

Communication

Individual Local Farmers' Perceptions of Environmental Change in Tanzania

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Abstract: Climatic and environmental changes are expected to affect in particular those regions where the economy is primarily based on the agricultural sector and where the dependency on water availability is high. This study examines how smallholder farmers in rural Tanzania perceived climatic and environmental changes over the past 20 years and the resulting effects on water availability and food security. The study is based on a household survey of 899 farmers in a semi-arid and a sub-humid region in Tanzania. It was found that (a) significant differences in perceptions of the environment by farmers can be attributed to agro-climatic location, while the distance to a water source has less impact on individual perception; (b) differently perceived changes affect individual water availability and food security; and (c) the farm level adaptation methods applied are linked to vulnerability to changes and the household dependence on the immediate environment. The authors conclude that the specific environmental surroundings paired with socio-economic factors can severely compound the negative effects of water scarcity on rural farmers.

Keywords: environmental change; local perception; food security; adaptation

1. Introduction

Changes in water availability can be quantified by advanced technology as well as individual perception. People whose livelihoods directly depend on water resources, such as farmers, are likely to perceive changes in water availability and their environment. However, there is mixed scientific evidence regarding the accuracy of this evidence [1–3]. Therefore, human perceptions of environmental changes are useful to supplement current environmental data methods and add a qualitative perspective regarding the effects of the changes [4,5].

Perception of the environment describes how a person perceives the environment through the brain's and their senses' ability to process and store information. The perceptual process is highly complex, but broken down it consists of six steps: the presence of objects, observation, selection, organization, interpretation, and response [6]. The selection, organization, and interpretation is personalized and driven by internal and external factors. For example, the motivation, personality, or experience of an individual plays a role in how they perceive their surroundings, but also a continued repetition of being exposed to an object or a situation can alter their personal perception. Observers are often very poor at reporting changes to their visual environment, but sensitivity to change does still occur in the absence of awareness and does not rely on the redeployment of attention. The more acute the change occurs, the more likely it will be perceived by the individual [6].

Perception of the environment as a diagnostic tool was first declared by the UNESCO's Man and the Biosphere program, stating that the study of perception of the environment is a fundamental tool for the management of places and landscapes [7]. Other studies have shown that perceived changes in the environment are instrumental towards policy design and sustainable resource management, as they may detect socio-environmental issues and interlinkages which other methods neglect [8–10]. Thus, an inconsistency between individual perception and scientific “measured” data can be utilized to critically review results and to guide interpretation and management methods [11].

Individual perception is an especially effective diagnostic tool for the review of regional environmental deviances on a small scale as present scientific measuring techniques may be too imprecise for a detailed and in particular for an individual analysis [4,12,13]. The effects of change in water availability can be highly succinct in terms of regional deviations and are subject to environmental as well as socio-economic conditions [3,12]. Accordingly, an analysis of the link between distance to water sources, the resulting amount of time spent outdoor in the environment, and perceived related environmental change grants insight on why some perceive environmental change more strongly than others.

This research on individual perceptions of water availability and food security in two study areas, in rural semi-arid and in sub-humid Tanzania, investigates the discrepancies between perceived changes in the environment and location across to regions. The objective is to discriminate perceptions between the two study regions and explore the importance of agro-climatic location in terms of the effects of environmental change on the individual perception. Furthermore, it aims to detect differences in perceived changes in water availability and food security based on the time needed by an individual to reach a drinking water source. We hypothesized that both agro-climatic location and distance from water source would influence individual perception insofar that harsher environmental surroundings stimulate sensitivity to change within those surroundings. Furthermore, it was expected that if environmental changes are perceived, measures would be put in place to prevent or reduce expected risks, which in turn could increase long-term water availability and food security.

2. Materials and Methods

2.1. Study Area

The Wami River drainage basin constitutes the hydrological unit encompassing the selected case study regions in Tanzania (Figure 1). Water availability in this area partly depends on the state of the Wami River basin's water resources, which have been and continue to be affected by strong hydrological changes due to population growth, agricultural sector development, and climate change [14–16].

This study was carried out in two agro-ecologically differing regions in Tanzania. The predominantly sub-humid Morogoro case study region (600–800 mm annual rainfall) features flat plains, highlands, and dry alluvial valleys [17]. The diverse food systems are based on maize, sorghum, legumes, rice, and horticulture, with livestock being only marginally integrated in the livelihood system. The semi-arid Dodoma case study region (350–500 mm annual rainfall) is predominantly characterized by flat plains. The food system is primarily based on sorghum and millet with a strong integration of livestock [17–19]. Morogoro contains areas with different levels of sensitivity concerning food security, while the areas in Dodoma are usually characterized by high food insecurity.

2.2. Data Collection

The study uses the findings of empirical qualitative research conducted in 2014 from six villages (Changarawe, Idifu, Ilakala, Iloilo, Ndebwe, Nyali; case study sites in Figure 1) in two rural regions in Tanzania. A baseline household survey (Faße, et al. [20]) interviewed 899 household heads to describe the climatic and environmental changes in their immediate surroundings over the past 20 years, in case they had perceived any. The surveyed households were selected randomly from a list of household

heads' names and the corresponding sub-villages they lived in. From each village, 150 households were randomly selected, collectively adding up to 900 surveyed parties in total from both districts.

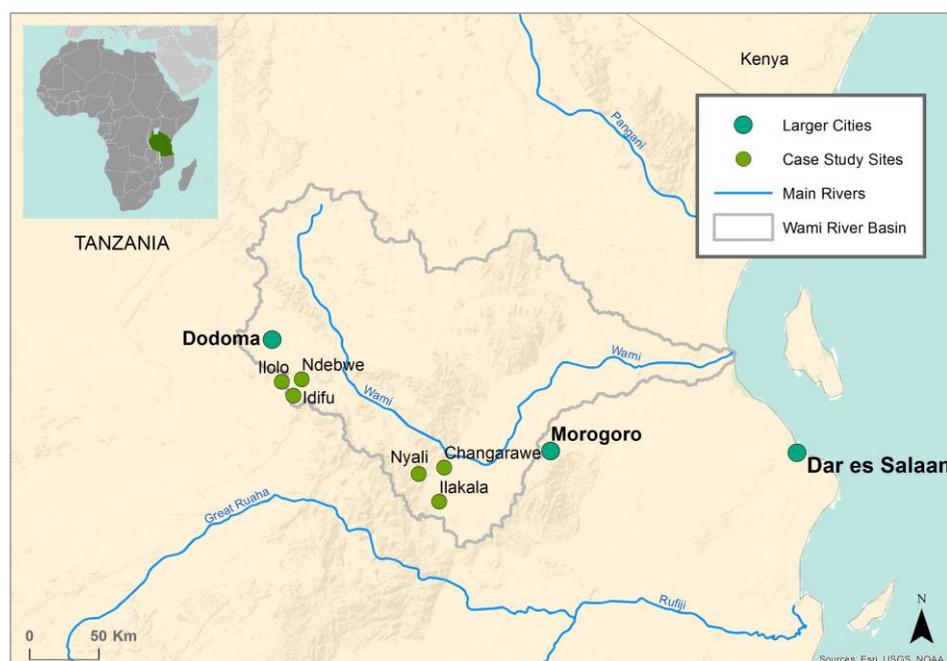


Figure 1. Location of case study sites, larger neighboring cities, major rivers and corresponding river basin in Tanzania.

2.3. Quantitative Analysis

A selected number of information from the survey sections regarding climatic changes, environmental changes, water sources and water availability were used for this study. Additionally, information on the location as well as the distance to cover to reach the main source of drinking water was extracted. After the data was collected, it was entered into a database and later exported to the statistical software STATA 13 for data cleaning. The data was cleaned in terms of income and consumption aggregation. The data was then analysed with IBM SPSS Statistics Version 16.0, using the Mann–Whitney-U test for testing regionally differing perceptions of the environment and using the Kruskal–Wallis-H test for verifying a possible relationship between distance categories to the water source and their perceptions of the environment.

3. Results

3.1. Region-Specific Perceptions

The results of the statistical analysis shows that perceptions of change related to climate (Table 1) and environment (Table 2) were significantly different between the two regions. While 97% of all farmers from both regions perceived climatic changes over the past 20 years, highly significant differences in perceptions became apparent for changes in temperature, forest, grazing lands, soil fertility, river water levels, food security and coping activities.

The perception of interviewees from Dodoma in regards to changes in temperature revealed that individuals felt less affected by potential changes than interviewees from Morogoro. Individuals from Dodoma more often expressed that they had not perceived any change in temperature as well as lower temperatures during the summer season. Interviewees from Morogoro reported to have suffered more heat days and extreme temperatures than those from Dodoma.

Table 1. Perceptions of climatic change in Dodoma and Morogoro (Mann–Whitney-U Test).

Parameter	Semi-Arid Dodoma	Sub-Humid Morogoro
Climatic Change	n.Sign.	n.Sign.
-No change	2.7%	3.1%
-Change	97.3%	96.9%
Rainfall	n.Sign.	n.Sign.
-Less annual rainfall	43.2%	46.2%
-Less rainy days	13.4%	13.1%
-Rainy season shorter	10.1%	8.0%
-Other ^b	33.3%	32.7%
Temperature	**	**
-No change	5.6%	1.8%
-Less hot in summer	5.0%	1.6%
-Hotter in summer	25.0%	17.8%
-Extreme temperatures	32.2%	41.9%
More heat days	23.4%	27.8%
Other ^b	8.8%	9.1%

** significance level $\alpha \leq 0.01$; ^b 'Other': answer categories that were selected by less than 10% of interviewees in both regions were aggregated.

Table 2. Perceptions of environmental change in Dodoma and Morogoro (Mann–Whitney-U Test).

Parameter	Semi-Arid Dodoma	Sub-Humid Morogoro
Environment	n.Sign.	n.Sign.
-No change	4.2%	5.6%
-Change	95.8%	94.4%
Forest	**	**
-No change	2.5%	9.4%
-Less forest area	40.6%	34.1%
-Less trees	20.3%	18.5%
-Less dense forest	17.2%	11.4%
-No more big trees	10.8%	17.6%
-Other ^b	11.1%	18.4%
Grazing Land	***	***
-No change	3.2%	23.5%
-Less grazing lands	35.9%	41.9%
-Less pasture	30.3%	8.8%
-Grazing lands degraded	22.7%	15.0%
-Other ^b	7.9%	10.8%
Soil Fertility	**	**
-No change	6.3%	16.2%
-Lower yields	85.2%	75.1%
-Other ^b	8.5%	8.7%
River Water Level Wet Season	***	***
-No change	37.7%	17.3%
-Lower water level	20.2%	63.7%
-Higher water level	16.1%	13.1%
-Other ^b	26.0%	5.9%
River Water Level Dry Season	n.Sign.	n.Sign.
-No change	31.3%	12.1%
-Lower water level	24.0%	14.5%
-Higher water level	20.4%	67.5%
-Other ^b	24.3%	5.8%

** significance level $\alpha \leq 0.01$; *** significance level $\alpha \leq 0.001$; ^b 'Other': answer categories that were selected by less than 10% of interviewees in both regions were aggregated.

People from Dodoma perceived more severe negative changes in forests and were more likely to notice a negative change in pasture compared to interviewees from Morogoro. While a higher percentage of people from Morogoro found no changes in soil fertility in comparison to those of Dodoma, the survey concludes that populations from both case studies have largely suffered lower yields, suggesting a cause for the extensive negative effects on food security in both regions. In terms of food security, respondents from Dodoma indicated to have suffered negative impacts more frequently, which is in line with their perception of climatic and environmental changes.

Coping activities to approach the declining food security varied strongly between the two regions. While nearly one fifth of interviewees from Dodoma chose to undergo no adjustment in the face of environmental change, even twice as many refrained from doing so in Morogoro. Many interviewees from Dodoma chose to take up non-farm employment. In Morogoro, popular coping mechanisms included growing more crop varieties, taking up non-farm employment, and saving money. Hardly any interviewees coped by migrating to another village or region or by investing in irrigation to cope with the changing circumstances.

3.2. Perception Based on Distance to Water Source

Perceptions based on individual household distances to the closest water source did not show any significant differences between water source distance classes (short distances less than 30 min by foot, long distances between 30 and 240 min' walk), except for soil fertility. Interviewees from longer distance households tended not to perceive changes in soil fertility compared to shorter distances. Though not significant, we found more rainfall in the early season and longer rainy seasons to be solely perceived by interviewees who only had to overcome short to medium distances to their next source of drinking water, while none of the interviewees with a journey longer than 30 min had noticed a positive change.

4. Discussion

4.1. Region-Specific Perceptions

Our aim was to discriminate between different perceptions on environmental change and the resulting effects on water availability and food security between (a) two agro-climatically differing regions and (b) households with differing distances to water sources. The study results proved that region-specific environmental variables affect individuals' perception of environmental changes [21–24], with highly significant perception differences on the regional level regarding changes in temperature, forest, grazing lands, soil fertility, river levels, food security, and coping activities. Region-specific environmental settings and possibly the associated social and economic circumstances [25–27] are predominant reasons for these differences. The interviewees of the semi-arid Dodoma region perceived negative climatic changes less than those from Morogoro region; they were, however, more likely to perceive changes within their environment, suggesting a linkage between perception of environmental changes and vulnerability to these changes [28]. Due to the unimodal and low annual rainfall within only few and erratic events, and high spatial variability in distribution, food insecurity is higher throughout Dodoma region. This places higher pressure on households to adjust their situation by applying coping mechanisms such as non-farm employment [29], even if they entail higher uncertainty [30].

Present environmental risks within a region increase the individual's perception of other environmental changes when the respective livelihoods highly depend on water availability and stability [31]. Greater changes in river water levels were perceived year-round in Morogoro in comparison to Dodoma, where surface water plays a minor role and is only available in the rainy season. Agricultural communities of Morogoro mainly live off of soils that are subject to seasonal flooding, intensifying their perception of changes in river water levels. The dependency on surface water increases vulnerability to environmental changes and in turn increases the likeliness for perception of

changes to natural surroundings. However, even though the low annual precipitation entails higher water and food insecurity in the Dodoma region, adoption of adaptation measures there is low amongst interviewees, even if somewhat higher than in Morogoro.

Perceived changes on a local and individual level may trigger community-level adaptation. Without the support of community-based mechanisms, however, individual coping strategies are limited and subject to risk. As this study shows, a high number of interviewees decided to refrain from action even though high-impact environmental changes were perceived (Table 3). Farmers may be constrained in undertaking adaptation measures due to lack of funds, poor planning, or due to the environmental changes themselves, for instance, shortage of water [30]. Others may perceive changes, but not fully realize the culminating associated risks.

Table 3. Perceptions of impact on food security and utilized coping activities in Dodoma and Morogoro (Mann–Whitney-U Test).

Parameter	Semi-Arid Dodoma	Sub-Humid Morogoro
Food Security	***	***
-Highly negative impact	49.3%	30.4%
-Medium negative impact	13.7%	17.2%
-Medium positive impact	5.9%	11.1%
-Highly positive impact	14.4%	16.8%
-Other ^b	16.7%	5.7%
Coping Activities	***	***
-No adjustment	17.7%	37.4%
-Non-farm employment	17.3%	9.7%
-Grow more varieties	5.9%	11.4%
-Save money	4.8%	8.4%
-Migrate to another village/region	0.2%	0.9%
-Invest more in irrigation	1.1%	0.9%
-Other ^b	53.0%	31.3%

*** significance level $\alpha \leq 0.001$; ^b 'Other': answer categories that were selected by less than 10% of interviewees in both regions were aggregated.

In line with Iqbal et al.'s findings, our results suggest that those farmers located further away from a major city or core village perceive environmental changes more [31]. The Dodoma region case studies are geographically clustered closely together in a notable distance to the next larger city, so perceptions were very similar amongst the villagers. However, in the Morogoro region, Changarawe and Nyali are notably closer to Kilosa town than Ilakala, whose inhabitants strongly perceived a highly negative impact of environmental changes on food security. Possible reasons may be a lack of interest, information and resources that farmers living in close proximity to a city have access to, as well as the availability of off-farm work.

4.2. Perception Based on Distance to Water Source

Unexpectedly, few significant differences were found in perceived environmental changes based on the time needed by an individual to reach the source of drinking water, except for perception on soil fertility. The time needed and the associated physical burden directly affects the volume of water consumed by households using non-networked sources [32]. Previous research also affirmed that households with water sources located more than 30 min away collect less water than is believed necessary for basic need [33]. It was expected that a higher distance to a water source encourages perception of environmental and climatic changes, as extended walks increases exposure. However, our study indicates a weak relation between walking time, the implied increased environmental exposure and the individuals' perception of change in water availability. Even more and to our assumption, those households with longer walking distances tended to be less likely to adapt to water

scarcity and food insecurity. It is suggested that those households who are currently accessing long distance water sources are also those with the least opportunities for incremental change. Ongoing further correlation analysis and synchronization of findings with regional expert interviews should deepen the understanding of these complex interactions.

5. Conclusions and Recommendations

The results of this study show that environmental surroundings paired with socio-economic factors affect the perception of climatic and environmental changes by rural farmers. Even though perceptions of changes and their effects on water availability and food security were very high, farm level adaptation measures were not applied by a large percentage of interviewees. The type of applied coping mechanism was especially dependent on the respective region of the individual. The lack of utilized adaptation methods underlines the present margin between perception and action. Alerting individuals for early warning signs of adverse environmental changes may be part of the solution. In addition to external activities such as financial aid, social learning activities and policy action, individuals could profit from being informed of cost-effective, long-term adaptation measures that they can implement themselves and that respond best to the mentioned changes of the environment. While farmers with access to urban centers or institutional services are more likely to implement adaptation measures, especially remote locations most vulnerable to environmental changes should be supported with targeted outreach programs with clear targets that need to be regularly monitored.

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