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Climate Variability and Agricultural Performance of Smallholder Farmers of Low Land Ecological Zone in Ileje District, Tanzania

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ABSTRACT

This study was conducted in order to assess the impact of climate variability on agricultural performance of smallholder farmers of Low Land Ecological Zone in Ileje District. Specifically the study intended to examine the changes that has occurred in the study area over the last five years (2006- 2010), their effects in agriculture, coping strategies adopted by farmers. The study employed a cross sectional survey and involved a total number of 104 respondents of which 99 were smallholder farmers who were selected by probability sampling and 5 were key informants who were purposively selected. Data were collected through questionnaires, interviews and documentary review and analysed by using Statistical Package for Social Sciences (SPSS). Descriptive statistics were run to give frequencies and percentages. Tables and figures were used to present different variables. Findings indicates that, climate variability in Ileje District have affected agricultural performance by increasing of cost of production which has been fuelled by the use of improved crop varieties as well as industrial fertilizers which are of high cost despite of being subsidized by the government. Moreover, for the last five years climate patterns have changed, whereby rains starts late compared to the past, temperature has increased together with wind. Farmers have adapted to climate variability in various ways which include selling of livestock, making charcoal and opening petty trade. It is therefore recommended/suggested that, government review its scheme on agricultural subsidies so as to find out effective way of supporting farmers, improvement of weather forecast system and review policies, strategies and institutional framework.

Keywords: *Climate variability, Agricultural performance, smallholder farmer, Ecological zone*

1. INTRODUCTION

Background Information The well being of large populations around the world depends on access, stability of food (Schmidhuber and Tubiello, 2007 in Rowhani, Lobell, Linderman and Ramankutty, 2010). This is especially true in the developing world with predominant small land holders and subsistence farmers for whom the on- farm agriculture and off- farm agricultural labour provides the main source of food and income (Ito and Kuroski, 2009 in Rowhani et al., 2010). Besides a series of non- climate related factors, the vulnerability of these smallholder and subsistence farmers is greatly influenced by variability in climate (Morton, 2007 in Rowhani et al., 2010). Variability in climate have already decreased crop yields in several regions and, for example, are estimated to have reduced global maize production by 12 Mt a year between 1981 and 2002 (Rowhani et al., 2010). It has been suggested that a larger percentage of the African population will enter poverty as short- term variations in climate will increase the stress on food production (Ahmed, Diffenbaugh and Hertel, 2009 in Rowhani et al., 2010). Sub- Saharan Africa (SSA) relies heavily on weathersensitive agriculture (Rowhani et al., 2010). Many scientists, economists and policy makers now agree that the world is facing a threat from climate variability (Dalfelt, Dinar and Mendelsohn, 2000). The degree of the impact and its distribution is still debated. The current evidence suggests that countries in temperate and polar locations may benefit from small economic advantages because additional warming will benefit their agricultural sectors. Many countries in tropical and sub-tropical regions are expected to be more vulnerable to warming because additional warming will affect their marginal water balance and harm their agricultural sectors (Dalfelt, et al., 2000). According to International 2 Institute of Environmental Development (IIED) 2009, climatic patterns are becoming both less predictable and more severe. It is predicted that temperatures will rise by 2– 4 oC by 2100 in Eastern Africa. This has a serious implication on food security and income of the poorest rural households engaging in agriculture. However, little research on the impact of climate variability on agriculture has been done on tropical countries, so the extent of these damages is not known. Various studies done have indicated that the problem is expected to be most severe in Africa where current information is the poorest, technological change has been the slowest, and the domestic economies depend most heavily on agriculture (ibid). African farmers have adapted to a certain amount of climate variability, but may as well force large regions of marginal agriculture out of production in Africa (ibid). The agricultural sector is a major contributor to the current economy of most African countries, averaging 21% and ranging from 10% to 70% of the Gross Domestic Product (GDP) (Andronova, Mendelsohn, Morison & Schlesingger, 2000a in Dalfelt, et al., 2000). Future development is likely to reduce agriculture's share of GDP. With an optimistic forecast of future development, the agriculture's share of GDP could shrink to as little as 4% by 2100 (Dalfelt, et al., 2000). Even with this scenario, several countries will still have large agricultural sectors of over 10% of GDP (ibid). Contrary Africa's future development path remains uncertain and thus is not clear what fraction of GDP will remain for agricultural sector. Experts are concerned that the agricultural sector in Africa will be especially sensitive to future climate variability. The current climate is already marginal with respect to precipitation in many parts of Africa. Further warming in these semiarid locations is likely to be devastating to agriculture. Even in the moist tropics, increased heat is expected to reduce crop yields. Agronomic studies (ibid) suggest that yields could fall quite dramatically in the absence of costly adaptation measures. The current farming technology is basic, and incomes are low, suggesting that farmers will have few options to adapt. 3 The agricultural sector in Tanzania is central to sustainable development as it is the mainstay of over 75% of the population, accounts for 45% of the GDP and is vital for food security and alleviating rural poverty (Mngodo, 2008). Tanzania has about 88.6 million hectares suitable for agricultural production, including 60 million hectares of rangeland suitable for livestock grazing, production of bio- fuels or carbon sequestration (ibid). The country has been subdivided in 7 agro- ecological zones, based on altitude, precipitation, pattern, dependable growing season, and average water holding capacity of the soils and physiographic feature (ibid). Under increasing temperature scenarios, it is anticipated that a decrease in amount of rainfall, increased evapo-transpiration and seasonal unpredictability will have serious consequences on crop yields, shifts in agro- biodiversity, increased outbreak of pest and diseases, reduced germ plasma diversity as well as expansion of livestock keeping into farmland as the area under range land shrinks (ibid). Since agriculture in Tanzania is predominantly rain- fed, it is anticipated that where the frequency and intensity of droughts and water scarcity are predicted, this will affect agricultural production, severely reducing the supply of different crops. In addition, if drier conditions occur in areas which now support more water demanding crops like maize, vegetables, banana and rice will become more marginalized, and replaced by more drought tolerant but less preferred crops like sorghum and millet this will affect food choices among the farming communities (ibid). According to Levira (2009) agriculture is a main economic activity for Tanzania, an activity more vulnerable to climate change that employs about 80% of the total population. The adverse impacts of climate variability on agriculture sectors include reduced crop yield due to drought and floods, and reduced water availability. Shifting of the seasonal rainfall, one of the predicted outcomes of climate change, may bring too much rain when it is not required, is predicted to damage plants. In addition, dramatically rising temperature trends, responsible for increased evapotranspiration in the soil, may keep crops from maturing due to lack of enough moisture in the soil leads to low production and thus affecting food shortages. While Tanzania economy depends mainly on agricultural activities which are prone to climatic variations, it is unfortunately that the government failed to incorporate climate variabilility issues in its National Strategy for Growth and Reduction of Poverty (NSGRP) (2005) and Agricultural Sector Development Strategy, while the issue partially dealt in the National Environmental Policy (1997). Perhaps most telling of all, the effect of climate variability to smallholder farmers and national economy is not even mentioned in the current Kilimo Kwanza pillars Strategy (2009). 1.3 Statement of the Problem Rain fed agriculture is the main stay of the economies of the most African Countries including Tanzania, consequently severe and recurring droughts have disastrous impacts on the socio- economic development of the countries (Chang'a, 2010). In recent years most parts of Tanzania experienced severe and recurring droughts. The most devastating were those of 1983- 1984, 1993- 1994, 2003 and 2005 (ibid). Following these droughts, Tanzania suffered from serious food shortage and energy crisis. The frequency and severity of droughts and floods are projected to increase under varying climate making the establishment of appropriate mitigation and adaptation strategies even more urgent (ibid). According to the Disaster Management Department in the Prime Minister's Office (PMO), between 1872 and 1990, about 33% of all disasters in Tanzania were caused by drought. On average, droughts occur every four (4) years and the impact of adverse climate change would likely be felt by the year 2050 especially in the central and North Eastern parts of Tanzania. Ileje District is one of the eight districts in Mbeya region. Its population largely depends on agriculture for food and income earning. Agriculture in Ileje District is mainly rain fed with small irrigation schemes in Ikumbilo, Chitete, Senga, Mbande, Sasenga, Mapogoro, Ilulu, Bupigu and Ibungu. Unpredictable climate patterns have been a challenge facing smallholder farmers in Ileje District. In the past it used to start raining at the midst of November until May. In recent years the situation has changed where it starts raining at the midst of December and stops late April. For instance November, 2008 and May, 2009 it was reported 0 mm amount of rainfall respectively {Tanzania Meteorological Agency (TMA)}, 2006-2010). The current long-term weather forecasts and provision of agricultural subsidies by the government are inadequate measures to address food insecurity in the country in the expense of climate variability to enable farmers adapt to climate variability that affect agricultural performance. While the efforts of the government have been to ensure food security in the country by implementing different programs, little is known on the impacts of climate change on agricultural performance of smallholder farmers. Therefore this paper examined the impact of climate variability on agricultural performance of smallholder farmers of Low Land Ecological zone in Ileje District where agricultural production is predominantly rain fed.

2. METHODS AND MATERIALS

Study area

The study was conducted in Ileje district, in three selected Wards in Bulambya Division. Ileje District is located in the South- Western part of Mbeya region. The District lies between latitudes 90 141 and 90 371 and longitudes 320 801 and 330 451 East. It is bordered by Kyela District in the East, Rungwe District in the North- East, Mbozi District in the North- West and Mbeya District in the North.

Table 1: Agroecological zones

Zones	Climate	Features	Economic Activities
Low Lands	• Rainfall of 750- 1,000 millimetres • Temperature ranging from 80^0 F to 90^0 F	• Lies between 1,300- 1,500 meters above sea level • Soils are sand and relatively poor	• Cultivation of maize, finger millet, groundnuts and beans
Cultivation of maize, finger millet, groundnuts and beans	• Rainfall varies from 900 mm to 1,200 mm • Temperatures range between 60^0 F and 70^0 F	• Lies between 1,000- 1,600 mm • Soils are clay and relatively fertile	• Crops grown include: Coffee, pyrethrum, maize and potatoes
Cultivation of maize, finger millet, groundnuts and beans	• Rainfall varies from 1,500 mm to 2,000 mm • Temperatures range between 70^0 F and 80^0 F	• Lies between 1,500- 2,000 mm • Soils are volcanic in nature	• All crops can be grown

Research Design

The study employed cross- Sectional design where data were collected at one point in time; it consisted of asking questions to the representative sample of the population on which closed ended and open ended questions were used. This facilitated the appropriateness of getting viable and reliable data from various sources on which conclusions and recommendations was drawn.

Sample size and sampling techniques

The sample size for this study was drawn from Bulambya Division which consists of 9 Wards, i.e. Mbebe, Chitete, Isongole, Bupigu, Itumba, Mlale, Ndola, Ibaba and Itale. Out of these wards three wards, i.e. Ndola, Ibaba and Itale were excluded from the study due to the fact that its ecological zones more less to North Eastern Highlands and The High Eastern Highlands which favours grown of perennial crops like coffee and pyrethrum.

This study used a sample size that represented a population under study. Sample size being the total number of selected subjects to take part in the study; was determined using Yamane (1967) formula; $n = N/[1+N(e)2]$

Where:
n =Sample size estimates
N = Size of study population or sampling frame
e = Error of the prediction/detection e.g 0.1 or 0.01 r 0.05
Given the sampling frame of 6,895 households, error of estimate/prediction being 0.1; sample size estimate was:
$n = N/ [1+N (e) 2] = 6,895/ [1+6,895(0.1) 2]$
$= 6,895/ [1+ 68.95]$
$= 6,895/69.95$
$= 98.57$

Sampling techniques

Two main sampling techniques known as probability and non- probability sampling are used in determining sample (Adam & Kamuzora, 2008). In this study both probability and non probability sampling were employed to obtain the sample size. Probability sampling was used to obtain farmers who provided information regarding the study. In regard to Probability Sampling, simple random sampling and systematic sampling techniques were employed whereby first respondent was chosen randomly by using simple random sampling and rest were selected by using systematic sampling after every (n /N) th member of the sampling frame. In this category 99 smallholder farming household were obtained. Non probability sampling was used to obtain respondents who were chosen purposively to give out informations that can not be obtained from other respondents. These informations were collected from DALDO, Tanzania Meteorological Representative and Ward Extension Officers.

Methods of data collection

This study employed four types of methods of data collection. These include, questionnaires, The study also used both closed and open- ended questionnaires to collect data. This method was chosen because of its ability to access many respondents at relative low cost (Kothari, 2004). In- depth interviews was employed to few farmers from the sample, where collection of information about the extent that smallholder farmers are informed of climate change and how they are involved in agricultural development planning, availability and reliability of weather forecast system and support given to farmers to help them adapt to climate change.

3. RESULTS AND DISCUSSION

Climate Variability that have taken place for the Last Five Years

This study revealed that there has been some changes over the last five years (2006- 2010). Farmers in the study area had the following information with regard to climate variability that has occurred in the study area; Many studies have revealed that agriculture in the country largely depends on rainfall which is increasingly becoming unpredictable and unreliable with worsening climate variability impacts (Omambia, et al., 2010).

…In the past it used to rain on 15th of September locally known as "Ndambamapushe" and that was a sign to us that it is going to be a good season, but for the last five years we have noticed big changes, it has never rained on the said date. Again when it start raining, it stops many times creating hardship to crops (Information from smallholder Farmer Adam E. Mpunga from Isongole Village at Isongole Ward, translated from Swahili version).

Many studies have revealed that agriculture in the country largely depends on rainfall which is increasingly becoming unpredictable and unreliable with worsening climate variability impacts (Omambia, et al., 2010).

Farmers Perceptions on Climate Variability

Farmers have different perception on climate variability in different areas. A report by Action Aid October, 2006 revealed that farmers perceives differently in different areas about climate variability. A study in Malawi by Action Aid farmers perceived climate variability as an increased frequency of floods and droughts, changes in rainfall patterns and increase in temperature. In this study farmers perception has been looked generally as well as more specific to three variables i.e. rainfall, temperature and wind.

Table 2: Distribution of farmers' response in perception on climate variability

Perception	Frequency	Percent
No Variations	1	1.0
Minor Variations	23	23.3
Big Variations	44	44.4
Some Variations	30	30.3
Doesn't know	1	1.0

Table 2 shows smallholder farmers perception on climate variability over the last five (5) year at Mbebe, Isongole and Bupigu Wards. One (1.0%) responded to have not seen any variations, 23 (23.3%) minor variations, 44 (44.4%) big variations, 30 (30.3%) some variations and 1 (1.0%) doesn't know if there has been a climate variations. These perceptions are similar to what was reported by URT, 2003 that in Tanzania there will be increase weather events. The extreme weather events in Tanzania are associated with flooding, droughts, cyclones, tropical storms all of which are projected to be more intense, frequent and unpredictable (ibid). Some respondents gave the reason for those variations as follows;

……Environmental destruction for instance is cutting down trees and crop cultivation near water sources as well as forest burning (Comment from smallholder Farmer Nuru Msokwa from Mbebe Village at Mbebe Ward, translated from Swahili version).

Another respondent argued that;

……Human population increase and activities has destructed environment. Activities include expansion of agricultural areas by clearing forest, by setting fire and cutting down trees (Comment from smallholder Farmer Laison Mtawa from Mbebe Village at Mbebe Ward, translated from Swahili version).

Anther reason is that;

……Increase of human activities have accelerated destruction of environment, the rate of tree cutting has increased, increase of human population than the land available and poverty increase in the community (Comment from smallholder Farmer Joseph Nyembele from Isongole Village at Isongole Ward, translated from Swahili version).

Reasons from Ward Extension Officers Other reasons include;

……Farmers are not taking into consideration conservation agriculture and worse enough cutting down of trees without planting others (Comment from DALDO, translated from Swahili version).

Reasons from Ward Extension Officers

……Farmers are cutting down tree carelessly for opening new land for agriculture and charcoal making and also large increase of human population and livestock (Comment from Ward Extension Officer Brown Mwakatundu from Mbebe Ward, translated from Swahili version).

Other reasons include;

……Tree cutting for firewood and for brick burning has increased too much, forest burning for opening new farms rearing large livestock in an area with few pastures (Comment from Ward Extension Officer Alkadi Mnzava from Isongole Ward, translated from Swahili version).

Table 3 shows that 94.9% of the respondents perceive rainfall as decreasing within the five years of study, while only 5.1% perceived as decreased. The majority declared that rainfall onset has changed because they used to plant crops in October/November but nowadays they have to plant in late November/December. Similar results were reported by Maddison (2006) whereby a significant number of farmers in eleven African countries believed that temperatures had increased and that precipitation had declined Majule et al, (2008) also reported the same.

Table 3: Farmers Perception on Climate Variability on Rainfall

Rainfall Change	Frequency	Percent
Has increased	5	5.1
Has decreased	94	94.9
Total	99	100

Table 4 shows the response from the respondents about the extent of climate variability on temperature. Out of 99 respondents interviewed on that phenomena 96 (97.0%) responded that there has been an increase of temperature, 2 (2.0%) has decreased and 1 (1.0%) responded to have not seen any changes on temperature. Such high temperature has great impact on agriculture, this is similar to what has been reported by (Challinor et al. 2007; Gregory et al. 2009), that the vulnerability of small scale farmers (smallholder farmers) is coupled with the higher temperatures that have been directly changing crop yields.

Table 4: Farmers Perception on Climate Variability on temperature

Temperature Change	Frequency	Percent
Has increased	96	97
Has decreased	2	2
No change	1	1
Total	99	100

Table 5 shows the extent of climate variability on wind variable. According to findings, 93 (93.9%) agreed to have noticed an increase in wind while 6 (6.1%) have noticed a decrease of wind. Wind has great influence on rainfall patterns.

Table 5: Farmers Perception on Climate Variability on Wind

Rainfall Change	Frequency	Percent
Has increased	93	93.9
Has decreased	6	6.1
Total	99	100

Effects of Climate Variability on Agricultural Performance

This part presents the effects of climate variability on Agricultural Performance on six variables i.e. cost of production for crops, food taste preferences, marketing of crops, availability of water, energy and pastures. According to Schmidhuber and Tubiello 2007, the well- being of large populations around the world depends on access, stability and availability of food. This is especially true in the developing world with predominant small land holders and subsistence farmers.

Table 6: Effects of Climate Variability on Crops Production Cost

Temperature Change	Frequency	Percent
Has increased	86	86.9
Has decreased	12	12.1
No change	1	1
Total	99	100

Table 6 shows that climate variability has impact on food production cost. The table shows that 86 (86.9%) indicates that production cost of farm activities has increased, 12 (12.1%) has decreased and 1 (1.0%) doesn't know. Lobell & Burke (2008), Challinor et al. (2007) and Wheeler et al. (2000) reported that Africa is the most vulnerable continent to climate variability impacts affecting livelihoods of the majority of people. Therefore, increased variation and changes in mean temperature and precipitation are expected to dominate future changes in climate as they affect crop production. This has also been reported by Action Aid that changing of rainfall patterns and higher temperatures have forced farmers to shorten the growing season and switch to more expensive hybrid crops.

Table 7 shows that climate variability has also an impact on food taste. According to research data 62 (62.6%) acknowledged that food taste for the local varieties is best, 24 (24.2%) revealed that food taste is same for both varieties and 13 (13.1%) food taste for the improved varieties is best.

Table 7: Effects of Climate Variability on Food Taste Preferences

Food Taste Preferences	Frequency	Percent
Food taste for the local varieties is best	62	62.6
Food taste is same for both varieties	24	24.2
Food taste for the improved varieties is best	13	13.1
Total	99	100

Climate variability has also affected agricultural performance in terms of crop(s) marketing. Table 8 shows that 8 (8.1%) responded that prices for improved varieties are high as compared to local varieties, 17 (17.2%) acknowledged that prices for improved varieties are low, 14 (14.1%) responded that prices for local varieties are high, 4 (4.0%) responded that prices for local varieties are low and 56 (56.6%) responded that prices are the same for both varieties.

Table 8: Effects of Climate Variability on Crop(s) Marketing

Market Prices for the Crops	Frequency	Percent
Prices for improved varieties is high	8	8.1
Prices for improved varieties is low	17	17.2
Prices for local varieties is high	14	14.1
Prices for local varieties is low	4	4.0
Prices are same for both varieties	56	56.6
Total	99	100

Weather forecast systems and its Reliability to smallholder farmers

This part presents information about weather forecast systems and its reliability to smallholder farmers. In this part two systems are presented i.e. convectional weather forecast system and traditional weather forecast system. In Tanzania Meteorological Agency (TMA) is responsible for monitoring and predicting weather and climate in Tanzania, including seasonal rainfall forecasting. Convectional weather and climate prediction is normally done using statistical and dynamic methods (Johnston et al., 2004; Gissila et al., 2004). Before the establishment of convectional weather and climate forecasting older generations especially in the rural areas in Tanzania have largely relied on traditional system to predict weather through observation and monitoring the behaviour of animals, birds, plants and insects (Kihupi et al., 2002; Mhita, 2006). This part therefore presents firstly if farmers were informed about the amount of rainfall last season, sources of information, number of respondents using either convectional or traditional weather forecast system and the reliability of the two systems according to farmer's perception.

Table 9: Information about the amount of rainfall last season 2011

Response	Frequency	Percent
Yes	63	63.6
No	36	36.4
Total	99	100

Table 9 indicates the number of respondents who had information about the amount of rainfall for the last farming seasons 2011. The table indicates that 63 (63.6%) respondents agreed to have information about the amount of rainfall for the last season while 36 (36.4%) didn't have information about the amount of rainfall.

Coping Strategies by smallholder farmers

This part preset coping strategies as per smallholder farmers in Ileje District. Coping strategies encompass both immediate response (e.g. sources of off-farm income, post- disaster financing sources, and emigration plans) and more structural and long term- term strategies, such as re- orientation of production and improvement of infrastructure for production (Mubaya & Yanda, 2011). It also includes strengthening entitlements systems, community empowerment, livestock grazing on failed plots, asset sales for cereal purchases and asset distribution, food transfers and migration for employment and human- environmental relations such as changes in land use and water management strategies, among others (Saldana, 2008; Enfors & Gordon, 2008 in Mubaya & Yanda, 2011).

Table 10: Strategies taken by farmers to cope with Climate Variability

Coping Strategies	Frequency	Percent
Selling livestock	23	23.2
Made Charcoal	8	8.2
Search for casual	24	24.2
Petty trade	44	44.4
Total	99	100

Table 4.21 shows that a total of 23 (23.2%) respondents coped with climate variability by selling livestock, 8 (8.2%) made charcoal, 24 (24.2%) went somewhere else to work for labour work and 44 (44.4%) engaged themselves on petty trade. Available literatures reveal that coping strategies refers to adjustment in natural or human systems in response to actual or expected climate stimuli or their effects. These strategies are employed to moderate harm and exploit beneficial opportunities (IPCC 2001, 2007; Carr 2008; Grist 2008; Deressa et al. 2009). Coping to climate variability takes place through adjustments to reduce vulnerability or to enhance resilience. Hence, coping includes taking action to reduce risk or enhancing benefiting from available opportunity (Blennow & Persson 2009).

4. CONCLUSION AND RECOMMENDATIONS

Conclusion:

Climate variability is really occurring and is affecting smallholder farmers in various aspects. Production costs for the crops have increased, food taste preferences have also been affected and marketing of the crops have also been affected. Weather forecast system is also important to farmers as it determines the type of crop varieties to be grown for the season. In this area farmers seemed to have relied more on traditional weather forecast system. Government support in terms of subsidized agricultural inputs and institutional set up is another area of concern as climate variability is concern. Farmers have been receiving subsidized agricultural inputs yet seemed not to be adequate and even the institutional setup seemed not to be addressing climate variability issues. 75 6.1.3 Recommendations Bases on the findings, the following are recommended as a way to assist farmers to mitigate or reduce climate variability impacts in Ileje District.

1) High costs of crops production, marketing of crops and changing of food taste preferences are among of the things that affect smallholder farmer's welfare. Costs of production have increased thereby affecting farmer's welfare. In this study the costs of subsidized agricultural inputs seemed to be very high. It is therefore important for the government to undertake in- depth study on the capability of the farmers to pay for the inputs.

2) Improvement of weather forecast system is also an important area where government needs to take strong actions so as weather reports from convectional weather forecast system becomes more reliable to farmers. Provision of enough instruments and expertise at local level is important so as farmers can get information at their localities

3) Review of agricultural policy and other related policies and strategies is also important. In this study the reviewed policies and strategies were very little known to farmers but also very little on climate variability was mentioned on these policies and strategies.

4) Organizational setup is also important in addressing climate variability issues. The current setup does not show a section that is dealing with climate variability issues. It is now a high time to establish a specific ministry that will be dealing with climate issues.

5) Implementation of Development Plan 2011/2012- 2015/2016 climate variability issues should be taken seriously.

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