We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,300

Open access books available

172,000

International authors and editors

190M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Role of Eco-Village Initiatives in Mitigating Desertification in Semi-Arid Areas of Tanzania

Fredy S. Mswima and Abiud L. Kaswamila

Abstract

Climate change adaptation actions for mitigating desertification and improving community livelihood in developing countries have attracted numerous scholarly works. However, there have been insufficient findings on the adaptation regarding the eco-village practices in semi-arid areas in particular. This inspired a study to assess the role of eco-village practices in strengthening climate change adaptive capacity and mitigating desertification in semi-arid areas of Chololo village, Dodoma region in central Tanzania. Data were collected using mixed methods, that is, household survey (92), focus group discussions (21), key informants interviews (6), field observation and documentary review. Statistical Package for Social Sciences (SPSS) and content analysis were used in analyzing quantitative and qualitative data respectively. The study found a relatively high level of community awareness on the eco-village initiative; the initiative rehabilitated village forest reserve; improved land productivity for sorghum and pearl millet; increased number of planted trees; and strengthening communities' adaptation to climate change through improved households' nutrition, income and reduced water stress.

Keywords: eco-village, Chololo, Dodoma, Tanzania, desertification, climate change, semi-arid

1. Introduction

The growing global climate change has already had observable effects on the environment and human welfare [1–4]. The impact has been manifested through changes in global average temperature that has increased by 0.8–1°C over the past 100 years and 2016 was the hottest (0.99°C) year on record [5]. Rainfall models indicate increases of precipitation near the equators, Arctic and Antarctic. The Mediterranean and Southern Africa regions have experienced precipitation drop of about 20%. Western Australia, Chile, and Central America/Mexico are likely to become around 10% drier [6]. Globally, these climate change indicators have had implications to the increased type, frequencies and intensities of extreme weather events like floods, droughts, tropical cyclones (hurricanes and typhoons) and heavy precipitation [7]. The growing impact has widely affected agriculture, water, livestock, forestry and the general ecological systems mostly in developing countries [8].

The climate change impacts in developing countries have mostly been noted through extended periods of droughts, loss of soil fertility, shortening of the

growing season negatively affecting crop yield that in turn worsen food insecurity, land degradation and desertification and subjecting many people at risk of hunger. As for the forestry sector which is resorted by more than 90% for wood fuel in Africa and Asia has recorded severe biomass deterioration through loss of biodiversity, limited forest products, ecosystem shift from forest to woodlands or woodland to grasslands and desertification [8].

The impact of climate change has compelled several interventions to redress the effects particularly in semi-arid areas of developing countries including use of Clean Development Mechanisms (CDM) and Reducing Emissions from Deforestation and forest Degradation (REDD) that aimed at commodifying forestry conservations efforts to the community owning and/or living adjacent to the managed forest(s). However, it has been reported that the initiatives inadequately embraced the socio-economic welfares of the community that were claimed to be the drivers for the deteriorating forests in the course of earning their livelihoods [9]. REDD, in particular, unsuccessfully supported alternative activities such as crop farming, domestic energy, beekeeping and brick making as means to redress shifting agriculture, exploitation of wood fuel and encroachment that were regarded as underlying drivers of deforestation and forest degradation [10].

Despite the ongoing debates on the effectiveness of CDM and REDD, the countries severely hit by the impact of climate change have embarked on the eco-village initiative as one of the renewed paradigm shifts to directly strengthen capacity of community for adaptation against negative impact of climate change. In the context of this study, eco-village means rural communities/settlements/village in a landscape devoted to increasing resilience and capacity to adapt to climate change through an integrated and multidisciplinary range of Climate Change Adaptation (CCA) activities in an indefinite future.

The eco-village initiative is an integral part for enabling community to adjust to the climate change focusing on consolidating people's welfare sectors, namely crop farming, livestock, forestry and ecological systems [11, 12]. The objective of this study is to assess the impact of the eco-village initiatives and/or practices in mitigating climate change and desertification in semi-arid areas of central Tanzania. Specifically, the chapter intends to (i) **to identify** eco-village initiatives and/or practices for Adaptation to Climate Change and mitigation of desertification and (ii) to assess the performance of eco-village initiatives and/or practices in smallholder farmer's yields before and after the eco-village interventions.

2. Methodology

2.1 The study area

The study was carried in Chololo village (**Figure 1**) located in Dodoma City one of the semi-arid areas in Tanzania. Dodoma is located at Coordinates 6°57' and 3°82' South of the Equator and between longitudes 36°26' and 35°26' East of Greenwich in the center of Tanzania. Chololo village has six sub-administrative villages, namely Kawawa, Lusinde, Jamhuri, Muungano, Siasa and Kizota. According to the United Republic of Tanzania 2012 census, Chololo village had 1111 households [13]. The site was previously characterized with vulnerable and deprived farming families dominated by the Gogo ethnic group, predominantly engaged with rain-fed agriculture and subsistence farming. Semi-arid areas is one of the agro-ecological zones of Tanzania distinguished by the low to medium undulating plains (200–1,500 m asl)

Figure 1.
Map of the study area.

with rocky hills and low scarps in central and south-eastern areas, with soils of variable fertility, localized salinity and hard-pan problems, and unreliable unimodal rainfall (500–800 mm per year) [14].

2.2 Data collection methods and analysis

Mixed research methods – household survey, key informant interviews, Focus group discussion, physical visits and documentary review were used in the study. Household Survey involved collection of both qualitative and quantitative data using a pre-designed household questionnaire. Key informant interviews involving village officials and village subject matter specialists were also planned. FGDs involving the elderly, youths and females were also held. Other methods were physical visits so as to assess the situation on the ground in crop farming, livestock, water resources, and forestry sectors and documentary reviews for the purpose of supplementing the collected field data.

The study employed both probability and non-probability sampling. Purposive sampling was used in selecting household heads, key informants, and focus group discussions participants. Purposive sampling is mostly applicable in qualitative research in which the representative population is identified and selected to provide rich information using limited resources [15]. In addition, it is useful in identifying and selecting the knowledge rich and experienced individuals regarding the phenomenon of interest [15], Simple random sampling using standard procedures was adopted in selecting two village hamlets (Kawawa and Siasa) out of four (Lusinde, Kawawa, Jamhuri and Kizota). Simple random sampling design renders equal chance of individuals in being picked up to form a sample; it is bias-free, time-efficient and cost effective; and data from this design can easily be analyzed and it is possible to generalize the results [16]. Statistical Package for Social Sciences (SPSS) and content analysis were used in analyzing quantitative and qualitative data respectively.

3. Results and discussion

3.1 Socio-economic characteristics of the communities

Socio-economic characteristics are presented in **Table 1** below. Results indicate that, on average, males were 83.7% of the respondents. This could have happened by chance. In terms of age, 54.3% were adults aged between 40 and 55 years old and 19.6% were youths aged between 24 and 39 years. Others (26.1%) were elders aged more than 55 years old. The age groups mean that the majority were economically active. In terms of education, more than 76.2% had primary education, implying that the illiteracy level was still high. Regarding household size, 51.2% had more than 4 people, 42.3% comprised of 3–4 people and 6.5% had 1–2 people. Findings further indicate that area is dominated by Gogo ethnic group and the majority (74%) practice both agriculture and livestock production. Only 26% depend solely on agriculture for a living.

3.2 Eco-village practices for adaptation to climate change and mitigating desertification

The common eco-village practices identified through thematic analysis are presented in **Figure 2** below. Of the several eco-village practices and/or initiatives use of oxen-drawn techniques, rehabilitation of village forest, improved chicken/poultry, use of energy saving stoves and afforestation were ranked by respondents as the most common.

Socio-economic characteristic variables		%
Sex of the household head	Male	83.7
	Female	16.3
Age	24–39	19.6
	40–55	54.3
	>55	26.1
Marital status	Unmarried	5.5
	Married	82.6
	Separated	3.2
	Divorced	—
	Widow(er)	8.7
Education	Primary	76.2
	Secondary	8.7
	Informal	15.1
Household size (%)	1–2 people	6.5
	3–4 people	42.3
	>4 people	51.2
Household economic activity	Crop farming & livestock/poultry	74
	Crop farming only	26
Ethnic group	Gogo	100

Source: Field data (2017).

Table 1.
Socio-economic characteristics.

Figure 2.
Major eco-village practices in Chololo eco-village. Source: Field data (2017).

The above five initiatives can be grouped into two major categories. First, oxen-drawn techniques and improved chicken/poultry initiatives were meant for livelihood. The fact that agriculture is the lifeline of these small-holder farmers use oxen to cultivate instead of hand-hoe hoping to make a difference in terms of increased plot size and land preparation hence increased production of drought resistant crops in the area, that is, sorghum, pearl millet, sunflower and groundnuts and improving soil structure.

During interview with one eco-village official in Chololo eco-village, he argued that turning over the upper soil with oxen-plow was advantageous in bringing fresh nutrients to the surface while burying weeds and previous crop residues and/or manure and allows decay of organic matter. Similarly, community involvement in improved chicken/poultry has been used as source of income and in improving household nutrition.

Second, rehabilitation of village forest, use of energy saving stoves and tree planning are meant to reduce forest and soil degradation, protection of water sources and protection of soil cover which in turn can play a very big role in mitigating desertification. Furthermore, energy saving stoves was meant to provide domestic energy for cooking and heating and indirectly spare much of forestry resources. Scholars (e.g. [17–21] suggest that the adverse impacts of climate change, appropriate responses and adaptive capacity advocated by the eco-village initiative are relatively more site-specific.

3.2.1 Oxen-drawn tillage

We used Binary Logistic Regression Analysis to assess community’s motive on oxen-drawn tillage techniques and results shows that the estimated odds ratio was 5.62 indicating that the households’ cropland preparation using oxen-drawn tillage techniques was 5.62 more appropriate for healthier crop growth in response to the impact of climate change compared to those who never used the techniques. Oxen-drawn tillage were appropriate techniques in response to the growing impact of climate change manifested through unpredictable rainfall, declining soil fertility and abnormal loss of soil moisture content that lowered cropland productivity.

The appropriateness of ox-drawn tillage technique in terms of user-friendliness and fitting to local knowledge and skills for generation of high benefits is consistent with the innovation-diffusion theory [22] which emphasizes that relevance of the practice motivates the users in carrying it for realization of benefits.

Views by eco-village initiative official, FGD participants and community seed producers in the study area had the opinions that the increased land productivity was a result of abandonment of previous slash-and-burn land preparation method, which was common in the past and adoption of oxen drawn tillage practice. Slash-and-burn used to remove grasses and any remaining crop residues. Despite slash-and-burn minimal effect on soil disturbance, still the unbroken hardpans restricted drainage of water and growth of plant roots in the face of growing impact of climate change. This decreased crop productivity and increased food insecurity and resulted into the increase in the number of people at risk from hunger in the area.

Oxen-drawn tillage involves turning over the soil and loosening it (**Figure 3**) immediately after the first rain season for sowing the early maturing and drought tolerant sorghum, pearl millet, sunflower and groundnuts, normally between late December and mid-January. During the interview with the eco-village official in Chololo eco-village, he argued that turning over the upper soil was advantageous in bringing fresh nutrients to the surface while burying weeds and previous crop residues and/or manure and allowing decay of organic matter.

Compared to slash-and-burn, ox-tilled land was useful in promoting soil moisture and fertility, and in reducing soil erosion; which in turn promote crop growth in a limited rainfall caused by the impact of climate change. The use of ox-drawn tillage in semi-arid areas was found to promote soil fertility, reduced soil erosion, and increased soil capacity in retaining rainwater [23, 24]. The ox-drawn tillage technique was of paramount importance adaptation practice in place against the unpredictable rainfall, the ever-declining soil fertility, increasing soil erosion and loss of moisture content through run-off and evaporation, which are mostly accelerated by climate change.

3.2.2 Rehabilitation of village Forest

Forest rehabilitation can be defined as the process of restoring the capacity of the degraded forest land to deliver forestry products and services [25]. In the context of this study, rehabilitation refers to the re-planting of degraded village trees in

Figure 3.
Farmer in Chololo eco-village cultivating using oxen-drawn plow in December 2017. Source: Field data (2017).

the village forest reserve to re-establish the presumed forest structure, productivity and tree species diversity for future delivery of the desired products and services.

We used Binary Logistic Regression Analysis to assess community's motive on rehabilitation of the Village Forest Reserve. Findings show that the rehabilitation of village forest reserve advocated by the eco-village initiative was 42 times more compatible with culture of restoring forest services to the participants in the era of increasing climate change stress to nearby forests compared to the non-participants. This means that participants of tree planting were more likely to restore the negative effects of over-exploitation of the long-standing village forest reserve for several uses such as wood fuel for domestic uses and extraction of building materials. Drawing from the adoption perception theory, the compatibility of the practice with the individuals' previous behavior, practice and/or way of living (for this case tree planting) is one of the motives for participation in the practice [26].

The loss of such previously vegetated forests had bearing on the increased rate of soil erosion, loss of soil fertility and wind disturbances. Similarly, the interview with one of the participants in tree planting in Chololo showed that, initially, before the eco-village initiative, forests management and conservation were actively observed; but deteriorated with time to respond to the impact of climate change manifested through elevated soil erosion and poor forest related services. In addition, forest resources became inadequate to support the growing wood fuel and building/construction demands.

The interviews with key informants and all FGDs showed that, after being mobilized and sensitized on environmental education and along with initial facilitation with seedling, the villagers participated in re-planting of such trees as catch (*Acacia polyacantha*) and neem (*Azadirachta indica*) in the degraded village forest reserve. Besides facilitation of community members and village leaders on afforestation, nursery management and tree planting in Chololo, it was observed that community were involved in planting about 3000 trees within the village forest reserve [24].

The practice of rehabilitation of village forestry is in line with the Tanzania's environmental policies that call for immediate measures in restoring the degraded forests to assume the productive state, partly promoting both environmental goods and services for the community [27]. The community's venture on rehabilitation of village forest reserve partly reflects the community's commitment in ensuring sustenance of village forestry services like building materials, windbreak, reduced erosion, scenic value in the course of adapting to climate change and mitigation against land degradation and desertification.

3.3 The performance of eco-village practices for adaptation to climate change and mitigation of desertification

3.3.1 Changes in average of small-holder farmers' yield

Paired-samples t-test was conducted to compare the average small-holder farmers' yield per hectare for four main crops - sorghum, pearl millet, groundnuts and sunflower before eco-village intervention and after intervention. Results indicates that there was a significant difference in the average small-holder farmers' yield per hectare in sorghum and pearl millet ($t = 5.361$, $p < 0.05$) and ($t = 6.656$, $p < 0.05$) respectively, compared to the situation before intervention (without using oxen). On the contrary, the change in average small-holder farmers' yield for sunflower and groundnuts ($t = 1.893$, $p > 0.05$) and ($t = 1.338$, $p > 0.05$) was statistically insignificant (**Table 2**).

An important implication of significant average increase in yield per hectare for sorghum and pearl millet is probably due to the fact that such crops are both major

Paired Samples Test			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Sorghum	Pair 1	YA- YB	.36	.44	.07	.22	.49	5.36	42	.00
Pearl millet	Pair 1	YA- YB	.42	.36	.06	.29	.55	6.66	32	.00
Sunflower	Pair 1	YA- YB	.34	.79	.18	-.04	.72	1.89	18	.07
Groundnuts	Pair 1	YA- YB	.13	.43	.09	-.07	.32	1.34	20	.19
YA, Average yield after the eco-village intervention; YB, Average farmers' yield before the eco-village intervention. Source: Survey data (2017).										

Table 2.
Changes in average yield for the major crops in Chololo.

staple food and cash crops and increased production creating surpluses motivated small-holder farmers to devote more efforts to transform knowledge and skills to increase land productivity. Increase in sorghum and pearl millet was also supported by key informants and FGD participants in the study area who argued that “Oxen-drawn tillage encouraged use of proper agronomical practices like appropriate spacing, thinning and weeding eventually, increased the number of meals taken per day from one to two”. It was further emphasized that ox-drawn tillage techniques promoted soil moisture and fertility, and reduced soil erosion and compaction; thus boosting the survival rate of the drought tolerant crops, high yielding and early maturing crops like sorghum and pearl millet. Eventually, it increased the land capacity in sustaining the crop growth under poor rainfall resulting from climate change.

The studies by [21, 24], in semi-arid areas reported the growing rate of small-holder farmers’ abandoning the traditionally low crop yield slash-and-burn (clearing land and sowing) to modern ox-drawn tillage (deep plowing and sowing) techniques especially after the eco-village initiative [24] also found that small-holder farmers in semi-arid areas managed to increase crop yield per cropland size cultivated by valuing and translating the acquired knowledge on ox-drawn tillage land preparation method into practice. As a result, there was improved household food security manifested in limited migration of community in search of foods, increase in number of meals to about two-three per day, and the reduction in number of months without food [21]. Drawing on the economic constraints theory, [28] argue that the decision made by the user/adopter of practice is consolidated by the experienced yields and profits.

3.3.2 *The gap between the potential yield and average smallholder small-holder farmers’ yield*

Table 3 presents results on the average gap between potential and average small-holder farmers’ yields for major crops cultivated in Chololo eco-village. The gap between potential and average small-holder farmers’ yields for major crops in Chololo ranged from 51.5% for pearl millet to 55.2% for sorghum after the initiative as of before ranged from 68.5% for pearl millet to 69% for sorghum.

In filling the gap, several scholars suggest a number of measures to crop production: firstly, by timely applications of irrigation and fertilizers based on crop requirements and soil conditions [29]. Secondly, by promoting smallholder farmers’ use of water-saving techniques such as mulching [30] and sprinkler irrigation

Major crop type	Performance before 2011 (at start)				Performance after (6 years)			
	FY (t/ha)	PY (t/ha)	Change (PY-FY)	% change	FY (t/ha)	PY (t/ha)	Change (PY-FY)	% change
Sorghum (<i>Sorghum bicolor</i>)	0.85	2.7	1.85	68.5	1.21	2.7	1.49	55.2
Pearl millet (<i>Pennisetum americanum</i>)	0.62	2	1.38	69	0.97	2	1.03	51.5

FY, Average small-holder farmers' yield; PY, Potential Yield.
Source: Survey data (2017).

Table 3.
Average small-holder farmers' yield in relation to potential yield.

(instead of furrow irrigation) to deal with the increasing water shortages in most of the areas. Thirdly, by improving the agro-technical service provision and government support would likely help smallholder farmers adjust their crop management and adopt more sustainable farming practices. Fourthly, by including the development of policies associated with land tenure to stimulate cooperation of individual households or allowing land transfer to merge the very small and fragmented farms (often less than one hectare) into larger land holdings. This would increase the yields in terms of efficiency use of labor and other production factors such as machinery, resulting in low labour productivity and profit [31].

The untimely availability or completely lack of industrial fertilizer and/or manure made small-holder farmers miss the correct application of fertilizer on crops to boost cropland productivity. Lack of oxen and plow, delayed some small-holder farmers in catching up with farm preparation and planting. Meanwhile, the repeated rainfall unpredictability and poor distribution in some incidences, impaired the whole crop farming planning processes resulting into massive crop failures, thus reduced crop yields.

Limited knowledge and lack of skills in crop production among small-holder farmers constrained crop production too; for instance, through inefficiencies in meeting the desired conditions of practices and failure to make appropriate choice of seeds. Similarly, previous studies point out that the shortage of farm implements; inadequate education on crop farming practices [30] and erratic rainfall on the rain-fed crop farming [31] are among the major factors that affect crop productivity in crop farming.

To promote the performance of such practices of the eco-village under crop farming, several suggestions were pointed out, namely: the government and all relevant stakeholders should participate effectively in timely provision of farm implements; they should promote knowledge and skills on crop farming through workshops, seminars, farmer field schools and exhibitions; and they should promote the user-friendly weather forecasting and prediction, and disseminate user-friendly information to the grass-roots levels involved in crop farming in rural areas.

3.3.3 The survival rate of trees in the Rehabilitated Village Forest reserve

A paired-samples t-test was conducted to compare the average tree survival after the rehabilitation of the village forest reserve advocated by the eco-village initiative and planted trees in village forest before intervention. Results showed that there was no significant difference in the average survival rate of trees in the rehabilitated village forest reserve ($t = -1.41$, $p > 0.05$) compared to the situation with no eco-village intervention (Table 4). The associated tree planting limitations in terms of costs, efforts, and maintenance can explain this.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	SA-SB	−1.20	2.69	.85	−3.13	.73	−1.41	9	.19

SA, Average number of tree survival before; SB, Average number of tree survival after eco-village intervention.
Source: Survey data (2017).

Table 4.
Average number of survived trees.

Furthermore, the slow growth rates and limited direct linkage of forest resources to the urgent felt needs can have bearing on the reduced community’s efforts in maintaining planted trees against harsh conditions and environment. One of the respondents and the eco-village official emphasized that unrestricted animal movements and untimely replacement of dead trees undermined the survival of planted trees in the area. On the other hand, focus group discussion for adult females had the opinion that “scarcity of water posed risk to survival of trees in the area”. On the other hand, adult female focus group discussion had the opinion that “scarcity of water posed risk to the survival of the trees progress in the area” [21] observed water scarcity and limited urgent response of tree planting practices to livelihood felt needs led to low survival of the trees planted. Other causes raised by respondents were inadequate supply of quality seedlings which demoralized the community’s participation in tree planting at household level and effect of termites on the transplanted seedlings during dry season [30, 31]. Reports that tree pests as well as insects and fungi, limited watering, and unavailability of quality seedling is among the factors hindering tree planting programmes at household and at the institutional levels.

To redress the challenges, the study suggests timing of planting trees during the wet season, establishment of charcoal dams for irrigating trees in areas with unreliable sources of water and selection of seedling with high survival rate under minimal watering. Meanwhile, the shortage of seedling can be addressed by promotion of seedlings at the local level that can be established and managed by individuals, groups and institutions like schools and the village for sustainable tree planting programme. In controlling termites, the study suggests the use of pesticides and/or adequate watering to manage soil wetness so as to boost the growth of transplanted seedlings at early stages.

4. Conclusions

The community in semi-arid areas of Chololo eco-village carried out practices that had a direct response to livelihood and success in addressing the impact of climate change and desertification. The practices and/or initiatives mainly, included oxen-drawn tillage and rehabilitation of village forests. These initiatives seemed to be appropriate in enhancing cropland productivity through reduced soil erosion, improved soil fertility/productivity and moisture conservation; improvement of income and food security; and mitigating land degradation and desertification. Despite the positive contribution of the crop farming practices in lessening desertification and improved livelihood, we noted that the average farmers yield were below the potential yield. The survival rate of trees with regard to forestry rehabilitation was not encouraging to attain desirable effects in mitigating desertification. It is recommended that the local communities in the study area, village

institutions and other relevant stakeholders should promote the best performing eco-village practices that have been evolved through participatory approaches; and Dodoma City Council should regularly facilitate the communities through provision of knowledge and technical support to sustain the eco-village practices.

Acknowledgements

We extend our appreciation to the University of Dodoma and the European Union for funding this study.

Author details

Fredy S. Mswima and Abiud L. Kaswamila*
Department of Geography and Environmental Studies, The University of Dodoma,
Dodoma, Tanzania

*Address all correspondence to: abagore.kaswamila6@gmail.com

IntechOpen

© 2021 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

- [1] Breidenich, C., Magraw, D., Rowley, A., & Rubin, J. W. (1998). The Kyoto protocol to the United Nations framework convention on climate change. *American Journal of International Law*, 92(2), 315-331.
- [2] Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., ... Miller, H. L. (2007). Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change, 2007: Cambridge University Press, Cambridge.
- [3] Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., ... Edmonson, N. (2006). *Stern Review: The economics of climate change* (Vol. 30): HM treasury London.
- [4] UNFCCC. (1992). United Nations framework convention on climate change: United Nations New York.
- [5] Osborn, T., Barichivich, J., Harris, I., van der Schrier, G., & Jones, P. (2017). Monitoring global drought using the self-calibrating Palmer Drought Severity Index [in" State of the Climate in 2016"]. *Bulletin of the American Meteorological Society*, 98(8), S32-S33.
- [6] Hausfather, Z. (2018). What climate models tell us about future rainfall, Published by Carbon Brief Ltd - Company No. 07222041.
- [7] Meehl, G. A., Stocker, T. F., Collins, W. D., Friedlingstein, P., Gaye, T., Gregory, J. M., ... Noda, A. (2007). Global climate projections.
- [8] McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (2001). *Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change* (Vol. 2): Cambridge University Press.
- [9] URT. (2011). *Tanzania Agriculture and Food Security Action Plan, 2011-12 to 2020-21*. Retrieved from Dar es salaam, Tanzania:
- [10] Mswima, F. S., & Kanyama, A. (2014). The Implication of livelihood situation of local community on Implementation of REDD+ project in Kilosa District, Tanzania.
- [11] Danielsen, F., Skutsch, M., Burgess, N. D., Jensen, P. M., Andrianandrasana, H., Karky, B., ... Ngaga, Y. (2011). At the heart of REDD+: a role for local people in monitoring forests? *Conservation letters*, 4(2), 158-167.
- [12] Kimbowa, R., Mwayafu, D., & Njaidi, R. (2011). Benefit sharing to make REDD+ work for communities and forest conservation in Tanzania: The Community Carbon Enterprise (CCE) Model. *REDD-net programme*.
- [13] URT. (2012). *Monitoring and Evaluation Framework for Climate Change Adaptation in Tanzania*. Dar Es Salaam, Tanzania: Vice P
- [14] URT. (2014). *State of the Environment Report 2*. Dar Es salaam, Tanzania: The Vice President's Office, Environment.
- [15] Engelbrecht, M. N. (2015). *The effect of supplements containing different protein and energy sources and essential oils on the performance of pasture finished heifers*. Stellenbosch: Stellenbosch University.
- [16] Garnett, J. (2016). Grassroots Environmental Adult Education: Developing Environmental Peace Infrastructure in the Nascent Democracy of Myanmar. *Peace & Conflict Review*, 9(1).
- [17] Mdoe, S. Y., & Kilawi, C. J. (2014). *Enhancing Climate Change Adaptation and Ecosystems of the Uluguru Mountains*,

Final Project Evaluation Report: Sokoine University of Agriculture.

[18] Myles, K., Olesen, G. B., Tamilselvam, D., & Poonia, A. (2015). "Evidence based advocacy for low-carbon, pro-poor sustainable "Eco-Village Development" (EVD) in South Asia. Retrieved from

[19] Njau, B. F., Farrelly, M., & Msumbuko, I. (2014). Climate Vulnerability and Capacity Analysis in Dodoma Region of Tanzania, F. Bernard Njau, Research Desk, 2014, . 3(1), 374-391.

[20] Gebregziabher, S., Mouazen, A. M., Van Brussel, H., Ramon, H., Nyssen, J., Verplancke, H., ... De Baerdemaeker, J. (2006). Animal drawn tillage, the Ethiopian ard plough, maresha: a review. *Soil and Tillage Research*, 89(2), 129-143.

[21] ESRF. (2014). Pro-Poor Economic Growth and Environmental Sustainable Development Poverty and Environmental Initiative (PEI): Support LGAS Working Sessions to Reflect P-E Objectives and Lessons Leant from Chololo Eco-Village. . Dar es salaam.

[22] de Jong, W. (2010). Forest rehabilitation and its implication for forest transition theory. *Biotropica*, 42(1), 3-9.

[23] Prager, K., & Posthumus, H. (2010). Socio-economic factors influencing smallholder smallholder smallholder farmers' adoption of soil conservation practices in Europe. *Human Dimensions of Soil and Water Conservation*". (Ed.): Napier, TL Nova Science Publishers, Last Accessed, 9, 2014.

[24] URT. (2004). *The National Environmental Management Act*. Dar es Salaam, Tanzania: The Vice President's Office (Environment).

[25] Karki, L. B., & Bauer, S. (2004). *Technology adoption and household food*

security. Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in Nepal. Paper presented at the Proceedings of Deutscher Tropentag Workshop.

[26] Liang, W.-l., Carberry, P., Wang, G.-y., Lü, R.-h., Lü, H.-z., & Xia, A.-p. (2011). Quantifying the yield gap in wheat-maize cropping systems of the Hebei Plain, China. *Field crops research*, 124(2), 180-185.

[27] Wang, H., Zhang, L., Dawes, W., & Liu, C. (2001). Improving water use efficiency of irrigated crops in the North China Plain—measurements and modelling. *Agricultural water management*, 48(2), 151-167.

[28] Khapayi, M., & Celliers, P. (2016). Factors limiting and preventing emerging smallholder smallholder smallholder farmers to progress to commercial agricultural farming in the King William's Town area of the Eastern Cape Province, South Africa. *South African Journal of Agricultural Extension*, 44(1), 25-41.

[29] Steduto, P., Hsiao, T. C., Fereres, E., & Raes, D. (2012). *Crop yield response to water* (Vol. 1028): fao Rome.

[30] Adesina, A. A., & Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *Agricultural economics*, 13(1), 1-9.

[31] Ball, J., Carle, J., & Del Lungo, A. (2005). Contribution of poplars and willows to sustainable forestry and rural development. *UNASYLVA-FAO*-, 56(2), 3.