Farmers’ adaptation choices to climate change impacts and implications on agricultural productions in Kolla Temben District, Tigray Regional State, Northern Ethiopia

Alemu Addisu1, Olago Daniel2, Wandiga Shem3, Omondi Philip4, Oriaso Silas5
1Mekelle University, P.O. Box 231, Mekelle, Ethiopia
2-3,5 Institute for Climate Change and Adaptation (ICCA), University of Nairobi, P.O Box 30197-00100, Nairobi, Kenya
4 IGAD Climate Prediction and Application Centre (ICPAC), P.O. Box 1030400100, Nairobi, Kenya

Abstract: The main focus of this study was to identify subsistence farming communities’ adaptations choices to climate change impacts and its implications on agricultural productions. The study was conducted in North Ethiopia, Tigray regional state, Kolla Temben district in 400 households. Multistage sampling was applied to select households for interview. In the first stage, 4 Kebelle (administration unit) was selected randomly out of the given 27 Kebelle in the district and then 400 households were selected through the probability proportional to size and simple random sampling techniques. Data on adaptations strategies that actually practiced by individual households to respond to perceived changes and total annual agricultural productions was used. Open ended and close ended questions were used to accommodate the views of all households in identifying the actual adaptation strategies practiced in the area. The adaptation strategies practiced by each farmers in response to actual impacts of climate change was statically tested to examine the correlations between households adaptation choices and agricultural productions. The commonly used and most effective adaptation strategies for agriculture sector in subsistence farming communities were: use of improved varieties of crops that resist drought, diseases and pests, and water harvesting practices and access to irrigation facility. The soundness of farmer’s adaptation decision determines the growth potential of agricultural production in arid and semi-arid areas.

Keywords: Farmers’ Adaptation choices, Impacts, Agricultural productions, correlations, Food consumptions,

Date of Submission: 23-10-2017
Date of acceptance: 18-11-2017

I. Introduction

Global climate changes and increasing climatic variability are likely to exert pressure on agricultural system and constrains attainments of future food production targets [1]. Sufficient knowledge of the ways in which the adverse impacts of droughts may be reduced through both mitigation and adaptation has accumulated but that knowledge has not been and is not being applied in an effective manner [2]. Household’s adaptive capacity to climate change has a positive correlation with food security status [3]. Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments [4]. Most of households’ perceptions on temperature trend are consistent with most of research findings but do not understand its long term consequences on their livelihood bases [5]. If the global poor are to adapt to global change, it is critical to focus on poor people and not poor countries [6]. The interests of poor people are not always the same as the interests of poor countries since in the interest of ‘development’, the poor may grow poorer [6]. According to [7] arguments the perspective of reducing the vulnerability of the poor through development to adapt to climate change is better than the approach of reducing the vulnerability of the poor through adaptation. Migration policy as adaption could be more useful if it accommodates changes in migration patterns that results from environmental degradation and economic crises [8]. There are certainly benefits in expanding opportunities for people to migrate as it widens people’s options to respond to climate change and more generally expands their opportunities to satisfy their needs and values [9]. Adaptation is place and context-specific with no single approach for reducing risks appropriate across all settings [4]. Major crops (wheat, rice, and maize) in tropical and temperate regions are projected to be negatively impacted for local temperature increases of 2°C without adaptation [4]. There should be a ways not just to avoid a warmer world but also ways to adapt to a more uncertain world where in certain regions the risk of crop failure on a year-to-year basis is likely to increase [10]. Cultural dimensions of climate change are important for the success of adaptation and mitigation at individual and community level [11]. There is a need to integrate local knowledge into formal mitigation and adaptation policies to reduce vulnerability to climate change impacts [2]. More research is
needed on climate change impacts to improve our understanding on trees responses to climate change, quantifying the adaptive capacity of forest sector and evaluate the suitability of adaptation measures [12].

Local solutions and experiences from available adaptation measures with advanced understanding from output of fundamental research is a key to successfully adapt climate change impacts in forest [12]. Development of a methodology and a tool to help individuals, communities, countries or regions in the decision-making process towards the best response to climate change is required [13]. There is need for the households to be made aware of the interconnections that exist between climate change, food supply and health [14]. To adequately project the impacts of climate change on agriculture, adaptation should not be seen anymore as a last step in a vulnerability assessment, but as integrated part of the models used to simulate crop yields, farmers’ income and other indicators related to agricultural performance [15]. No one strategy is optimal in adaptation; each has particular circumstances in which it may be more or less appropriate [16]. Farmers living in different agro ecological settings used different adaptation strategies [10]. Farmers farming experiences promote adaptation to climate change impacts [17]. Future policy should focus on providing adaptation technologies through encouraging more agro ecology based research activities [18]. This study was therefore initiated to identify the types of adaptation strategies famers are and have actually practiced in response to climate change impacts in the Kolla Temben district and; to examine whether their choices had implications on agricultural productions.

II. Materials And Methods

One of the important concepts in the areas of climate change science is the adaptation strategies. Adaptation can be autonomous or planned one in its approach. Autonomous adaptation is a strategy that can be initiated by individual households based on the level of understanding they have on the changes. Autonomous is bottom up and real world based approach but Planned adaptation is an adaptation which is centralized, policy intervention and top-down based approach. Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments [4]. Adaptation is place- and context-specific, with no single approach for reducing risks appropriate across all settings [4]. This study was therefore focused on the adaptations strategies that are practiced by individual households (bottom up approach) to respond to perceived changes. In this regard the data was collected from 400 sampled households through structured interview schedules by asking them to list out the actual adaptation strategies they were practicing to adapt to the changing climate. The researchers used open ended and close ended questions to accommodate all households’ views on the adaptation strategies. Responses was coded as “0” for “No” responses and “1” for “Yes” in computer software. Finally, the adaptation strategies practiced by each farmer in responses to actual impacts of climate change was statically tested to examine the correlations between households adaptation choices and annual agricultural productions. The Chi-square statistical test was applied to examine the relationships between household’s adaptation choices and agricultural productions. The types of tests used in the analysis were the 2-tailed tests. This was used to scrutinize the impact of farmer’s adaptation decisions in all directions (positive or negative).

III. Results

Table 1. Household’s adaptation strategies to climate change in agriculture sector

<table>
<thead>
<tr>
<th>Lists of locally practiced adaptation strategies to climate change impacts</th>
<th>Households status in using these adaptation strategies in response to climate change impacts</th>
<th>Total</th>
<th>Missed value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>Yes</td>
</tr>
<tr>
<td>Planting different varieties of crops as adaptation strategies</td>
<td>19</td>
<td>4.8</td>
<td>375</td>
</tr>
<tr>
<td>Using different planting dates as adaptation strategies</td>
<td>45</td>
<td>11.3</td>
<td>350</td>
</tr>
<tr>
<td>Diversifying farm activities as adaptations</td>
<td>89</td>
<td>22.3</td>
<td>302</td>
</tr>
<tr>
<td>Change from crop production to livestock production as adaptation strategies</td>
<td>160</td>
<td>40.0</td>
<td>234</td>
</tr>
<tr>
<td>Change livestock to crop production as adaptation strategies</td>
<td>300</td>
<td>75.0</td>
<td>95</td>
</tr>
<tr>
<td>using irrigation facility as adaptation strategies</td>
<td>331</td>
<td>82.8</td>
<td>64</td>
</tr>
<tr>
<td>Practicing soil conservations as adaptation strategies</td>
<td>294</td>
<td>73.5</td>
<td>101</td>
</tr>
<tr>
<td>Used drainage as adaptation strategies</td>
<td>102</td>
<td>25.5</td>
<td>291</td>
</tr>
<tr>
<td>Used short gestation crops as adaptation strategies</td>
<td>191</td>
<td>47.8</td>
<td>205</td>
</tr>
</tbody>
</table>

DOI: 10.9790/2402-1110043945 www.iosrjournals.org 40 | Page
### Table 2. Correlations tests between household’s adaptations strategies and total household income from crops

<table>
<thead>
<tr>
<th>Households total annual income from crops production in ETB</th>
<th>Household’s total annual income from crops in ETB</th>
<th>households used drought tolerant crop varieties as adaptation strategies to climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td>131</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.009</td>
<td>0.99</td>
</tr>
<tr>
<td>N</td>
<td>397</td>
<td>393</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.05 level (2-tailed).

Sources: field Study results, 2016/17

### Table 3. Correlations tests between household’s adaptations strategies and total household food consumption in kg

<table>
<thead>
<tr>
<th>Households using irrigation facility as adaptation strategies to climate change</th>
<th>Household annual food consumption in kg</th>
<th>Households using irrigation facility as adaptation strategies to climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>0.099</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.051</td>
<td>0.099</td>
</tr>
<tr>
<td>N</td>
<td>396</td>
<td>391</td>
</tr>
</tbody>
</table>

Sources: field Study results, 2016/17

### Table 4. Relationship tests between household’s adaptations strategies used irrigation facility as adaptation strategies to climate change and total household crop production in Kg

<table>
<thead>
<tr>
<th>Households using irrigation facility as adaptation strategies to climate change</th>
<th>Household total annual crop production in Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>0.093</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.067</td>
</tr>
<tr>
<td>N</td>
<td>391</td>
</tr>
</tbody>
</table>

Sources: field Study results, 2016/17

### Table 5. Correlations tests between household’s adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total food consumptions from own harvest in kg

<table>
<thead>
<tr>
<th>Households used drought tolerant crop as adaptation strategies to climate change</th>
<th>Household total annual food consumption in kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>0.055</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>0.055</td>
</tr>
<tr>
<td>N</td>
<td>394</td>
</tr>
</tbody>
</table>

*Correlation is significant at less than 0.10

Sources: field Study results, 2016/17
Table 6. Correlation tests between household’s adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total annual crop sells in market

<table>
<thead>
<tr>
<th></th>
<th>Households used drought tolerant crop as adaptation strategies to climate change</th>
<th>Household total annual crop sells in Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households used drought tolerant crop as adaptation strategies to climate change</td>
<td>Pearson Correlation: 1  Sig. (2-tailed): 0.007</td>
<td>N: 396  383</td>
</tr>
<tr>
<td>Households total annual crop sells in Kg</td>
<td>Pearson Correlation: 0.007  Sig. (2-tailed): 0.891</td>
<td>N: 583  386</td>
</tr>
</tbody>
</table>

***. Correlation is significant at the 0.01 level (2-tailed).

Sources; field Study results, 2016/17

Table 7. Correlations tests between household’s adaptations strategies used disease or pest resistant crop varieties as adaptation strategies to climate change impacts and household total incomes from crops in ETB

<table>
<thead>
<tr>
<th></th>
<th>Household total annual income from crops in ETB</th>
<th>Households used disease or pest resistant varieties as adaptation strategies to changing climate impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households total annual income from crops in ETB</td>
<td>Pearson Correlation: 1  Sig. (2-tailed): 0.144</td>
<td>N: 397  393</td>
</tr>
<tr>
<td>Households used disease or pest resistant varieties as adaptation strategies to changing climate impact</td>
<td>Pearson Correlation: 0.144  Sig. (2-tailed): 0.004</td>
<td>N: 393  396</td>
</tr>
</tbody>
</table>

***. Correlation is significant at the 0.01 level (2-tailed).

Sources; field Study results, 2016/17

Table 8. Correlation tests between household’s adaptations strategies used water harvest practices as adaptation strategies to climate change impacts and household total incomes from crops in ETB

<table>
<thead>
<tr>
<th></th>
<th>Household’s total annual income from crops in ETB</th>
<th>Households used water harvest practices as adaptation strategies to climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households total annual income from crops in ETB</td>
<td>Pearson Correlation: 1  Sig. (2-tailed): 0.112</td>
<td>N: 397  392</td>
</tr>
<tr>
<td>Households used water harvest practices as adaptation strategies to climate change</td>
<td>Pearson Correlation: 0.112  Sig. (2-tailed): 0.026</td>
<td>N: 392  395</td>
</tr>
</tbody>
</table>

*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

Table 9. Correlations tests between household’s adaptations strategies used flood tolerant crops as adaptation strategies to climate change impacts and household total crop productions in Kg

<table>
<thead>
<tr>
<th></th>
<th>Household’s total annual crop production in Kg</th>
<th>Households use flood tolerant crops as adaptation strategies to climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households total annual crop production in Kg</td>
<td>Pearson Correlation: 1  Sig. (2-tailed): 0.012</td>
<td>N: 396  392</td>
</tr>
<tr>
<td>Households use flood tolerant crops as adaptation strategies to climate change</td>
<td>Pearson Correlation: 0.012  Sig. (2-tailed): 0.806</td>
<td>N: 392  396</td>
</tr>
</tbody>
</table>

*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

Table 10. Correlations tests between household’s adaptations strategies used drought tolerant crop as adaptation strategies to climate change impacts and household total income from crops in ETB

<table>
<thead>
<tr>
<th></th>
<th>Household total annual income from crops in ETB</th>
<th>Households used drought tolerant crop as adaptation strategies to climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households total annual income from crops in ETB</td>
<td>Pearson Correlation: 1  Sig. (2-tailed): 0.131</td>
<td>N: 397  393</td>
</tr>
<tr>
<td>Households used drought tolerant crop as adaptation strategies to climate change</td>
<td>Pearson Correlation: 0.131  Sig. (2-tailed): 0.009</td>
<td>N: 392  396</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

Sources; field Survey results, 2016/17
The study found higher annual crop production. Irrigation facility had significant impacts on household’s adaptation strategy to climate change impacts and household total crop production in Kg (r=.159, p<0.014). This result revealed that households which used drought tolerant crop varieties as adaptation strategies to climate change were found consuming more food. This makes clear that household’s consumption pattern was impacted by household’s adaptation strategies (Table, 5).

Table 11. Correlations tests between household’s adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total crop production in Kg

<table>
<thead>
<tr>
<th>Household’s total annual crop production in Kg</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household’s changed from livestock to crop production as adaptation strategies to climate change</td>
<td>0.016</td>
<td>0.124</td>
<td>391</td>
</tr>
</tbody>
</table>

Sources; field Study results, 2016/17

Table 12. Correlations tests between household’s adaptations strategies used changing from crop production to livestock production and household total crop production in Kg

<table>
<thead>
<tr>
<th>Household’s total annual crop production in Kg</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household’s changed from livestock to crop production as adaptation strategies to climate change</td>
<td>0.124</td>
<td>0.016</td>
<td>390</td>
</tr>
</tbody>
</table>

Sources; field Study results, 2016/17

Table 13. Correlations tests between household’s adaptations strategies used different planting dates as adaptation strategies to changing climate impacts and household total annual crop production in Kg

<table>
<thead>
<tr>
<th>Household’s total annual crop production in Kg</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household’s using different planting dates as adaptation strategies to changing climate</td>
<td>0.027</td>
<td>0.598</td>
<td>391</td>
</tr>
</tbody>
</table>

Sources; field Study results, 2016/17

IV. Discussions

Many farmers were found using different types of adaptation strategies to cope with climate change impacts. Mostly practiced adaptation strategies in the agriculture sector in the kola Temben district were; use of different crop varieties (93.8%), applications of different planting dates (87.5 %), diversifying farm activities (75.5%), shifting of production areas (from crop to livestock (58.5%), livestock to crop production (23.5%)), use of irrigation facilities (16%), use of pest resistant crops (66%), and water harvesting practices (62.5). The least practiced adaptation strategy in the area was the use of irrigation facility (16 %), (Table, 1).

The result in Table 2 revealed that there was a statistically significant positive correlations between the usage of drought tolerant crop varieties as adaptation strategies and total annual income from crop productions (r=.131, p<.01). Households who used drought tolerant crop varieties as an adaptation strategy to climate change impact was found getting higher incomes than those not used (Table, 2).

The research finding revealed that there was a statistically significant positive correlations between use of irrigation facility as adaptation to climate change impacts and household’s annual total food consumption amount (r=.099, p<.010). Households with an access to irrigation facilities had a high probability of to feed family from own harvest and to consume more food (Table, 3).

The study found that access to irrigation facility and total annual crop productions had statistically significant positive correlation (r=.159, p<.001). Households with more access to irrigation facility were found with higher annual crop production. Irrigation facility had significant impacts on household’s annual total crop productions (Table, 4).

The study result in Table 5 found that there was a statistically significant positive correlations between the usage of drought tolerant crop varieties as adaptation strategies and household’s annual total food consumptions (r=.055, p<.010). This result revealed that households which used drought tolerant crop varieties as adaptation strategies to climate change were found consuming more food. This makes clear that household’s consumption pattern was impacted by household’s adaption strategies (Table, 5).
This study also make clear that that there was significant positive correlation between the use of drought tolerant crop variety as adaptation strategies and households’ total annual crop sell (r=.891, p<.01). Household’s adaptation strategies had impacts on market stability. The study also revealed that household’s adaptation decisions had direct impacts on the availability of agricultural production in a market (Table, 6).

The field study result in Table 7 revealed that there was a statistically significant positive correlations between the use of pest resistant crop varieties as adaptation strategies and household’s total annual incomes from crop productions (r=.144, p<.01). The use of crop variety that can resist pests and disease outbreak was found as the effective adaption strategies to improve crop productivity under all the stress of climate change (Table, 7).

The study result in Table 8 clearly shows that there was a statistically significant positive correlation between household water harvesting practices and household’s total income from crop productions (r=.159, p<.001). Water harvesting practices was found as one of the effective adaptation strategies to climate change impacts in the agriculture sector. Water harvesting practices and agricultural productivity had a direct and positive correlation (Table, 8).

Flood is one of the climate change related impacts and affects agricultural productivity and production. The field study result in Table 9 revealed that there was a statistically significant positive correlations between use of flood tolerant crop varieties as adaptation strategies to climate change impacts and total annual crop production (r=.806, p<.05).

Drought is one of the climate change related factors that determine agricultural production. Effective adaption strategy is very important to sustain the productivity of the agriculture sector and to feed the fast growing population. The study result in Table 10 clearly revealed that there was a statistically significant positive correlations between the use of drought tolerant crop varieties as adaptation strategies to climate change impacts and total annual income from crop production (r=.131, p<.01).

The aim of this analysis was to see if household’s adaptation decisions to shifting production areas from livestock rearing to crop productions had impact on total agriculture productions. The field study result in Table 11 revealed that there was a statistically significant positive correlations between total annual crop production and shifting of productions areas from livestock to crop production as adaptation strategies to climate change (r=.759, p<.05). Households who changed their agricultural focus from livestock rearing to crop productions were found with more total harvest (Table, 11).

This study also reveal that household’s decisions to change from crop production to livestock rearing as adaptation strategies to climate change impact had statistically significant positive correlations with total annual crop production they got (r=.124, p<.05). Decisions to change the types of agricultural activities as adaptation strategies to the stimulus of climate were found as one of the effective area specific strategies to cope with the adverse impact of climate change (Table, 12).

The use of different planting dates as adaptation strategies to climate change impacts had a statistically significant positive correlations with annual total crop production (r=.598, p<.05). Managing the date when crops should be planted was found having a positive contribution to the annual increments of crop production and productivity per spot of land (Table, 13).

V. Conclusions

Farmers are using their own adaptation strategies to cope with the impacts of climate change. The commonly used and most effective adaption strategies in the agriculture sector are; use of improved varieties of crops that resists drought, diseases and pests. Water harvesting practices and access to irrigation facility are the most effective adaptation strategies for subsistence farming communities. The soundness of farmer’s adaptation decision determines the growth potential of agricultural production in arid and semi-arid areas. Agriculture sector becomes very sensitive to climate change impacts and it is easily affected by climate variability. Household’s ability to adapt to climate impacts become very important to sustained agricultural production and to feed a family in particular and a nation in general. Household’s adaptation choices are one of the major determinants of household’s annual total income earn from the agriculture sector. Future development policy should consider the importance of addressing climate impacts and having mechanisms to reduce household’s vulnerability to climate change impacts. Further research on the impacts of climate change at different agro-ecological zones, crop varieties, animal species and possible human interventions to facilitate adaptation and moderate damage is very vital. More research works on the options of ‘no regret adaptation’ approach is very curial to guide future development policy under the uncertain global climate system.

Acknowledgements

Authors of this research article would like to express their appreciation to the Mekelle University for the research fund support.
References

[1]. Pk Aggarwal, Global climate change and Indian agriculture: Impacts, adaptation and mitigation, journal of Agricultural Sciences, 78(10), 2008, 911-919


[6]. Robert W. Kates, cautionary tales: adaptation and the global poor, journal of climate change, 45, 2000, 5-17

[7]. E. Lisa F. Schipper, Climate Change Adaptation and Development: Exploring the Linkages, Tyndall Centre for Climate Change Research, Working Paper 107, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK, 2007


[9]. Colette Mortreux and Jon Barnett, Climate change, migration and adaptation in Funafuti, Tuvalu, journal Global Environmental Change, 2008


[12]. Marja Kolström, Marcus Lindner, Terhi Vilen, Michael Maroschek, Rupert Seidl, Manfred J. Lexer, Sigrid Netherer, Antoine Kremer, Sylvain Delzon, Anna Barbati, Marco Marchetti and Piermaria Corona, Reviewing the science and implementation of climate change adaptation measures in European forestry, Forests, 2, 2011, 961-982; doi:10.3390/f2040961


[17]. Rashid Hassan, Determinants of African farmers’ strategies for adapting to climate change: Multinomial choice analysis, journal of AfJARE 2 (1), 2008


Alemu Addisu Farmers’ adaptation choices to climate change impacts and implications on agricultural production in Kolla Temben District, Tigray Regional State, Northern Ethiopia.” IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), vol. 11, no. 10, 2017, pp. 39-45

DOI: 10.9790/2402-1110043945 www.iosrjournals.org 45 | Page