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03

ASSESSMENT OF TRADITIONAL ENVIRONMENTAL KNOWLEDGE SYSTEMS APPLIED TO CLIMATE CHANGE AND VARIABILITY ADAPTATION IN ROMBO DISTRICT, TANZANIA

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Abstract: *This study was done to assess the efficacy of traditional environmental knowledge systems (TEKS) applied to climate change and variability adaptation in Rombo District, Tanzania. Different methods of data collection, analysis and presentation were employed for sensible report. Results indicate the study community have, to some extent, managed to withstand the effects of climate change and variability and other stressors by employing TEKS. The devised adaptation strategies to crop failure resulted from climate change and variability can be related to agronomic techniques, social coherence and livelihood diversification. The efficacy of the devised adaptation strategies were hindered by small land sizes, location, insolvency, technical knowhow, and climate change and variability. For effective adaptation to climate change and variability, multidisciplinary approaches that consider location and socio-economic characteristics of individuals are recommended.*

Key words: Climate Change and Variability, Traditional Environmental Knowledge Systems

Introduction

Climate change and variability have been given special attention mainly due to their disastrous effects on ecosystems. It is projected that the rising global temperature will cause increasing drought in mid-latitudes and semi-arid latitudes and increased water stress in many parts of the world affecting more people each year (Kotir, 2011). In addition, the impacts of climate change and variability are projected to be more severe in the developing countries despite their insignificant contribution to them because their livelihoods depend on climate with less capacity to adapt (Mertz *et al*., 2009). Since the impacts of climate change and variability are both local and global, adaptation also requires a collective action that cuts across from the grassroots to international levels and vice versa (Chatterjee and Huq, 2002). However, for the resource-poor countries like Tanzania, disaster management is predominantly built on traditional environmental knowledge systems (TEKS) from the early warning to mitigation stage (Rugumamu, 2000).

Literature Review

TEKS is described as a cumulative body of knowledge, strategy and belief, evolving by adaptive processes and handled down through generations by cultural transmission (Riedlinger and Berkes, 2001). Orlove *et al.* (2010) argue that TEKS should not be seen as a rigid, static repertoire of traditions that is unable to incorporate change, rather a flexible entity which by virtue of its diverse and empirical nature can integrate skills and insights from other knowledge systems as well as experimental practice. TEKS is intimately interwoven with local and regional processes of ecological and historical change that impinge on local landscapes and life ways (Roncoli *et al*., 2002).

TEKS can facilitate understanding and effective communication and increase the rate of dissemination and utilisation of climate change adaptation options at local level (Nyong *et al*., 2007) since most of the impacts of climate change are local and site-specific (Berks and Jolly, 2001). TEKS is regarded by Mukhopadhya (2009) as a precious national resource that can facilitate the process of disaster prevention, preparedness and response in a coast-effective participatory and sustainable ways. The importance of TEKS in addressing climate change issues has been described by Speraza *et al.* (2010) to be a driven need because it is communicated in local languages by local experts who are known and trusted by local communities.

Mertz *et al.* (2009) stressed the importance of TEKS in facilitating adaptation to climate change and recommended to consider current local practices rather than imposing nationally decided adaptation options. Kpadonou *et al.* (2012) add that for any adaptation which is implemented at local scale, its efficacy will be less dependent on the action of others. The failure of some adaptation projects is primarily due to the failure of development planners to effectively involve local communities in the process (Srinivasan, 2004). This has been observed by Barbier *et al.* (2009) in Northern Burkina Faso where improved seeds, mechanization, irrigation and ranching failed because the adoption of these new techniques remained disappointing due to market failure. Egeru (2012) stressed the importance of involving local people in designing and implementing adaptation projects because when all the modern project implementers leave, the challenge remains with the resident people to maintain their wellbeing.

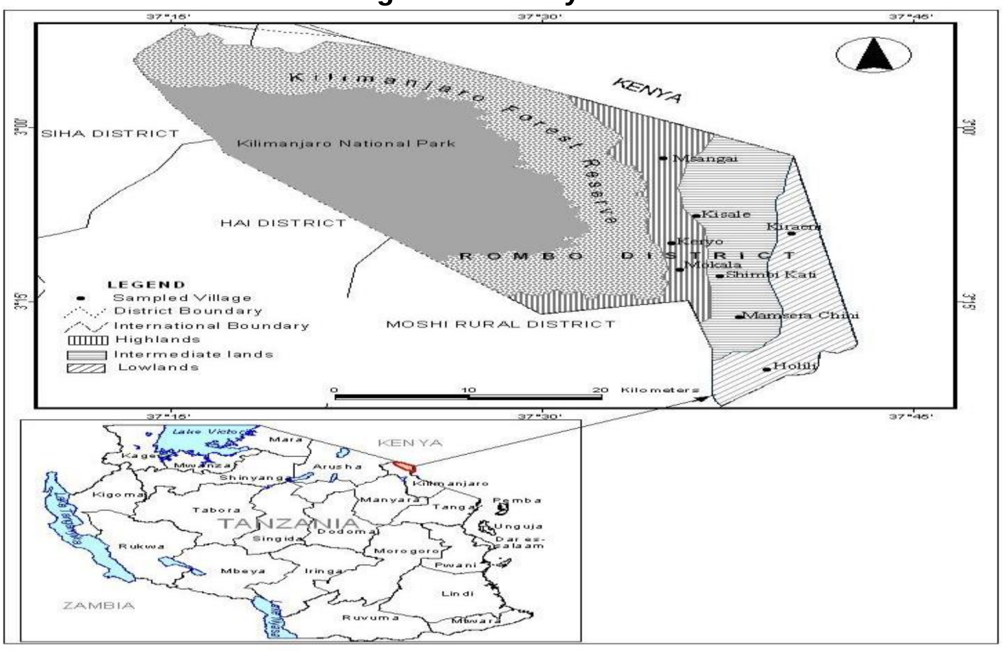
A study by Mongula (2000) revealed that, communities in the lowlands of Rombo District were severely affected by recurrent drought, which also caused food insecurity, water shortages and pasture deterioration. The report had further predicted that the drought was escalating and could affect more people. As the damage caused by climate change and variability to the environment is high and is projected to continue irrespective of the present mitigation attempts, adaptation is necessary to deal with the current and near-term impacts of climate change and variability (Mertz *et al*., 2009; Prabhakar *et al*., 2009).

Studies have also indicated that some local communities managed to withstand the impacts of climate change and variability by employing their TEKS. Notable examples include the Canadian Western Arctic Communities (Berks and Jolly, 2001), the indigenous people of the Sahel (Nyong *et al*., 2007) and the Maori of New Zealand (King *et al.,* 2008). Although communities in Rombo District live in a changing climate, to-date there is no substantive research conducted to assess the efficacy of TEKS applied to climate change and variability adaptation. Therefore, the present study intends to assess the efficacy of TEKS applied to climate change and variability adaptation in Rombo District as a basis for achieving sustainable development.

Research Area and Methodologies

The study was conducted in Rombo District (Figure 1). The district is characterised by mountainous climate with two distinctive rainfall regimes. The short rain season occurs in October through December, and the long one during March to May.

Figure 01: Study Area



The study used questionnaire, interview, focus group discussion and observation to have diverse and detailed findings on TEKS applied to climate change and variability. Questionnaires were directly administered to 611 respondents who were obtained through random sampling in eight villages in three agroecological zones (AEZs). Three focus group discussions were also used to collect narrative information from 21 participants who were purposively selected from the three AEZs of the study area. Furthermore, 10 leaders from the village and district levels were interviewed to determine official support to adaptation to climate change and variability. Field observation was also employed to collect none verbal information. Quantitative data were analysed with a Statistical Package for Social Sciences Software (SPSS, version 16) and Word Excel, while qualitative data from interviews and focus group discussions were thematically analysed and presented in frequency tables and narrations.

Results and Discussion

Characteristics of respondents

Some basic characteristics of respondents related to this study are summarised in Table 1. The table shows that agriculture is the main livelihood activities with the majority of respondents (45.9 percent) owned 2 acres of land where 85.6 percent acquired land through inheritance. Cultivated crops are coffee, banana, maize and beans. Others are cassava, millet, sorghum, sweet potatoes, sunflower, yams, fruits and vegetables. Animals kept in the area include cattle, goats, sheep, pigs and poultry.

Table 01: Basic characteristics of respondents (N=611)

Household Characteristics	**Description**	**Responses based on the AEZ (%)**			
		Highland (n=230)	Intermediate (n=274)	Lowland (n=107)	Average
Sex	Male	87.8	84.7	81.3	**84.6**
	Female	12.2	15.3	18.7	**15.4**
Size of land	> 1 acre	24.2	28.0	5.0	**19.1**
	2 acres	50.4	47.4	40	**45.9**
	3 acres	17	23.2	20	**20.1**
	4 + acres	8.3	1.1	35	**14.8**
Land acquisition	Inherited	83	95.1	78.8	**85.6**
	Bought	15.5	4.9	19.2	**13.2**
	Invaded	1	0	2.1	**0.8**
	Given free	0.4	0	0	**0.1**
Livelihood activities*	Agriculture	100	100	100	**100**
	Entrepreneurship	63	62.7	62.1	**62.6**
	Causal labour	22.8	32.5	19.7	**25.1**
	Formal employment	14.2	4.8	21.1	**13.4**

Source: Field Data ** Based on multiple responses*

TEKS Applied to Climate Change and Variability Adaptation

The study findings show that the local community in the study area are rich in adaptation practices and strategies based on their TEKS to ensure that they are food secured (Table 2).

Soil Water Conservation Measures

It was found that about 31 percent of the respondents have devised various strategies based on their TEKS to conserve soil water. The mentioned and observed soil water conservation measures were agroforestry, mulching and water halting structures. Interview with the District Agricultural and Livestock Development Officer (DALDO) revealed also that households of the study area are advised to plant cover crops such as pumpkins (*Cucurbita spp*.) and lablab bean (*Lablab purpureus* L.*)* to conserve soil water. Interview with the DALDO further revealed that farmers are advised to practice deep tillage because it creates micro-relief which store rain water temporarily and provide time for infiltration. All these indicate that the study community is aware on the decreased soil moisture resulted from climate change and variability, which corroborate with Fisher *et al*. (2010) who have indicated that it was difficult to gain insights into the potential for human adaptation if the effects of climate change had not yet been experienced or were just beginning to be felt.

Table 02: Adaptation strategies to climate change and variability (N=611)

Strategy	**Response based on AEZ (%)**			**Average**
	Highland (n=230)	Intermediate (n=274)	Lowland (n=107)	
Soil water conservation measures	30.3	37	27.3	**31.5**
Buying food	13	17	20.9	**17.1**
Use of improved crops	14.7	7.2	12.3	**11.4**
Intercropping	9	11.2	8	**9.4**
Food storage	6.4	7.2	9.6	**7.7**
Early planting	8.6	3.4	5.9	**6.0**
Drought resistant crops	3.7	4.6	7	**5.1**
Food aid	4.2	4	3.7	**4.0**
Farming different AEZs	5.7	4	2.1	**3.9**
Replant	0	0.2	0.5	**0.2**
No strategy	4.4	4.4	2.7	**3.8**

Source: Field Data

Buying of food

The findings presented in Table 2 reveal that heads of household in the study community bought food to ensure that there was food to feed their household members. The findings show that there were more heads of household who withstood food shortage through food purchases as an adaptation measure to crop failure in the lowland than other AEZs. This implies that the lowland AEZ was more affected by rainfall failure than other zones. The practice of buying food was stated to be limited in its scope because it was determined by the financial capability of a buyer. Moreover, the majority of the households in the study area depend on agriculture for livelihoods (Table 1). As such, it was difficult for the heads of household to feed their household members with bought food in the face of crop failure because it limits the financial capability of particular households. These findings concur well with those by Zorom *et al.* (2013) and Speranza *et al*. (2010) who found that local people severely suffered from food shortage not because of availability of food in the market but due to insolvency.

The study found that money for buying food could be obtained from selling trees and livestock. Selling trees may intensify climate change and variability unless the harvesting is carefully done to avoid deforestation. On the other hand, the selling of livestock to get money for buying food may deny households milk, eggs, and, more importantly, manure for their farms. Zorom *et al.* (2013) found that farmers were keen on selling livestock to buy food where they first sell chicken, goats and sheep whereas cattle was sold at critical point.

Use of Improved Crop Types and Varieties

The study also found that, in addition to the use of improved crop types and varieties supplied to local people by both authorised and unauthorised dealers, local people have knowledge of selecting desired crop types and varieties for planting. It can be argued on the basis of the study findings that, neither local nor new varieties of crops are hundred percent perfect in meeting the desired qualities of crops. The qualities in question are maturity rate, resistance to environmental changes and market values. Although the local varieties of banana withstand drought, they have poor market value; on the other hand, local varieties of avocado mature late but have excellent market value. The opposite is respectively observed for new varieties of banana and avocado. Local crops are less susceptible to pests and diseases (Shayo, 2006) whereas new crops were mainly introduced to diversify and secure better income in the Rural Sahel and not for the need to adapt to climate change and variability (Mertz *et al.*, 2009).

The study also found that the adoption of new and improved crop types and varieties were stymied by lack of funds and delays in seed supply by the agents. Based on these findings, it can be deduced that the use of TEKS in crop production diminishes when people are timely supplied with alternative resources. In this regard, studies by Barbier *et al.* (2009) in northern Burkina Faso, Stringer *et al.* (2009) in Malawi, McDowell and Hess (2010) in Bolivia and Wilk *et al.* (2013) in South Africa established that farmers' inability to buy improved seeds necessitated planting of seeds from the previous harvests. This finding reinforces the view that TEKS are mostly important to poor individuals.

Intercropping

The reported and observed tradition of intercropping which involved planting of perennial and annual crops in the study area should also be acknowledged. Similarly, intercropping of annual crops alone to include maize, cassava, beans, groundnuts, and sunflower should equally be weighed. This is due to the fact that intercropping increases the possibility of harvests in the changing climate (Stringer *et al.* 2009 Tambo and Abdoulaye, 2012) and reduces crop susceptibility to bio-physical factors such as a pest outbreak (Bradshaw *et al.*, 2004). However, the intercropping observed might not necessarily reflect the adaptation to climate change and variability due to land fragmentation, which necessitates agricultural intensification. Similarly, Manandhar *et al.* (2011) found that changes in cultivation practices in Nepal were not only due to climate change but also due to increased population pressure and availability of new technology.

Findings by Barbier *et al.* (2009) also show that most of the changes in agriculture in northern Burkina Faso were caused by land shortage and a decline in soil fertility and not climate change and variability. In this study, however, peasants could increase the area for cultivation but it was not possible due to the land acquisition system and location of the study area. It should be recalled from Table 1 that majority of the respondents acquired land through inheritance from their parents, which they should in turn distribute to their sons. This system of land acquisition does not favour agricultural intensification as it exacerbates the fragmentation of the present land. Also, the location of the study area limited the manoeuvres of the farmers as the area did not allow the clearing of new land for cultivation because the area is bordered by the Kilimanjaro Forest Reserve to the west and north and Kenya to the east (Figure 1). The only way to increase crop production is through intensification.

Food Storage

Food storage is a traditional strategy for adapting to climate change and variability, which focuses on assuring year-round availability of foodstuffs (McDowell and Hess, 2010; Jones and Boyd, 2011). Food storage facilities must be adequate enough to ensure that surplus stocks from the favourable agricultural years can be retained for the survival of the community during times of scarcity (Robinson and Henderson-Sellers, 1999). Food storage as adaptation to crop failure found to be common in the area under study is questionable because about 60 percent and 91 percent of heads of household mentioned to harvest less than 100 kilograms of maize and beans respectively. The stored maize and beans preceded by treating them with insecticides to guard them against damage caused by insects. There is a danger of stored crops being damaged because more than half (59.4 percent) of the heads of household mentioned storing their food crop harvests in sacks. Sacks can easily be damaged by rodents and moisture. In fact, poor storage facilities have been reported to be the main cause of post-harvest food loss, which is estimated to contribute to 10 percent food lose in the third world countries and 30 percent in Africa (Jones, 2004).

The findings on food storage reveal that food storage is determined by rainfall characteristics, size of land, soil infertility and farmers' willingness to follow advice provided by agricultural extension officers. Small sized pieces of land do not contribute to low crop yields only but also hinder the establishment of demonstration plots that could trigger agricultural innovations among peasants in the area under study. Unfortunately, where pieces of land are a bit larger (i.e. intermediate and lowland AEZs), climate change and variability are so precarious that harvests are not always guaranteed. It is in these zones where several replanting incidents were reported to be increasing (Table 2). This has discouraged some individuals from getting involved in crop production while others have adjusted to growing crops during the long seasons only.

Early Planting

The study found that the researched community had knowledge that early planting reduces the chances of crop failure likely to result from early cessation of rainfall. Similar findings have been reported by Tambo and Abdoulaye (2012) in Nigeria's Savannah area to the effect that, farmers sowed millet seeds in dry soil for them to germinate with the first rain. The practice of planting crops early varies with AEZ with only few heads of household resorted to early planting in the lowland due to the presence of termites which gobble sowed seeds. The lowland AEZ is endemic to termites. As such, early planting and, especially, using animal manure was reported to be more catastrophic because manure attracts even more termites. The study also found that early planting was hindered by the delay in the supply of seeds by agents, unreliable rainfall, and financial constraints for land preparation and buying of seeds on time. Orlove *et al.* (2010) also found that the high cost of seeds and unreliable rainfall made early planting less common in southern Uganda.

Growing of Drought-Resistant Crop Types and Varieties

Crops such as sorghum, cassava, finger-millet and sweet potatoes are known to tolerate dry conditions. The growing of such drought-resistant crops established by the study conforms to the recommendation by the Tanzania Agricultural and Livestock Policy (URT, 1997). The findings show that the growing of drought-resistant crops and varieties was a challenging practice. For example, the growing of sorghum was found to be affected by low consumption value that severely limited its market. These findings concur with the studies by Eriksen *et al*. (2005), Barbier *et al.* (2009) Kalungu *et al.* (2013) who reported market and preference to constrain the cultivation drought resistant crops. This indicates that farmers' adaptation depends not only on their respective socio-economic endeavours but also on external influence.

Food Aid

The findings presented in Table 2 show that the population under review has sometimes been depending on food aid from relatives, government or religious institutions to lessen the hunger resulting from crop failure. As a matter of fact, overdependence on food aid is not encouraged as it may create a population that is reluctant to get involved in agricultural production in particular and other developmental activities. Food aid can also contribute to price fluctuations, disincentives to agricultural production and market development and a cycle of dependency in poorly targeted and managed farming communities (Vermeulen *et al*., 2012).

Findings from an interview with the VEO at Msangai Village reveal that food aid was tied with priorities: disabled, aged, widows, etc. The groups with these variables are known to be less resilient and, therefore, need to be given prioritised whenever hunger strikes in any community. This study found further that food aid from the government did not reach the needy persons in time and when it did it was always not enough to support dietary intake. The delay in food aid delivery was reported to be inevitable due to the existing bureaucracy. On the other hand, food aid led to conflicts between households and government officials due to corruption associated with its distribution. This corruption among African countries tends to lead to failure of most developmental initiatives (Shemsanga *et al.,* 2010) and social philanthropy.

Although relying on aid from relatives and friends can minimise the effects of climate change and variability in a short time, the strategy was found to be ineffective because it was based on the individuals' capacity and willingness. The findings also show that the children, who worked as shopkeepers and house workers in towns, were grossly underpaid, which limited their capacity to provide aid to their relatives in the villages. They also have to accumulate some capital for their future endeavours too despite their limited earnings.

Farming in Different Agro ecological Zones

Studies by Laube *et al.* (2012) in Ghana, McDowell and Hess (2010) in Bolivia and Roncoli *et al.* (2002) in Burkina Faso found that farmers, who owned farms in different AEZs, sought to increase the likelihood of better harvests under the changing climate. Farming in different AEZs increases the probability of harvest since each AEZ has a distinct climatic regime. Findings from this study reveal that cultivation in different AEZs is prompted by small land sizes particularly in the highland AEZ and not necessarily by climate change and variability. Despite their home cultivated plots, Table 2 shows that about 4 percent of respondents may own farms in the Kilimanjaro Forest Reserve, lowland AEZ or Kenya side. In this case, people had to move from their home to attend farms. Attending to farms far from their homes also consumed a lot of time that could otherwise been devoted to other developmental activities.

In addition to the time spent on attending to farms located in different AEZs; cultivation in Kenya is hindered by the high cost of hiring farming lots, low probability of harvest due to unpredictable rainfall and destructive birds and animals. Laube *et al.* (2012) reported that many farmers in Bolivia have abandoned farms in favour of other activities due time spent away from home in the mountainous areas where most farms were located but without getting substantial harvests for their troubles. Similarly, farmers in Morogoro Region have ceased to cultivate during short rains in some locations because of low and uncertain yields (Paavola, 2006). In other words, the adaptation to climate change and variability is also affected by the climate itself due to unpredictable rainfall characteristics.

Conclusion and Recommendation

The study community uses TEKS to withstand the effects of climate change and variability on crops through agronomic techniques, social coherence and livelihood diversification. The efficacy of the devised adaptation strategies were hindered by small land sizes, location, insolvency, technical knowhow, and climate change and variability. For effective adaptation strategies, government and financial institutions should support local people through micro-credit, crop insurance and marketing infrastructure to increase their resilience. Local people's participation in planning, implementation and evaluation of any climate change and variability adaptation project is paramount to ensure its success.

References

1. Barbier, B., Yacouba, H., Karambiri, H., Zoromě, M. and Somě, B. (2009) Human Vulnerability to Climate Variability in the Sahel: Farmers' Adaptation Strategies in Northern Burkina Faso. *Environmental Management* Vol. 43 pp. 790-803.
2. Berkes, F. and Jolly, D. (2001) Adapting to Climate Change: Social-ecological Resilience in a Canadian Western Arctic Community. *Conservation Ecology* Vol. 5 (2) pp. 18.
3. Bradshaw, B; Dolan, H. and Smit, B. (2004) Farm-Level Adaptation to Climatic Variability and Change: Crop Diversification in the Canadian Prairies. *Climatic Change* Vol. 67 pp. 119-141.
4. Egeru, A. (2012) Role of Indigenous Knowledge in Climate Change Adaptation: A Case Study of the Teso Sub-Region, Eastern Uganda. *Indian Journal of Traditional Knowledge* Vol. 11(2) pp. 217-224.
5. Chatterjee, K. and Huq, S. (2002) A Report on the Inter-Regional Conference on Adaptation to Climate Change. *Mitigation and Adaptation Strategies for Global Change* Vol.7 pp. 403-406.
6. Eriksen, S.H., Brown, K. and Kelly, P. M. (2005) The Dynamics of Vulnerability: Locating Coping Strategies in Kenya and Tanzania. *The Geographical Journal* Vol. 171 **(**4) pp. 287-305.
7. Fisher, M., Chaudhury, M. and Mccuske, B. (2010) Do Forests Help Rural Households Adapt to Climate Variability? Evidence from Southern Malawi. *World Development* Vol. 38 (9) pp. 1241-1250.
8. Jones, H. (2004) *Population Geography* 2nd Ed. SAGE Publications Ltd, London
9. Jones, L. and Boyd, I. (2011) Exploring Social Barriers to Adaptation: Insights from Western Nepal. *Global Environmental Change* Vol. 21 pp. 1262-1274.

10. Kalungu, J. W., Filho, W. L. and Harris, D. (2013) Smallholder Farmers' Perception of the Impacts of Climate Change and Variability on Rain-fed Agricultural Practices in Semi-arid and Sub-humid Regions of Kenya. *Journal of Environment and Earth Science* Vol. 3 (7)
11. King, D. N. T., Skipper, A. and Tawhai, W. B. (2008) Maori Environmental Knowledge of Local Weather and Climate Change in Aotearoa-New Zealand. *Climate Change* Vol. 90 pp. 385-409.
12. Kotir, J. H. (2011) Climate Change and Variability in Sub-Saharan Africa: A Review of Current and Future Trends and Impacts on Agriculture and Food Security. *Environment, Development and Sustainability* Vol. 13 pp. 587-605.
13. Kpadonou, R. A. B., Adegbola, P. Y. and Tovignan, S. D. (2012) Local Knowledge and Adaptation to Climate Change in Oueme Valley, Benin. *African Crop Science Journal* Vol. 20 (2) pp. 181-192.
14. Laube, W., Schraven, B. and Awo, M. (2012) Smallholder Adaptation to Climate Change: Dynamics and Limits in Northern Ghana. *Climate Change* Vol. 111 pp. 753-774.
15. Manandhar, S., Vogt, D. S., Perret, S. R. and Kazama, F. (2011) Adapting Cropping Systems to Climate Change in Nepal: A Cross-regional Study of Farmers' Perception and Practices*. Regional Environmental Change* Vol. 11 pp. 335-348
16. McDowell, J. Z. and Hess, J. J. (2010) *Vulnerability to Competing Social and Climatic Stressors in the Bolivian Highlands*. 2nd International Conference on Climate, Sustainability and Development in Semi-arid Regions. August 16-20, 2010, Fortaleza-Ceara, Brazil.
17. Mertz, O., Mbow, C., Reenberg, A. and Diouf, A. (2009) Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management* Vol. 43 pp. 804-816.
18. Mongula, B. (2000) *Food Security, Appropriate Technology and Micro-Industry: The Case of Drought Areas of Rombo District in Tanzania*. Institute of Development Studies, University of Dar es Salaam.
19. Mukhopandhyay, D. (2009) Cultural Values, Indigenous Knowledge for Climate Change Adaptations in Developing Countries. *Earth and Environmental Science* Vol. 6.
20. Nyong, A., Adesina, F. and Elasha, B. O. (2007) The Value of Indigenous Knowledge in Climate Change Mitigation and Adaptation Strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change* Vol. 5 (12) pp. 787-797.
21. Orlove, B., Roncoli, C., Kabugo, M. and Majugu, A. (2010) Indigenous Climate Knowledge in Southern Uganda: the Multiple Components of a Dynamic Regional System. *Climatic Change* Vol. 100 pp. 243-265.
22. Paavola, J. (2006) Livelihoods, Vulnerability and Adaptation to Climate Change in the Morogoro Region of Tanzania. Centre for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia, UK Working Paper, pp. 8-12.
23. Prabhakar, S. V. R. K., Srinivasan, A. and Shaw, R. (2009) Climate Change and Local Level Disaster Reduction Planning: Need, Opportunities and Challenges. *Mitigation and Adaptation Strategies to Global Change* Vol. 14 pp. 7-33.
24. Riedlinger, D. and Berkes, F. (2001) Contribution of Traditional Knowledge to Understanding Climate Change in the Canadian Arctic. *Polar Record* Vol. 37 (203) pp. 315-328.
25. Robinson, P. J. and Henderson-Sellers, A. (1999) *Contemporary Climatology*. 2nd Edition, Pearson, England.
26. Roncoli, C., Ingram, K. and Kirshen, P. (2002) Reading the Rains: Local Knowledge and Rainfall Forecasting in Burkina Faso. *Society and Natural Resources* Vol. 15 (5) pp. 409-427.
27. Rugumamu, W. (2000) Managing Environmental Disasters: A Search for an Institutional Framework for Tanzania. *Journal of Geographical Association of Tanzania* (29) pp. 79-92.
28. Shayo, C. M. (2006) Adaptation Planning and Implementation: Agriculture and Food Security UNFCCC Paper Presented on African Regional Workshop on Adaptation, 21-23 September 2006, Accra, Ghana.
29. Shemsanga, C., Omambia, A. N. and Gu, Y. (2010) The Cost of Climate Change in Tanzania: Impacts and Adaptations. *Journal of American Science* Vol. 6 (3).

30. Speranza, C. I., Kiteme, B., Ambenje, P., Wiesmann, U. and Makali, S. (2010) Indigenous Knowledge Related to Climate change and variability: Insights from Droughts in Semi-arid Areas of former Makueni District, Kenya. *Climatic Change* Vol. 100 pp. 295-315.
31. Srinivasan, A. (2004) *Local Knowledge for Facilitating Adaptation to Climate Change in Asia and the Pacific: Policy Implications*. Working Paper Series No. 002. IGES Climate Policy Project.
32. Stringer, L. C., Dyer, J. C., Reed, M. S., Dougill, A. J., Twyman, C. and Mkwambisi, D. (2009) Adaptation to Climate Change, Drought and Desertification: Local Insights to Enhance Policy in Southern Africa. *Environmental Science and Policy* Vol. 12 pp. 748-765.
33. Tambo, J. K. and Abdoulaye, T. (2012) Smallholder Farmers' Perceptions of and Adaptations to Climate Change in the Nigerian Savannah. *Regional Environmental Change* Vol. 13(2) pp. 375-388.
34. United Republic of Tanzania (URT, 1997) *Agricultural and Livestock Policy*. Ministry of Agriculture and Co-Operative Development, Dar es Salaam.
35. Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., Hansen, J. W., Ingram, J. S. I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G. C., Thornton, P. K. and Wollenberg, E. (2012) Options for Support to Agriculture and Food Security under Climate Change. *Environmental Science and Policy* Vol. 15 pp. 136-144.
36. Wilk, J., Andersson, L. and Warburton, M. (2013) Adaptation to Climate Change and other Stressors among Commercial and Small-Scale South African Farmers. *Regional Environmental Change.* Vol. 13 (2) pp. 273-286.
37. Zorom, M. Barbier, B. Mertz, O. and Servat, E. (2013) Diversification and Adaptation Strategies to Climate Variability: A Farm Typology for the Sahel. *Agricultural Systems* Vol. 116 pp. 7-15