Journal of Environmental Science and Management 19(1): 46-57 (June 2016) ISSN 0119-1144

Climate Change Awareness and Farm Level Adaptation of Farmers (Central Dry Zone) in Monywa Township, Sagaing Region, Myanmar

ABSTRACT

Climate change will affect the agricultural productivity in dry zone area due to insufficient knowledge, inadequate human capacity development, and limited institution al interventions dealing with farm level climate change adaptation. This paper examined factors influencing climate change awareness, the effects of climate change as perceived by farmers and farm level adaptations practiced by farmers in coping with climate variation and other factors in Myanmar. One hundred fifty respondents were interviewed from three geographical strata in Monywa Township (Central Dry Zone), Sagaing Region, in Myanmar namely upstream, midstream and downstream. Climate change awareness influenced by socio-economic and institutional factors can provide the effective decisions for better farming practices to minimize the risks of climate variation in rainfed areas. The development and application of relatively simple and reliable methods for assessing the impacts of climate change and adaptation strategies at the agricultural system and/ or household level are still demanded to provide timely recommendations for alternative technologies and policies.

Key words: *climate change, adaptation, agriculture*

Myo Win Maung[1*]
Juan M. Pulhin[2]
Maria Victoria O. Espaldon[3]
Nelita M. Lalican[4]

[1] Agricultural Extension Division, Department of Agriculture, Myanmar and former student, SESAM-UPLB
[2] College of Forestry and Natural Resources, University of the Philippines Los Banos, College, Laguna
[2] School of Environmental Science and Management, UPLB
[4] College of Agriculture, UPLB

E-mail: agrimwmaung007@gmail.com
(*corresponding author)

INTRODUCTION

Climate change introduces numerous uncertainties over the livelihoods of farming communities that depend heavily on weather and climate. According to *Bierbaum et al.* (*2007*) and *Gohar and Cashman* (*2016*), farmers in rainfed areas in developing countries are among the most vulnerable and face more severe consequences to the impacts of climate change. The most experienced impacts of climate change are erratic rainfall, reduction in crop yield, prolonged drought and shift in cropping season (*Dumenu and Elizabeth 2016*). Adaptation to these longer-term changes is required both by farming communities and those stakeholders with whom they interact and on whom they often depend (*Cooper et al. 2008*).

The *IPCC* (*2007*) reported that impacts of climate change on agriculture will likely be very severe especially for those in rain-dependent regions. Limited financial, institutional and human resources, and high ecosystem dependent economic and livelihood activities such as subsistence farming leave the poor highly vulnerable. The *UNDP* (*2011*) described that across the Dry Zone in Myanmar, water is scarce, vegetation cover is thin, and soil is degraded due to severe erosion. The Dry Zone is characterized by clay and sandy soils with areas at high risk of water and wind erosion leading to land degradation and declining agricultural production due to high temperature and erratic rainfall (*MOAI 2015*). Food production also relies on the availability of water at a given place and time, and this availability is also influenced by climatic conditions (*Hammer et al. 2001; Esteve et al. 2015*). The *Asian Development Bank* (*2009*) reported that Myanmar is one of the countries most vulnerable to climate change and that drought and water scarcity are the dominant climate-related hazards in the Dry Zone.

Socio-economic and demographic factors to climate change awareness

Key factors affecting farmers' decisions are their perceptions of and attitudes toward risk as well as farm personnel characteristics, such as age, education, experience and type of economic organization (*Paustian et al. 2006*). Understanding the interaction between farmers and their supporting institutions is a useful precursor to understanding the importance of technology in the process of adaptation to climate change. The role of technology is even more crucial in developing countries where food security remains a struggle for a significant portion of the population, with the impending climate change impacts expected to make the condition even worse (*Chhetri et al. 2012*).

Institutional Influence on Farm Level Adaptations

Adaptation will require the involvement of multiple stakeholders, including first and foremost, farmers, but also policymakers, extension agents, NGOs, researchers, communities and the private sector. Policies aimed at promoting successful adaptation of the agricultural sector must be based on the better understanding of the farmers' perceptions of climate change, ongoing adaptation measures, and their decision-making process (*Batisani et al. 2010*; *Bryan et al. 2013*).

For instance, crop selection by farmers is not only based on the expected yield of a particular crop variety, but also on available labor, individual experience, availability and prices of seeds, government policies and a host of environmental factors including climatic and soil conditions and available surface flow (*Ministry of Forestry 2011*).

An understanding of rainfall variability and trends is needed to help vulnerable dryland agriculturalists farmers and policymakers address current climate variation and future climate change (*Batisani and Brent 2010*). Monitoring and evaluation, together, are concerned with the farmers' reception and opinion of the recommended innovations; change in knowledge, attitude, skill, and awareness (KASA), rate of adoption of innovations and adaptation of new innovations to local conditions (*Dejene 1989*). Public investment in rural infrastructure, available and technically efficient use of inputs; a good education system that provides equal chances for women; and strengthening of social capital, agricultural extension and micro-credit services are the best means of improving the adaptation of the farmers (*Below et al. 2012*).

Potential Effects of Climate Change on Agricultural Insect Pests and Diseases

Changes in climate may result in changes in geographical distribution, population growth rates, crop-pest synchrony, and interspecific interactions of migrant pests including increase in overwintering, the number of generations and risk of invasion as well as the extension of the development season. Climate and weather can substantially influence the development and distribution of insects (*Porter et al. 1991*).

Temperature is the dominant abiotic factor directly affecting the growth (increase in size) and development (onset of reproductive maturity) rate of insects (*Bale 2002*). Drought and flood-stressed plants can be more susceptible to pests and pathogens, especially when combined with higher temperatures, which can suppress host defence responses (*Finlay and Luck 2011*).

Farm Level Adaptations Among Rainfed Farmers in Dry Zone Area

Autonomous adaptation is the reaction of a farmer to changing precipitation patterns when he or she changes crops or uses different harvest and sowing dates (*FAO 2007*). In contrast to monocropping, (the growing of only one crop on a piece of land year after year) that makes farmers extremely vulnerable to climate-induced shocks. Multi-cropping still has potential to be up-scaled as an adaptation practice across the Dry Zone (*WFP 2009*). The diversification of crops provides a number of resilience and adaptation benefits, including an economic buffer in case of crop failures, and recognized benefits for soil fertility.

Multiple cropping systems or growing two or more crops on the same field either at the same time or after each other in a sequence provides more harvest security for farmers, allow for crop intensification and furthermore influence ground cover, soil erosion, soil chemical properties, pest infestation and the carbon sequestration potential (*Norman et al. 1995*). In these systems, the risk of complete crop failure is lower compared to single cropping systems and monocultures thus, providing a high level of production stability (*Francis 1986a*).

Mixed cropping is growing two or more crops simultaneously intermingled without any row pattern on the same piece of land. It is a common practice in most of dry land areas. On the other hand, Intercropping is growing two or more crops simultaneously on the same piece of land with a definite row pattern (*Kumar et al. 2012*). Crop rotation is changing the type of crops that are planted in a given section of the field in each growing season (*http://www.wisegeek.com/what-is-crop-rotation.htm*).

Several strategies for adaptation to climate change have been proposed to address crop productivity. One strategy emphasizes changing cultural practices. Many farmers are changing the timing of planting or altering irrigation regimes (*Mercer et al. 2012*).

This study aimed to: identify the factors influencing climate change awareness among farmers cultivating rainfed areas; determine the effects of climate change as perceived by farmers categorized according to four major crops, namely, pigeon pea, chick pea (pulses), onion and garlic (culinary crops); and identify the farm level adaptation practiced by farmers in coping with climate variation and other factors.

Conceptual Framework

Variables relating to farm level adaptation of rainfed farmers in the Dry Zone area are categorized into three: Socio-demographic factor; social economic factors; and Institutional factors. The socio-demographic factors include age, gender, level of education, cultivated area and crop, number of household members who completed schooling, and farmer experience. The socio-economic factors comprise household annual income, input cost of farm operation and commodity prices. Institutional factors include provision of agricultural support such as fertilizer, insecticide and improved variety, and provision of farm machinery. These independent variables influence the of climate change awareness and the effectiveness of farm level adaptation in rainfed areas. Therefore, the conceptual framework of farm level adaptation to climate change of rainfed farmers is laid down in **Figure 1**.

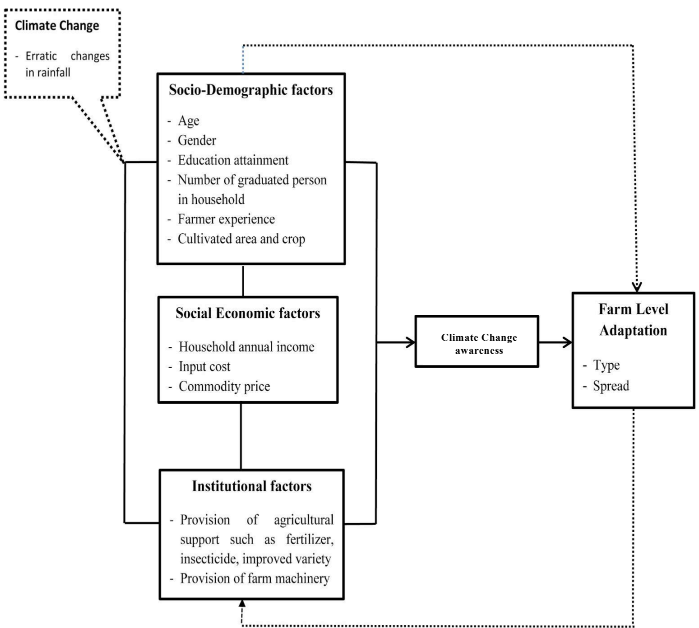

Figure 1. Conceptual framework of farm level adaptation of farmers (Central Dry Zone Area) in Monywa Township, Sagaing Region, Myanmar.

METHODOLOGY

Locale of the Study

Myanmar, formerly known as Burma, is located in Southeast Asia and is characterized by three main seasons, namely, summer, rainy season, and the cold season. Summer months usually commence in March and ends in mid-May; the rainy season from mid-May to the end of October; and the cold season starts in November and ends in February. Myanmar's weather conditions differ widely from place to place due to different topographical situations.

The Dry Zone lies between latitudes 19º 20″and 22º 50″ north and longitudes 93º40″ and 96º 30″east, stretching across the southern part of Sagaing Region, the western and middle part of Mandalay Region and most parts of Magway Region. It is one of the most climate sensitive and natural resource-poor regions.

Monywa has a tropical wet and dry climate and there are 62 villlage tracts comprising of 182 villages in Monywa Township with 231,259 acres (1 ha = 2.47 acre) of total arable land including 133,307 acres for rainfed area (**Figure 2**).

Research Design

The present study aimed to examine the farm level climate change adaptation of rainfed farmers in the Monywa Township, Sagaing Region in Myanmar as well as the factors influencing the farmers' decision making To achieve this objective, descriptive and correlational research designs were employed. This is to obtain information concerning the current status of a phenomenon to describe "what exists" with respect to variables or conditions in a situation, moreover, the correlational study is a quantitative method of research, will determine the relationship between two or more quantitative variables from the same group of subjects. Microsoft excel and Statistical Package for Social Science (SPSS) software for Windows release, were applied in the computation of means, frequency and range, and correlation coefficient.

Sampling Techniques for Respondents

For purposes to determine the sample respondents, a geographical stratification of Monywa Township was employed. Monywa Township which strategically lies perpendicular to the Chindwin River was clustered into three geographical strata, namely; upstream, midstream, and downstream. For each stratum, a listing of farmers was secured and from the list, 50 respondents were selected by simple random sampling. Information on the socio-economic and demographic conditions, institutional factors, awareness on climate change, and farm level adaptation of farmers were collected using a survey instrument

Table 1. Distribution of farmer-respondents sampled, by village (stratum).

Village	Farmer population	Sample
Kyawe Ye (Upstream stratum)	348	50
Le Zin (Midstream stratum)	1173	50
KyarPaing (Downsteam stratum)	339	50
Total	1860	150

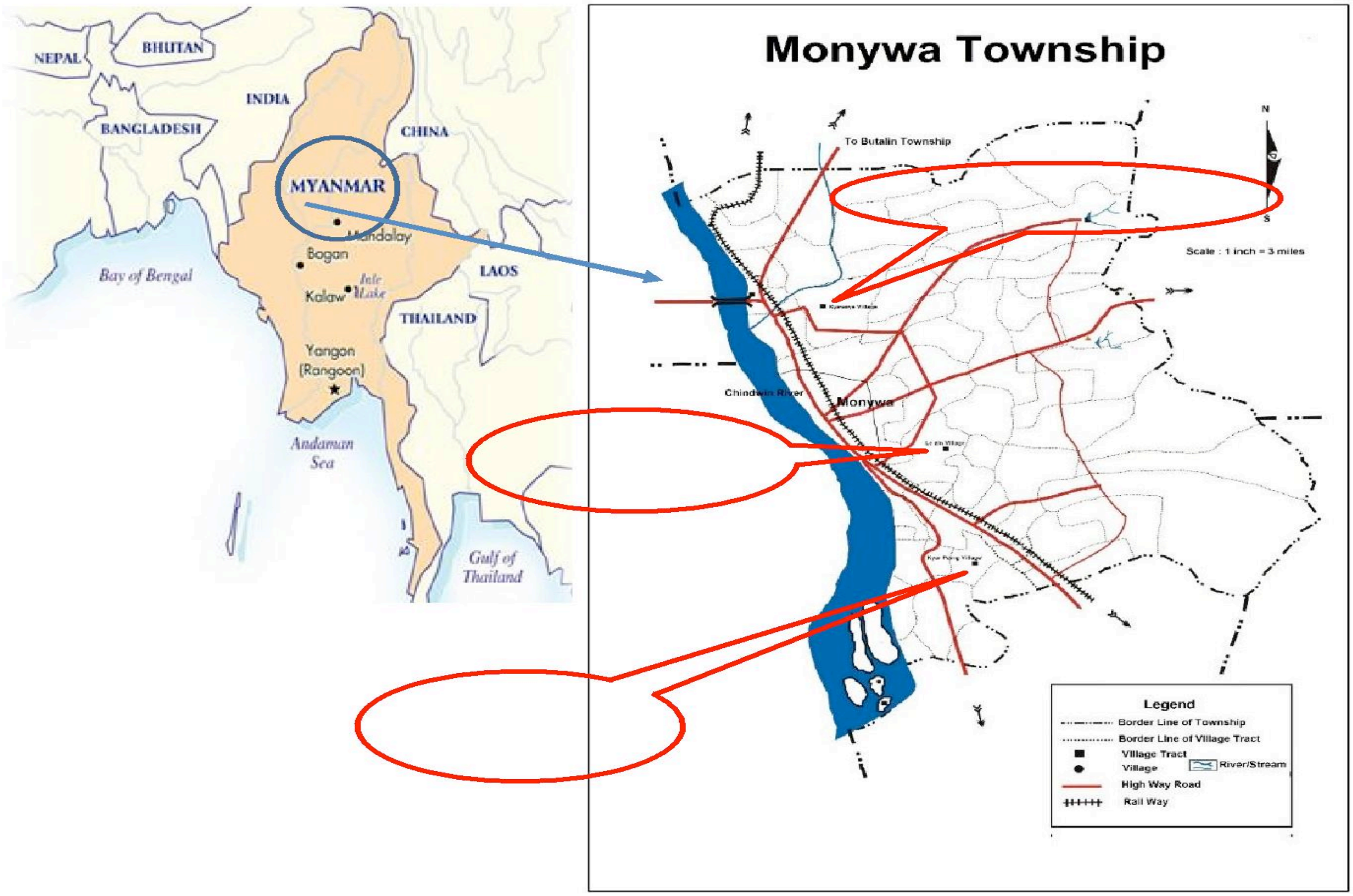

Figure 2. Map showing relative location of the study area. (Source: Settlement and land Records Department (2013), MOAI)

administered to each of the 50 farmer-respondents from each village. Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted in three villages (**Table 1**).

RESULT AND DISCUSSION

Climatic Condition in Monywa Township: Distribution of Rainfall in Monywa Township Over the Past 20 Years (1993 – 2012)

Myanmar has a varied tropical wet and dry climate that ranges from the hot humid zone in the south/coastal area to the arid and semiarid in the central dry zone. In the past 20 years, the overall rainfall pattern varied with slight increase and decrease until September with rainfall availability of 175.22mm at its peak (**Figure 3**). The winter dry season from November to April recorded less. Rainfall was erratic with a slight increase and decrease until 2007 and with sharp decline in 2008 with the lowest amount of rainfall recorded at 427.48 mm during the months of December to March. Because of this pattern, the beginning of the rainy season in July received less rainfall than the summer wet season.

There was a marked rapid increase in rainfall availability in Monywa with 1098.8mm recorded in 2010. However, this dropped dramatically in 2012. In the end of the period, the rainfall pattern suddenly changed with sharp increase and decrease affecting agriculture production in the process. Rainfall pattern in Monywa Township has been characterized by unstable distribution pattern and erratic occurrence. Rainfall was basically scarce providing a detrimental effect on crop production directly affecting the livelihood of many farmers.

Socio-Economic and Demographic Profile of Farmer-Respondents Based on Crops Grown

Based on interviews made in the three villages of KyarPaing, Le Zin, and Kyawe Ye, slightly more than half or 52% of the total number of farmer-respondents earned their livelihood from growing culinary crops and 43% from the cultivation of pulses (**Table 2**). Only five percent earned income from the cultivation of paddy and other crops. In KyarPaing Village, majority (96%) of the farmers produced culinary crops, while 84% of the respondents in Le Zin Village grew pulses. In Kyawe Ye Village, there was almost

Table 2.Crops grown as sources of livelihood in the study area.

Source of Livelihood	Kyar Paing Village (n=50)		Le Zin Village (n=50)		Kyawe Ye (n=50)		Total (n=150)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Culinary Crops	48	96	7	14	23	46	78	52
Pulses (chick pea and pigeon pea)	1	2	42	84	21	42	64	43
Paddy and others	1	2	1	2	6	12	8	5
Total	50	100	50	100	50	100	150	100

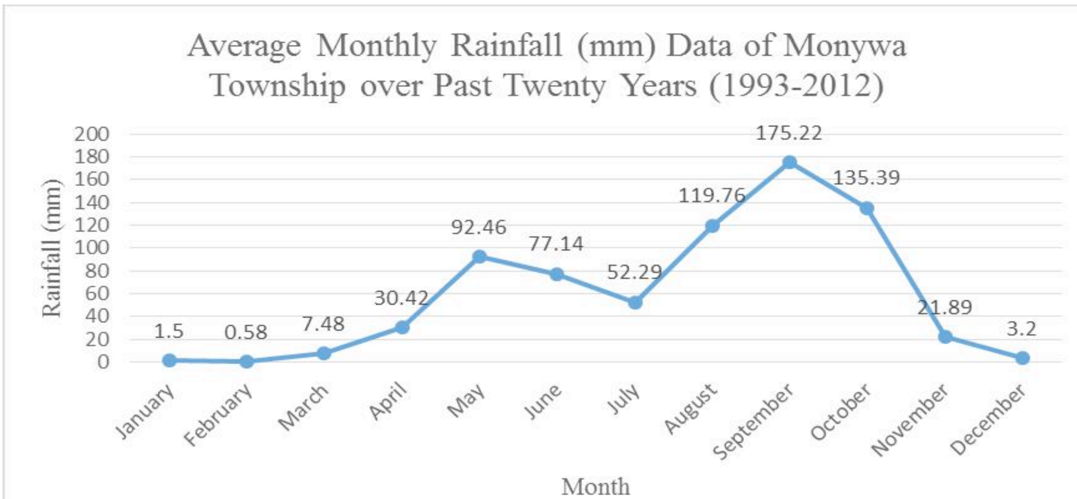

Figure 3. Average monthly rainfall data of Monywa Township (1993-2012).

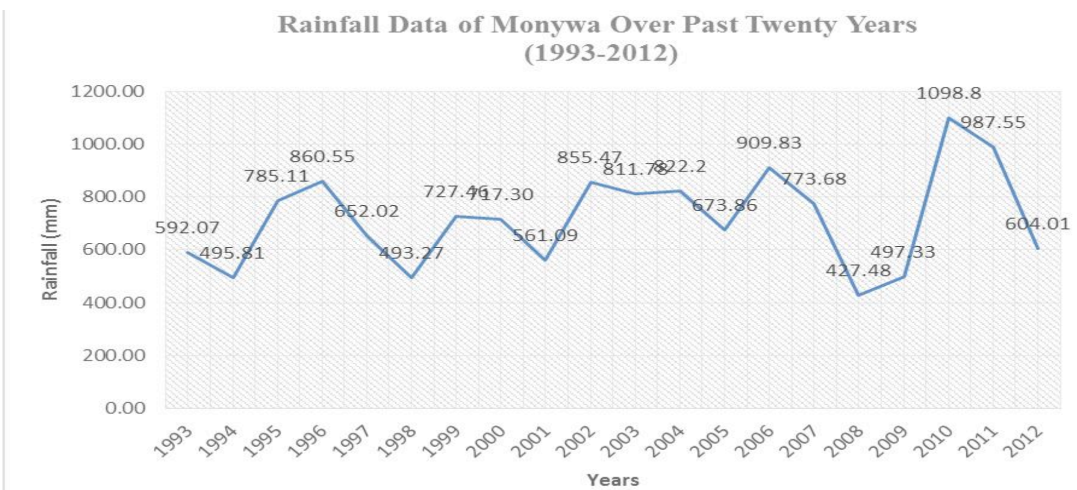

Figure 4. Rainfall data of Monywa over the past 20 years (1993-2012). Source: Regional Manager Office of DoA, 2013

the same number of farmers raising culinary crops (46%) or pulses (42%).

Correlation Coefficient Between Social-Economic/ Demographic Factors and Climate Change Awareness

Relationship Between Gender and Climate Change Awareness

The socio-economic and demographic characteristics of the farmer-respondents including, age, gender, level of education, number of graduated family member, income, and changes in cropping practices (independent variables) were correlated with awareness on climate change (dependent variable). Of the independent variables, gender was found to be significantly and positively correlated withclimate change awareness at 0.05 level of significance and correlation coefficient (rs) of 0.160 (**Table 3)**. This means that male farmers would tend to have more knowledge on climate change compared to their female counterparts, because they may have easier access to information and have more opportunities for capacity building on how to deal with climate change. According to *Goh* (*2012*), in developing countries, women seem to suffer more negative

Table 3. Correlation coefficient of social-economic and demographic factor and awareness of climate change.

Factor	r_s	Significant Level
Demographic factors		
Age	0.018^{ns}	0.825
Sex	0.160*	0.05
Educational status	(-) 0.045^{ns}	0.584
Number of graduated person in farmer household	0.003^{ns}	0.976
Socio-Economic Factors		
Annual Income	0.059^{ns}	0.475
Changes of cropping system depending on farm input costs	(-) 0.225**	0.006

Trivial association (r_s = 0.01 to 0.09), Weak association (r_s = 0.10 to 0.29), Moderate association (r_s = (0.30 to 0.49), Substantial association (r_s = 0.50 to 0.69), Strong association (r_s = 0.70 to 0.89), Very strong association (0.90 to 0.99), *significant at 5% level (α ≤ 0.05 level), ** significant at 1% level (α ≤ 0.01 level), ns – non significant at 5 % level

impacts of climate change in terms of their assets and well-being. This is because of social and cultural norms regarding gender roles and their lack of access to and control of assets, although there are some exceptions.

Relationship Between Changes in Farming Practices Based on Input Costs and Climate Change Awareness

The farmers' decision to change their farming practices on the basis of input costs is highly but negatively correlated with climate change awareness (P = 0.006). This implies that farmer-respondents who alter their farm practices based on input costs tend to have a low level of climate change awareness (**Table 3)**.

As the literature on adaptation makes clear, these resource constraints are influenced by the nature of available technology, the responsiveness of local institutions, the dissemination of knowledge and information, and most crucially, by the human and social capital that different actors are able to command. Farmers have responded by changing cropping and water use strategies, but limited economic resources and institutional support stymie further action. Small landholdings and financial needs limit some adaptation options (*McDowell and Hess 2012; Hisali et al. 2011*).

Farmers in the dry zone have poor access to credit needed in invest in agricultural inputs, and small income generating activities. To minimize the number of respondents who change farming based on farm input costs, there is a need for innovations such as cash interventions and the provision of agricultural inputs supporting a sustainable microfinance sector with affordable rates in the dry zone. Mitigation and adaptation to climate change for sustainable agriculture need substantial investment (*Huang and Wang 2014*). Job opportunities should be created through investments in small-scale social, economic and environmental infrastructure schemes and support to rural non-farm enterprises through capacity building in entrepreneurship, skills training and product development for alternative livelihood should the climate be not favorable for agriculture.

Correlation Coefficient between Institutional Support Factors and Climate Change Awareness

Relationship between Provision of Farm Machinery by either the Private Sector or DOA and Climate Change Awareness

The provision of farm machinery by either the private sector or the public sector through the Department of Agriculture (DA) is highly but negatively correlated with climate change awareness (**Table 4**). Ten percent of total respondents acquired farm machinery by installment from private sector while 13% got farm machinery supported by DA. It can be concluded that if the number of respondents who received provision of farm machinery by the private sector is lower then, the level of climate change awareness for farm level adaptation tends to be high (**Table 4**).

Results are consistent with *Below et al.* (*2012*) who found that farmers learned about the impacts of climate change from the introduction of improved cropping techniques, such as crop rotation, the use of organic fertilizer and power tillers in climate change adaptation. According to *Bussmann et al.* (*2016*), a stronger agricultural extension service, including know-how transfer related to varieties, application of fertilizers and pesticides as well as easy access to loans and credits for investments in farm level strategies are important conditions for the climate

Table 4. Correlation coefficient of institutional factors and climate change awareness.

Factor	r_s	Significant Level
Provision of Farm machinery by private sector	(-) 0.268**	0.001
Provision of Farm machinery by DoA	(-) 0.300**	0.000
Changes of cropping system depending on agricultural support program	(-) 0.369**	0.000

Trivial association (r_s = 0.01 to 0.09), Weak association (r_s = 0.10 to 0.29), Moderate association (r_s = (0.30 to 0.49), Substantial association (r_s = 0.50 to 0.69), Strong association (r_s = 0.70 to 0.89), Very strong association (0.90 to 0.99), *significant at 5% level (α ≤ 0.05 level), ** significant at 1% level (α ≤ 0.01 level), ns – non significant at 5 % level change adaptation of any farming practice, which can help optimize sowing dates under climate variability. These include limited agricultural extension service, weeds, basic machinery and low input of fertilizers, herbicides and pesticides. Current coping strategies can serve as a base to advance long-term agricultural policies that guarantee sufficient institutional support and create an enabling environment for knowledge transfer and technical solutions.

Effective strategies to promote community resilience in the dry zone area must include capacity building of individuals and communities to make agricultural productivity and household incomes sustainable. Human capacity development should be prioritized for effective farm level adaptation using farm machinery. Well experienced farmers with knowledge in climate change can manage their practices maximizing crop productivity based on paterns in climate variation.

Relationship between Changes in Farming Practices based on Agricultural Support and Climate Change Awareness

The correlation test between changes in farmer-respondents' farming practices based on the availability of agricultural support and climate change awareness show a highly significant difference at 0.01% level (P = 0.000) and the relationship between them is negative with moderate correlation (r_s = - 0.369). It can be deduced that climate change awareness tends to be lower among farmer-respondents who change their farming practices based on agricultural support.

Most farmers in the dry zone change their practices based on commodity prices, farm input costs and agricultural support. This is without considering climate conditions, that is, whether or not weather is favorable for growing a specific crop, which might be due to the poor or lack of knowledge about climate change. While climate change mitigation may not be a main interest of farmers, farm level adaptation will become increasingly important in the future. Adaptation is subject to the awareness of farmers on climate change, the availability of adaptation options and adaptation costs (*Schonhart et al. 2016*). It is therefore important to provide training and capacity building programs that will prepare farmers in coping with or becoming resilient.

Perceived Effects of Climate Change According to Farmer-Respondents Based on Crops Grown

All of 150 respondents, regardless of crops grown answered "yes," when asked if they were experiencing impacts of climate change (**Table 5**). Majority (79%) noted the negative effects of climate change, including pest (95%) and disease (97%) infestations, experience shorter

Table 5. Perceived effects of climate change according to farmer-respondents, by crops grown.

Source of Livelihood	Farmer Category by crops grown						All Farmers (n=150)	
	Culinary Crops (n=78)		Pulses (n=64)		Paddy and Others (n=8)			
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Are you aware of climate change?								
Yes	78	100	64	100	8	100	150	100
No	0	0	0	0	0	0	0	0
Effect of Climate Change								
Positive	1	1	0	0	0	0	1	1
Negative	62	80	53	83	3	38	118	79
Both	15	19	11	17	5	62	31	20
Pest Infestation Experience								
Yes	73	94	62	97	8	100	143	95
No	5	6	2	3	0	0	7	5
Disease Infestation Experience								
Yes	74	95	63	98	8	100	145	97
No	4	5	1	2	0	0	5	3
Length of growing season								
Longer	20	26	8	13	2	25	30	20
Shorter	48	62	50	78	1	13	99	66
Both	10	12	6	9	5	62	21	14
Occurrence of weather pattern								
Increased (Erratic weather pattern)	75	96	63	99	6	75	144	96
Decreased (Erratic weather pattern)	3	4	1	1	2	25	6	4

growing seasons (66%), and increase in erratic occurrence of weather patterns (96%) (**Table 5**).

Generally, there has been a decrease in yield per unit hectare for most of the food crops. Crop pests also reduce crop yield. Frequent occurrence of the crop pests, diseases and weeds is being associated with climate change (*Nkomwa et al. 2014; Yin et al. 2016*). The effects of climate changes are evident in the increase in global average temperature, changes in rainfall pattern and extreme climatic events (*Karuppaiah and Sujayanad 2012*). These seasonal and long term changes affect the fauna, flora and population dynamics of insect pests because microorganisms and insect pests are *r* strategists. The population increases immediately at an exponential rate causing pest infestation on crops if the environment is favorable and declines quickly if otherwise. The abiotic parameters are known to have direct impact on insect population dynamics through modulation of developmental rates, survival, fecundity, voltinism and dispersal.

Cultivated Area of the Four Major Crops in Monywa Township

Monywa Township is characterized by four major crop production zones, namely, irrigated, culinary crop production, chick pea production, and pigeon pea production. A variety of crops such as paddy, wheat, groundnut, sesame, sunflower, butter bean, lablab bean, pepper, and like are grown in these areas. After culinary crops, pulses such as chick pea and pigeon pea are the second dominant crops in the study area.

Varietal selection of three kinds of crops (pigeon pea, chickpea, and groundnut) was conducted in the Dry Zone areas of Sagaing (Monywa), Magwe, and Mandalay from 2007-2008 to 2009-2010 (*Kyi 2011*). Monywa Township is the seed source of Yezin–8 (White chickpea) which is distributed in the different regions of the country. Dry Zone is the main production area for pulses which earn foreign exchange through exports. The cultivated area of pigeon pea, chick pea, and culinary crops (onion and garlic) varied from 2003 to 2013 (**Table 6**).

Effects of Climate Change on the Production of the Four Major Crops

Although climate change is evident based on generated data, the production of chick pea, onion, and garlic has not been affected by the erratic rainfall pattern. This is in the study area (**Figure 6**). Rainfall, the only water source for agriculture in the rainfed areas directly affected crops which were cultivated during rainy season. From secondary data from the DA, area cultivated and production performance of chick pea and culinary crops gradually increased simultaneously with changes in rainfall pattern but the area cultivated to pigeon pea declined in 2007 to 2010 (**Figure 7**).

Farm Level Adaptation

Type and spread of farm level adaptation of the Farmer-respondents

There are five types of farm level adaptation systems employed by the respondents, namely, mono-cropping, intercropping, mix-cropping, crop rotation, and multiple cropping (**Table 7**). The farmer typologies according to crops grown (culinary, pulses, paddy) were further categorized based on different farm level adaptation systems. Seventy-eight percent of culinary crop farmers practiced mono-cropping, followed by those who did crop rotation (12%) and intercropping (10%). Seventy-three percent of pulse growers also engaged in mono-cropping. Nearly three-fourths (72%) of the total respondents planted only one or same crop in their land year after year.

Most (84%) of the mono-crop growers considered their practice as a traditional farming method, while two percent thought that mono-cropping can get much money per harvest time. Five percent answered that mono-cropping can save farm input costs, while nine percent did not answer (**Table 8**). The rest engaged min mono-cropping to save on farm input cost (3%) and get more money during harvest time (2%).

These results are assumed to be attributable to the Government's policy until 2009 where farmers were encouraged to meet the target yields of ten principal crops namely: paddy (5.15 mt ha^{-1}), maize (4.93 mt ha^{-1}), groundnut (1.40 mt ha^{-1}), sesame (1.21 mt ha^{-1}), sunflower (1.79 mt ha^{-1}), black gram (1.61 mt ha^{-1}), green gram (1.61 mt ha^{-1}), pigeon pea (2.02 mt ha^{-1}), sugarcane (74.13 mt ha^{-1}) and long staple cotton (1.61 mt ha^{-1}) (*Myanmar AgricultureService and Current Situation of Some Major Crops 2009*).

Table 6. Cultivated area (000 ha) of the four major crops in Monywa Township.

Years	Pigeon Pea	Chick Pea	Onion	Garlic
2003-04	7.25	6.11	1.82	0.12
2004-05	7.29	6.15	1.84	0.12
2005-06	7.39	6.17	1.95	0.11
2006-07	7.38	6.87	1.98	0.11
2007-08	6.96	6.47	1.94	0.14
2008-09	6.97	7.03	2.00	0.14
2009-10	6.98	7.08	2.16	0.12
2010-11	7.02	7.08	2.17	0.12
2011-12	7.03	7.08	1.82	0.12
2012-13	7.01	9.04	2.22	0.13

Source: Department of Agriculture, 2013

Table 7. Type and spread of farm level adaptation.

Items	Farmer Category by crops grown						All Farmers (n=150)	
	Culinary Crops (n=78)		Pulses (n=64)		Paddy and Others (n=8)			
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Farm level adaptation								
Mono-cropping	55	71	47	73	6	75	108	72
Intercropping	8	10	8	13	0	0	16	11
Mix-Cropping	2	3	2	3	0	0	4	3
Crop Rotation	9	12	7	11	1	13	17	11
Multiple cropping	4	5	0	0	1	13	5	3
Usage of drought tolerant variety or deep water tolerant variety/GMO	0	0	5	8	1	13	6	4
Application of agro-chemicals	78	100	64	100	8	100	150	100
organic agriculture	4	5	13	20	1	13	18	12

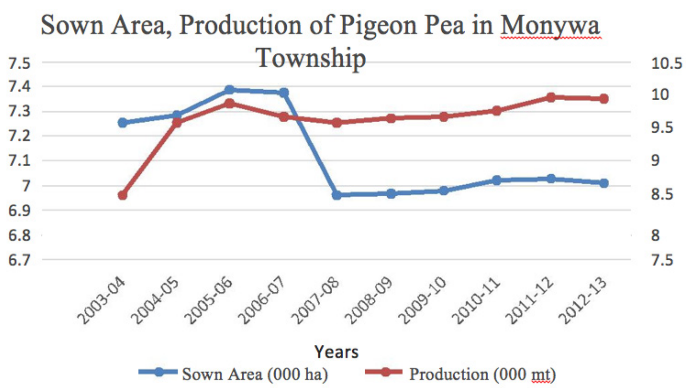

Figure 5. Area cultivated and production performance of Pigeon Pea in Monywa Township.

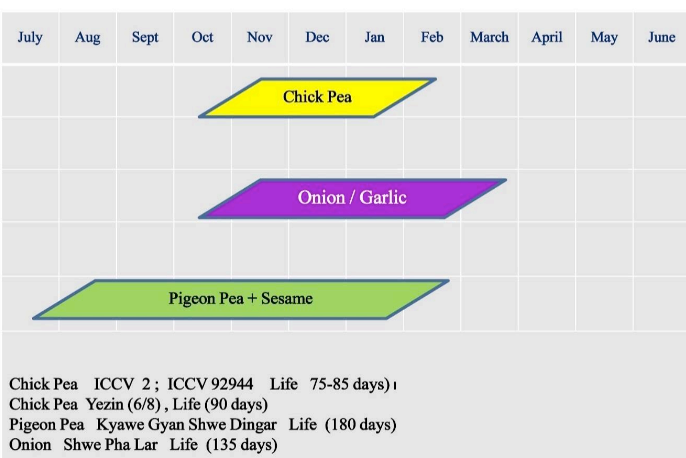

Figure 6. Cropping pattern in Monywa Township, Central Dry Zone, Myanmar.

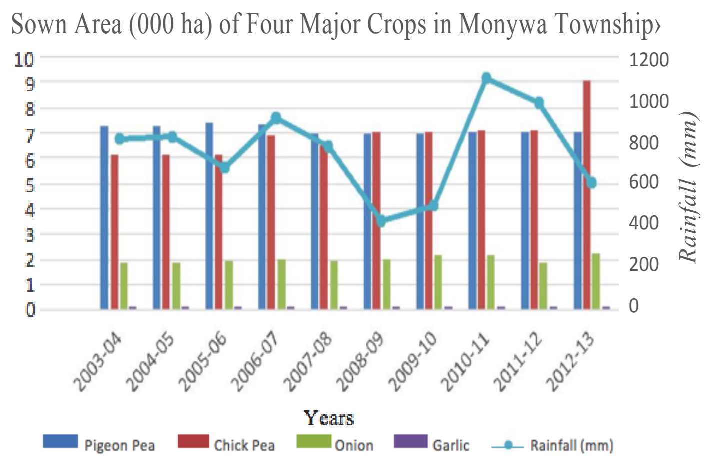

Figure 7. Rainfall pattern and area cultivated (000 ha) of four major crops in Monywa Township.

Table 8. Farmer-respondents' reasons for engaging in monocropping.

Reasons	Frequency	Percent
Traditional farming	91	84
Much income per harvest time	2	2
Low input cost	5	5
No answer	10	9
Total	108	

An initiative of the *Food Security and Agriculture Thematic Group* (*2010*) reported that the government has encouraged farmers to expand new agricultural land by allocating new plots and to diversify by introducing multiple income generating farms such as agroforestry. It also promoted crop rotations, crop diversification to reduce risk in case of the failure of one crop. The government set up program for the improvement of water storage by renovating dams, diverting water from streams and creeks, and lifting water from rivers with the use of pumps have resulted to the efficient utilization of ground water. This is further supplemented by the introduction of high-yield, drought resistant crop varieties the efficient use of fertilizers, community-based compost production, integrated pest and disease management, agricultural mechanization, provision of farm tools and training for repairing farm machinery.

Currently, the farmers start to shift from traditional farming (mono-cropping) to crop diversified farming such as intercropping, mixing cropping, crop rotation and multiple cropping systems. Most (86%) of the respondents engaged in other practices (crop diversification growers) said that they changed their cropping system because of income generation from another crop when they failed in one crop due to the effects of climate change (**Table 9**).

All the farmers surveyed applied agro-chemicals in their farms to improve crop production (**Table 7**). Only 4 percent used improved variety only for example, drought-tolerant. The selection of drought-tolerant genotypes with shorter growing seasons than the present genotypes is another adaptation measure that should be considered to alleviate the adverse impacts of climate change (*Bakri et al. 2010*). Meanwhile, 12 percent of the respondents went into organic farming because of the input costs.

Table 9. Farmer-respondents' reasons for engaging in other farming practices.

Items	Frequency	Percent
Income generation	36	86
Soil fertility	4	10
No answer	2	4
Total	42	

SUMMARY AND CONCLUSION

The increase in awareness of the climate chage phenomenon is of paramount importancefor farmers in the Dry Zone area to be able toimprove farm level adaptation strategies.

Among the farmers' socio and demographic characteristics only gender was found to be significantly correlated with climate change awareness. The other variables, like education, number of family members who completed schooling, farmer experience, cultivated area and crop yield performance, and annual family income were not found to be major influencing factors.

In terms of the institutional factors, the provision of farm machinery either by DA or the private sector was highly but negatively correlated in awareness on climate change. Changing of te cropping system based on farm input costs and agricultural support from the private or government sector were major factors influencing climate change awareness.

Seventy nine percent of farmer-respondents noted that the negative impacts of climate change on agricultural productivity manifest in the heavy infestation of pests and diseases, shorter growing season and increase erratic rainfall pattern. Climate change (erratic rainfall pattern) directly affected crops cultivated in the rainy season.

Farmer-respondents had different types of farm level adaptation systems, namely mono-cropping, intercropping mix-cropping crop rotation and multiple cropping. Nearly three-fourths of the farmers started to shift from traditional farming (mono-cropping) to diversified crop farming such as intercropping, mixing cropping, crop rotation and multiple cropping system because of the perceived increase in income generation (from another crop) due to the effect of training programs.

The development and application of relatively simple and reliable methods for assessing the impacts of climate change and adaptation strategies at the farm level are still demanded to provide timely recommendations for alternative technologies and policies.

REFERENCES

Asian Development Bank (ADB). 2009. Building climate resilience in the agriculture sector in Asia and the Pacific. Mandaluyong City, Philippines.

An Initiative of the Food Security and Agriculture Thematic Group. 2010. Framework for Action for the Central Dry Zone, United Nations in Myanmar.

Bryan, E., R. Claudia, O. Barrack, R. Carla, S. Silvia and H. Mario. 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinants, *Journal of Environmental Management* 114: 26-35

Bakri, J. A., A. Suleiman, F. Abdulla and J. Ayad. 2010. Potential impact of climate change on rainfed agriculture of a semi-arid basin in Jordan, *Journal of Physics and Chemistry of the Earth* 35: 125-134

Bussman, A., A.E. Nadir, F. Manar, and R. Lars. 2016. Sowing date determinants for Sahelian rainfed agriculture in the context of agricultural policies and water management, *Journal of Land Use Policy*, 52: 316-328

Bale, J. 2002.Herbivory in global climate research: Direct effects of rising temperature on insect herbivores. *Global Change Biol*. 8: 1–16.

Batisani, N. and Y. Brent. 2010. Rainfall variability and trends in semi-arid Botswana: Implications for climate change adaptation policy. *Applied Geography*, 30: 483-489.

Below, T.B., K. D. Mutabazi, D. Kirschke, C. Franke, S. Sieber, R. Siebert, and K. Tscherning 2012. Can farmers' adaptation toclimate change be explained by socio-economic household-level variables? *Global Environmental Change*, 22: 223-235.

Bryan, E., R. Claudia, O. Barrack, R. Carla, S. Silvia and H. Mario. 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinants, Journal of Environmental Management 114: 26-35Bierbaum, R., J.P. Holdren, M. Maccaren, R.H. Moss, and P.H. Raven. 2007. Confronting climate change: Avoiding the unmanageable and managing the unavoidable. US: United Nations Foundation and Sigma Xi.

Chhetri, N., P. Chaudary, P. R. Tiwari and R. B. Yadaw. 2012. Institutional and technological innovation: Understanding agricultural adaptation to climate change in Nepal. *Journal of Applied Geography*, 33: 142 -150.

Cooper, P.J.M., J. Dimes, K.P.C. Rao, B. Shapiro, B. Shiferaw and S. Twomlow. 2008. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Journal of Agriculture, Ecosystems and Environment*, 126: 24-35.

Dejene, A. 1989. The training and visit agriculture in rainfed agriculture: Lessons from Ethiopia, *Journal of World Development*, 17 (10): 1647-1659.

Esteve, P., V.O. Consuelo, B. G. Irene and E. D. Thomas. 2015. A hydro-economic model for the assessment of climate change impacts and adaptation in irrigated agriculture. *Journal of Ecological Economics*, 120: 49-58

FAO. 2007. Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities. Rome, Italy: Food and Agriculture Organization of the United Nations.

Dumenu, W. K. and A. O. Elizabeth. 2016. Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications, *Journal of Enviornmental Science and Policy* 55: 208-217

Finlay, K.J., and J.E. Luck. 2011. Response of the bird cherry-oat aphid (Rhopalosiphumpadi) to climate change in relation to its pest status, vectoring potential and function in a crop–vector–virus pathosystem. *Journal ofAgriculture, Ecosystems and Environment*, 144: 405–421.

Francis, A. 1986a.Future perspectives of multiple cropping. In: Francis, A. (Ed.), Multiple Cropping System. New York: MacMillan Publishing Co.

Goh, A. H. X. 2012. A Literature review of the gender-differentiated impacts of climate change on women's and men's assets and well-being in developing countries. Collective Action and Property Rights (CAPRi). USA: University of Maryland

Gohar, A.A and A. Cashman 2016. A methodology to assess the impact of climate variability and change on water resources, food security and economic welfare, *Journal of Agricultural Systems*. 147: 51-64

Hammer, G.L., J.W. Hansen, J.G. Phillips, J.W. Mjelde, H. Hill, A. Love and A. Potgieter. 2001. Advances in application of climate prediction in agriculture. *Agric. Syst*. 70, 515–553.

Hisali, E., P. Birungi and F. Buyinza. 2011. Adaptation to climate change in Uganda:evidence from micro level data. *Global Environmental Change* 21, 1245-1261

Huang, J.K. and Y.J. Wang. 2014. Financing Sustainable Agriculture Under Climate Change, *Journal of Integrative Agriculture*, 13(4):698-712

IPCC. 2007. Summary for policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (Eds.)]. UK: Cambridge University Press.

Karuppaiah, V. and G.K. Sujayanad. 2012. Impact of climatechange on population dynamics of insect pests, *Journal of Agricultural Sciences 8* (3):240-246.

Kumar, P., R.K. Nanwal, A.S. Dhindwal, and S.K. Yadav. 2012. Cropping systems and sustainable agriculture, Department of Agriculture, CCS Haryana Agricultural University

Kyi, T. D. 2011. Assessment on vulnerability and risk for climate change adaptation of rural farmers in central dry zone of Myanmar, Farm level case study, Department of Agricultural Planning, Myanmar.

McDowell, J.Z AND J. J. Hess, 2012. Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate, *Journal of Global Environmental Change*, 22: 342-352

Ministry of Agriculture and Irrigation, 2015, Myanmar Climate-Smart Agriculture Strategy, Myanmar

Ministry of Agriculture and Irrigation. 2013. Settlement and Land Records Department, Myanmar.

Mercer, K.L., H.R. Perales and J.D. Wainwright. 2012. Climate change and the transgenic adaptation strategy: Smallholder livelihoods, climate justice, and maize landraces in Mexico. *Global Environmental Change*, 22: 495-504.

Ministry of Forestry. 2011. Proposal for addressing climate change risk on water resources and food security in the Dry Zone of MyanmarMinistry of Agriculture and Irrigation. 2009. Myanmar agriculture service and current situation of some major crops, Myanmar.

Nkomwa, E.C., M. K. Joshua., C. Ngongondo, M. Monjerezi and F. Chipungu. 2014. Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka village, Chikhwawa, Southern Malawi, *Journal of Physics and Chemistry of the Earth* 67-69: 164-172

Norman M.J.T., C.J. Pearson, and P.G.E. Searle. 1995. The ecology of tropical food crops. UK: Cambridge University Press

Paustian, K., J.M. Antle, J. Sheehan, and E.A. Paul. 2006. Agriculture's rol e in greenhouse gas mitigation. Arlington, VA: Pew Center on Global Climate Change.

Porter, J.H., M.L. Parry and T.R. Carter. 1991. The potential effects of climatic change on agricultural insect pests. *Journal of Agriculture and Forestry Meteorology*, 57: 221-240.

Schonhart, M., T. Schauppenlehner, M. Kuttner, M. Kirchner and E. Schmid. 2016. Climate Change impacts on farm production, landscape appearance and the environment: Policy scenario results from an integrated field-farm-landscape model in Austria. *Journal of agricultural Systems,* 145: 39-50

UNDP. 2011. Report of addressing climate change risks on water resources and food security in Dry Zone of Myanmar. United Nations Development Programme.

WFP. 2009. Food security assessment in Magway Division. Vulnerability Analysis and Mapping Unit, Yangon. World Food Programme. Retrieved from http://home.wfp.org/stellent/ groups/public/documents/ena/ wfp215 466.pdf.

Yin, X., J. E. Olesen, M. Wang, I. Ozturk, H. Zhang and F. Chen. 2016. Impacts and Adaptation of the cropping systems to climate change in the Northeast Farming Region of China, *European Journal of Agronomy* 78: 60-72

http://www.wisegeek.com/what-is-crop-rotation.htm

ACKNOWLEDGMENT

This research was funded by the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (DAAD-SEARCA) at the University of the Philippines Los Banos, College, Laguna, Philippines. The authors would like to thank the farmers who take part in the survey.