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Knowledge and Perception of Users on Ecosystem Services in Mount Kilimanjaro, Tanzania and Taita Hills, Kenya

[1]**Kilima F. T. M.**, [1]**Kadigi R. M.J.**, [2]**Kashaigili, J. J.**, [3]**Abdallah, J.**, [1]**Steven, C. and** [1]**Shimbe, S.**

Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture, Morogoro, Tanzania.
Department of Forest Menstruation, Sokoine University of Agriculture, Morogoro, Tanzania
Department of Forest Economics, Sokoine University of Agriculture, Morogoro, Tanzania,

Abstract

The capacity of ecosystems of Mount Kilimanjaro in Tanzania and Taita Hills in Kenya to continue providing vital ecosystem services is dwindling over time, mainly due to over-exploitative uses of ecosystem services and climate change. Many of the efforts to identify effective approaches for sustainable management of the ecosystem in these areas have not explicitly embraced stakeholders' perceptions. This paper offers a comprehensive review of users' knowledge and perception of climate change and Ecosystem services in Mount Kilimanjaro and Taita Hills. The intent is to profile users' knowledge and perception to pin-point leverage points for future awareness creation and community mobilization strategies to hedge against negative impacts of climate change. Data were collected through interviews from 352 respondents who were randomly selected from three distinct altitude zones (low, middle and high) of Mount Kilimanjaro and Taita Hills. Descriptive statistics for socio-economic and demographic variables as well as measures of users' perception of the ecosystems and climate-related challenges were computed. None parametric statistics (Kruskal-Wallis H statistic, Mann-Whitney U test and Kendall-tau test) were performed to test whether some of the variables were correlated. Results show that users of ecosystems of Mount Kilimanjaro and Taita Hills are aware the ecosystems values to humans and the need to conserve these ecosystems in order to sustain the benefits and flow of ecosystem goods and services. However, there are marked spatial and demographic differences in their perception of ecosystems, which can potentially alter the value they attached to different ecosystem services and the spatial significance of climate change. In view of these differences there is a need to devise an effective communication strategy, which can address the users' knowledge gap with respect to indicators in relation to the severity of climate change, and inform policy about the extent to which users of ecosystems at different altitudinal gradients can collaborate to overcome climate-related challenges.

Key words: *Users' Knowledge and Perception, Ecosystem Services, Mount Kilimajaro and Taita Hills*

Introduction

Mount Kilimanjaro and Taita Hills are renowned as world heritage with diverse flora and fauna and they provide a wide range of vital ecosystem services to over one million mountain communities. Meanwhile, lowland residents in these areas depend on water flowing from the ecosystems (Agrawala and Berg, 2002, Adriaensen *et al*., 2007). However, the capacity of the ecosystems to continue providing these vital services is dwindling over time, mainly due to over-exploitative uses and climate change (Adriaensen *et al*., 2007; Hemp and Beck, 2001 ; Himberg, 2009; Newmark, 2002). The threat paused by this over-exploitation along with real and potential consequences of ecosystem degradation and climate change have encouraged conservators and regulators to identify more effective approaches for sustainable management of this ecosystem rather than dealing explicitly with stakeholders' perceptions (Adriaensen *et al*., 2007; Kijazi and Kant, 2011 Swallow *et al*., 2009).

Scholars acknowledge the importance of integrating biophysical, economic and political factors to mediate access and apportion ecosystem goods and services among competing users and uses. An ideal way to achieve this integration is to incorporate the multiple values of ecosystem goods and services in conservation and environmental management plans (Raymond and Brown, 2006; Kumar and Kumar, 2008; Naidoo *et al*., 2008; Turner *et al*., 2003). Thus, the valuation of ecosystem goods and services should consider all possible tradeoffs and explore economic and local values which stem from the intrinsic relationship between culture and nature, and people and place. These broadly defined values form a major component of payment for ecological services that is increasingly being adopted to craft policies and regulations that govern the use of ecosystems (World Bank, 2005).

Manzo (2005) underscores the need to understand spatial variation in values that people attach to ecosystem goods and services. This knowledge is required to identify negative values that can potentially lead to degradation of ecosystems (Folke, 2006). The knowledge can also allow managers of ecosystems to clearly understand people's strength and a wide range of community values that can shape planning for targeted conservation and environmental management.

This paper offers a comprehensive review of knowledge and perception of climate change and Ecosystem services in Mount Kilimanjaro, Moshi, Tanzania and Taita Hills, Kenya. The intent is to profile people's knowledge and perception to pin-point leverage point for future awareness creation and community mobilization to hedge against negative impacts of climate change.

People's knowledge could be enhanced to encourage the appreciation of nature and benefits of ecosystems for sustainable use and management. This focus has generally been rare as analysts have increasingly adopted market oriented approaches in prioritizing the ecosystems and devising strategies to influence the use of ecosystems. The maintained hypothesis underlying the analysis is that perceptions of ecosystems services and climate change do not vary across altitudinal gradients and users' category. The hypothesis seeks evidence to challenges the conventional (market oriented) approach that downplays the importance of users' perception that tends to be influenced by both socio- and demographic variables.

The paper is presented in five sections including this introduction. The second section offers a comprehensive review of users' perceptions and its effect on ecosystems use and management along with issues surrounding its measurement. Section three describes the study area and data collection and analysis. Section four offers a brief discussion of the main findings while the last section gives a summary of main findings and its implication on the governance of the ecosystems.

Pertinent Issues in Ecosystem Use and Management

The relationship between people's perception and nature (ecosystems) could be viewed in three different lenses: Firstly, people are agents of biological and physical impacts on the ecosystems. Secondly, people are perceived as static receivers and processors of information from the ecosystems. Lastly, people are active users of ecosystem goods and services—their knowledge affects how they think, feel and use/manage the ecosystems (Zube, 1987). The literature shows that knowledge on ecosystems occurs when users know both the functions of ecosystems and benefits to mankind (Millenium Ecosystem Assessment, 2005). There are a variety of material and non-material benefits that people derive from ecosystems—the former are those which can be accounted for through economic markets while the later are more difficult to quantify, and attach monetary values (De Groot *et al*., 2002; Raymond *et al.*, 2009; Chan *et al*., 2012(a)). Knowledge on ecosystem is normally shaped by a complex interaction of factors underlying users' perception of ecosystem values—aesthetic, biodiversity, cultural, economic, historic, recreation and existence (Brown and Reed, 2000; Raymond and Brown, 2006; Alessa *et al*., 2008). Moreover, others factors like technological innovations (e.g. control of emissions, efficiency of water use) have also been identified to influence people's knowledge as well as the use and management of ecosystem goods and services (Dietz *et al.,* 2003).

In view of the complex interaction between ecosystems and people it is important to gauge the extent to which users of ecosystem are able to identify and map specific values and threats associated with ecosystem services and share this knowledge in a way that improves planning for sustainable use and management as well as other long-term environmental outcomes.

Valuation of Ecosystem Services

The primacy of market-oriented approaches of valuating ecosystems is principally founded on their main functions such as provisioning, regulating, and supporting services that downplays the relative importance of cultural services that are perceived to be less important owing to their intangible nature. It is should be noted that intangible benefits are difficult and contentious to value in monetary terms (Chan *et al*., 2012(b)). However, these intangible dimensions that underlie the changes of a principally psychological nature could be more important to people than material benefits (*Ibid*.). Ariely (2008) and Stiglitz *et al*., (2010) reveal that decisions underlying the use and management of ecosystems are seldom based exclusively on economic value. Nevertheless, methods of prioritizing ecosystems and corresponding interventions have rarely accommodated stakeholders' inputs and views. There are only a few analysts who have thoroughly examined stakeholders' perception of ecosystems in countries other than Tanzania (e.g. Shelton *et al*., 2001; Iceland *et al*., 2008). Thus, in socio-ecological perspective it is difficult to disentangle the ecological from the social causes of ecosystem change.

In summary, the weakness presented here revolves around the fact that cultural ecosystem services are rarely accommodated in ecosystem decision making tools, despite the widespread recognition of their importance (Millennium Ecosystem Assessment, 2005). Hence, minimizing environmental risks to humans has become a dominant theme in government policy, public debate, media coverage, and academic research. The debate has increasingly centred around the implications of human perception and judgment on ecosystem use and management.

People's Knowledge and Perception of Climate Change

In general there are many discipline- and context specific definitions of knowledge (Anderson, 2008; Alavi and Leidner, 2001; Soliman and Spooner, 2000). However, all the definitions underscore that knowledge refers to information, understanding, or skill gained through experience or education.

Thus, knowledge on ecosystems refers to users' valid understanding and beliefs about their relationship with the environment that generates the ecosystem services. This knowledge reflects the users' viewpoints on how the ecosystems

should be exploited and managed. It consists of explicit knowledge representing codified and easily translated facts and information about how the ecosystems are valued and used and tacit knowledge that reflects personal know-how about the subject which is hard to confirm or establish (Eraut; 2000; Fazey *et al*., 2006; Petrides and Guiney, 2002). This knowledge influences their feelings (attitude) towards ecosystems as well as other preconceived ideas that they may have towards the ecosystems (perceptions).

In a climate change perspective, perception can simply be defined as the perceived likelihood of dangers or negative consequences related to climate change (Sarkar and Padaria, 2010). Thus, perception is synonymously interpreted as people's judgement of climate change. The risk of adverse climatic conditions that create danger such as insecurity or lack of safety to users of ecosystems depends upon their personal experiences, perceived values of ecosystem goods and services, awareness levels, trust as well as cultural and institutional processes underlying the use of ecosystems (Mastrandrea and Schneider, 2004).

There are at least two contrasting perspectives on adverse climate change namely the 'external' and 'internal' definitions of risk. External definitions are usually based on scientific risk analysis of system characteristics of the physical or social world whereas internal definitions recognize that adverse conditions are either experienced or perceived to be present by an individual or a group of individuals (Dessai *et al.*, 2004). A more comprehensive definition of adverse climate change should therefore encompass these two definitions.

The assessment of human judgment had its origins in experimental work that adapted psychometric scaling methods to characterize people's perceptions and the decision making process, which has to date, evolved to a point where individual characteristics that influence their risk assessment and attitude can be identified (McDaniels, 1995). The psychometric method has conventionally been used to identify the characteristics influencing people's perceptions of risk. The assumption underlying the use of this method is that risk is inherently multidimensional, with many characteristics other than the probability of an adverse event occurring, which in turn, affect individuals' judgments (McDaniels, 1995; Melissa *et al.*, 2000). However, the scientific community argue that this approach may not be relevant when the perceived risk is delayed rather than immediate and the cost (consequences), are imposed directly on subsequent generations of users of the ecosystems (Sunstein, 2006).

Affect heuristic is an alternative approach to assess human judgment when confronted with risky choices (Melissa *et al.*, 2000). This approach

acknowledges that people's choices may occasionally stem from affective judgement that precludes a thorough evaluation of options. Affective reactions to stimuli are often the very first reactions that occur naturally and automatically to guide subsequent information processing. In summary, the approach underscores the fact that users of ecosystems may view the realization of potential benefits and occurrence of risks as isolated events thereby leading to judgements that are based on what the net difference between risks and benefits is for any particular use/option regardless of whether the rating scale focuses only on benefits or risks.

The main argument in favour of affect heuristic is that it considers both cost and benefits. However, its application is not based on vivid illustrations of real or potential harm leading to biased emphasis on short-term effects (Alhakami and Slovic, 1994; Cass, 2006). These twin problems affect both the users' decision and the capacity of analysts to overcome the challenges without using their own imaginations.

Recently, the focus of this type of analysis has shifted to "cultural cognition"—a risk-related approach to assess judgment which is rooted on cultural orientations. This approach is perceived to be a variant of affect heuristic for more fine-grained judgments (Douglas and Wildavsky, 1983; Kahan, 2012). The approach amplifies the view that individuals are expected to form their own beliefs about societal dangers that reflect and reinforce their commitments to codified forms of social priorities. While it is seemingly superior to affect heuristic, the application of this approach is constrained by two challenges: Firstly, empirical studies have shown that scales that are used to measure people's views perform poorly as these scales are not standardized/harmonized to allow objective comparisons (Marris *et al*., 1998; Sjöberg, 1998); Secondly, there is a possibility of having a single individual with competing orientations thereby invalidating the scales used to measure the views (Marris *et al.*, 1998).

In short, none of the discussions regarding analyzing perception seem to be adequate in explaining the perceived difference between expectations and observations. A pragmatic way to deal with this problem is to conceive this challenge during the design stage of the study to ensure that it is focused on events that trigger users' awareness leading to more accurate revelation of perception (Birkland, 1997; Beratan, 2007). Triggering events are those associated with real adverse effects (occurrence of a climatic effect) like severe drought, destructive rainfall and extreme heat (temperature), which can increase people's awareness and concern about a climate change event. These events can potentially induce positive changes in attitude with respect to the use and management of ecosystems, particularly in terms of subsequent efforts to hedge

against such risks or collective strategies to minimize the occurrence of negative events.

Methodology
Data Collection
Data for this paper were collected from three distinct altitude zones of Mount Kilimanjaro in Tanzania and Taita Hills in Kenya that are habitable. Mount Kilimanjaro and Taita hills are within the Eastern Afromontane biodiversity hotspots that are globally recognized as important for species conservation (Blackburn and Measey, 2009; Brooks *et al.*, 2002; Fjeldså *et al.*, 2006; Tolley *et al.*, 2011). These two hotspots were purposefully selected because there is commercial production of crops such as coffee, crucifer[1] and avocado. These activities coupled with high pressure on land use make the locations more vulnerable to land degradation and climate change. Thus, it is important to assess the users' awareness, knowledge, and perception of climate change in relation to their adaptation strategies. The zones were established during a transect walk to undertake a rapid assessment of ecosystems and the services they provide to local communities.

The altitude zones included lowland which is about 700-1200 meters above sea level (masl); middle land (1200-1500 masl) and highland (1500-1700 masl). The zones represented strata of villages[2] sharing common ecological features, agricultural practices and climatic challenges. The lowland zone, for example, is below the catchment area and is characterized by extensive livestock keeping and open crop fields, with remnant bush land patches. Residents are basically down-stream users of water flowing from the mountain. The middle zone is closer to the catchment areas but detached from thick forests. This zone is predominantly a maize-bean belt which is a mosaic of home gardens and open fields, with few bush land patches that are interspersed. The highland zone is within the catchment area and it shares borders with mountain forests—some of which are protected or conserved (Figure 1). The highland zone is characterized by home gardens dominated by coffee and banana, with many large trees.

The transect walk was followed by a survey using a structured questionnaire to seeks detailed information from users with respect to the use and management of the ecosystems and climate-related challenges. Interviews with key informant and focused group discussions were also conducted during the survey to capture community-wide and general information with respect to key issues under investigation.

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[1] Crucifer are vegetables of the family *brassicae* such as cabbage, cauliflower and broccoli that are widely grown in the two sites.
[2] Note that all villages that are located along the transect were included in the survey.

The sample consisted of 352 (211 males and 141 females) household heads who were randomly selected from two villages in each of the three zones. The sample size was consistently greater than 5% of the total population of each zone - a minimum size to ensure meaningful statistical inference (Boyd *et al.,* 1981). The respondents provided information on various demographic variables (Table 1) and their knowledge and perception with respect to ecosystem quality, management and climate change.

Data Analysis

Descriptive statistics such as frequencies and percentages were calculated for socio-economic and demographic variables as well as measures of knowledge and perception. Other descriptive statistics like the minimum, maximum, mean and standard deviation were also calculated, especially for continuous variables. None parametric statistics were used to compare variables (spatially and demographically) and test whether some of the variables were correlated.

Knowledge was measured in terms of respondents' awareness of the ecosystems and ecosystem services. To gauge respondents' awareness levels, facts about the ecosystems (phrased as sentences) were presented to be assessed as true/false. To gauge their perception on climate change several questions related to frequencies and trends of extreme climatic events such as temperature, drought, floods and wind were asked.

The Kruskal-Wallis H statistic, a non parametric equivalent of a one-way ANOVA, was used to test whether perception of respondents in the three zones are different[3]. The null hypothesis states that there was no difference between three or more group medians for variables associated with occurrences of abnormally high or low temperature, high speed wind and floods, against the alternative hypothesis that a significant difference exists between the medians (Chan and Walmsley, 1997). The test statistic is based on the sum of the ranks for the groups that are being compared. The more different these sums are, the stronger is the evidence that responses are systematically larger in some groups than in others, hence coming from groups that are different. The test statistic is calculated as:

$$H = \frac{12}{N(N-1)} \sum \frac{R_i}{n_i} - 3(N+1) \qquad (1)$$

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[3] It is important to note that cases for variables being tested must have scores on an independent or grouping variable and on a dependent variable. Since knowledge was measured in terms of percentages, this requirement precluded the use of this statistic to test differences in knowledge/awareness levels between the groups considered.

Where:
H=Kruskal-Wallis H statistic
N=Sample size for all groups;
n_i=Size of an independent sample within group *i;*
R_i =sum of the ranks for the ith sample.

The Mann-Whitney U test was used to identify significant mean differences between male and female respondents for selected indicators of climate change. This is a non-parametric test that allows two groups or conditions or treatments to be compared without making the assumption that values are normally distributed. The necessary conditions for this test include the following: the samples should be independent and random, variables should be measured as continuous units and the scale used should at least be ordinal. The logic behind this test is that when the samples differ, the distributions of the two populations will differ only with respect to the central location. If the sum of rankings from one sample differs enough from the sum of rankings from the other sample, the conclusion is that there is a difference in the population medians (Kasuya, 2001). The test statistic is computed as:

$$U_1 = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - \sum R_1$$

$$U_2 = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - \sum R_2$$

(2)

where:

n_1 and n_2 are the two sample sizes;
$\sum R_1$ and $\sum R_2$ = Sum of ranks for samples 1 and 2, respectively.

The Kendall-tau test was used to test for correlations between non-intervals scaled ordinal variables such as perception of rainfall patterns vis-à-vis floods and drought.[4] The Kendall-tau test is a non-parametric correlation coefficient used to measures the strength of the relationship between two non-interval ordinal scaled variables. Like Pearson correlation coefficient, Kendall's tau takes values between -1 and +1 where a positive correlation indicate that the ranks of both variables increase together whilst a negative correlation indicates that the rank of one variable increases while the rank of the other one decreases (Conover, 1980).

The computation of this statistics entails counting the number of different pairs between two ordered sets. This number gives a distance between sets which is technically referred to as the symmetric difference distance. This difference is

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[4] Like Kruskal-Wallis H statistic this test was not used to test differences in knowledge that was measures as percentage. Kendal tau requires the scale variable being tested to be ordinal.

obtained through a set operation which associates to two sets the set of elements that belong to only one set. The symmetric difference distance between two sets of ordered pairs P_1 and P_2 is denoted $d\Delta(P_1, P_2)$

The coefficient is obtained by normalizing the symmetric difference such that it is restricted between −1 and +1; where −1 is the largest possible distance that is obtained when one order is the exact reverse of the other order and +1 is the smallest possible distance. The coefficient is zero when both orders are identical. Analytically Kendall-tau is calculated as:

$$\tau = \frac{\frac{1}{2}N(N-1) - d\Delta(P_1; P_2)}{\frac{1}{2}N(N-1)} = 1 - \frac{2X[d\Delta(P_1; P_2)]}{N(N-1)} \qquad (3.0)$$

where all variables are as previously defined.

Results and Discussion
Profile of Users of Ecosystems
The sample consisted of 352 ecosystem users of whom 60% were male and 40% female. In terms of age structure 35% of the users were below 45 years; 34% were 45-60 years old and the rest (31%) were above 60 years. The minimum age was 17 years while the maximum was 101 years with a mean of 53 years (s^5=16.89). About 12% of the respondents did not attain formal education while 68%; 17% and 3% attained primary, secondary and post secondary education, respectively. Overall 53% of the respondents were married, 25.6% were widowed, 15.5% were single; 4% were separated and the remaining 2% were divorced.

Knowledge and Perception on Ecosystem and Climate Change
In general, users of ecosystems demonstrated high levels of awareness with respect to the importance of the ecosystems, threat to the ecosystems and consequences resulting from over-exploitation of ecosystems resources and other external shocks of climate change. Most respondents (96.2% males and 97.2% females) agreed with the view that ecosystems offer vital services to support human life and should be conserved to ensure sustainable flow of services and goods. About 77.2% of these users acknowledged that they were aware of climate change and were also aware that the change jeopardized the ecosystems whereas 90.1% revealed that the quality of ecosystems was being degraded. In terms of experiencing adverse climatic conditions many

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[5] Note that *s* stands for sample standard deviation which is used to show the variation of a variable about its mean.

acknowledged experiencing periods of extreme drought (92%), higher temperature (82%) or other climate related disasters such as floods and destructive wind (97%).

The users of ecosystems perceived rainfall amount to have decreased after 2004 (98% responses). However, many respondents suggested that temperature (75%), drought (95%) and incidences of abnormally high-speed wind (57%) have increased although they did not perceive incidences of floods (70%) to have changed during the study period spanning from 2004 to 2014. According to respondents' views, inadequate and erratic rainfall (98% responses), drying up of traditional wells and boreholes (71% responses), quick drying up of irrigation water (73% response), cracking of top soils (76% responses) and drying up of tender leaves (67% responses) are the main indicators of climate change. It is important to note that the overall assessment revealed no differences in the two study locations—the responses on these attributes did not vary between the locations.

Variation in Users' Perception across Altitudes

A comparison across the three altitude gradients and study locations using Kruskal Wallis test shows that there is no variation in respondents' perceptions, except with respect to the occurrences of floods which seems to be significantly higher in the lowland zone than the other zones $\left(\chi^2 = 4.92; p < 0.01\right)$. Perceptions of extreme temperature being higher $\left(\chi^2 = 4.62; p < 0.1\right)$ and lower $\left(\chi^2 = 11.86; p < 0.01\right)$ seem to be more prevalent in the middle land than in the other zones. However, perceptions of occurrences of destructive (abnormally high-speed) wind were lowest in the highland zone and highest in lowland zone $\left(\chi^2 = 7.60; p < 0.01\right)$. Coincidentally, there were more respondents in the lowland who felt that incidences of abnormally high-speed wind increased after 2004 $\left(\chi^2 = 27.39; p < 0.01\right)$. The background information reveals that crop production is predominantly in the low land, which normally leads to higher deforestation exposing the land to wind.

With respect to indicators of climate change there was a remarkable difference in respondents' perception on whether erratic rainfall is an indicator of climate change. Results show that there was an overwhelmingly high support for this indicator in lowland but this support diminished with increasing altitude $\left(\chi^2 = 6.47; p < 0.01\right)$. Similarly there were more lowland residents who revealed that drying-up of traditional wells and boreholes $\left(\chi^2 = 19.01; p < 0.01\right)$; drying or

cracking of soils $\left(\chi^2 = 414.93; p < 0.01\right)$; quick drying-up of irrigation water $\left(\chi^2 = 14.93; p < 0.01\right)$ were other indicators of climate change.

The results reveal that the proportion of residents perceiving temperature to be increasing over time was highest in lowland compared to all the other zones $\left(\chi^2 = 18.76; p < 0.01\right)$. Meanwhile, the proportion of lowland and middle land residents perceiving drought to be increasing was almost the same but higher than the corresponding proportion in the highland zone $\left(\chi^2 = 10.54; p < 0.01\right)$. It has been established that the highland zone is very close to catchment areas, which implies that there is more soil water in highland soils than in lowland and middle land. Naturally, temperature falls with increasing altitude. Hence, any increase in temperature is more likely to be felt in lowland than highland.

The implication of these findings is that users of goods and ecosystem services, who reside in different zones, are subjected to different threats of climate change. It is worth noting that the severity of degradation in one zone can generate external (climate) effects to users in other zones. Interventions leading to awareness creation about the "causes" and "effect" of ecosystems degradation may facilitate inter-community negotiations for best environmental outcomes, which have minimal impacts from ecosystem degradation.

Variation in Users' Perception between Age Groups
An assessment of perception among ecosystem users disaggregated by age groups shows that users from Mount Kilimanjaro and Taita Hills with different age groups revealed consistent perception although those who were relatively young were the majority supporting the view that incidences of destructive wind increased after 2004 $\left(\chi^2 = 6.432 p < 0.01\right)$. Many of these residents also argued that quick drying-up of irrigation water $\left(\chi^2 = 7.82; p < 0.01\right)$ and drying-up or cracking of soils $\left(\chi^2 = 48.41; p < 0.01\right)$ signify climate change effects.

In terms of patterns of floods the older respondents felt that there were no changes in incidences of floods during the reference period spanning from 2004 to 2014 $\left(\chi^2 = 11.26; p < 0.01\right)$. In contrast a slightly higher proportion of those who were older felt that temperature was increasing during this reference period $\left(\chi^2 = 7.36; p < 0.01\right)$.

In general, this analysis reveals that all groups shared similar perception but with a varying magnitude of severity. While the young generation supported a

particular view with respect to climate change a significant proportion of older generation members did not support such a view. Thus, it is difficult to speculate which of the group perception describes well the changes resulting from ecosystem degradation and climate change in the study area. However, it is realistic to conclude that the old generation who have accumulated sufficient knowledge and experience were more likely to make better informed opinions than the young users. Harmonizing these views could be an entry point to promote shared values of ecosystem goods and services across generations, leading to sustainable use and management practices.

Variation in Perception across Users' Levels of Education
The overall response on occurrences of extreme climatic events such as drought and temperature for users of ecosystem with different levels of education residing along slopes of Mount Kilimanjaro and Taita Hills were similar. However the proportion of users of ecosystems goods and services in these locations acknowledging the occurrence of abnormally high-speed wind during the last decade was highest among those with post secondary education followed by those who attained secondary education $\left(\chi^2 = 8.81; p < 0.1\right)$. However the overall opinion was that the pattern of wind speed was increasing during the reference period $\left(\chi^2 = 12.48; p < 0.05\right)$. Unlike others, the most elite users of the ecosystems revealed that erratic rainfall is an indicator of climate change $\left(\chi^2 = 11.57; p < 0.05\right)$. However only 46% of these users indicated that drying up of traditional wells and bore holes were indicators of climate change $\left(\chi^2 = 8.34; p < 0.1\right)$. Overall, all ecosystem users believed that incidences of drought were increasing over time $\left(\chi^2 = 16.13; p < 0.01\right)$.

The varied opinions portrayed by users of the ecosystems with different levels of education underscores the fact that perceptions and attitudes are normally rooted on both indigenous and traditional values that are fundamentally linked to systems of practice and knowledge (Millennium Ecosystem Assessment, 2005). The impact of formal education is to reshape community values to accommodate what scientific and traditional knowledge can offer to optimize and sustain the benefits of ecosystem services. Thus, it is likely that users with limited exposure to traditional or scientific knowledge can potentially understate or overstate the levels of degradation and its implication on climate change. The implication of these oversights may be to understate the willingness to pay (WTP) and the willingness to accept compensation (WTAC) when payments for ecosystem goods and services are contemplated.

Perception and Attitudes of Users of Ecosystems Disaggregated by Sex
In general, the findings show that the only difference in knowledge and perception regarding ecosystems and climate changes among male and female users in the two study locations is with respect to two aspects: Firstly, the proportion of female respondents who were not knowledgeable of and those who have experienced extreme climatic events was significantly higher than that of male respondents $(Z = -1.97; p < 0.1)$ and; secondly, the proportion of females reporting increased incidences of storms was significantly higher than that of male respondents $(Z = -1.86; p < 0.1)$.

In summary, male and female respondents have consistently shown similar patterns in their perceptions with respect to the benefit, use and management of ecosystems. However, a relatively higher proportion of female respondents reported having experienced extreme climatic events. Unlike many this group also perceived that the incidences of storms were increasing over time. These differences between males' and females' views imply that these views should be evaluated further using meteorological data from the study areas.

Relationship between Variables
Results from the correlation analysis reveals that the perception of ecosystem users regarding rainfall patterns were positively related to their perception on drought pattern (Kendall-tau=0.55, p=0.03) as well as floods (Kendall-tau=0.093, p=0.074) and temperature patterns (Kendall-tau=0.115, p=0.026). The users' opinion regarding erratic rainfall as an indicator of climate change were positively related to their opinion with respect to quick drying-up of irrigation water (Kendall-tau=0.097, p=0.069) and drying or cracking of soils (Kendall-tau=0.185, p=0.01). These findings support the view that a complex interaction of climate change and regional weather factors indicators play an important role in the production of extreme weather events that tend be correlated and occur sequentially (Chen, 200; Trenberth, 1999).

Summary and Conclusion
This study has established that users of ecosystems are sufficiently knowledgeable of the values of the ecosystems to humans and the need to conserve these ecosystems to sustain the benefits and flow of ecosystem goods and services. However, there are marked spatial and demographic differences in their perception of ecosystems, which can potentially alter the value they attached to different ecosystem services and the spatial significance of climate change. In view of these observed differences there is a need to devise ecosystems' conservation plans that take into account the following realities:

Users of ecosystems in Mount Kilimanjaro and Taita Hills have demonstrated high levels of knowledge and some positive attitude in favour of ecosystem conservation. However some of the perspectives seem to vary across age groups and sex of respondents. This difference needs further investigation to validate the views and identify perceived ideas that are wrong in order to inform the design of corrective measures, encompassing awareness creation and community mobilization for shared ecosystems conservation agenda;

There are notable differences with respect to the magnitude or severity of ecosystem degradation and challenges imposed by climate change. Flooding and water scarcity appear to be more pronounced in the lowland and middle altitude areas than in the highland. These differences can potentially inform policy about the extent to which users might be willing to collaborate or participate in addressing their unique challenges bearing in mind the potential impacts and benefits to other users outside their own zone. Policy makers can potentially tape into these differences to initiate and promote payments for ecosystem goods and services from one group of users to another.

The users' knowledge on magnitude and frequencies of extreme climatic events appears to be mainly influenced by variables such as experience (age), cultural values and academic orientation. While these differences in knowledge on climate change events are a natural phenona, there is a need for more rigorous assessment of time series climate variables to gauge (in a long-term perspective), their magnitude, cycles and frequencies and disseminate widely the results for more effective assimilation into ecosystem use and management plans.

Findings of this study also show a significantly larger proportion of female respondents revealing different information about the occurrence of some extreme climatic events like storms. In policy perspective this difference implies that awareness creation and sensitization on ecosystem use and management should be founded on rigorous assessment of traditional as well as scientific knowledge and tailored to address unique knowledge gaps of different gender groups.

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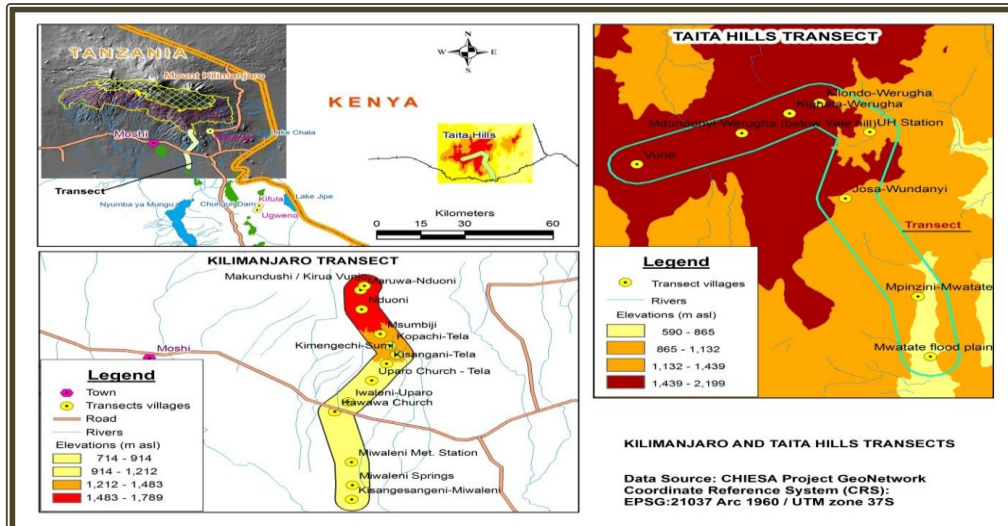
Figure and Tables

Figure 1: Map of the study area showing location of Kilimanjaro and Taita Hills Transects

Table 1   Respondents' socio-economic and demographic variables

Serial No	Variable Name	Variable type	Measurement Scale
1	Age	Categorical	1=Young (0-45 years) 2=Old (45-60 years) 3=Very old (>60)
2	Sex	Binary	1=Male 2=Female
3	Education level	Categorical	1=No formal education 2=Primary education 3=Secondary education 3=Post secondary education
4	Marital status	Categorical	1=Single 2= Married 3=Separated 4=Divorced 5=Widowed
5	Altitude	Ordinal	1=Lowland 2=Midland 3=Highland