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*Full Length Research Paper*

# The perceived impact of climate change and variability on smallholder dairy production in northern Malawi

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**Farmers' perception of climate change is very important for their adoption of adaptation strategies. This paper analyses dairy farmers' perceptions of changes in rainfall patterns and its impact on dairy production in northern Malawi. Farmers' perception was obtained through a survey and analysed using descriptive statistics, Chi-square test and a multi-nominal regression model. The accuracy of farmers' perceptions was assessed with reference to actual rainfall data in the study area. The results revealed that majority (40%) of the respondents perceived that the amount of rainfall that the area had received over the past five years had increased. However, this was not supported by actual rainfall data. The farmers were also of the view that an increase in the amount of rainfall led to an increase in pasture production, water availability and milk production. Results from the multi-nominal regression model showed a strong relationship between milk production on one hand and water availability, and pasture production on the other. The results imply that dairy farmers in the study area do not perceive climate variability as an immediate problem and highlight the need to sensitize them about the current and projected changes in climate, their vulnerability and adaptation strategies.**

**Key words:** Climate change and variability, dairy production, Malawi, multi-nominal regression, perception.

## INTRODUCTION

Perceptions of climate change and variability, particularly within rural farming communities, are very important in addressing social vulnerability and adaptation to climate. For farmers to decide whether or not to adopt a particular measure they must first perceive that climate change has actually occurred. Thus, perception is a necessary prerequisite for adaption (Maddison, 2006). Therefore to enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have full knowledge of farmers' perception on climate change, potential adaptation measures, and factors affecting adaptation to climate change (Fosu-Mensah et al., 2010).

Most studies on farmers' perception on climate change and variability focus on the entire agricultural sector. Recent farmers' perception studies in Africa include: Kalinda (2011) for Zambia; Mengistu (2011) and Deressa et al. (2008) for Ethiopia; Rao et al. (2011) for Kenya; Sofoluwe et al. (2011) and Ishaya and Abaje (2008) for Nigeria; Fosu-Mensah et al. (2010) for Ghana; Gbetibouo (2009) for South Africa; and Lema and Majule (2009) for Tanzania. In addition, Maddison (2006) reports results from a study that assessed the ability of farmers in 10 African countries (Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa and Zambia) to detect and adapt to climate change. Results from all these studies have shown that farmers indeed perceive a change in climate over time and take some actions to adapt to such changes. Overall these studies reveal vital information for designing agricultural

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innovation systems that deal with impacts of climate change and variability. Such interventions include provision of improved seeds, water supply (water harvesting), information on climate change, and provision of credit.

This paper however focuses on livestock farming in general and dairy production in particular. It is well acknowledged that dairy farming both contributes to and is affected by climate change. Dairy production plays a part in greenhouse gases (GHGs) emissions, particularly methane, which contributes to climate change (Siemes, 2008). Methane is by far the largest contributor to total GHG emissions from the dairy sector - accounting for over half of total emissions (FAO, 2010). While the livestock sector as a whole is responsible for 18% of total anthropogenic GHG emissions measured in carbon dioxide ($CO_2$) equivalent (FAO, 2006), global dairy production accounts for 4% of the total global anthropogenic GHG emissions (FAO, 2010). This figure includes emissions associated with milk production, processing and transportation, as well as the emissions from meat production from dairy-related culled and fattened animals. Thus, for sustainable dairy production, there is need to reducing GHGs emission from the dairy sector through improved feeding and manure management.

Dairy farming is vulnerable to climate change through increased temperatures and changes in rainfall patterns. These factors affect feed and water availability, animal health and breeds, and in turn milk production. Warmer and drier conditions increase the likelihood of heat stress in cattle. Heat stress adversely affects reproductive performance in dairy animals (Van den Bossche and Coetzer, 2008). There is normally a decrease in milk production for cows under heat stress (Chase, 2006). Changes in rainfall patterns affects pasture growth patterns thereby affecting the quality and quantity of both feed grains and fodder produced outside dairy areas. Droughts lead to water shortage which in turn leads to a decrease in milk production (Siemes, 2008).

There is also ample evidence that climate change and variability has an impact on livestock disease prevalence (Gale et al., 2008; Van den Bossche and Coetzer, 2008). Brückner (2008) gave three examples of disease outbreaks that are believed to be related to climate change: the unprecedented spread of Avian flue; the rapid spread of bluetongue across Europe; and the spread of Rift Valley Fever in parts of Africa which resulted from severe floods. The other consequence of climate change as highlighted by Hoffmann (2010) is the increased risk that geographically restricted rare breed populations have due to climatic disturbances. Breeding goals may therefore have to be adjusted to account for higher temperatures, lower quality diets and greater disease challenges. Breeds that are well adapted to such conditions may become more widely used (Hoffmann, 2010).

This paper analyses smallholder dairy farmers' perceptions of changes in rainfall patterns and its impact on water availability, parasite and disease occurrences, pasture production, and milk production within Mzuzu Agricultural Development Division (Mzuzu ADD) in northern Malawi. Mzuzu ADD is one of the eight Agricultural Development Divisions in the country and comprises four districts. It has a cattle population of approximately 194,000 of which about 4,000 are dairy cattle (MZADD, 2010). The dairy population has been increasing overtime. For instance, the dairy herd increased from 3,328 in 2006/07 to 3,782 in 2009/10 (MZADD, 2007, 2010). The increase in dairy animals is in line with Government's policy in dairy production whose goal is to ensure adequate supply and consumption of milk and milk products.

Climate change models paint a bleak picture for Malawi. Global warming is projected to increase temperature by 2 to 3ºC by 2050, with a decline in rainfall and water availability (UNDP, 2007). Recent climate change projections over the southeastern southern Africa (including northern Malawi) predict shorter rainfall seasons associated with a later start to the season, earlier rainfall cessation, increases in mean dry spell length and reductions in rain day frequency (Tadross et al., 2007). Climate projections for the period 2010 to 2075 exhibit a decrease in mean cumulative rainfall over most parts of Malawi ranging from -4.8 to -0.7% in annual rainfall changes. The rainfall change is predicted to be worse in some parts of southern Malawi but with little change for most parts of the northern Malawi (Malawi Government, 2011). Indeed other empirical studies have shown that smallholder farmers in Malawi are experiencing changes in climate which is reducing productivity (Chadza and Tembo, 2012; Khamis, 2006). For instance changing rainfall patterns and higher temperatures have led to shorter growing season and farmers are forced to switch from local crop varieties to more expensive hybrid crops (Khamis, 2006).

## MATERIALS AND METHODS

In order to establish the perceived changes in rainfall patterns and its impact on milk production by smallholder farmers within Mzuzu ADD, the study used qualitative data from a baseline survey of dairy farmers within the ADD. The survey was conducted in the three districts of Mzimba, Rumphi, and Nkhata-Bay. These districts are actively involved in dairy farming. Within the three sampled districts, 13 Extension Planning Areas (EPAs) were purposefully selected for the study. These EPAs were the ones that are actively involved in dairy farming, hence their selection for the study. In each EPA, simple random sampling was used to select the most actively participating milk bulking groups (MBGs[1]), dairy farming clubs, local institutions and individuals for the study. The sample that was selected in this study represented about 40% of

[1] MBGs are organized farmers producer groups operating collection, checking, cooling and selling of milk to processors on behalf of member farmers. Membership includes farmers that do not own dairy animals either because the animals died or because they are new waiting to receive calves from a 'pass-on' programme.

approximately 700 households (DAHLD, 2005) participating in dairy farming activities in the ADD. Data was collected using household interviews. From the sample, only households that had dairy animals were selected for the study. Further, from the selected households, farmers who were present within their households were interviewed during the study.

A structured questionnaire with recall questions was used during data collection. The questionnaire was designed to capture information on socio-economic characteristics of the respondents and on six thematic areas of dairy farming namely: animal breeds, feeding and feed availability, animal health and services, animal housing, farmer networks and climate change. On climate variability, respondents were asked to indicate whether they had experienced any changes in the amount of rainfall over the past five years based on their memory of the intensity and distribution of rainfall. The five-year period was set because dairy production in the study area had tremendously expanded over that period, and as such most new farmers could not relate the impact of climate change to dairy production beyond that period.

A likert scale was used for the respondents to indicate whether the amount of rainfall had increased, decreased or remained constant over the five-year period. Apart from indicating their perceptions on change in rainfall pattern, respondents were also asked to mention the effects of those changes on dairy farming. In particular, respondents were asked to indicate their perceived effects of changes in rainfall on the following attributes of dairy farming: pasture production, disease occurrence, parasite occurrence, water availability and milk production.

Data collection was carried out from the 5th to 12th April 2009. A team of 12 researchers was involved in data collection. The researchers were divided into 3 groups of 4 members each: one of whom was a group leader. This team was trained for a day on how to administer the questionnaire and the questionnaire was pre-tested and modified based on practical experience. Field agricultural officers guided and introduced the research team to the appropriate households and respondents in each of the extension planning areas.

Data on perceived change in rainfall patterns and its impact on the selected attributes of dairy farming was initially analysed using the Statistical Package for Social Scientists (SPSS) version 11.5. Descriptive statistics such as percentages and frequencies were used for summarizing and presenting the results. Pearson Chi-Square ($\chi^2$) test was used to determine (at 5% significance level) the statistical significance of the differences in perceptions of changes in rainfall patterns among the dairy farmers. To assess the accuracy of the farmers' perceptions to changes in rainfall patterns, a comparison was made with published rainfall data (Government of Malawi, 2010) from four major meteorological stations of the study area covering the period from 2001 to 2010. The stations are Nkhata Bay (Mkondezi), Rumphi (Bolero), Mzimba (Mzuzu Airport) and Mzimba (Mzimba Aerodrome).

Rainfall data was analysed by calculating some basic descriptive statistics namely mean, minimum, maximum, standard deviation and correlation with time. In addition, rainfall trend and its significance were also analysed. Rainfall data was analysed using Microsoft Excel. Cross-tabulation was used to generate Pearson Chi-Square ($\chi^2$) values which were used to test any association between the farmers' perceived changes in rainfall pattern and changes in pasture production, disease occurrence, parasite occurrence, water availability and milk production.

Furthermore, a multi-nominal (logistic) regression model (Pallant, 2006) was used to analyse the farmers' perceived relationship between milk production and water availability, disease occurrence and pasture production. Milk production was coded as a categorical dependent variable with the following values: 0 = decrease in milk production; 1 = constant milk production; and 2 = increase in milk production. Water availability, disease occurrences, and pasture production, were also coded as categorical independent variables with the following values: 0 = decrease; 1 = constant; and 2 = increase. SPSS was again used to run the logistic regression model.

## RESULTS

A total of 284 farmers were interviewed during this study. Of the total, 150 (52.8%) were female and 134 (47.2%) were male. In terms of farmers' perception on rainfall patterns, the results revealed that majority (40%) of the respondents indicated that the amount of rainfall that the area had received over the past five years had increased while 32% indicated that the amount of rainfall had decreased (Figure 1). A Chi-square ($\chi^2$) test showed that the differences in dairy farmers' perception of changes in rainfall pattern is statistically significant ($\chi^2$ = 76.72; DF = 3; P-Value = 0.001) implying that it is unlikely that the differences in perceptions can be due to chance alone.

Analysis of published rainfall data from 2001 to 2010 in the study area showed that there is no statistically significant trend in the data except for Mzimba district which showed a significant decreasing trend (p = 0.02). The correlation between rainfall and time is also weak and insignificant except for Mzimba district (correlation coefficient = -0.72). Only Rumphi station produced a positive coefficient of correlation, nevertheless this correlation was weak and statistically insignificant (Table 1 and Figure 2). Thus, while the majority of the dairy farmers are of the opinion that rainfall in the study area is increasing; this cannot be supported by actual rainfall data.

Table 2 presents results of the perceived influence of changes in rainfall pattern on pasture production, disease occurrence, parasite occurrence, water availability and milk production. The results showed that majority of the respondents who noted that there was an increase in the amount of rainfall, felt that it led to an increase in pasture production (31.76%). A Chi-square ($\chi^2$) test showed a significant association between dairy farmers' perceptions of changes in rainfall patterns to changes in pasture production ($\chi^2$ = 74.22, DF = 4 P-Value = 0.001). However, a Chi-square test at 5% level of significance showed no significant association between dairy farmers' perceptions of changes in rainfall patterns and changes in disease and parasite occurrences. The majority of the farmers who indicated that there was an increase in the amount of rainfall were of the view that it led to an increase in water availability (30.41%) and milk production (19.60%). There was a significant association between the perceived changes in rainfall pattern and analyzed the farmers' perceived relationship between milk production on one hand and water availability, disease occurrence, and pasture production on the other hand are presented in Table 3. The results showed a statistically significant relationship between a fall in milk production and a decrease in water availability (p = 0.019), constant water availability (p = 0.003), and

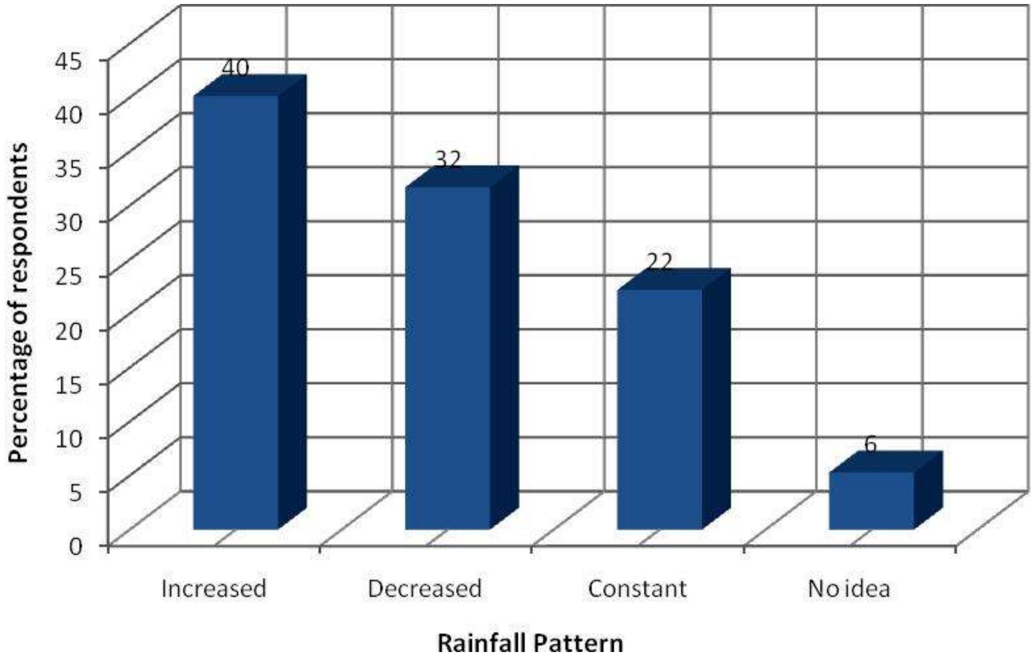


**Figure 1.** Perceptions of respondents on change in rainfall pattern over time ($\chi^2$ = 76.72; DF = 3; P-Value = 0.001).

**Table 1.** Analysis of rainfall data in the study area (2001 to 2010).

| Meteorological station | Rainfall data | | | | |
|---|---|---|---|---|---|
| | Mean (mm) | Standard deviation (mm) | Minimum rainfall (mm) | Maximum rainfall (mm) | Correlation (rainfall / time) |
| Nkhata Bay | 1625.7 | 223.1 | 1105 | 1928 | -0.35 |
| Rumphi | 685.5 | 88.5 | 477 | 780 | 0.32 |
| Mzuzu (airport) | 1183.3 | 152.8 | 948 | 1411 | -0.23 |
| Mzimba | 839.8 | 164.3 | 621 | 1171 | -0.72 |

decrease in pasture production (p = 0.021). Constant milk production resulted from constant water availability (p = 0.002), and constant disease occurrences (p = 0.043). Thus, the perceived relationship between constant water supply and milk production is mixed, in that constant water supply can lead to either constant or decrease in milk production.

The Cox and Snell $R^2$ and the Nagelkerke $R^2$ were 0.317 and 0.360, respectively; suggesting that between 32 and 36% of the variation in milk production was explained by the three variables. The percentage accuracy in classification was about 60%.

## DISCUSSION

The perception of many farmers (40%) that there was an increase in the amount of rainfall over the past five years has not been supported by actual rainfall data, particularly for Mzimba district which showed a statistically significant decreasing trend in rainfall over time. This is also not in line with climate projections for the region as presented by Tadross et al. (2007), UNDP (2007) and Malawi Government (2011) and empirical results by Khamis (2006) and Chadza and Tembo (2012). The results are also contrary to most findings from similar studies in Sub-Saharan Africa. For example, Gbetibouo (2009) in a study of farmers' perceptions and adaptations to climate change and variability in the Limpopo Basin – South Africa, show that farmers' perceptions about increasing temperature were in accordance with statistical records. Similarly, Rao et al. (2011) found that farmers in five districts of Eastern Province of Kenya were able to recollect past seasons fairly accurately especially the 'good' and 'poor' season which corroborated well with meteorological records. In the Nile

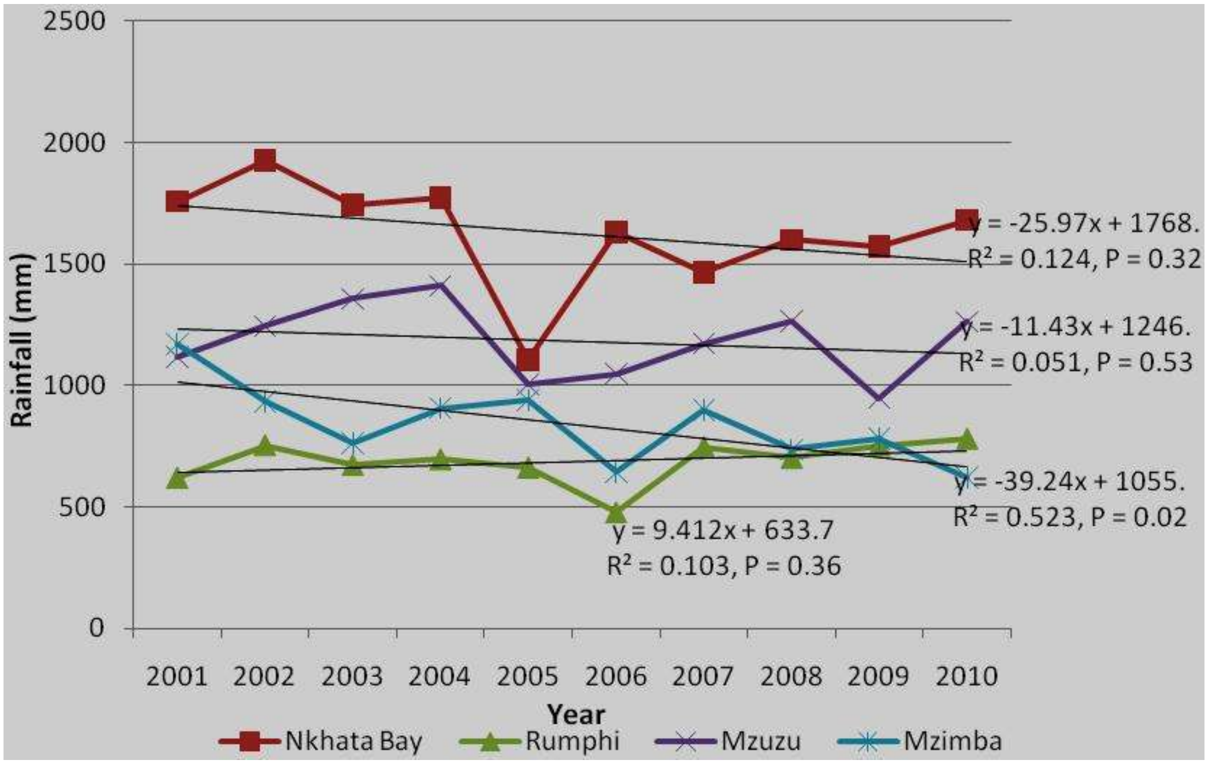


**Figure 2.** Rainfall trends in the study area (2001 to 2010).

Basin of Ethiopia and the semi arid areas of Tanzania, Deressa et al. (2008) and Lema and Majure (2009), respectively also found that farmers' perceptions with respect to changes in temperature and rainfall variability were in line with meteorological data.

The perceptions of dairy farmers in northern Malawi may have been influenced by the general increase in crop yield realized over the period and luck of extreme weather events related to climate change such as droughts and floods within the study area. The five-year period that farmers indicated their perceived changes in rainfall patterns covered a time that Malawi and the study area enjoyed bumper crop harvest due to favorable rains and successful implementation of an input subsidy programme by the Malawi Government. Since most farmers relate changes in rainfall pattern to crop yield, it may not be surprising to note that most farmers indicated that the amount of rainfall had increased over the bountiful five-year period. The results can also be explained by the fact that although the study area is climatically sensitive, it has not yet faced any extreme weather event associated with climate change and variability such as severe drought or flooding. Maddison (2006) notes that farmers' perception of climate change appear to hinge on experiences of such events. The studies reviewed in the foregoing were purposefully conducted in areas that were already experiencing climatic hazards, such as drought and floods, and as a result it was easy for the farmers to relate those effects to changes in temperature or precipitation which corroborated well with meteorological data.

One limitation of the study is that no conclusion can be made regarding the farmers' perception on climate change. While climate variability is the short-term fluctuation (years to a few decades) in weather conditions, climate change is the long-term change (from decades to millions of years) in average weather patterns. Thus, the five-year period under which farmers were asked to state their perceived rainfall pattern was too short for climate change analysis. Indeed most studies that investigate farmers' perception on climate change target old and experienced farmers because they are better at distinguishing climate change from merely inter-annual variation of weather scenarios (Ishaya and Abaje, 2008). The five-year period was set because most of the dairy farmers have been in dairy farming for less than five years and as such they could not relate the impact of climate change to dairy production beyond this period.

Farmers' perception that an increase in rainfall would be associated with increases in pasture production, water availability and milk production is in agreement with literature (Siemes, 2008). However, the farmers had problems in establishing the association between changes in rainfall patterns and changes in disease and parasite occurrences because this relationship is

**Table 2.** Perceived effect of changes in the rainfall pattern on dairy farming.

| Effect on dairy farming attributes (%) | | Perceived change in rainfall pattern (%) | | | $\chi^2$ value | P-value (DF = 4) |
|---|---|---|---|---|---|---|
| | | Decrease | Constant | Increase | | |
| Pasture production | Decrease | 24.32 | 3.38 | 4.05 | 74.22 | 0.001 |
| | Constant | 9.46 | 10.81 | 6.08 | | |
| | Increase | 3.38 | 6.76 | 31.76 | | |
| Disease occurrence | Decrease | 16.22 | 9.46 | 12.84 | 9.32 | 0.054 |
| | Constant | 12.84 | 6.08 | 9.46 | | |
| | Increase | 8.11 | 5.41 | 19.59 | | |
| Parasite occurrence | Decrease | 18.24 | 10.14 | 13.51 | 8.39 | 0.078 |
| | Constant | 12.16 | 4.05 | 11.49 | | |
| | Increase | 6.76 | 6.76 | 16.89 | | |
| Water availability | Decrease | 13.51 | 2.70 | 2.70 | 50.91 | 0.001 |
| | Constant | 18.24 | 12.84 | 8.78 | | |
| | Increase | 5.41 | 5.41 | 30.41 | | |
| Milk production | Decrease | 17.57 | 10.81 | 14.86 | 9.83 | 0.043 |
| | Constant | 11.49 | 3.38 | 7.43 | | |
| | Increase | 8.11 | 6.76 | 19.59 | | |

**Table 3.** Perceived determinants of milk production.

| Change in milk production[1] | Variable | B value | Std. error | Wald | P level | Exp (B) | 95% confidence interval for exp. (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower bound | Upper bound |
| Decrease | Intercept | -0.821 | 0.390 | 4.425 | 0.035 | | | |
| | Water = 0 | 1.657 | 0.709 | 5.465 | 0.019 | 5.244 | 1.307 | 21.043 |
| | Water = 1 | 1.842 | 0.622 | 8.768 | 0.003 | 6.309 | 1.864 | 21.351 |
| | Disease = 0 | -0.676 | 0.531 | 1.620 | 0.203 | 0.508 | 0.179 | 1.441 |
| | Disease = 1 | -0.420 | 0.603 | 0.485 | 0.486 | 0.657 | 0.201 | 2.144 |
| | Pasture = 0 | 1.427 | 0.617 | 5.352 | 0.021 | 4.167 | 1.244 | 13.964 |
| | Pasture = 1 | 0.246 | 0.611 | 0.162 | 0.687 | 1.279 | 0.386 | 4.233 |
| Constant | Intercept | -1.974 | 0.578 | 11.670 | 0.001 | | | |
| | Water = 0 | -0.326 | 1.048 | 0.097 | 0.756 | 0.722 | 0.093 | 5.630 |
| | Water = 1 | 2.095 | 0.674 | 9.660 | 0.002 | 8.123 | 2.168 | 30.432 |
| | Disease = 0 | 0.387 | 0.688 | 0.316 | 0.574 | 1.472 | 0.383 | 5.666 |
| | Disease = 1 | 1.437 | 0.710 | 4.092 | 0.043 | 4.207 | 1.046 | 16.926 |
| | Pasture = 0 | 1.063 | 0.724 | 2.159 | 0.142 | 2.896 | 0.701 | 11.958 |
| | Pasture = 1 | -0.654 | 0.709 | 0.850 | 0.357 | 0.520 | 0.130 | 2.088 |

[1]The reference category is: Increase. Results for water = 2, disease = 2, and pasture =2 have not been presented because they are redundant.

complex. Nevertheless an increase in rainfall due to climate change is normally associated with an increase in vector-borne and non-vector-borne diseases prevalence (Van den Bossche and Coetzer, 2008).

Results from the multi-nominal regression model confirm the perception that there is a strong relationship between milk production on one hand and water availability, and pasture production on the other. In an assessment of the constraints that affect smallholder dairy farmers in the northern region of Malawi, Tebug et al. (2012) found that feed shortage was one of the important limitations to smallholder dairy farming in the region. This has an important implication for the development of adaptation strategies because shortage of feed could be exacerbated with climate change.

Overall, results from this study show that dairy farmers in the study area do not perceive climate variability as an immediate problem. However, they are able to envisage the impact of any change to milk production when it occurs. The farmers' perception on climate variability is not supported by meteorological data which not only shows a significant decline in average rainfall for Mzimba district (Government of Malawi, 2010) but also predicts a decrease in mean cumulative rainfall in northern Malawi (Malawi Government, 2011) and shorter growing seasons (Tadross et al., 2007). As Maddison (2006) concludes, if farmers' perception of climate change does not correspond to evidence of change provided by data from nearby meteorological stations then the farmers reveal themselves to be in dire need of help. Considering the possible negative effects of climate change and variability on livestock production in general and dairy production in particular, it would be important to sensitize the communities in the study area about the current and projected changes in climate. In addition it would be fundamental to identify and analyse the effects of such changes on dairy production in the study area and other related areas and provide appropriate adaptation methods. Thus, there is need for further studies in the vulnerability and adaptation of smallholder dairy farmers to climate change in the area. The adaptation studies may consider the development and utilisation of improved breeds and alternative sources of animal feed and water to match the evolution in farming systems arising from climate change. In developing these technologies and alternatives, it would be important to ensure that they suite local conditions in order to be beneficial and relevant to the dairy farming communities.

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### REFERENCES

Bruckner G (2008). Climate change – a threat for animal health. [www.sustainabledairyfarming.com] Retrieved on 05/01/10.

Chadza W, Tembo D (2012). Climate Change Scoping Study Report, ActionAid International Malawi, Lilongwe.

Chase LE (2006). Climate Change Impacts on Dairy Cattle. Climate Change and Agriculture: Promoting Practical and Profitable Responses program. [www.climateandfarming.org.] Retrieved on 05/01/10.

Deressa T, Hassan RM, Alemu T, Ysuf M, Ringler C (2008). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798.

Department of Animal Health and Livestock Development (DAHLD) (2005). Department of Animal Health and Livestock Development Annual Report 2004/2005. Ministry of Agriculture and Food Security, Lilongwe.

FAO (2006). Livestock's long shadow: environmental issues and options. Rome: Food and Agriculture Organization.

FAO (2010). Greenhouse gas emissions from the dairy sector: A life cycle assessment. Rome: Food and Agriculture Organization.

Fosu-Mensah BY, Vlek PLG, Manschadi AM (2010). Farmers' Perception and Adaptation to Climate Change; A Case Study of Sekyedumase District in Ghana. Tropentag, September 14-16, 2010, Zurich.

Gale P, Adkin A, Drew T, Wooldridge M (2008). Predicting the impact of climate change on livestock disease in Great Britain. Veterinary Record 162:214-215 doi:10.1136/vr.162.7.214.

Gbetibouo GA (2009). Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849.

Government of Malawi (2010). Statistical Yearbook 2010. National Statistical Office, Zomba [www.nso.malawi.net]. Retrieved on 12/07/12.

Hoffmann I (2010). Climate change and the characterization, breeding and conservation of animal genetic resources. Anim. Genet. 41:32-46.

Ishaya S, Abaje IB (2008). Indigenous people's perception on climate change and adaptation strategies in Jema'a local government area of Kaduna State, Nigeria. J. Geogr. Reg. Plann. 1(8):138-143.

Kalinda TH (2011). Smallholder farmers' perceptions of climate change and conservation Agriculture: Evidence from Zambia. J. Sustain. Dev. 4(4):73-85.

Khamis M (2006). Climate change and smallholders in Malawi: Understanding poor people's experiences in climate change adaptation. A report by Action Aid International.

Lema MA, Majule AE (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. Afr. J. Environ. Sci. Technol. 3(8):206-218.

Maddison D (2006). The Perception of and Adaptation to Climate Change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. University of Pretoria, Pretoria, South Africa.

Malawi Government (2011). The Second National Communication of Malawi. Environmental Affairs Department, Ministry of Natural Resources, Energy and Environment, Lilongwe, Malawi.

Mengistu DK (2011). Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, Central Tigray, Ethiopia. Agric. Sci. 2(2):138-145.

Mzuzu Agricultural Development Division (MZADD) (2007). Agricultural Produce Estimates 2006/07: First Round. Ministry of Agriculture and Food Security, Mzuzu Agricultural Development Division – Mzuzu.

Mzuzu Agricultural Development Division (MZADD) (2010). Agricultural Produce Estimates 2009/10: First Round. Ministry of Agriculture and Food Security, Mzuzu Agricultural Development Division – Mzuzu.

Pallant J (2006). SPSS Survival Manual: A step by step guide to data analysis using SPSS for Windows (Version 12). Open University Press: Berkshire UK.

Rao KPC, Ndegwa WG, Kizito K, Oyoo A (2011). Climate variability and change: Farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. Exp. Agric. 47(2):267-29.

Siemes H (2008). Climate change – Dairy sector will take the bull by the horns. [www.sustainabledairyfarming.com] Retrieved on 05/01/10.

Sofoluwe NA, Tijani AA, Baruwa OI (2011). Farmers' perception and adaptation to climate change in Osun State, Nigeria. Afr. J. Agric.

Res. 6(20):4789-4794.

Tadross M, Suarez P, Lotsch A, Hachigonta S, Mdoka M, Unganai L, Lucio F, Kamdonyo D, Muchinda M (2007). Changes in growing-season rainfall characteristics and downscaled scenarios of change over southern Africa: implications for growing maize, IPCC regional Expert Meeting on Regional Impacts, Adaptation, Vulnerability, and Mitigation, Nadi, Fiji, June 20-22. Meeting Report Papers, pp. 193-204.

Tebug SF, Kasulo V, Chikagwa-Malunga S, Wiedemann S, Roberts DJ, Chagunda M (2012). Smallholder dairy production in Northern Malawi: production practices and constraints. Trop. Anim. Health Prod. 44(1):55-62 DOI 10.1007/s11250-011-9887-0.

UNDP (2007). Human Development Report 2007/2008, Fighting Climate Change: Human Solidarity in a Divided World, UNDP, New York, USA.

Van den Bossche P, Coetzer JAW (2008). Climate change and animal health in Africa. Rev. Sci. Tech. (International Office of Epizootics) 27(2):551-562.