Rice Farmers’ Perceptions and Indicators for Weather Variability in Tanzania: What are the Obstacles for \textit{in situ} Adaptations?

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Abstract. The study was conducted to cultivate the understanding of different weather perceptions as well as indicators by rice farmers of Mbarali and Kyela districts in Mbeya region of Tanzania. Primary and secondary data were obtained from the research area and Tanzania Meteorological Agency. Garret technique and Multipredictor logistic regression were applied for data analyses. The result shows that farmers have different perceptions on various weather variables like rainfall, temperature, drought, wind, and floods. Likewise with logistic regression is affirmed that awareness towards weather variations increased by 0.60 times and 2.0 times if farmer’s education and extended floods each increase one times respectively. In addition, various weather variability indicators like lack of enough rainfall, increase in temperature, drying of tender tree leaves, and severe sunshine were identified. More so, factors hampering immediate local adaptations to weather variability were also identified. Authors recommended on establishment of a working coordination mechanism by incorporating local perceptions, indicators, and adaptions to rescue rural communities from the ongoing food insecurity threats.

1. Introduction

Rural crops production systems in Africa and especially in Tanzania are usually affected by weather changes [1]. These effects are so enormous that the relationship between crops production and weather cannot be neglected [2-3]. Many avowals regarding climate change have already reconnoitered the long term effect of both spatial and temporal variations of climate change, however, there is a gap for the short term effect from which the marginalized rural households are encountered with. In addition, the prevailing gap is been broadened by lack of clear knowledge, local perceptions, and lack of correct adaptive measures [4] [5]. With high rainfall-fed reliance, Tanzania agriculture production is always subjected to ad-hoc weather shocks thus leaving people’s livelihoods at risk [6-7]. Several studies including Mkonda \textit{et al}, Rao \textit{et al}, and Roco \textit{et al} have insisted on understanding farmers’ general perceptions on weather behaviour [8-10]. Furthermore, Panda (2016) and also Tambo \textit{et al}, (2013) insisted that basing on farmers’ perception on meteorological data variability is of
paramount important [2][11]. Others previous findings regarding perceptions on meteorological variables particularly rainfall and temperature includes; (URT, 2012; Silvia, 2011; Mkonda, 2017) who combined both perceptions and adaptations taken by farmers [6-8]. On the view of the previous studies; Lisandro et al, (2015) reported that farmers in the rural areas of Chile did not have clear perceptions of weather variability. Additionally, a very recently similar work on perception and awareness by Ado et al, (2018) in Niger reported knowing perceptions and awareness was significantly affected by weather information as a factor. In Tanzania, studies of perceptions and adaptations on weather variability are quite limited. Recent studies include Mkonda (2017) in the Semi-arid area of Tanzania [4] and Mwasalupo et al (2015) in Mount Kilimanjaro localities.

Due to the significant contributions of weather variables more attention is given to mainly rainfall and temperature but in real sense there are many of them including sunshine, wind, droughts, and also humidity. However, perceptions, their influence to crop yield, indicators differ from individual to individual, community to community, as well as locality to locality [17]. Henceforth, the current study was proposed to cultivate the rice producers’ perceptions on weather variability, factors influencing rice yield, indicators for weather variations, and also the local counter-attacks as a result of extreme weather events.

2. Materials and Methodology

2.1. Data collection

The study involves 240 rice farmers collected from Mbarali and Kyela district in Mbeya region of Tanzania. In addition, personal interviews were conducted using structured questionnaires. The collected data were coded by epidata software and later transferred to Stata computer software. Garret ranking technique and Logistic regression were used for data analyses.

2.2. Garret Ranking Technique

In 1969, Garret and Woodworth introduced their method in studying Psychology and education. They formulated a formula for Percentage position calculation as shown in equation (3).

\[
\text{Percentage position} = 100 \times \left[ \frac{R_{ij} - 0.5}{N_j} \right]
\]

(1)

Where, \( N_j \) is the total items ranked by the \( j^{th} \) individual (let’s say farmers), \( R_i \) is the rank of a factor \( f^\text{th} \) for the \( j^{th} \) individual, and \( R_j \) is the factor \( f^\text{th} \). According to Garret and Woodworth (1969) the percentage position is converted into scores as is given by the Garret table.

2.3. Multipredictor - Logistic regression Model

Awareness as behaviour towards weather variability. The logistic regression model is chosen because of its ability to measure binary decisions of the dependent variable (whether a respondent is aware toward environmental changes as 1, or is not aware as 0). Therefore, the model describe that individual’s behaviour to perceive weather variations \( (h_a) \) equation( 2a-3) apart from the related weather changes such as extended drought, extended floods, also others factors such as house-hold’s head age, education, landownership, and location specificity also could affect their perceptions drives.

\[
h_a = f(Q_i) = f(\alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \mu_i)
\]

(2a)

Therefore for a multiple predictors we could obtain equation 2b

\[
h_a = f(\alpha_0 + \beta_1 \text{extdrougt} + \beta_2 \text{extflood} + \beta_3 \text{Age} + \beta_4 \text{edu} + \beta_5 \text{land} + \beta_6 \text{i.wads} + \mu_i)
\]

(2b)

Substituting the values in eqn 2b we could obtain equation 3 for model predictions

\[
h_a = \alpha_0 + \beta_1 \text{extdrougt} + \beta_2 \text{extflood} + \beta_3 \text{Age} + \beta_4 \text{edu} + \beta_5 \text{land} + \beta_6 \text{i.wads} + \mu
\]

(3)

Where \( h_a \) = binary variable for household awareness towards weather perception, \( \beta_1...\beta_6 \) = Parameters to be estimated, \text{extdrougt} = extended drought event, \text{extflood}=extended floods event, \text{edu}=education of house-hold head, \text{Age}=Age of the house-hold head, \text{land}=landownership and \text{i.wads}=respective wards (Kajunjumele, Mahongole, and Ruia) while taking Ikolo ward as a base ward and \( \mu \) is an error tern.
3. Results and Discussions

3.1. Results from Garret Ranking Technique

Influencing factors for rice yield. Rice yield is influenced by various factors like rainfall as shown in Fig. 1. Rainfall was the most important factor for rice production according to the respondents. Majority farmers (20.4%) earmarked as the main yield influencing factors (Figure 1). About 18% of farmers pointed Fertilizer as major factor influencing rice yield within their locality. Availability of fertilizer was reported as one of the major factors backing to poor rice yields in the study area. About 16 % of farmers claimed seed to be among the factor, however, accessibility to both quality and improved seeds was also a noticeable challenge to most farmers. Majority farmers are using local seeds which add to poor yields. Others’ factors included Extension services (12%) and pest and diseases (3%).

![Factors influencing rice yield](image1.png)

Figure 1. Factors influencing rice yield. Source (Author’s Survey, 2018)

3.2. Farmers’ Perceptions on weather changes

3.2.1. Rainfall. Results (Fig. 2) revealed that about 75% of the respondents perceived that rainfall is decreasing. Farmers attested to have a continuously rainfall changes in their localities while 12%, 9%, and 4% declared no changes, increases, and not aware of the rainfall pattern respectively. Furthermore, respondents cemented that in actual sense rainfall has been declining from time to time thus even the wet spell periods have clearly condensed contrary to dry spell periods. In line with farmers’ responses the actual monthly rainfall data from 2010-2017 (Fig 3) support their claims on rainfall variations. In addition, they confirmed on regular changes of planting dates from late December–January to mid-January- early February due to hesitations resulted from unpredictable rainfall patterns. Furthermore, respondents reported that poor rainfall patterns in recent years have decisively threatened their income and livelihoods thus call for possible interventions. Similar results were reported by Ado et al and also Mugula et al in Niger and Tanzania respectively [13][18].

![Farmers’ perceptions on weather variability](image2.png)

Figure 2. Farmers’ perceptions on weather variability. Source (Author’s Survey, 2018)
3.2.2. Temperature pattern. About 69% of the respondents perceived that temperature pattern has been increasing from time to time. On the other hand, 18% of respondents pointed that the temperature is normal, 9% was decreasing, and 2% noted for not been aware of any fluctuations. Majority of farmers claimed that low rainfall and high sunshine intensity results to the increase in temperature during day and night.

3.2.3. Droughts pattern. The results show’s that 53% of the farmers highlighted on the increased patterns of drought in the study area. Decreased rainfall, and in addition to increase in sunshine intensity has direct correlations with reoccurrence of drought. Most of the respondents still perceive that if the daily heating up from sunshine and less rainfall continue in their areas there is possibility of what they perceive as catastrophe to affect people’s life especially those who depends on agriculture produces as sources of living. Additionally, about 3%, 7%, and 5% explained that drought pattern was decreasing, not aware, and they don’t see any changes respectively.

3.2.4. Floods pattern. Generally, floods are the results of heavy rainfall. If an area experience floods frequently apart from other activities agricultures could be hugely affected. Among the respondents, 59% had perceived on the decreased floods cases, however, 29% claimed perceived contrarily. With these few, they reported to experience floods only during heavy rains fall and there are reported cases of farmers who retreated their rice fields due to heavy floods.

3.3. Indicators for weather variability
Among farmers, 61.3% (Table 1) agreed that receiving less rainfall than previous seasons was an indicator to show that weather has changed. However, 38.7% of the farmers disagreed though they commented that there has been a tendency a delayed onset and also immature length of wetness. Another indicator pointed by the farmers (69.7%) was the dryness of tender tree leaves. Respondents declared that whenever this situation happens is an indicator for weather fluctuations particularly lack of rainfall and increase in sunshine intensity. Additionally, about 95.4% of farmers agreed on disappearance of some tree species due to drought, severe sunshine, and population upsurge.
Table 1. Indicators for the observed patterns of weather Changes.

| Number | Indicators                                    | Response n=240 | Total % |
|--------|----------------------------------------------|----------------|---------|
| 1      | Inadequate rainfall                          | 61.3 38.7      | 100     |
| 2      | Tender leaves dries                          | 69.7 38.3      | 100     |
| 3      | Disappears of indigenous tree species        | 95.4 4.6       | 100     |
| 4      | Drying water sources                         | 61.7 38.3      | 100     |
| 5      | Land become dry and cracks                   | 20.0 80.0      | 100     |
| 6      | Rise of day temperature                      | 72.1 7.9       | 100     |
| 7      | Severe sunshine                              | 92.1 7.9       | 100     |

Source: Author’s Survey (2018)

Accordingly, a relatively low number of farmers (20%) identified dryness and cracks on the land as major indicators for changes in weather variable patterns. Additionally, 95.5% agreed that disappearance of indigenous tree species previously existed in their area was an indicator for weather changes. Contrarily, about 4.6% of individuals disagreed with this fact as an indicator for weather pattern changes due multipurpose uses of many natural tree species in the area such as source of traditional medicinal, building constructions, animal feeds, and many others uses which may be the major reasons for the desertions. More so, among seven indicators for the weather pattern for the observed changes sunshine was the highly ranked (92.1%).

3.4. Responses to Abnormal weather changes

The research findings show that rice farmers in Mbeya region have different type of reactions to various weather abnormalities including changes in rainfall, sunshine, temperature, drought, and wind (Table 2).

Table 2. Farmers’ responses on abnormal weather changes (N=240)

| Response Variable | Abnormal rainfall | Abnormal temperature | Abnormal sunshine | Abnormal winds | Abnormal drought |
|-------------------|-------------------|----------------------|-------------------|----------------|-----------------|
|                   | Responses by percentage |                      |                   |                |                 |
| Change Crops      | 63                | 6                    | 27                | 13             | 86              |
| Shift to another area | 0                | 5                    | 45                | 77             | 4               |
| Use Mulching      | 1                 | 13                   | 20                | 5              | 2               |
| Use resistance Seed | 20               | 11                   | 1                 | 3              | 1               |
| Other Methods     | 16                | 65                   | 8                 | 3              | 7               |
| Total             | 100               | 100                  | 100               | 100            | 100             |

Source. Author’s Survey, (2018)

Farmers had identified different measures to curb the situation related to the above variations including; shifting to other areas, applying mulching in their fields, use of the resistance seeds varieties, and many others. In totality, 63%, 6%, 27%, 13%, and 86% of farmers opted to change crops in case of abnormal rainfall, temperature, sunshine, winds, and drought respectively. Specifically, 63%, 20%, 1%, and 20% of farmers reported to adapt abnormalities by changing crops, applying mulching at early stages of developments, using drought resistances seed varieties respectively, while 16% applied other methods such as changing planting dates and use of early weaned seeds.

Furthermore, major adaptation methods during abnormal temperature were the applications of mulching (13%), use of adaptable seeds (11%), meanwhile use of others methods such as tree planting for shed purposes were also applied. During cases of abnormal sunshine where was associated with less rainfall, high temperature, and high speeds winds, farmers reacted by planting trees, stop sowing seeds or wait for a favorable weather to come. Hills (2015) commented on similar findings in Mountain Kilimanjaro area of Tanzania [17].

3.5. Obstacles for immediate adaptations

Farmers claimed that of the factors poor weather information was ranked first by 20.2% of the respondents. Actually, lack of up to date weather information (Fig. 4) especially for rainfall and
temperature was earmarked as a major problem to plan for adaptation. Similar findings were reported by Lisandro et al., (2015) who reported that, access to weather information was a crucial to rural farmers in Chile [10] and also Elia et al, (2014) in Tanzania [19]. In addition, up to date weather information could help farmers to plan for subsequent farm management practices. Another factor was lack of access to irrigation infrastructures as was reported by 18.7% of the respondents. Additionally, (14%) reported lack of access to fertilizer as among the constraints for immediate adaptation. Farmers affirmed that their soil has lost its vigor due to recurrent erosions and over-faming, thus, fertilizer remains the only available solution to increase crop yields. Another important factor hindering adaptation is the limited access to extension services as was reported by 11.3%. On the other hand limited labor and limited farm size were reported by 10.6% and 10.5% respectively. Similar results were found in India as small sized land was among the major constraints to most rural farmers [21].

![Factors affecting adaptations](image)

Figure 4. Factors which hinder local adaptations

Other factors reported to hinder local adaptation to weather variability is limited to agricultural training. About 7.9% of the farmers reported lack of training and specifically training offered by agricultural experts, also related to environmental conservations as their major factor which hamper them to adapt quickly to weather variations challenges. Additionally, 6.8% reported to have limited access to financial services in terms of credits to support their farm operations. Most of the immediate adaptive measures were too demanding including fertilizers, hired labors, improved seeds varieties, pesticides and herbicides thus became burden to most farmers to curb the changes.

3.6. Results from the logistic regression Model

**Education of the House-holds.** The results (Table 1) depict that as education increase one times increases farmer’s perceptions towards weather variation by 0.603 times provided other independent variables in the model are fixed. Thus, shows the important of education for farmers.

**Extended floods.** According to the logistics regression empirical results, if floods prolong one times it increases farmer’s awareness towards the prevailing changes of weather by 2.002 times given other independent variables in the model are fixed.
Table 3. Logistic and Step-wise logistic regressions results for awareness to weather

| aware_change | Variable name                  | Odds Ratio | Std. Err | z     | P>|z| |
|--------------|--------------------------------|------------|----------|-------|-----|
| ext_floods   | extended floods                | 2.00232    | 0.6349629| 2.19  | 0.029*** |
| edu          | education of household         | 0.6034623  | 0.0867146| -3.51 | 0.000*** |
| lv005_2      | Kajunjumele ward               | 0.3340971  | 0.1064145| -3.44 | 0.001*** |
| cons         | constant                       | 1.930104   | 0.5726552| 2.22  | 0.027 |

Number of Obsn 240

Prob>chi^2 0.000

LR chi^2 (9) 26.48

Pseudo R^2 0.0797

b. Logistic regression

| ext_drought  | extended drought               | 0.7346225  | 0.2319281| -0.98 | 0.329 |
| landown      | land ownership                 | 1.343119   | 0.6190089| 0.64  | 0.522 |
| age          | age of household               | 0.9954164  | 0.0118676| -0.39 | 0.700 |
| ext_floods   | extended floods                | 1.990734   | 0.6632412| 2.07  | 0.039** |
| edu          | education of household         | 0.5984913  | 0.0898062| -3.42 | 0.001*** |
| riceTrend_weather | rice yield trend with weather | 0.9843777  | 0.1684853| -0.09 | 0.927 |
| lv005_2      | Kajunjumele ward               | 0.3156062  | 0.128844 | -2.82 | 0.005* |
| lv005_3      | Mahongole ward                 | 0.9301439  | 0.415042 | -0.16 | 0.871 |
| lv005_4      | Ruiwa ward                     | 1.19148    | 0.5406901| 0.39  | 0.699 |
| cons         | constant                       | 2.316907   | 2.019147 | 0.96  | 0.335 |

Number of Obsn 240

Prob>chi^2 0.008

LR chi^2 (9) 28.47

Pseudo R^2 0.0857

Location specificity: Regarding to locations it is shown that ability to perceive some changes of weather variables also varies within and between wards. Therefore, at any one times increase in farmers in Kajunjumele ward the farmers’ perception of weather variability increases by 0.33 times.

4. Conclusion and recommendation

Farmers have attested on good understandings of the weather variability, the challenges and their implications to crop yield and food security. This clinches that weather variability is taking place in Mbeya region, however, the biggest challenges are on adaptation to curb the variations. In order to curb the negatives challenges brought by weather variations there must be efficient and collaborative approaches which can involve local communities, researchers, and other responsible institutions.

Acknowledgments

This article was supported by the CAAS Science and Technology Innovation Project (number: CAAS-ASTIP-2018), founded by Chinese Academy of Agricultural Sciences.

References

[1] M. A. Khan and M. S. Akhtar, Agricultural Adaptation and Climate Change Policy for Crop Production in Africa, 2015.
[2] A. Panda, “Exploring climate change perceptions, rainfall trends and perceived barriers to adaptation in a drought affected region in India,” Nat. Hazards, 2016.
[3] F. Terdoo and G. Feola, “The Vulnerability of Rice Value Chains in Sub-Saharan Africa: A Review,” Climate, vol. 4, no. 3, p. 47, 2016.
[4] M. Y. Mkonda, Are Rainfall and Temperature Really Changing? Farmer’s Perceptions, Meteorological Data, and Policy Implications in the Tanzanian Semi-Arid, 2017.
[5] A. D. A and O. P. O. “Uptake and Use of Climate Information Services to Enhance Agriculture and Food Production among Smallholder Farmers in Eastern and Southern Africa Region,” Int. J. Adv. Res, vol. 6, no. 5, pp. 2320–5407, 2018.
[6] URT. “United Republic of Tanzania Vice President’s office-National Climate Change Strategy,”
8

2012.

[7] M. Silvia and S. E. Lazos, “Indigenous perception of changes in climate variability and its relationship with agriculture in a Zoque community of Chiapas, Mexico,” pp. 363–389, 2011.

[8] M. Y. Mkonda and X. He, “Yields of the major food crops: Implications to food security and policy in Tanzania’s semi-arid agro-ecological zone,” Sustain., vol. 9, no. 8, 2017.

[9] K. P. C. Rao, W. G. Ndegwa, K. Kizito, and A. Oyoo, “Climate variability and change: Farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya,” Exp. Agric., vol. 47, no. 2, pp. 267–291, 2011.

[10] L. Roco, A. Engler, B. E. Bravo-Ureta, and R. Jara-Rojas, “Farmers’ perception of climate change in mediterranean Chile,” Reg. Environ. Chang., 2015.

[11] J. A. Tambo and T. Abdoulaye, “Smallholder farmers’ perceptions of and adaptations to climate change in the Nigerian savanna,” Reg. Environ. Chang., 2013.

[12] N. Debela, C. Mohammed, K. Bridle, R. Corkrey, and D. McNeil, “Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia,” Springerplus, 2015.

[13] A. M. Ado, J. Leshan, P. Savadogo, L. Bo, and A. A. Shah, “Farmers’ awareness and perception of climate change impacts: case study of Agui district in Niger,” Environment, Development and Sustainability, 2018.

[14] M. Fisher, T. Abate, R. W. Lunduka, W. Asnake, Y. Alemayehu, and R. B. Madulu, “Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa,” Clim. Change, 2015.

[15] L. Roco, D. Poblete, F. Meza, and G. Kerrigan, “Farmers’ Options to Address Water Scarcity in a Changing Climate: Case Studies from two Basins in Mediterranean Chile,” Environ. Management, 2016.

[16] J. A. Tambo and T. Abdoulaye, “Climate change and agricultural technology adoption: The case of drought tolerant maize in rural Nigeria”, Mitig. Adapt. Strateg. Glob. Chang., 2012.

[17] M. Hills, “Earth Science & Climatic Change Smallholder Farmers” Perspectives on Climatic Variability and Adaptation Strategies in East Africa: The Case of Mount Kilimanjaro in,” vol. 6, no. 10, 2015.

[18] V. Mugula. and E. Mkuna, “Farmer’s perceptions on climate change impacts in different rice production systems in Morogoro Tanzania,” Int. J. Sci. Res. Publ., vol. 6, no. 2, pp. 334–340, 2016.

[19] E. F. Elia, S. Mutula, and C. Stilwell, “Indigenous Knowledge use in seasonal weather forecasting in Tanzania: the case of semi-arid central Tanzania,” South African J. Libr. Inf. Sci., vol. 80, no. 1, pp. 18–27, 2014.

[20] J. J. Kashaigili, P. Levira, E. Liwenga, and M. V. Mdemu, “Analysis of Climate Variability, Perceptions and Coping Strategies of Tanzanian Coastal Forest Dependent Communities,” Am. J. Clim. Chang., vol. 3, no. June, pp. 212–222, 2014.

[21] S. Neenu, A. K. Biswas, and A. S. Rao, “Impact of Climatic Factors on Crop Production - A Review,” vol. 34, no. 2, pp. 97–106, 2013.