Climate Change and Agricultural Adaptation in Indonesia

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Abstract. This research strives to provide answers regarding adaptation patterns of farmers in confronting climate change in Indonesia. The method utilized for this research is a mixed methods. Qualitative data was acquired through a series of focus group discussions and in-depth interviews with farmers and agricultural stakeholders in Gunung Kidul and Sleman, Indonesia. Additionally, the survey was carried out to 220 farmers in both research locations. The two research locations were chosen based on the difference in agricultural land. The findings of this research show that farmers understand climate change is occurring in their region and it influences their cultivation method. Farmers utilize their personal experiences as well as local practices in adapting to climate change. The impact most felt by farmers is crop failure and a decrease in quality and quantity of agricultural crops. The ensuing implication is that farmer's income declines more and more. This research found that agricultural product cost increased by almost as much as 50%, whilst farmer's income merely increased half of that, which is 25% since climate change has affected their farming. Responding to the matter, the strategy farmers employ is by changing the planting pattern, using soil cultivation technique, plant pest management technique, and watering/ irrigation technique.

Keywords: adaptation, climate change, agriculture

Introduction

Increased intensity and frequency of storms, drought, and flooding altered hydrological cycles, and precipitation variance have implications for future food availability. The potential impacts on rainfed agriculture and irrigated systems are still not well understood. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts. Future climate change is one of the defining challenges today along with poverty alleviation, environmental degradation, and food security. It is widely known that an increasing variation in climate change has significant impacts on agriculture and the environment. Scientists assume that the enhanced greenhouse effect could intensify climate variability, particularly for the agricultural sector. The changes in temperature and rainfall could significantly affect production of agricultural farms, management of crop and livestock such as seedling dates, crop variety choices, pests and diseases and water (Murad, Molla, Mokhtar & Raquib, 2010).

A study conducted by Manne, Mendelsohn, & Richels (1995) classified damages to vary between market and nonmarket damages. Market damages includes the primary sector, another sector, loss of property and natural disaster, while nonmarket damages (ecological) covers bio-diversity, human wellbeing and natural disaster (Figure1). The impact of climate change is especially affecting farming com munities in both developing and developed countries in which farm in ecologically fragile zones and which rely directly on their immediate environments for subsistence and livelihood (UNFCCC, 2004). The

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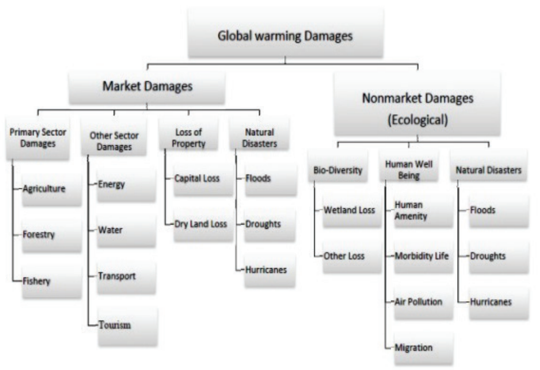

Figure 1. Overview of Global Warming Damages

Source: (Manne et al., 1995)

productivity of agriculture can be affected by climate change in two ways; first, changes in temperature, precipitation and CO2 levels. The latter affecting crop productivity. Second, through changes in soil quality, distribution and frequency of infestation by pests, diseases, insects, and weeds (Sarina and Bhupendra, 2009).

According to FAO (2007) climate change impacts can be roughly divided into biophysical impacts and socio-economics impacts. Biophysical impacts vary from physiological effects on crops, pasture, forests and livestock (quantity and quality); changes in land, soil and water resources (quantity and quality); increased weed and pest challenges; shifts in spatial and temporal distribution of impacts; sea level rise, changes in ocean salinity; sea temperature rise causing fish to inhabit different ranges. At the same time socio-economic impacts can be seen from decline in yields and production; reduced marginal GDP from agriculture; fluctuations in world market prices; changes in geographical distribution of trade regimes; increased number of people at risk of hunger and food insecurity; and migration and civil unrest.

FAO conducted studies from many countries in the world about the impact of climate change in the agricultural sector. The studies showed that the impact may differ from one country to others. For Europe, the Former Soviet Union and Centrally Planned China for instance, impacts could be mostly positive. Concerning the adaptation scenario, Tol et al. comment that former studies often assumed "limited capacities of farmers to adapt to changing circumstances" (Tol 2002, p. 52). Another place such as in Africa, the estimate is that 25–42 percent of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which include indigenous foods and plant- based medicines (McClean, Colin et al., 2005).

In developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural GDP (FAO Committee on Food Security, Report of 31st Session, 2005). Agriculture in developing countries contributes as the main source of food, creates livelihoods, and generates income. However, on the other hand agriculture also instigate vulnerability and marginalized communities (Jafry, 2012). The current impact of climate change and shifting of the global economy are bringing about significant changes in agricultural production and system. Climate change and variability is predicted to have the potential to impose pressures on availability, accessibility and demand of water for agriculture. Al Gamal, Sokona & Abdel-Kader (2009) studied that climate change is likely to have an impact on groundwater resources affecting groundwater quantity and quality. Rapid climate change could harm agriculture, especially those that are already suffering from poor soil and climate conditions. Therefore, it will affect the life of farmers to be more impoverished and vulnerable than the previous years.

The increase of Surface Air Temperature (SAT) is seen as the main climate change issue caused by the anthropogenically driven increase of CO2 and other greenhouse gas emissions. Results of observed monthly SAT in Indonesia over a period of 100 years show that a certain degree of climate change has occurred in Indonesia. The data that have been collected from the limited number of stations suggest that a temperature increase of around 0.5ºC has occurred during the 20th century. This magnitude of temperature increase is in agreement with the rate of averaged global temperature increase as estimated in IPCC AR-4, which is about 0.7ºC ± 0.2 per century (Suroso, Hadi, & Salim, 2009). Indonesia's agricultural sector has succeeded in increasing rice production during the last three years, with a rate of about 5.2% per year. However, impacts of climate change should be considered seriously because climate change is foreseen to directly or indirectly reduce agricultural food production. The climate change impact on

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agriculture is highly dependent on the locally specific context and hence its vulnerability. Global warming will potentially alter water vapor flux and may increase humidity, hence more intensive rainfall in one area. However, projected rainfall change shows that precipitation will be more concentrated during the wet season, while the dry season tends to be dryer. The decrease in food production due to rainfall change in 2050 compared to current condition is predicted to be as follows: rice (-4.6%), maize (-20%), soy (-65.2%), sugar (-17.1%) and palm oil (-21.4%) (Suroso et al., 2009).

Based on existing research, the impacts of climate change in Indonesian agriculture can be seen from the fact that roots and stems of the 30–40-days-old maize decayed. Their leaves turned yellow, as did paddy leaves. Other crops, such as chili, were also badly affected (Winarto & Stigter, 2011). These surprising facts were examples of real risks resulting from an increase of climate variability and climate-related extreme events as consequences of climate change.

In climate change debate, lack of analysis and research adaptation is quite evident. A definitive shift towards more adaptation research is necessary as there is increasing scientific realization that mitigation policies cannot protect the society from the environmental impacts of climate change in the foreseeable future (Tompkins & Neil Adger, 2005). This present study explored adaptation and coping strategies of the agricultural system in Indonesia. The overall objective of this study is to assess the vulnerability of farmers' communities in Sleman and Gunung Kidul, Yogyakarta Indonesia to climate change and also to understand the adaptation strategies taken to mitigate climate-induced change on agriculture.

Research Methods

The current study uses a mixed method approach, employing qualitative and quantitative research methods. Information related to the literature identified key of agricultural adaptation strategy to climate change was collected through the survey, in-depth and semi-structured interview, and also focus group discussion (FGD). The locations of this research were selected from two different places which are Sleman Regency (Prambanan and Moyudan subdistricts) and Gunung Kidul Regency (Saptosari and Ponjong), Yogyakarta, Indonesia. These two regions possess differing characteristic. Most of the agriculture lands in Sleman are technical irrigation land with flatlands geographical feature. As for Gunungkidul Regency, its agriculture land is dominated by rain fed farmlands with the geographic feature of a hilly dry rain fed karst ecosystem. The differing characteristic of the two regions was able to provide a varied adaptation pattern of farmers in confronting climate change. The characteristic of farmers in this research is presented in Table 1. In this research, the status of farmers' land ownership is that most farmers own the land and cultivate their own lands, only a few farmers in Gunungkidul are farmers who are not workers (2.8%) and farmers who work on other's land as much as 10.81% in Sleman.

Table 1
Status of Land Ownership

	Gunung Kidul	Sleman
Owner farmer non worker	2.8	15.32
Owner farmer and worker of own farmland	61.1	59.46
Owner farmer and worker of own and other's farmland	8.3	14.41
Farmer worker of other's Farmland	27.8	10.81

Mixed method research was, therefore, applied in this study because it aims to fill the gap between quantitative and qualitative methods. Mixed method research also increases the reliability and validity of the case study. By using this approach, the researcher aims to match the qualitative methods employed with the quantitative methods in order to combine the analysis into dichotomous categories, that is, exploration versus confirmation (Howe, 2004 :49). Qualitative data were gathered through in-depth and semi-structured interview with 40-key informants who were classified into eight groups. The groups of informants were the representatives of local government, heads of sub-districts, farmers, on-field counselling officers, *Gapoktan* (Farmer Groups Collective) organizers, retailers and distributors of fertilizers, brokers, and organizers of women farmers. FGD was conducted for three rounds that represent the group of government, farmers and agricultural stakeholder in each location.

Quantitative data were collected from

a survey to 110 farmers for each location. The total number of farmers surveyed was 220 individuals. The survey conducted used a purposive sample method called judgmental sampling in which the researcher selects participants who have knowledge and expertise in the area on which the research focuses (Creswell, 1994). The farmers chosen were from the two differing types of agriculture i.e. technical irrigation agricultural area and rainfed agricultural area. The survey was intended to support the findings of the qualitative data as well as to provide balancing information from the farmers as the target for the local government's policy.

Research Areas: Sleman Regency

Sleman Regency Area is spread out from 110 ° 13′ 00″ until 110° 33′ 00″ Eastern Longitude, and from 7° 34′51″ until 7° 47′03″ Southern Latitude, with the altitude between 100 – 2.500 meter above the sea level. The south area is a fertile lowland area, while the north area is a mostly dry land area of unirrigated agricultural fields and yards, and it also has slope surface to the south with the northern most area bordering with Mount Merapi. Based on Meteorological, Climatological and Geophysical Agency data, the average rainy days in a month is 24 days. The highest average rainfall is 699.0 mm. Maximum wind speed is 10.8 m/s and the minimum one is 0.00 m/s, while the highest average nisby humidity is 100.0 % and the lowest one is 19.9 %. The air temperature, the highest is 34.4 0C and the lowest is 16.4 0C. Production of wet rice fields and dry ones in Sleman Regency in 2012 is 312,815 tons (in the form of milled dry rice). Compared with that of 2011, it saw an increase of 34.42 percent with production of 232,715 tons. Sleman Regency's regional development potential as an agricultural area covers wet agricultural land areas (21,113 hectares) and dry agricultural land areas (9,117 hectares) spread throughout 17 districts.

In the implementation of food security, compared to 2012, food availability in 2013 experienced a decrease in paddy land productivity due to the presence of plant pests (OPT – *Organisme Pengganggu Tumbuhan*) particularly rats, stemborer moth, and rice blast disease. In 2013, the productivity of paddy and other food sources were as much as 6.272 tons/ha. This is a decrease when compared to 2012. Prambanan and Moyudan Districts are areas of eastern Sleman which are one of the pillars in paddy productions in Yogyakarta Special Region (DIY). Different to the areas of western Sleman which plants paddy for 3 seasonal cycles in a year, the eastern area farmers plant paddy twice, and *palawija* (secondary crop).

Gunung Kidul Regency

Geographically, Gunung Kidul regency is located between 7° 46′ – 8° 09′ south latitude and 110° 21′- 110° 50′ east longitude. Meanwhile, its altitude varies between 0-700 meters above sea surface. The amount of rainfall in this area is 2100.14 mm and 88.87 of rain days per year. In 2002, a large portion of paddy production was not from wetland paddy. This contributed to about 71.17 percent of the whole production of paddy, which was 291,696 tons, or was about 204,689 tons. Most of the agriculture occurring in Gunungkidul Regency is rain-fed dry lands (± 90 %) which is dependent on the climate cycle particularly rainfall. The farmlands have relatively narrow irrigation and most of them are rain fed. Mining resources included in the C category are available, such as limestone, pumice, calcite, zeolite, bentonite, trass, caoline, and quartz sand.

The extent of land ownership to farmers in Gunungkidul Regency, based on the 2013 census, is generally limited, i.e. as much as 23,153 households (13.92%) with a cultivation spread of less than 0.1 Ha, as much as 35,997 households (21.64%) with spread of 0.1 - < 0.2 ha, as much as 66,332 households (39.88%) with spread of 0.2 -< 0.5 ha, as much as 30,503 households (18.34%) with spread of 0.5 - <1.0 ha, as much as 8,783 households (5.28%) with spread of 1.0 -< 2 ha, as much as 1,131 households (0.68%) with spread of 2.0 -< 3 ha, and as much as 432 households (0.26%) with spread of >3,0 ha. Compared to the 2003 census results, there was an average drop of the extent of land ownership as much as 4.51%. This decrease is seen sequentially in landownership of 2.0 -< 3 ha which declined 43.56%, more than 3.0 ha declined 39.41%, spread of 0.1 - < 2 ha declined 30.58%, landownership of 0.5 -< 1.0 ha declined 23.25%. Therefore, in its entirety the average landownership had decreased by 4.51%. Regarding the comparison between subsistence/smallholder farmers and non-subsistence/substantial farmers was 75.43%: 24.57%. The agricultural commodity which became the superior item in Gunungkidul Regency in 2013 one of them was food crops.

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In 2012, most of the paddy production in Gunungkidul Regency was produced from a dryland paddy variety. This variety of paddy contributed as much as 70.17% of the entire paddy production which was recorded as 291,696 ton or approximately 204,689 ton. Meanwhile, the rest was produced from wetland paddy.

Climate Change and Adaptive Capability

Inter-governmental Panel on Climate Change (IPCC) defines climate change as any significant change in climate over time whether due to natural variability or as a result of human activity (IPCC, 2007c). The response of natural climate to changes in the production patterns, socio-economic and demographic patterns and alternate technologies cannot be easily ascertained. Thus, it is likely that some impacts are inevitable, so it has become imperative to incorporate adaptation actions along with mitigation initiatives (Frankhauser & Tol, 1996).

Climate change is a global phenomenon while adaptation is largely site specific (Choudri, Al-Busaidi, & Ahmed, 2013). Related to this matter, IPCC defined climate change adaptation as the adjustment in the natural or the human systems in response to climatic stimulus or its effect (actual or expected), which reduces the harmful effect or exploits beneficial opportunities (IPCC,2007a). Intentional efforts and changes are important in our existing community to defend it from negative impacts of climate change (Stehr & Storch, 2005). Adaptation options include both enhancing the ability of individuals, organizations, communities or government to adapt to climate change effects and transformation of the capacity into action by implementing adaptation decisions (Tompkins & Neil Adger, 2005). The nature of the adaptive action will depend on the level of threat from a particular climatic impact on the local environment and the inherent adaptive capacity of the actor. Anticipated impacts are a function of locational attribute and adaptive capacity is a function of the socio-economic capacity. Adger et al. (2003) have emphasized that all communities are fundamentally adaptive and there are many conditions in the past that indicated communities have adapted to changes in climate and risks. Therefore, adaptive capacity is defined as the ability of a system to adjust to climate change in order to take advantage of opportunities or to cope with the consequences brought about by the change (IPCC, 2001). Adaptive capacity is also synonymous with a number of concepts such as adaptability, coping ability, management capacity, stability, flexibility, and resilience. Therefore the forces that influence the ability of the system to adapt are the drivers or determinants of adaptive capacity (Smit & Wandel, 2006).

Agricultural Vulnerability

One of the chief concerns commonly associated with climate change is a vulnerability. A vulnerability has a complex relationship with this occurring climate variability, such that it encompasses an extensive range of areas and involves a number of factors. To have a better grasp at the concept, this section will first investigate the different definitions that identify vulnerability and later on examine the issues surrounding it. the United Nations International Strategy for Disaster Reduction (UNISDR) views vulnerability as the characteristics of a community, including the physical, social, economic and environmental factors that make it susceptible to the damaging effects of a hazard. Vulnerability, it maintains varies significantly within a community and over time as a result of the varied characteristics of individuals and households. Applied to the more specific issue of climate change, the IPCC defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability as a result of its adaptive capacity (Parry et.al., 2007, p. 783). In this respect, the IPCC relates vulnerability to both the exposure and the adaptive capacity of communities to environmental hazards.

The direct and indirect effects of climate change on agriculture will influence agriculture sustainability such as the necessity of human food, feed, and fiber needs, and contribute to biofuel needs; environmental quality and the resources base; economic viability of agriculture; and the quality of life for farmers, farm workers, and society as a whole. Vulnerability and adaptive capacity are characteristics of human and natural systems, are dynamic and multi-dimensional, and are influenced by complex interactions among social, economic, and environmental factors (Adger et al. 2007). The vulnerability of a system is a function of the exposure and the sensitivity of the system to hazardous conditions mediated by the ability of the system to cope, adapt or recover from the effects of those conditions, i.e., the adaptive capacity or resilience of the system (Smit and Wandel, 2006). Because agricultural systems are human-dominated ecosystems, the vulnerability of agriculture to climatic change is strongly dependent not just on the biophysical effects of climate change but also on the responses taken by humans to moderate those effects (Marshall 2010). Adaptive decisions are shaped by the operating context within which decision making occurs (for example, existing natural resource quality and non-climate stressors, and government policy and programs), access to effective adaptation options, and the individual capability to take adaptive action.

Result and Discussion

Climate change phenomenon occurrs throughout Indonesia. Rainy seasons on the islands of Java, for example, start later and stop earlier, while the amount of rain remains roughly the same, resulting in higher rainfall intensities. Indonesia is highly vulnerable to climate change and as a developing country with agrarian society, Indonesia is very dependent on natural resources and the agricultural sector. Agriculture is of utmost importance in Indonesia, not only because most of Indonesia population are farmers by profession, but also because agriculture is the defining sector in realizing food security. However, the development of the agricultural sector is very behind in comparison to other sectors due to lack of human resource, the magnitude of land conversion, and this is made even worse with the advent of climate change.

Table 2
Knowledge on Climate Change

Topic	GK	Sleman
Knows about climate change	65.4	65.8
Climate consideration originating from local customs	38.9	81.1
Experiences climate change	74.8	83.3
Currently rainy season is longer	52.8	59.5
Rainfall and intensity is high	37	36
Temperature conditions are hotter	59.3	46.8
Wind conditions are stronger	44.4	51.8
Climate change felt in the last 3-4 years	78.1	65.1
Clim a te change affects farming activities	63.6	73.9

The survey conducted on 220 farmers in Sleman and Gunungkidul, Indonesia found that farmers are aware and have experienced climate change (Table 2). The most significant change experienced by farmers was longer rainy seasons indicated by the high intensity of rainfall. Additionally, most farmers also felt current temperature conditions are hotter and wind conditions are stronger. The change in weather and climate has been felt by farmers in the last 3-4 years. More than 60% of the farmers participating in the survey admitted that climate change highly influences farming activities.

Table 3
Climate-Source Information for Farmers

Source	Gunung Kidul	Sleman
Sub-District officials	10.2	32.7
Training	3.7	2
Mass Media	21.3	27.7

This research also found that both farmers in Gunungkidul and Sleman acquired information regarding climate from the mass media and a small portion of them obtained it from training conducted by the regional administration (Table 3). The remaining portion acquired knowledge on climate and climate change based on personal experience and local practices which have been adopted in their culture, as stated by Crate and Nuttall (2009, p. 12) that climate change is ultimately about culture. In addition to that, farmers can rely on their memories and recent experience to develop their expectations of the future, and this shapes their knowledge of climate phenomena and their understanding of climate information (Roncoli, Ingram, Jost, Kirshen, & Orlove, 2003, p. 181). The farmer's knowledge regarding the climate is called pranata mangsa (literally: season provisions). Many Javanese farmers know about pranata mangsa, a worldview based on the Javanese lunar cyclical calendar (the position of stars). The Gunung Kidul and Sleman farmers depend on this cosmology, as well as observations of the environment, to work out their planting schedule. However, these farmers are now

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confused and worried that the guidance they receive from pranata mangsa and local observations, built up over time, is no longer of much use. Observations that used to indicate the start of the rainy season are, for example, falling leaves, singing birds or noisy insects. Another example is regarding rain that usually came in mongso enem (sixth season), now it often changes and influences the cropping system. Villagers view this situation as a man-made disaster caused by greed. These bizarre weather conditions from 2005–2015, which were not in line with farmers' local cosmology (*pranata mangsa*) in crop farming, left them confused and unsure of the appropriate actions to take. Therefore, as soon as the farmers realized that they were experiencing a prolonged drought or on the contrary, a prolonged wet period, they would either fear the risks to their crops or feel grateful for the new opportunities they would get. Yet, the latter could imply consequences beyond their knowledge and create risks more severe than previous years.

Table 4
Climate Change Impact to Agriculture

Impacts	GunungKidul	Sleman
Crop Failure	28	31.4
Decline in quality	31.7	24.5
Decline in quantity	40.2	44.1

The most significant impacts of climate change on the agricultural sector felt by farmers are crop failure and the declining product of in both quality and quantity (Table 4). The cause of crop failure as well as decline in quality and quantity is afforded to the rise of several plant diseases. Farmers in both research areas admitted that the highly unpredictable climate change wherein the dry seasons are long and the rainy seasons are short and vice versa causes the appearance of numerous types of plant diseases. An instance of local diseases which appeared due to climate change among others is wungkul and dengkluk (a type of fungus). This fungus causes paddy stem to become brittle and stops the paddy seed from appearing. The destruction of plants leads to a reduction in crop productivity. In addition to pest-induced crop damages, farmers also have difficulty in determining the type of pest control substances to use since the existing pesticides often bring about the negative impact to fertility of agricultural land. Moreover, the population of rodents has also increased and they consume paddy that is ready for harvest.

The decline in quality and quantity of agricultural yield ultimately affects the decline of farmer's income. In this research, it is found that between the periods of 2005 –2015, there has been an increase in the rate of agricultural production by 32.4% with an increase in the cost of production by 42.8%, however, the income of farmers merely rose only by 25%. This condition contributes to the view that farmer as a profession is no longer considered profitable particularly to the younger generation. This condition is clearly illustrated by Ellis (2000) in a book titled Rural Livelihoods and Diversity in Developing Countries. Ellis emphasized that due to the fact that the farming conditions is no longer profitable, smallholder and subsistence farmers often practice in off-farm employment such as working in informal sector as well as crop and livestock production to fulfill their cash and direct food requirements. Farmers in Gunungkidul and Sleman are always holding side employments as a coolie, carpenter or merchant when the harvest season ends and planting season hasn't started due to a delayed rainy season. Furthermore, the type of agricultural ownership in areas of research is usually smallholder agriculture. Smallholder agriculture is used generally to describe rural producers who farm using mainly family labor and for whom the farm provides the principal source of income (Cornish, 1998). Climate change and its implication on agriculture have been proven to marginalize farmers. This is in tune to the study conducted by Matarira *et al*. that agricultural and rural livelihood vulnerability is a function of exposure to a climatic stress and livelihood capital (Matarira, Pullanikkatil, Kaseke, Shava, & Mantsa, 2013).

Adaptation Strategies

This survey also revealed that farmers have carried out adaptation strategies in order to overcome the issue of climate change, such as always considering the weather factor to determine and alter the time of planting. In accordance with climate change, farmers have also conducted changes in planting patterns, soil cultivation techniques, plant pest control (OPT), and watering techniques due to the limited water supply for agriculture (Table 5).

The survey results acquired were

also supported by a series of discussions conducted by farmers from both locations and stakeholders in the agricultural sector. It is found in the research that farmers currently could no longer depend on weather forecast based on local wisdom or what is known as *Pranata Mangsa*.

Table 5
Agriculture Adaptation to Climate Change

Form of Adaptation	GunungKidul	Sleman
Always taking weather factors into considerations during planting time	45.8	60.2
Farmers changing planting time	41.7	62.2
Current climate conditions affecting water supply for agriculture	65.7	63.6
Changing planting pattern	26.9	28.8
Changing soil cultivation pattern	18.5	28.8
Changing plant pest control technique	15.7	24.3
Changing watering technique	20.4	19.8

Therefore, what they could do is carry out adaptation strategies to climate change. Based on community experiences in the study location, farmers have survived by adopting a variety of strategies: Firstly, the use of the Planting Technique**.** The planting technique developed by farmers is *legowo* row planting 2-1, and 4-1. According to farmers, this technique is believed to yield better crop results. For drylands, the planting technique developed is *Tabela* (direct seeding). This technique can be carried out without having to wait for seeding period wherein the seeds are directly sowed. By using the *tabela* method the planting period can be shortened and consequently quicken the paddy harvesting process. Additionally, farmers also employ terracing technique on the mountain slopes. The goal is to prevent soil erosion and maintain soil fertility. Terracing can increase the productivity of land and crops. The farmers also plant fodder grass as land cover to prevent erosion. In the Prambanan sub-district for example, the planting technique used is simultaneous planting. It could be simultaneously on one spread of land. The type of crop planted is also the same. So, during paddy planting period, everyone plants paddy, while during the *palawija* planting period, everyone plants *palawija*. Furthermore, in the Prambanan region, the pattern is not constantly paddy planting since the planting of *palawija* could break the pest cycle.It is this planting pattern/cycle which does not continually plant paddy that leads Prambanan Sub district to have relatively fewer pests than other regions.

Moreover, a novel technique employed by farmers to shorten the planting period is the *Tabela* or direct seeding technique. What differentiates it from conventional planting technique is that this technique directly spreads seeds in an agricultural land without the need to plant seeds in another location and subsequently move it to cultivated land after a few days. The Tabela technique could save approximately one week time and there are also more seedlings produced from the seeds sowed, it also saves labor cost for planting work which must be spent by farmers.

Secondly, the Type of Seed. In adapting to climate change which affects water supply and causes the prevalence of various pests, farmers have also made adjustments in the type of seeds used. The type of seed used for dry agricultural land is bagendit or ciherang, while the variety used is inpari.

Thirdly, Fertilizer. The fertilizers used by farmers in the Prambanan Regency are nonorganic fertilizers such as urea, NPK and Za; and organic fertilizers originating from animal waste. The government is actually encouraging farmers to switch to organic fertilizers due to considerations of soil ecological system sustainability.

Fourthly, Water Usage. The scarcity of water experienced by Gunungkidul farmers leads to a once a year paddy harvest period. After paddy harvest, the lands are planted with choy sum, spinach, cassava and chili peppers which relatively use little water. The scarcity of water is addressed by using embung or angkruk, in addition to conducting coordinative actions along with regional government institution in charge of water and irrigation management as well as utilizing available water in the dam. Farmers also create rain water storage tanks to maintain water availability.

Fifthly, Plant Pest. The most confronted plant pest due to climate change is rodents. Their population increase caused a lot of crops on agricultural lands being devoured by

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rodents. A number of efforts in eradicating this pest, among others, is by conducting gropyokan tikus (an event where farmers work together to exterminate rodents in the crop fields), using owls, and educating farmers to conduct simultaneous planting in one spread of land.

Sixthly, the Type of Plant. Crop yield variability is a defining characteristic of agriculture. Variations in yield and production are strongly influenced by fluctuations in weather. Planting various food crops and vegetables by intercropping is also carried out. For instance, during the wet seasons, the principal crops are hybrid rice (IR 64, Cisedane) with intercropping of cassava, maize, beans, eggplant and peppers while in the dry seasons the principal crops are red rice (Slegreng) and aromatic rice (pandan wangi) with cassava, maize, koro (local beans). This type of intercropping is effective because these types of plants have adapted to the local environment (wet and dry lands) and are thus more resilient to climate changes. The type of crops and vegetables that farmers plant is adjusted to the current season, i.e. firstly, paddy is only planted during the rainy season with one harvest. Secondly, cassava is planted during the *mareng* (post rainy season) with one harvest. Thirdly, corn can be harvested twice and planted during the rainy and *mareng* seasons. Fourthly, peanuts could only be planted during rainy season with one harvest.

Aside from that, the farmers have developed a local rice (Red Rice Slegreng) or any other varieties which are able to survive the dry season, including types of rice resistant to drought, pests and disease, and also short-life plants that can be harvested within 75-80 days. Red rice is superior in nutrients, especially high protein and thiamine and low carbohydrate and is suitable for diabetics. Farmers also plant trees for wood. The species used for reforestation include: (a) Plant wood: acacia, mahogany, sengon; and (b) Fruit trees: mango, jackfruit, and coconuts.

The last one is diversifying food to be consumed. There are various types of carbohydrates for community meals from rice, maize , and cassava, complemented by vegetables from the garden. Diversification of food needs to be developed so people not only depend on rice as a source of carbohydrate.

This research also mapped regional policies relating to improving farmers' capacity in facing climate change. According that has emerged is the need to improve farmers' capacity to use climate forecasts and other agrometeorological information in their activities. In order to do this, the government has created Kalender Tanam (Planting Calendar–KATAM) Information System. KATAM is a technology which contains various planting information from the provincial to the sub-district level throughout all of Indonesia which will be improved every season and updated once every two months with the latest data and suitability of soil elements from every province in Indonesia. The Integrated KATAM provides information on planting pattern potentiality, planting time, potential scope of planting area and recommendations of adaptive technology at the provincial to the sub-district level throughout all of Indonesia. This system is very operational, and it is created based on the seasonal climate forecast, and it can be integrated with recommendations for fertilizing, seeding and integrated pest management (IPM).

Additionally, the government has also been developing climate field school, integrated planting management field school, integrated pest management field school, as well as conducting development of new superior varieties of rice, development and usage of organic farming on paddy field, development of soil cultivation technology and water-economical plant, building improved water storage, dissemination of compost-making devices, manure management to generate bio-energy, monitoring of flood and drought susceptibility on paddy field area, and adjustment of planting calendar for the islands of Java and Sumatra. The aim of such programs is that farmers need to enhance their adaptive capacity to face both present and future climate change outside their experienced coping range. Among agricultural communities, increasing knowledge and raising awareness of climate change are essential starting points in building adaptive capacity. Hence, farmers can only adapt if they are aware of the concept of climate change and have knowledge of potential climate change impacts.

Conclusions

The issue of climate change is the most serious and complex multidimensional challenge faced by mankind in the start of the threat and challenges of climate change and global warming which is strongly connected to human behavior and lifestyle, political decisions, development patterns, choice of technology, socio-economic conditions and international agreements. Its negative impacts could spread rapidly from a global level to a local one. When the earth's temperature rises, the pattern of rainfall drastically changes, climate and weather become more extreme. The frequent prevalence of drought, storms, and flood leads to heatwave and forest fires becoming more numerous and widespread. Once the earth's temperature has reached a certain heating point, the ice caps in the Polar Regions as well as snow would melt subsequently creating a symptom of sea water expansion, wherein the sea level rises with the capacity to sink lowlands, coastal regions and densely populated small islands in developing countries. Tens of millions of vulnerable poor will lack clean water and become more threatened by crop failure, decline of productivity and results in farming, plantation, and fisheries.

The present study established that temperature in study area has been increasing and rainfall decreasing. This has affected the production and management of crops. The agriculture sector, particularly the food crop sector will be the most impacted by climate change. There are three main factors relating to global climate change which impacts the agriculture sector, namely: (1) change in rain pattern; (2) increase in occurrences of extreme climate (flood and drought); and (3) increase in air temperature. The influence of climate change towards the agricultural sector is multidimensional, starting from its resource, agriculture infrastructure, agriculture production system, up to the aspect of security, food independency and farmer welfare. This impact becomes more visible with the advent of cultivated land reduction, the higher level of land conversion, expansion of critical lands, spread of damage in irrigation networks, decrease of water availability in dams, as well as increase in flood frequency which implicates the rise of various pests and disease.

Farmers adopt different practices which will reduce variability on economic livelihoods and food security. The major climate change adaptation strategies used by the farmers in the study areas include planting different crop varieties, cultivating different crops, soil and water conservation measures and changing planting dates. Other strategies including expanding land under crop production, use of chemical fertilizer, irrigation, seeking off-farm income sources and conservation agriculture practices (mulching, changing rotations and tillage practices) are reported by few farmers as important adaption strategies. One of the ways farmers adapt to climate change is by using their past experiences. By using their ability to stick to their knowledge, confidence, and belief in the sustainable practices they had developed in the past.

An example of farmers' adaptation to climate change is Pranata mangsa (Javanese calculation of the seasons) which was once a standard but is difficult to use nowadays. Hence,in order to respond to climate change, the government needs to (1) reduce the uncertainty and risk caused by climate variability and improve farmers' societal awareness of climate change itself; (2) reduce the risk and impact of climate change upon infrastructure, production systems, and socio-economic aspect of agriculture; and (3) increase the role of the agriculture sector in mitigating greenhouse gas (GHG) emissions.

References

Adger, W., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. (2007). Assessment of adaptation practices, options, constraints and capacity. in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. Van Der Linden and C.E. Hanson (eds.). Climate change 2007: Impacts, adaptation and vulnerability: Working Group II contribution to the Fourth Assessment Report of the IPCC Intergovernmental Panel on Climate Change. pp. 717-743. Cambridge, UK: Cambridge University Press.

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulmeet, M. (2003). Adaptation to Climate Change in the Developing World. *Progress in Development Studies, 3* (3), 179-195.

Al-Gamal, S. A., Sokona, Y., & Abdel-Kader, D. (2009). Climate Changes and Ground Water Resources in Africa. *International Journal of Climate Change, Strategies and Management, 1*(2), 133-145.

Choudri, B. S., Al-Busaidi, A., & Ahmed, M. (2013). Climate Change, Vulnerability and Adaptation Experiences of Farmers in Al-Suwayq Wilayat, Sultanate of Oman. *International Journal of Climate Change, Strategies and Management, 5* (4), 445-454.

Cornish, G. A. (1998). *Modern Irrigation Technologies for Smallholders in Deve loping Countries*. L ondon: Intermediate Technology.

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Crate, S. A., & Nuttall, M. (2009). Introduction: Anthropology and Climate Change. In S. A. Crate & M. Nuttall (Eds.), *Anthropology and Climate Change: From Encounters to Actions*. California: Walnut Creek.

Creswell, J. W. (1994). *Research Design: Qualitative and Quantitative Approaches*.

Thousand Oaks, CA: Sage Publications. Ellis, F. (2000). *Rural Livelihoods and Diversity in Developing Countries*. Oxford: Oxford University Press.

FAO. (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities. Rome: Italy

FAO. (2005). Impact of Climate Change, Pests and Diseases on Food Security and Poverty Reduction."Special event background document for the 31st Session of the Committee on World Food Security. Rome: Italy

Frankhauser, S., & Tol, R. S. J. (1996). Climate Change Costs: Recent Advancements in the Economic Assessment. *Energy Policy, 24*(7), 665-673.

Howe, K.R. (2004). A Critique of Experimentalism. *Qualitative Inquiry*(10), 42-61.

IPCC. (2001). Climate Change 2001: Impact, Adaptation, Vulnerability *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: UNEP/WMO.

IPCC. (2007a). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. New York: Cambridge University Press.

IPCC. (2007c). *Climate Change 2007: The Physical Science Basis*. New York: Cambridge University Press.

Jafry, T. (2012). Global Trade and Climate Change Challenges: A Brief Overview of Impacts on Food Security and Gender Issues. *International Journal of Climate Change, Strategies and Management, 4*(4), 442-451.

Marshall, N.A. (2010). Understanding social resilience to climate variability in primary enterprises and industries. Global Environmental Change 20(1): 36-43

McClean, Colin J. et al. (2005) . African Plant Diversity and Climate Change. Annals of the Missouri Botanical Garden. 92(2): 139–152.

Manne, A., Mendelsohn, R., & Richels, R. (1995). MERGE - A Model for Evaluating Regional and Global Effects of GHG Reduction Policies. *Energy Policy, 23*(1), 17-34.

Matarira, C. H., Pullanikkatil, D., Kaseke, T., Shava, E., & Mantsa, D. (2013). Socio-Economic Impacts of Climate Change on Subsistence Communities: Some Observations from Lesotho. *International Journal of Climate Change, Strategies and Management, 5* (4), 404-417.

Murad, M. W., Molla, R. I., Mokhtar, M. B., & Raquib, M. A. (2010). Climate Change and Agricultural Growth: An Examination of the Link in Malaysia. *International Journal of Climate Change, Strategies and Management, 2*(4), 403-417.

Parry, M., O.F. Canziani, J.P. Palutikof, P.J.v.d. Linden, and C.E. Hanson, (2007). Climate change 2007: Impacts, adaptation and vulnerability appendix 1: Glossary, in Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Roncoli, C., Ingram, K., Jost, C., Kirshen, P., & Orlove, B. (2003). Meteorological Meanings: Farmers' Interpretation of Seasonal Rainfall Forecast in Burkina Faso. In S. Strauss & B. Orlove (Eds.), *Weather, Climate, Culture* (pp. 181-200). Oxford and New York: Berg.

Sarina, L. and Bhupendra, D. (2009). "Vulnerability of mountain communities to clim a te cha nge a nd a da pta tion strategies", The Journal of Agriculture and Environment, Vol. 10, pp. 65-71.

Smit, B., & Wandel, J. (2006). Adaptation, Adaptive Capacity and Vulnerability. *Global Environmental Change, 16*, 289-292.

Stehr, N., & Storch, H. V. (2005). Introduction to Papers on Mitigation and Adaptation Strategies for Climate Change: Protecting Nature from Society or Protecting Society from Nature? . *Environmental Science & Policy, 8* (6), 537-540.

Suroso, D. S. A., Hadi, T. W., & Salim, W. (2009). Indonesia Climate Change Sectoral Roadmap (ICCSR). Jakarta, Indonesia: National Development Planning Agency.

Tol, R.S.J. (2002). 'New Estimates of the Damage Costs of Climate Change, Part I: Benchmark Estimates', Environmental and Resource Economics, 21 (1), 47-73.

Tompkins, E. L., & Neil Adger, W. (2005). Defining Response Capacity to Enhance Climate Change Policy. *Environmental Science & Policy, 8*(6), 562-571.

UNFCCC .(2004). The First Ten Years, Climate Change Secretariat, Bonn, p. 69, available at: http://unfccc.int/resource/docs/publications/first_ten_years_en.pdf

Winarto, Y. T., & Stigter, K. (Eds.). (2011). *Agrometeorological Learning: Coping Better with Climate Change*. Saarbrücken: Lambert Academic Publishing.