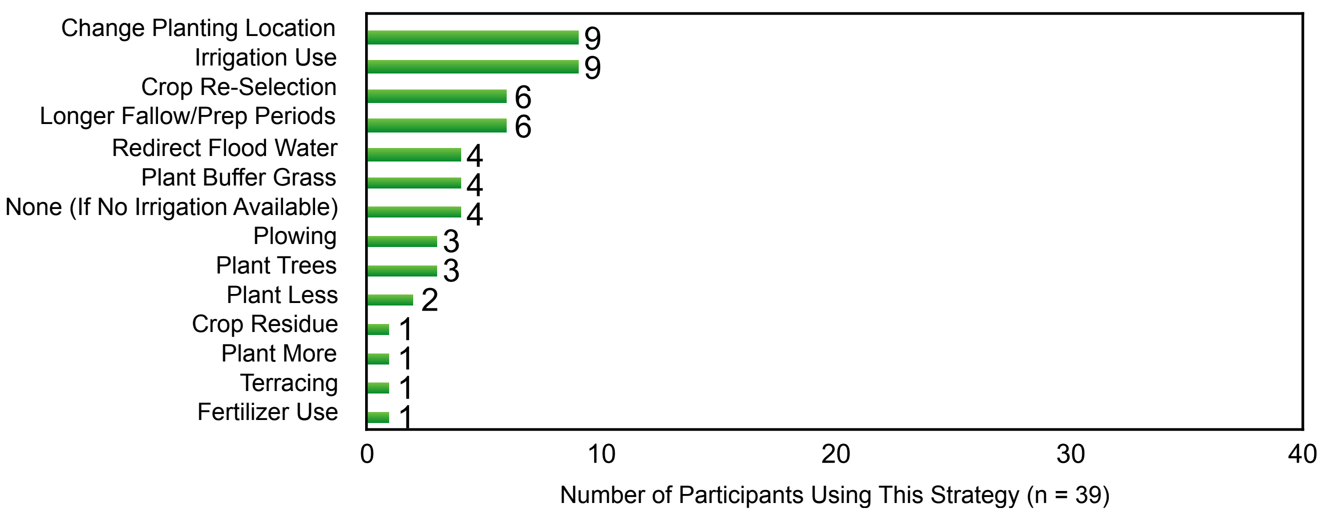


Figure 6. Resilience strategies in response to changing wet season rainfall patterns - Question 2A-2

Only the 39 respondents who perceived a change in wet season rainfall patterns are included. All strategies of changing planting location were in-farm changes — respondents would plant in different parts of their farm, but would not change locations of their farm. Crop re-selection here refers to a re-evaluation of which crops to plant depending on observed climatic conditions. Longer fallow/prep periods describes the action of extending preparation (usually plowing) times for the fields without planting until rains come.

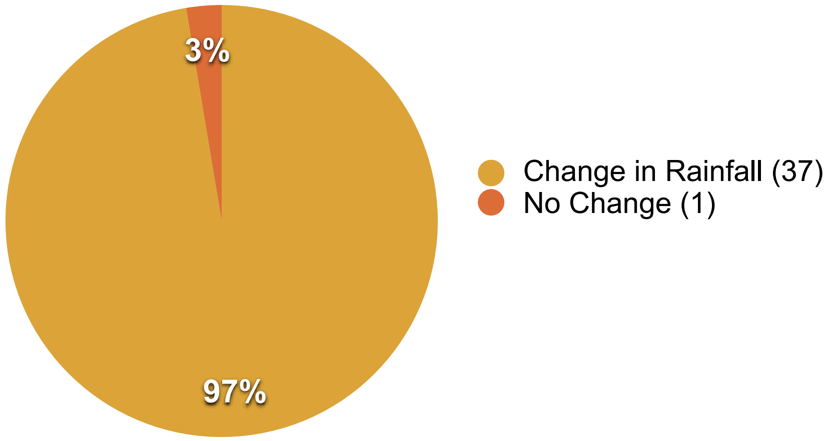


Figure 6. Perceptions of dry season rainfall patterns over time - Question 2B

The sample size for this question was only 38 participants, due to difficulty in translation in three instances early in the study period.

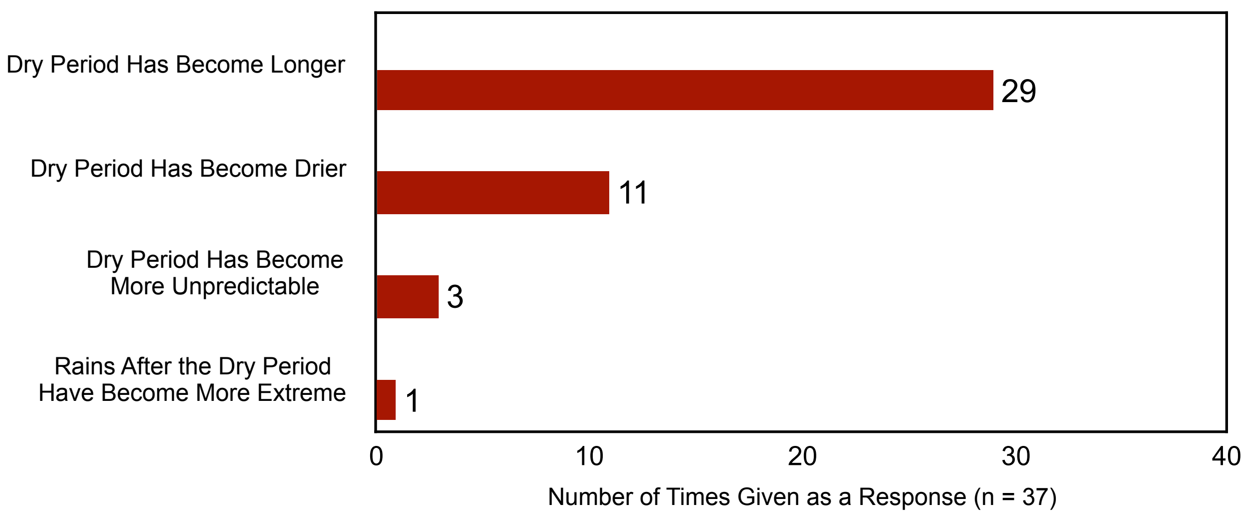


Figure 7. Perceptions of specific changes in dry season rainfall patterns - Question 2B

Only includes the 37 individuals who noted a change over time in dry season rainfall patterns. The second most common answer denotes a perception of a decrease in rainfall during the dry season over time. Respondents who perceived increased unpredictability noted changing timings of the dry season, both of the season itself (start and end times) and in-season rainfall timings.

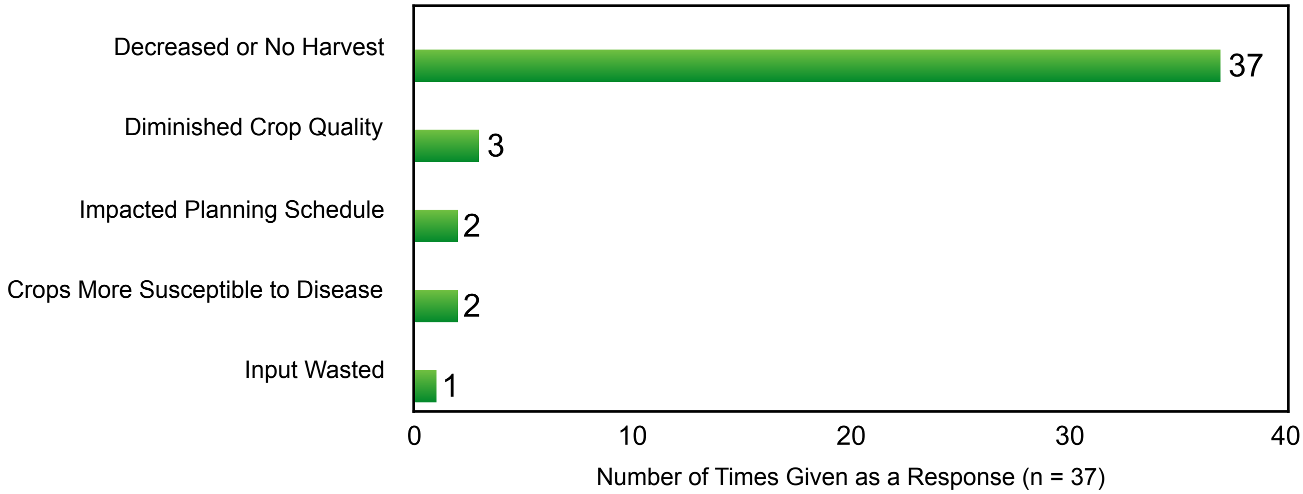


Figure 8. Perceived effects of dry season rainfall change on crops - Question 2B-1

Only includes the 37 individuals who noted a change over time in dry season rainfall patterns. Each individual noted a resulting reduced harvest, and although many described as having lost entire harvests due to these changes it was unclear how much of this was accurate and how much was exaggeration.

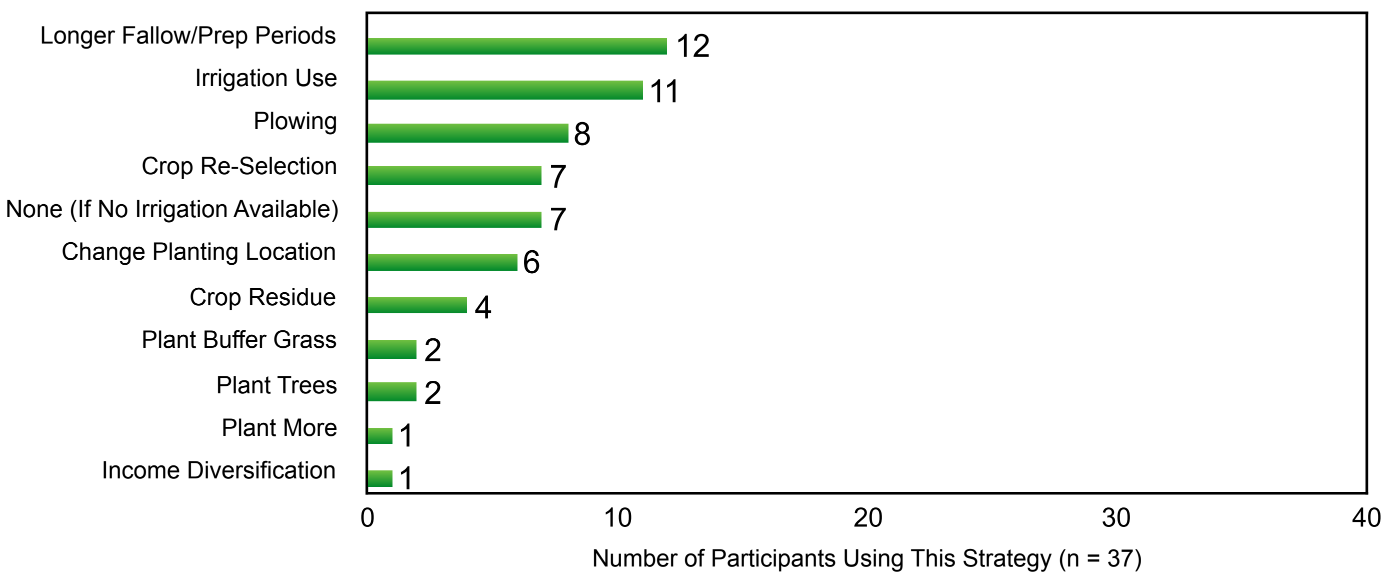


Figure 9. Resilience strategies in response to changing dry season rainfall patterns - Question 2B-2

Only the 37 participants who perceived a change in dry season rainfall patterns are included. The most common response described not planting and either extending a brief fallow period or continuing to prepare the field through plowing until the rains came. While 11 individuals cited using irrigation as a strategy of coping, 7 noted that without irrigation they could do nothing.

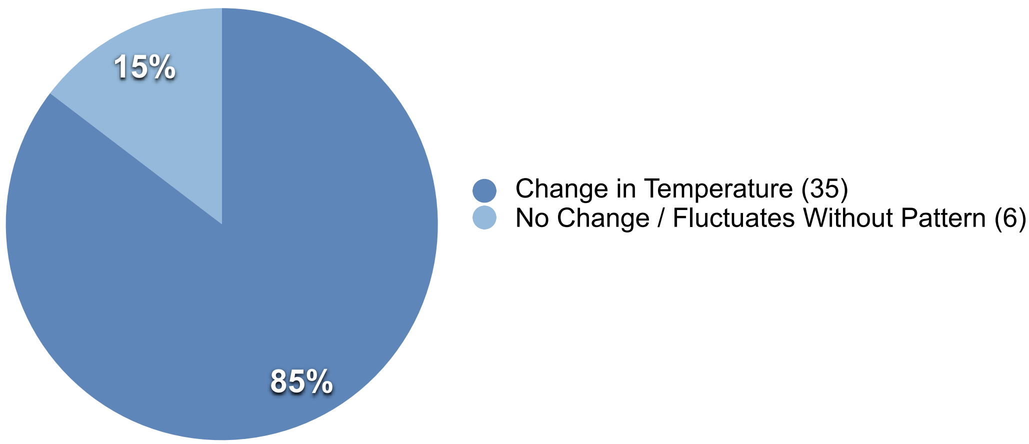


Figure 10. Perceptions of annual temperature patterns over time - Question 2C

This question had a full sample size of 41 out of 41 participants. 6 of the respondents perceived either no change in annual temperature or fluctuations that did not form a pattern over the years they had been farming.

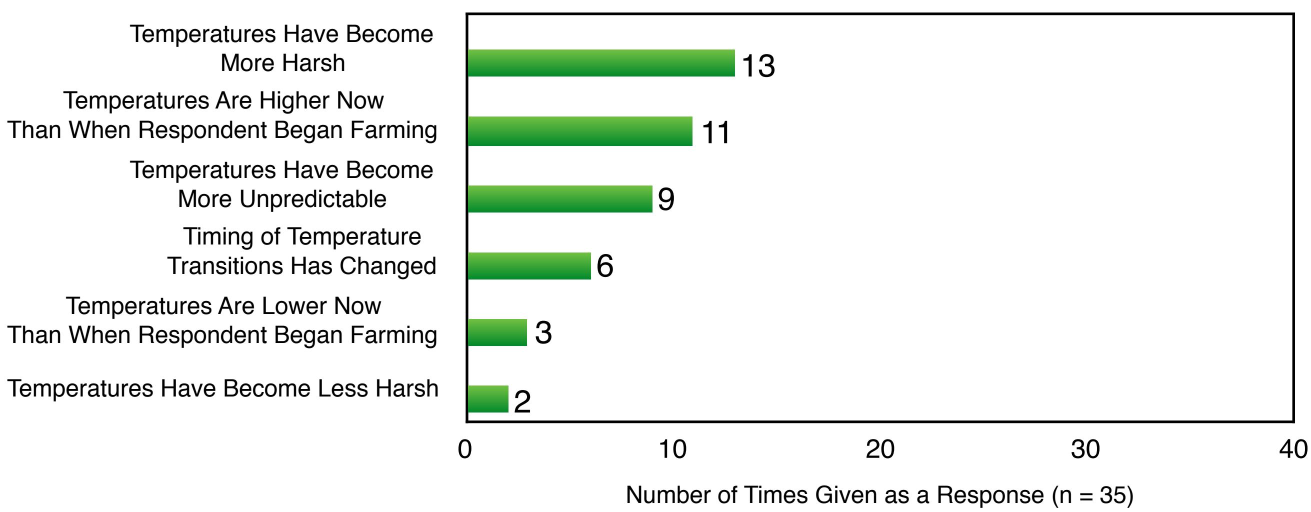


Figure 11. Perceptions of specific changes in temperature over time - Question 2C

Only the 35 results describing a change in temperature over time are included. Harshness here denotes relatively hot and cold temperatures becoming hotter and colder, respectively. Unpredictability here refers to perceptions of unseasonal temperatures.

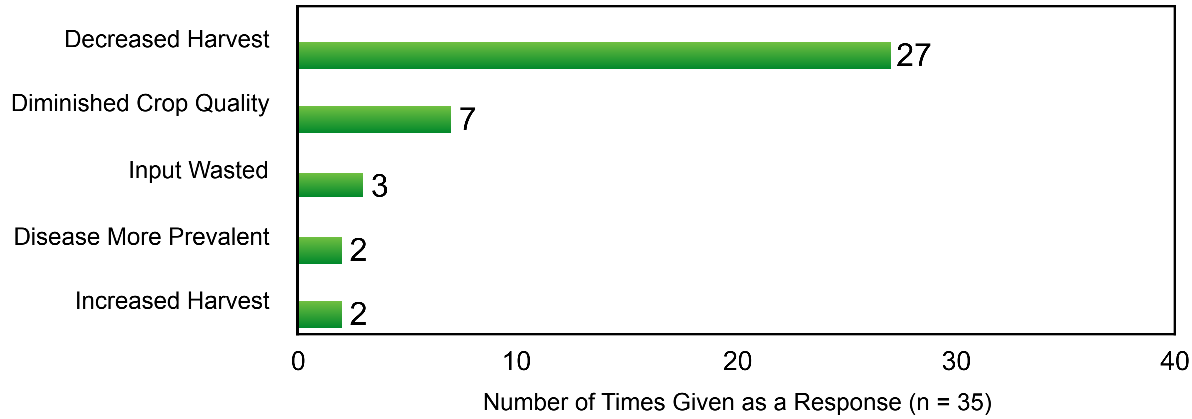


Figure 12. Perceived effects of annual temperature changes on crops - Question 2C-1

Sample size of 35 individuals who noted a change in temperature over time. Input wasting described the loss of labor and financial investment into a crop when it had a poor harvest due to temperature changes. Disease here refers to crop diseases, not disease in humans. Two respondents who perceived temperatures as becoming less harsh recently also here noted that their harvests have increased in recent times.

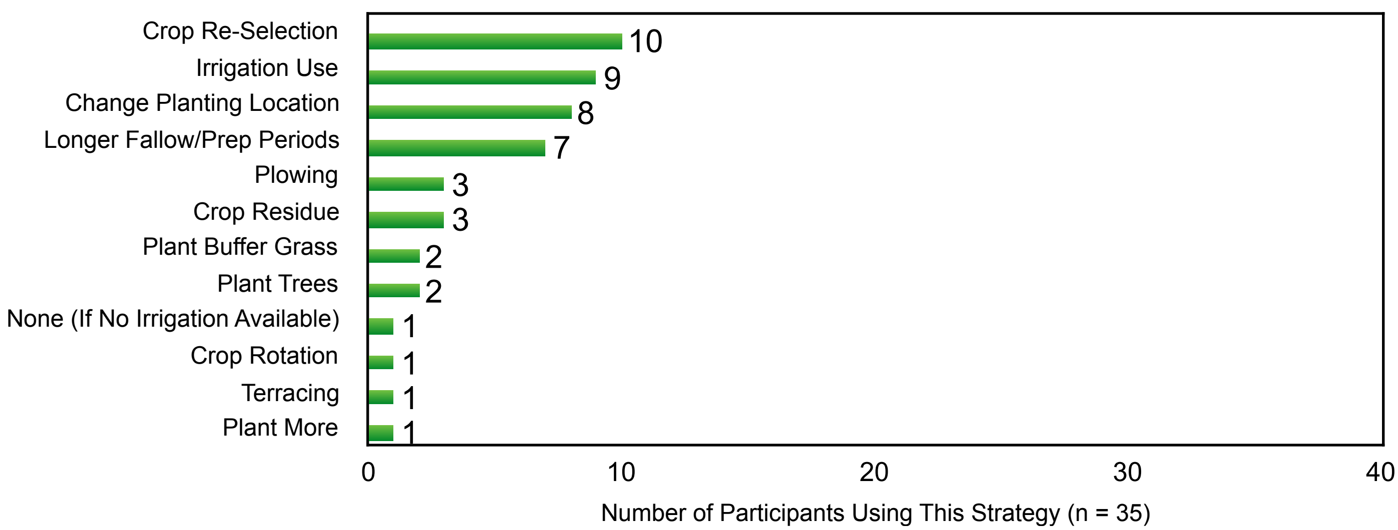


Figure 13. Resilience strategies in response to changing annual temperatures - Question 2C-2

Only the 35 individuals who noted a change in temperature over time are included.

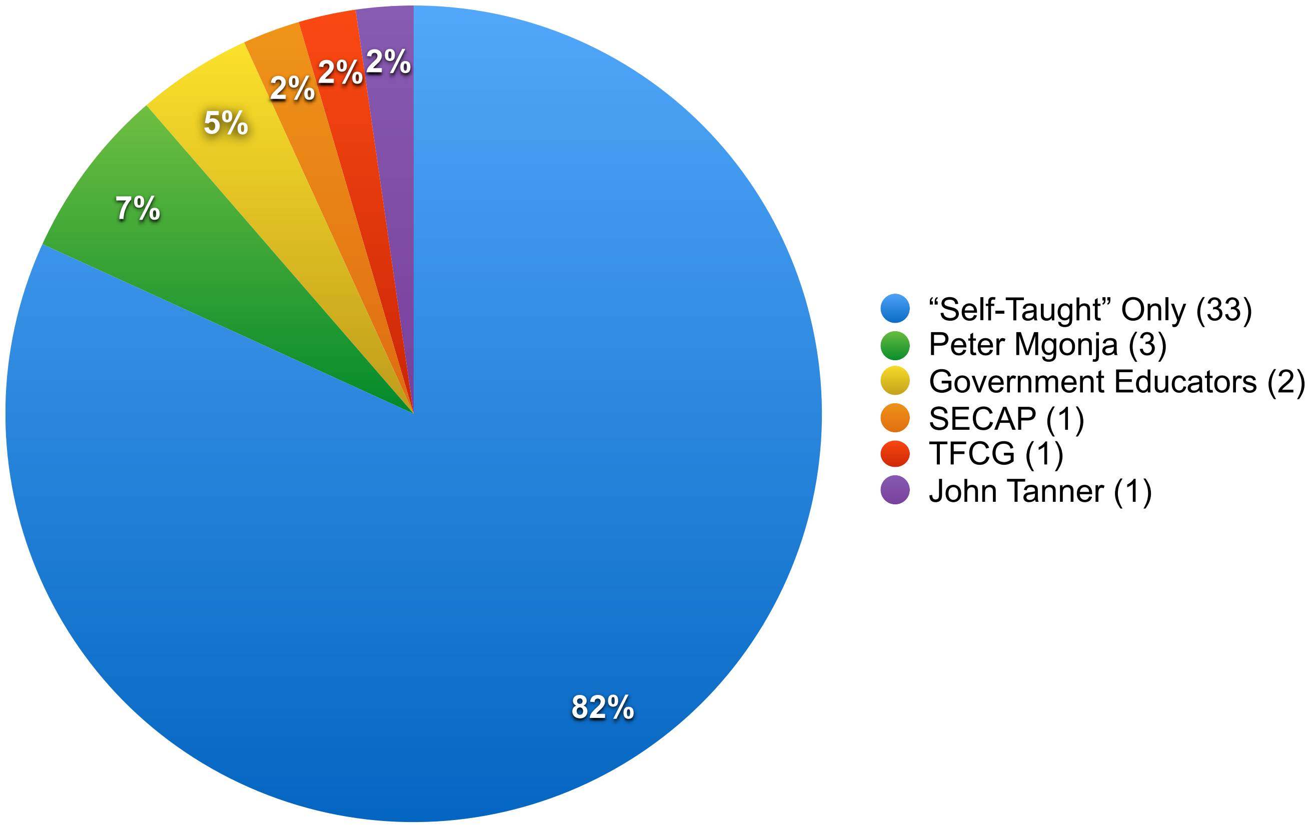


Figure 14. Source of Agricultural Education - Question 2D

This question was answered by 41/41 respondents. Numbers in the legend denote the number of participants who gave each response. Peter Mgonja refers to the Agriculture and Livestock Extension Officer of Mgwashi Ward who was interviewed. Government educators were given as unspecific responses to the question. SECAP is an active NGO in the region (Soil Erosion Control and Agroforestry Project). TFCG is also an active NGO in the region (Tanzania Forest Conservation Group). One respondent noted that he had worked for John Tanner, the Swiss landowner who left the area in 1987, and that Tanner had provided some agricultural education for all the men he employed. large majority of study participants responded that they were self-taught in terms of their farming techniques. However, this response is likely slightly inaccurate. Children in Sagara are taught common farming techniques by their families from a young age, and there is currently an agriculture practical component of primary school education. "Self-taught" here most likely means that the participant received no formal agricultural education outside of these usual avenues.

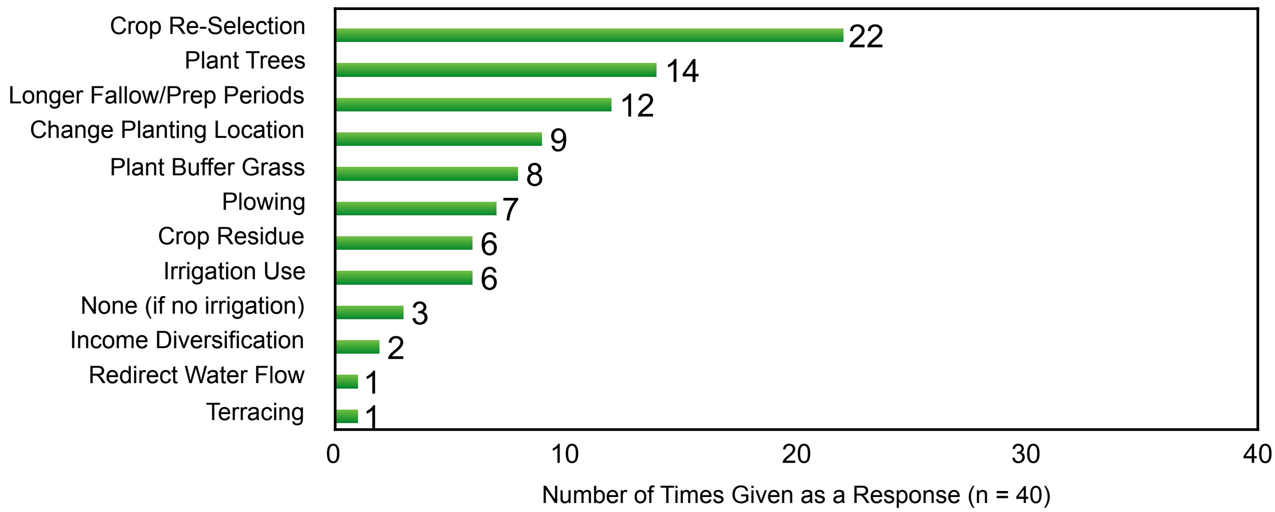


Figure 15. Predicted or potential strategies of resilience to hypothetical future climate - Question 3C-1

Sample size for this question was 40/41 because of difficulty in translation with one participant. Interestingly, tree planting was a much more common response for this question than for any questions of resilience strategy in the past or present.

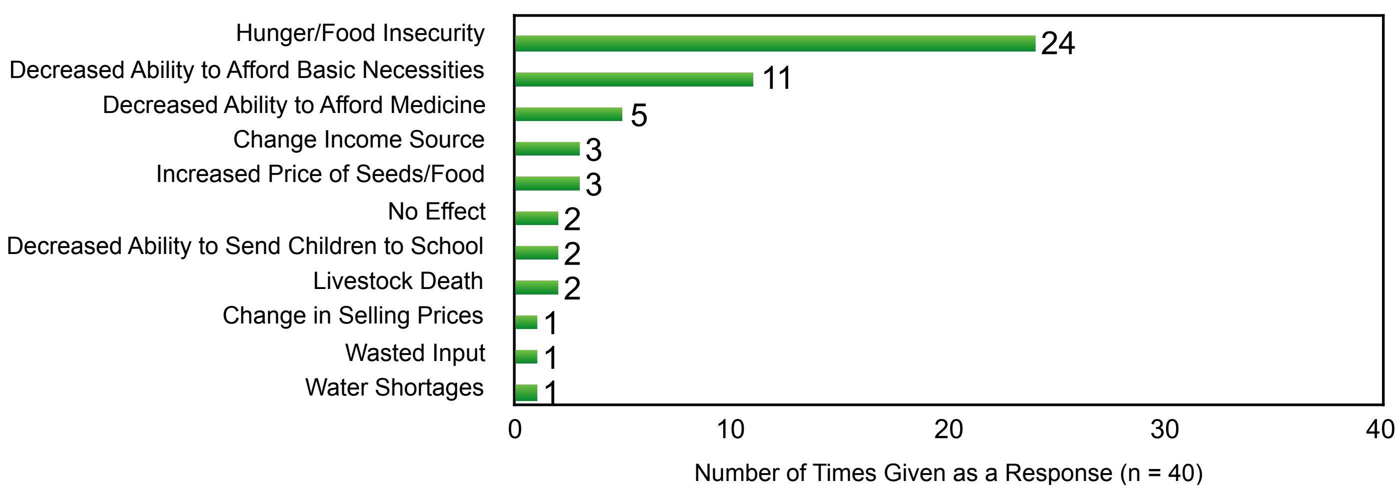


Figure 16. Predicted or potential effects of hypothetical future climate on non-agricultural life - Question 3C-2

Sample size of 40/41 due to a translation difficulty with one participant.

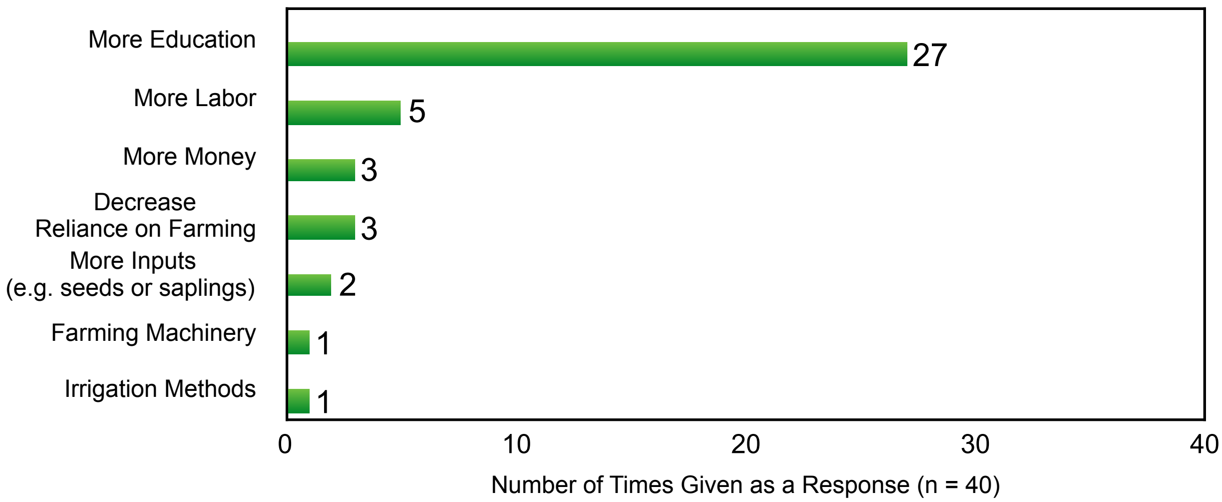


Figure 17. Needs for being able to better respond to climatic changes - Question 3D
Only forty participants responded accurately to this question, due to one issue in translation.

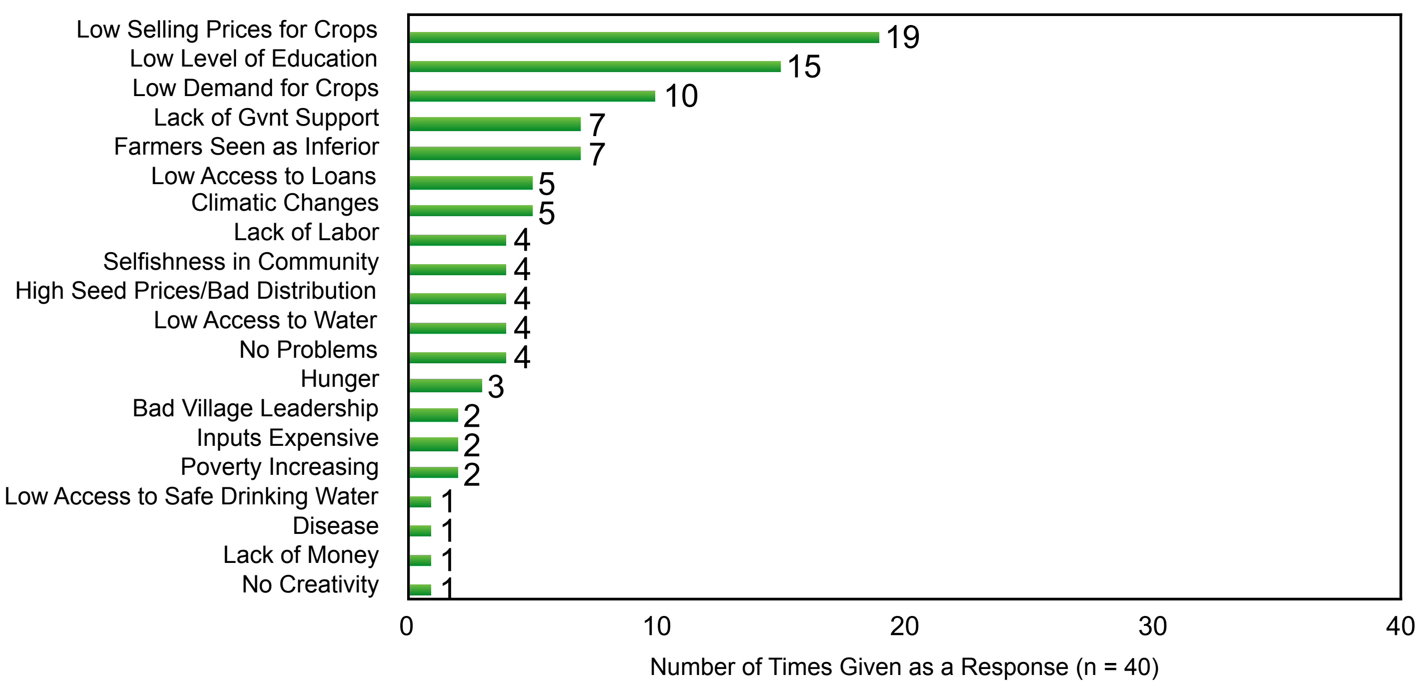


Figure 18. Perception of the biggest issues for agriculture in Sagara Village - Question 4A
Sample sizes of forty individuals due to a difficulty in translation in one case. It is unclear whether the response "low level of education" was meant to describe agricultural education specifically or education more generally. Note that low selling prices and low demand for crops are two of the three most common responses, suggesting additional economic difficulties even with a good harvest for a season.

Discussion

There were several notable findings in terms of farmer perceptions of climatic changes. Over 76% of farmer respondents observed less precipitation falling during the wet months than when they began farming. Similarly, 78% of respondents noticed the same change during the dry season, and both changes were largely perceived to have caused decreased crop harvests. Changed annual temperatures were noted by 85% of respondents, and 77% of the farmers correlated these changes with decreased crop harvests. Farmers described a wide range of agricultural responses they made to address these climatic changes. Altogether, sixteen adaptive and coping strategies were described as having been employed in response to climatic changes. The most common strategies mentioned were crop re-selection, irrigation use, changing planting location, extending fallow/prep times, and planting trees. Notably, responses to changes in wet season and dry season rainfall changes, as well as annual temperature changes, all included strategies of irrigation use, but with no alternative strategies if irrigation became unavailable. This response was especially popular for changes in dry season rainfall: it was given by 7 individuals, the same number who noted crop re-selection, and thus the fourth/fifth most popular response. As demand for irrigation continues to increase with population growth, as well as potentially continually worsening climatic conditions, it is unclear how viable this coping technique will be in future years. It is interesting to note that while tree planting was a relatively unpopular response to current changes in rain or temperature, it was the second most popular response to a potential future climate. It is unclear why this may be as many farmers interviewed listed trees for firewood and timber harvesting as something they currently grow. It is possible the cost of saplings or of moving trees is too high for many farmers right now.

While a total of sixteen unique answers were given as responses to climatic changes, crop diversification is arguably a seventeenth response that most, if not all, farmers employed. Distributing risk across many different crops and crop types helps to diminish the chance of a bad season destroying an entire harvest altogether. By planting a mix of cash and non-cash crops, crops with differing climatic needs, and crops with and without inputs, farmers are able to insure against a total crop failure for a season. This strategy is simultaneously one of economic viability, for largely the same reasons. If the selling price or demand for certain crops is unfavorable one season, having a wide range of crops to sell can give the farmer some flexibility in what they choose to keep for eating and what they choose to sell.

There were numerous sources of agricultural education in the farmer sample group, however, a large majority of farmers reported as having received no additional eduction than from the usual avenues. These avenues were education by family members as a child and some potential primary school farming education. It becomes evident just how substantial of an issue this is when this finding is compared to what the interviewed farmers listed as their biggest personal obstacles to becoming better able to adapt to climatic changes. While 82% of participants responded as having never received farming education, 67.5% of individuals stated that agricultural education is necessary for improving their capacity to respond to changes in rainfall and temperature. Both Peter Mgonja and Leonard Mshaka-Ngoto described providing agricultural education to farmers through village meetings, meeting with village leaders, and direct interactions with farmers. Mr. Mgonja even noted that the farmers of Sagara were often more open to new techniques and ideas shared by Mgonja, as well as by TFCG. However, there seems to be a breakdown in how, where, when, or to whom this education is provided, as only three of the interviewed individuals mentioned receiving agricultural education from Mgonja. Further investigation is needed to understand this perceived lack of agricultural education, but it is clear that the interviewed farmers believe education is the way forward to a more successful and resilient agricultural future, and that many do not believe they have had notable or formative agricultural education thus far.

The perceptions of the farmers of the biggest problems in Sagara Village for agriculture were telling of the wide range of challenges these farmers face as smallholders. None of the three most popular responses to this question addressed environmental stressors, but rather the first and third most common responses depict the economic difficulties of farming in a relatively remote and highly agrarian setting. Low selling prices and low demand for crops were two problems mentioned by a large portion of the sample group. While farmers were perceiving changes and unpredictability in their environment and climate, these economic challenges seemed to be some unfortunate consistencies in their lives. It was noted to me several times by farmers that even when a good harvest could be had, the next challenge was always trying to sell the crops before they began to rot. Previous research in the area has found that the lack of economic markets is a serious negative burden to the farmers, and that the lack of buyers for agricultural outputs result in decreased income for the farmers (Casey, 2013). When asked about this issue, Peter Mgonja agreed that it was a challenging and pressing matter for many people in the area. He contended that the resulting lack of money among the farmers was partially responsible for many farmers' inability to buy improved seeds, or seeds that have been found to perform better than local varieties that are sometimes treated with pesticides and fertilizer. These improved seeds can be more resistant to common crop diseases, more drought-tolerant, and can grow faster, leaving less time for a climatic change to negatively impact a crop before harvesting (Mgonja, pers. comm. 2017). Adding to this difficulty, the lack of agricultural markets or demand is not an issue the farmers can autonomously adapt to in a significant way. Change must come from higher institutional levels as the farmers of Sagara and other nearby villages do not have the capital required to transport crops to far-off markets where demand and prices are higher (ibid). Mgonja mentioned a potential future arrangement with farmers in other regions he hoped could improve economic conditions for smallholder farmers. He envisions an information sharing network which could be used to better organize planting and harvesting schedules so that farmers could have more control over the prices of their crops, however, it is unclear when this idea could come to fruition, if at all.

Limitations and Recommendations

This study had numerous limitations, the foremost of which was that the group of farmers interviewed was not representative of Sagara Village altogether. This diminishes the usefulness of the study, because even though several of the responses from the farmers were overwhelmingly one-sided, it is unclear if this opinion is shared overall throughout Sagara. Second, perceptions of change in rainfall and/or temperature levels could have been impacted by the intense drought last year. While this drought is relevant to the study, it does have the potential to skew perceptions of climatic changes more towards an increase of dryness and a decrease or rain. Third, the participant accounts of their responses to a changing climatic factor were not necessarily thorough. Participants responded to the question and then we moved on, and so they did not necessarily give their only agricultural responses or even their most used ones. Lastly, this study had serious time restrictions and it would have been more feasible to interview a far larger sample size with more time.

For future study I recommend meeting with the village government of Sagara and, if feasible, randomly selecting participants of the study from a list of village residents. It would be interesting to do a comparative study in Kizanda or Mgwashi, which both Peter and Leonard told me are worse off than Sagara in terms of irrigation availability and forest quality.

Conclusion

The smallholder farmers of Sagara Village have perceived significant and consequential climatic changes in rainfall amounts and temperature over the past decades. Overall, farmers say it has gotten drier during the wet and dry seasons, the dry season has gotten longer, and temperatures have become warmer, harsher, and less predictable. Overwhelmingly, farmers said that these climatic changes were responsible for significantly diminished harvests of their crops. Farmers had a total of seventeen response strategies, including crop diversity. While these response strategies are likely helping the farmers, many noted that there was only so much they could do given an at-times extremely unfavorable and increasingly unpredictable climate.

Most farmers had no formal agricultural education, and did not report having ever met with the resident Agriculture and Livestock Extension Officer, Peter Mgonja. They overwhelmingly cited increased agricultural education as a path forward in increasing their capacity to respond to climatic changes. When asked what they perceived as the biggest problems for agriculture in their village, few residents mentioned climatic changes. The vast majority mentioned low education rates, low demand for crops, and low crop prices. While these climatic variations are adding new and significant challenges to the lives of these farmers, their biggest issue was often that it is difficult to make a living even when their harvests are plentiful. As climate change will continue to intensify, the environmental challenges for the farmers of

Sagara Village will only increase. Their adaptive capacity is supported largely through their many strategic agricultural responses, however, there is only so much the farmers can do autonomously. Larger scale changes like providing increased agricultural education, and transportation for crops to further food markets, will likely be increasingly needed to add to the farmers' adaptative capacity in the face of growing risk and a worsening climate.

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Appendix

A1. Interview Questions for the Farmers of Sagara Village

I. Section 1 — Establishing Basic Data
   A. (if quote consent is given) What is your name?
   B. How old are you?
   C. How many years have you been farming?
   D. Which crops do you grow?
      1. Which are for consumption and which are for selling?
      2. How much land do you give to crops you eat, how much land to those you sell?
   E. Do you use any inputs, such as fertilizer or pesticides? Which ones?
   F. Do you use irrigation for any crops in any seasons? Which ones?

II. Section 2 — Experience with Changing Climatic Conditions & Past Resilience
   A. Do you think the amount it rains in the wet season has changed since you began farming?
      1. How has this impacted your agriculture?
      2. Did you change anything about your farming in response to changing rainfall amounts? What did you change?
   B. Do you think the amount it rains in the dry season has changed since you began farming?
      1. How has this impacted your agriculture?
      2. Did you change anything about your farming in response to changing rainfall times? What did you change?
   C. Do you think the temperatures have changed in the past 30 years?
      1. How has this impacted your agriculture?
      2. Did you change anything about your farming in response to changing temperatures? What did you change?
   D. Where did you learn about these responses?

III. Section 3 — Future Resilience
   A. Do you think the rainfall times or amounts will change in the future? How?
   B. Do you think the temperature will change in the future? How?
   C. Given a future climactic condition hypothetical (hotter in the warmer months, cooler in the colder months, more rain in wet months, less rain in dry months than currently):
      1. How would you change your farming techniques?
      2. How would this impact you in ways other than agriculture?
   D. What do you need most to be more able to adapt to a changing climate?

IV. Section 4 — Miscellaneous Questions
   A. What is the biggest problem for agriculture in the village?
   B. Do you have any questions for me?