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Climate Change Impacts and Adaptation Options as Perceived by Vegetable Farmers in South Sulawesi, Indonesia

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ABSTRACT: *Understanding the impacts of climate change requires knowing how farmers might adapt to a changing climate. The study aimed at examining the perceptions of South Sulawesi vegetable farmers on the impacts of and adaptations to climate change. A survey was carried out to collect data from 220 randomly selected respondents. Most respondents perceive that the three most important impacts of climate change are increased crop failure risks, increased financial loss risks and increased occurrence of severe pest incidences. Meanwhile, most farmers claim that they have implemented some adaptation options, such as the use of better irrigation/drainage, planting early in the rainy season, crop rotation systems, the use of manure/compost and the use of minimum tillage. Respondents' socio-economic factors, mainly education, and attitude factors, mainly attitudes towards needs for more attention to climate change, significantly affect farmers' decision to implement the adaptation options. In the meantime, the two main identified constraints of adaptation are insufficient government policies regarding climate change mitigation, increasing production costs and lacking of technologies specifically designed for adaptation. Policy makers critically need to devise a holistic and coordinated approach in a way that may overcome many of the interrelated constraints.*

Keywords: *climate change; impacts; adaptation; perceptions; vegetables*

I. INTRODUCTION

Climate change has been increasingly recognized as one of the most challenging environmental problems facing the world. Negative impacts from climate change that are projected to extend exponentially within the close future are anticipated to be mostly experienced by agricultural sector [1, 2]. The general consensus suggests that changes in the soil and water regime resulted from changes in temperature and precipitation have affected agricultural productivity. Various aspects of internal relationship between farming and climate change have made the latter as the most cause of biotic and abiotic stresses, which have negative impacts on crop yield [3, 4, 5].

Moreover, some studies also indicate that the effects of climate change on agricultural production are expected to be more severe in tropical regions developing countries. These countries' vulnerability is relatively more acute since they are also confronting technological, resource and institutional constraints. In the tropics, some experts predict a decrease in agricultural productivity in conjunction with an increase in the poverty level. The prediction begins with conjecture that the livelihood opportunities for the population work in the agricultural sector will become increasingly vulnerable because of climate change stresses [6, 7, 8].

Small-scale farmers are considered as one of the most exposed groups affected by climate change since they heavily depend on resources accommodated by the environment that is increasingly pressurized by climate uncertainties. Climate change further exacerbates smallholder farmers' vulnerability due to its damaging effects to crop production suitability and crop yields they rely on, and because of their lack of access to supports that could improve the adaptation capacity [9, 10, 11]. Horticultural crops are very vulnerable to the potential impacts of climate change, such as extreme high temperatures and limited soil moisture. As climate change negatively affects smallholder horticulture producers, crop failures, decreased yield, reduced quality and increased pest and disease incidence will render farm loss or farm unprofitability [12, 13].

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Under the above circumstances, climate change adaptation strategies at farmers' level are considered essential and recognized as pressing and necessary. Adaptation to climate change can be differentiated into an adaptation with deliberate intervention (planned) or an adaptation without deliberate intervention (autonomous). Under planned adaptation, for example, farmers adopt a drought tolerant variety to replace the old intolerant variety. On the other hand, autonomous adaptation is reactionary in nature, for example, farmers practice water conservation during long dry season caused by climate change [14, 15, 16]. Some studies have indicated that climate change adaptation enables to lessen impacts and avert a likely harm to farmers and their livelihoods [17, 18, 19]. However, the implementation of adaptation strategies, like improved crop, soil, land, and water management technologies remains low due to differences in farmers' ability cope and other socio-economic factors. The degree of adaptation to global climate change depends on farmers' adaptive capacity level and it only applies when the specified resources are available [20, 21, 22].

In Indonesia, climatic uncertainty and variability that affect agricultural productivity and water availability may lead to the occurrence of food insecurity [23, 24, 25] and water insecurity [26, 27] in the near future, and even threaten to decrease the contribution of agricultural sector to the national Gross Domestic Product [28]. Studies on climate change adaptation in Indonesia show varied results. Rice farmers, especially in highland agro-ecosystem, incline to be less adaptive and tend to implement reactionary rather than anticipatory adaptation actions [29]. Some farmers that rely on their own experience and common local practices in adapting to climate change have experienced increased production costs that are much higher than their earned profits [30]. By implementing adaptation strategies, such as crop variety changes, irrigation pumps, planting time adjustments, organic fertilizer use, non-chemical pesticides use, and cropping pattern changes, some rice growers in Central Java can obtain higher yield than the other farmers who do not practice these actions [31]. Socio-economic variables, such as farmers' education, land tenure status, irrigation infrastructure availability, cropping system, chemical fertilizer use, access to extension services, and participation in farmer groups have been identified as significantly affect rice farmers' adaptation capacity [32]. Furthermore, a study carried out in tropical forest of Papua suggests that in gaining more local engagement, the development and promotion of relevant adaptation strategies should be more focused on the existing traditional ecological knowledge, and an assessment of local needs and concerns [33].

Farmers' perceptions about climate change are pre-requisites for dealing with climate risks and uncertainties, and undertaking appropriate coping strategies to combat the negative impacts of climate change [34, 35]. Appropriate perception unequivocally depends on farmers' knowledge and access to information. Meanwhile, knowledge itself is conditioned by farmers' educational attainment and experience. In spite of farmers correctly perceive the climate change phenomenon, sometimes they do not respond with adaptive actions because of capacity, resources, and information insufficiency. Unresponsiveness may be also caused by their different orientation or belief. Farmers are mostly aware of the adverse effect of pesticide excessive use, but they keep practicing it because their focus is on maintaining the yield and sustaining their income rather than concerning on environmental sustainability [36, 37]. Farmers' perception of climate change is closely related to their attitude and behavior toward the adaptation strategies they will be using. Hence, this paper seeks to explore farmers' perceptions on climate change impacts and to assess farmers' choice of adaptation measures responding to climate change.

II. Materials and Methods

Survey research method was used to collect data from vegetable farmers in South Sulawesi province, Indonesia. Selected respondents were randomly chosen to represent vegetable producing areas from two different agro-ecosystems (lowland < 400 m and highland > 700m above sea level), and three different seasonal-pattern sectors (western - rainy season in October-March and dry season in April- September; eastern - rainy season in April-September and dry season in October-March; and transitional-regions that have both seasonal patterns). A total of 220 respondents were interviewed with the distribution as follows: (a) 55 respondents - lowland-western sector, (b) 55 respondents - lowland– eastern sector, (c) 55 respondents - highland-transitional sector, and (d) 55 respondents - highland- western sector [38].

Data were collected through interviews by using a structured questionnaire. The questionnaire includes a variety of questions regarding: (a) socio-demographic characteristics; (b) farmers' perceptions of climate change

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impacts; (c) farmers' perceptions of climate change adaptation; (d) factors influencing adaptation to climate change, and (e) constraints to climate change adaptation. Depending on each specific objective, data were analyzed by using descriptive statistics, binomial test, and multinomial logistic regression model. The order of importance of a set of factors is identified by ranking method using multiple weighted score analysis.

III. Results and Discussions

3.1 Socio-economic characteristics of respondents

Most respondents who fall into the age range of 30-39 and 40-49 have a high school educational background (Table 1). Respondents in the younger age range (20-29 years) are dominated by farmers who have primary and junior secondary educational background. Total respondent is almost evenly distributed about 30% each between elementary, junior high, and high school educational backgrounds.

Table 1. Cross tabulation between respondents' level of education and age

Level of education	Age (n = 220)						Total
	< 20	20-29	30-39	40-49	50-59	60-70	
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Elementary	0.0	6.4	9.5	7.7	6.8	5.0	35.5
Middle	1.8	5.0	7.7	6.4	3.2	0.9	25.0
High	0.5	2.3	15.5	8.2	2.7	0.9	30.0
College	0.0	0.9	2.7	4.1	0.9	0.9	9.5
Total	2.3	14.5	35.5	26.4	13.6	7.7	100.0

Table 2 confirms that ownership is the dominant land tenure status for most of the respondents. Unlike in Java, 68.6% of the total respondent cultivates vegetables in their own land. It is only about one-fifth of respondents use rented land for cultivating vegetables

Table 2. Cross tabulation between land size and land tenure status

Land size – m^2	Land tenure status (n = 220)				Total
	Owned (%)	Rented (%)	Owned & rented (%)	Shared (%)	
500 - 2 500	10.5	5.5	0.5	0.5	16.8
2 501 - 5 000	23.2	6.8	2.3	4.1	36.4
5 001- 10 000	24.1	4.5	1.8	2.3	32.7
10 001 – 20 000	7.7	0.5	0.0	1.8	10.0
20 001 – 30 000	1.8	0.5	0.5	0.0	2.7
30 001 – 50 000	1.4	0.0	0.0	0.0	1.4
Total	68.6	17.7	5.0	8.6	100.0

3.2 Impact of climate change on weather and climatic uncertainties

Most respondents notes that climate change has caused an increased temperature (90.9%) and decreased rainfall (65.5%). Moreover, they perceive the occurrence of heavy rains and long rainy season, and erratic rainfall as significant impacts of climate change. In smaller proportion, respondents also indicate the events of unusual early rainy season, long period of dry season, and the start of rainy season postponement have occurred as impacts of climate change (Graph 1). Overall, respondents consider the three most important climate change impacts are erratic rainfall, increased temperature, and unusually earlier rainy season (Table 3).

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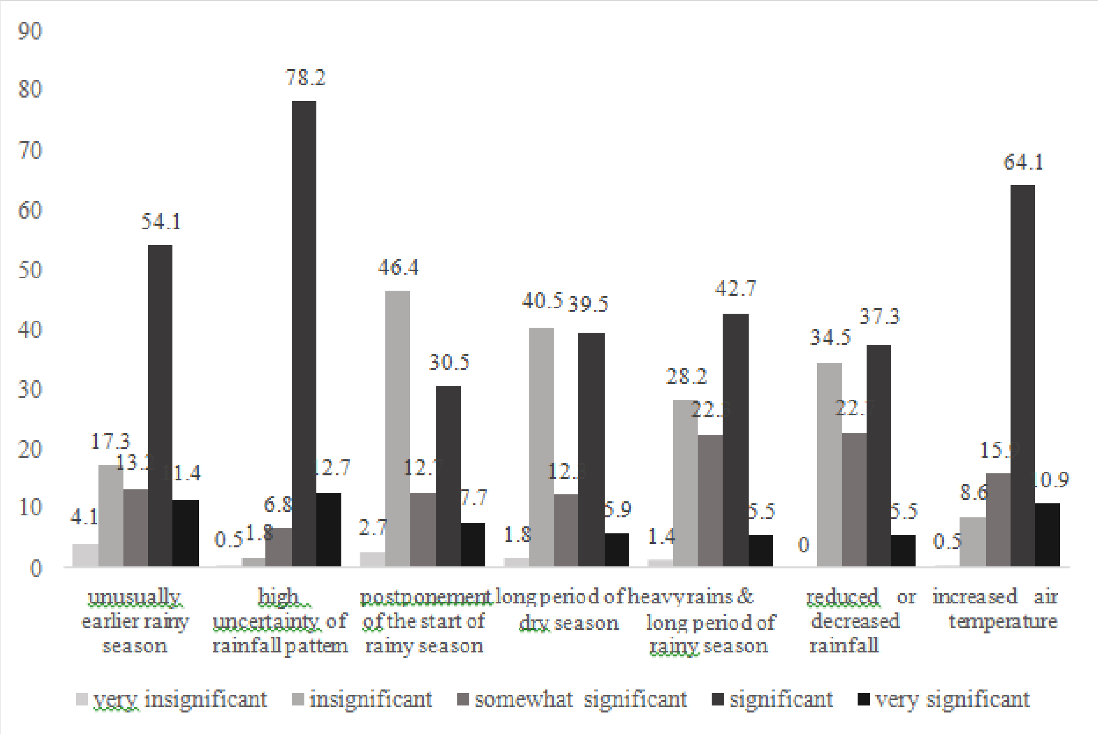

Graph 1. Impacts of climate change on weather and climatic uncertainties

Table 3. Rank of importance on weather and climatic uncertainties as the effects of climate change

Weather or climate uncertainties	Average of rank value	Rank of importance
Unusually earlier rainy season	3.51	III
High uncertainty of rainfall pattern	4.01	I
Postponement of the start of rainy season	2.94	VII
Long period of dry season	3.07	VI
Heavy rains & long period of rainy season	3.23	IV
Reduced or decreased rainfall	3.14	V
Increased air temperature	3.76	II

3.3 Impact of climate change on cultivated crop and farm-business

As perceived by most respondents (94.5%), climate change has impacted in a higher risk of farm- business loss that may directly affect the farm sustainability. Based on their experience over the last five years, respondents indicate a higher risk of crop failure (95.5%), increased post-harvest and marketing costs (81.8%), yield decrease (92.3%), increased pest/disease incidence (90%), under- developed natural enemies (67.8%, more intensive input-used (94.6%), increased irrigation costs (80.4%), decreased produce quality (90.1%), and early forced harvest because of poor crop performance (66%) (Graph 2). Overall, respondents consider the three most important climate change impacts on the farm are a higher risk of crop failure, a higher risk of farm-business loss, and increased pest/disease incidence (Table 4).

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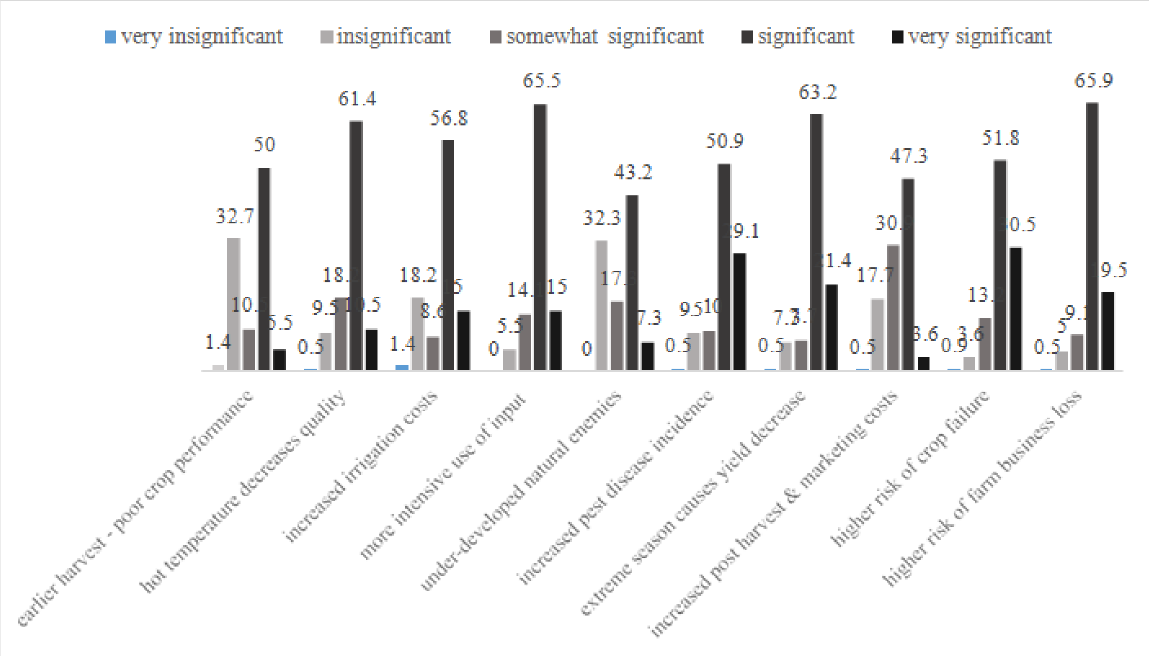

Graph 2. Impacts of climate change on crop yield and farm-business

Table 4. Rank of importance of climate impacts on cultivated crop and farm business

Climate change impacts	Average of rank value	Rank of importance
Early harvest because of poor crop performance	3.25455	IX
Hot temperature pressure that causes decreasing product quality	3.71818	VI
Increasing cost of irrigation both in long dry season – buying extra water, and in long wet season – adjusting drainage	3.65909	VII
Changes in cultural practices that tend to demand more intensive use of input – increasing total cost of production	3.90000	V
Higher air temperature that causes difficult development of natural enemies	3.25455	X
Higher air temperature that causes the increase of pests/diseases incidence and the emergence of new pests and diseases	3.98636	III
Extremely long dry or wet season that causes yield decrease	3.97727	IV
Increasing post-harvest and marketing cost per unit product	3.35909	VIII
Higher risks of crop failure	4.07273	I
Increasing loss-risk in farming business that may directly affect farm sustainability	3.99091	II

3.4 Adaptation options to climate change

Table 5 shows various adaptation options used by a larger proportion of respondents, and some of them are even implemented across the three seasonal pattern regions. As consequence of changing planting dates, farmers carry out time adjustments or changes in land preparation and they start to practice minimum tillage. Adapting to erratic rainfall pattern, farmers make some adjustments in planting time and promptly carry out the planting at the beginning of rainy season. Crop planting begins with the preparation of better seeds or seedlings, sowing the seeds a bit deeper, and the use of recommended planting distance. Due to climate change farmers are aware of the possibility of accelerated soil fertility degradation, so they are willing to use manure or compost more intensively. Although still using chemical pesticides as an option to adapt, farmers are aware that they have to start reducing chemical inputs in their crop cultivation. Farmers apply mechanical method more frequently to control pest and. disease by increasing weeding intensity. In confronting water shortage caused by climate change, farmers practice water-use conservation and use better irrigation and drainage systems. Crop failure is a significant impact of climate change and variability,

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farmers have tried some adaptation strategies, such as avoiding planting the same crop in a row in the same field, applying inter-cropping or relay cropping systems, and using multiple cropping or crop diversification systems. In addition, farmers also carry out adjustments or changes in harvesting time, and practice post-harvest handling that minimizes yield-loss.

Table 5. Adaptation options implemented by a larger proportion of respondents

Adaptation options	West-seasonal pattern			East-seasonal pattern)			Transition-seasonal pattern		
	Category	N	Exact Sig. (2-tailed)	Category	N	Exact Sig. (2-tailed)	Category	N	Exact Sig. (2-tailed)
Conserving the use of water	1	70	.000(a)	1	52	.000(a)	1	59	.000(a)
	0	10		0	18		0	11	
More intensive use of manure	1	72	.000(a)	1	40	.282(a)	1	61	.000(a)
	0	8		0	30		0	9	
The use of compost	1	58	.000(a)	1	39	.403(a)	1	50	.000(a)
	0	22		0	31		0	20	
The use of cover crops	0	63	.000(a)	1	11	.000(a)	0	54	.000(a)
	1	17		0	59		1	16	
The use of minimum tillage	1	61	.000(a)	1	33	.720(a)	1	46	.012(a)
	0	19		0	37		0	24	
The use of good irrigation and	1	54	.002(a)	1	48	.003(a)	1	46	.012(a)
drainage system	0	26		0	22		0	24	
The use of chemical pesticides	1	78	.000(a)	1	62	.000(a)	1	67	.000(a)
	0	2		0	8		0	3	
Reducing the use of chemical	1	52	.010(a)	1	36	.905(a)	1	45	.022(a)
inputs	0	28		0	34		0	25	
Increasing weeding intensity	1	71	.000(a)	1	58	.000(a)	1	60	.000(a)
	0	9		0	12		0	10	
Preparing better seeds or	1	66	.000(a)	1	47	.006(a)	1	56	.000(a)
seedlings	0	14		0	23		0	14	
Seed planting a bit deeper	1	51	.018(a)	1	39	.403(a)	1	47	.006(a)
compared the usual	0	29		0	31		0	23	
Planting promptly at the	1	63	.000(a)	1	45	.022(a)	1	61	.000(a)
beginning of rainy season	0	17		0	25		0	9	
The use of multiple cropping or	1	64	.000(a)	1	41	.188(a)	1	61	.000(a)
crop diversification systems	0	16		0	29		0	9	
The use of inter-cropping or	1	68	.000(a)	1	37	.720(a)	1	63	.000(a)
relay cropping systems	0	12		0	33		0	7	
Changing/adjusting the time for	1	62	.000(a)	1	43	.072(a)	1	49	.001(a)
planting	0	18		0	27		0	21	
The use of recommended	1	71	.000(a)	1	52	.000(a)	1	61	.000(a)
planting distance	0	9		0	18		0	9	
Avoiding planting the same	1	60	.000(a)	1	47	.006(a)	1	55	.000(a)
crop in a row in the same field	0	20		0	23		0	15	
Carrying out time adjustments	1	57	.000(a)	1	44	.041(a)	1	47	.006(a)
or changes in land preparation	0	23		0	26		0	23	
Carrying out adjustments or	1	58	.000(a)	1	45	.022(a)	1	50	.000(a)
changes in harvesting time	0	22		0	25		0	20	
The use of post-harvest	1	68	.000(a)	1	40	.282(a)	1	61	.000(a)
handling that minimizes loss	0	12		0	30		0	9	

(a): the probability of two-sided significance based on the Z approximation

Table 6 shows various adaptation options implemented by a smaller proportion of respondents and those that are proportionally not significant (statistically). Smaller number (proportion) of respondents use plastic mulch across the three seasonal pattern regions as an adaptation measure. In the meantime, the options of early harvest variety, pest/disease resistant variety, drought tolerant variety, heat tolerant variety, salinity tolerant variety, natural/bio-pesticides, and crop-livestock systems are also used by smaller proportion of respondents. Since the productive land availability is relatively fixed, it is understandable that smaller proportion of respondents use the

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adaptation options of reducing land size, adding land size and moving out from risky location. Limited employment alternatives in the rural areas have made limited number of farmers use employment changes (farmer to trader, producing vegetable to food crop or livestock, and more intensively looking for part-time off-farm employment) as options to adapt. Meanwhile, further study seems to be needed to explain why only few farmers are willing to look for complete climate variability information as an adaptation option.

Table 6. Adaptation options implemented by a smaller/similar proportion of respondents

	West-seasonal pattern			East-seasonal pattern)			Transition-seasonal pattern		
	Category	N	Exact Sig. (2-tailed)	Category	N	Exact Sig. (2-tailed)	Category	N	Exact Sig. (2-tailed)
The use of flood or drought	1	35	.314(a)	1	19	.000(a)	1	25	.022(a)
resistant varieties	0	45		0	51		0	45	
The use of pest/disease resistant	1	34	.219(a)	1	34	.905(a)	1	33	.720(a)
varieties	0	46		0	36		0	37	
The use of natural/bio-	1	30	.033(a)	1	23	.006(a)	1	32	.550(a)
pesticides	0	50		0	47		0	38	
The use of early harvest	1	38	.738(a)	1	30	.282(a)	1	33	.720(a)
varieties	0	42		0	40		0	37	
The use of plastic mulch	1	27	.005(a)	1	25	.022(a)	1	20	.000(a)
	0	53		0	45		0	50	
The use of heat tolerant	1	37	.576(a)	1	20	.000(a)	1	24	.012(a)
varieties	0	43		0	50		0	46	
The use of salinity tolerant	1	10	.000(a)	1	10	.000(a)	1	5	.000(a)
varieities	0	70		0	60		0	65	
The use of crop-livestock	1	31	.057(a)	1	17	.000(a)	1	31	.403(a)
systems	0	49		0	53		0	39	
Looking for complete	1	18	.000(a)	1	12	.000(a)	1	8	.000(a)
information on climate change	0	62		0	58		0	62	
Moving out from very risky	1	35	.314(a)	1	20	.000(a)	1	35	1.000(a)
location to the climate change	0	45		0	50		0	35	
Reducing the size of land-	1	35	.314(a)	1	26	.041(a)	1	33	.720(a)
holding	0	45		0	44		0	37	
Adding the size of land-holding	1	38	.738(a)	1	30	.282(a)	1	35	1.000(a)
	0	42		0	40		0	35	
Changing employment from	1	8	.000(a)	1	10	.000(a)	1	14	.012(a)
farmer to trader	0	72		0	60		0	56	
Changing from producing vegetable to food crop or	1	10	.000(a)	1	9	.000(a)	1	5	.000(a)
livestock	0	70		0	61		0	65	
More intensive to look for part-	1	3	.000(a)	1	4	.000(a)	1	2	.000(a)
time off-farm employment	0	77		0	66		0	68	

(a): the probability of two-sided significance based on the Z approximation

The multinomial logistic regression model is used to estimate the effect of respondents' socio- economic characteristics and their attitude towards climate change on the farmers' adoption to choose adaptation options (Table 7). The results indicate that age affects the respondents' decision in implementing six out of ten selected adaptation options. Educational background significantly influences seven out of ten selected adaptation strategies that are used by respondents to adapt. Land size affects the decision of respondents to implement the option of planting immediately at the start of rainy season and preparing better seeds or seedlings. Farmers' choice of increasing weeding intensity and preparing better seeds or seedlings as adaptation options is influenced by their land tenure status. The option of using recommended planting distance is affected by respondents' age, education, farming experience, and attitude towards impact on farmers' adaptive capacity. Meanwhile, the respondents' initiative of changing from growing vegetable to food crop or raising livestock is significantly influenced by age, education, farming experience, attitude towards climate change in general, attitude towards impact on farmers' adaptive capacity, and attitude towards the need for more attention to climate change. Education turns out to be a variable of respondents'

 Received- 18-11-2020, Accepted- 28-11-2020

characteristic that has the most frequent effect on farmers' decision to adapt to climate change. This implies that the higher the education, the more likely farmers implement the adaption options. More educated farmers are more knowledgeable since they have more ability to access information pertaining to climate change adaptation strategies. Meanwhile, from attitudinal perspectives, the higher the approval level of farmers toward the need for more attention (from government and society in general) to climate change also significantly affects farmer's decisions.

Table 7. Logistic regression between selected adaptation options and respondents' profile and attitude towards climate change

Independent variable (X)	Dependent variable (Y)									
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}
Age	-.384**	-.303**	.364***	.428**	.347***	.066	-.181	-.181	.155	-.332**
Education	.358**	.147	.164	.595*	.638*	.324**	.269***	.158	.424*	.282***
Land size	-.081	.092	-.165	.183***	.006	.117	-.188**	-.055	.080	.112
Tenurial status	-.297	.058	-.414**	.053	.015	-.123	-.299**	-.176	-.105	-.196
Training	-.030	.144	.162	-.042	.134	-.039	-.129	-.174	-.156	.030
Farming experience	.309	.371***	-.209	.020	-.378**	.344	-.084	.106	.317	.570*
Attitude towards climate change in general	-.750	.006	.374	.169	-.352	.267	.378	-2.32**	.036	1.618**
Attitude towards impact on farm productivity	1.944*	-18.498	.097	.223	.514	-.034	-.175	2.309**	-1.516	-1.290
Attitude towards impact on farm profitability	-1.108	53.276	-.722	-.344	.019	-.563	-.235	-.264	.979	1.665
Attitude towards impact on farmers' adaptive capacity	-.088	-.126	.084	.148	-.724*	.607**	-.138	.489**	.551**	.418***
Attitude towards the need for more attention to climate change	-.484*	-.679*	-1.190*	-.145	-.163	-.853*	-.845*	-1.423*	-.785*	-1.699*
Attitude towards impact on decreasing quality of life	-.131	.488	.593	-.405	-.171	.413	-.166	-.191	.066	.409
Constant	3.065**	-34.086	2.954**	-2.116	.286	-.245	4.532*	2.107	-.140	-1.390

* : significantly different at $\alpha = 0.01$
** : significantly different at $\alpha = 0.05$
*** : significantly different at $\alpha = 0.10$

Y_1 More intensive use of manure
Y_2 The use of minimum tillage
Y_3 Increasing weeding intensity
Y_4 Planting promptly at the beginning of rainy season
Y_5 The use of recommended planting distance
Y_6 Avoiding planting the same crop in a row in the same field
Y_7 Preparing better seeds or seedlings
Y_8 The use of plastic mulch
Y_9 Changing/adjusting the time for planting
Y_{10} Changing from producing vegetable to food crop or livestock

3.5 Constraints to climate change adaptation

There are at least six identified obstacles to climate change adaptation which based on the order of importance are as follows: low attention and weak government' climate change policies, increased production costs, lack of availability of specific climate change designed technologies, difficulty to access specific climate change designed technologies, ineffective services of agricultural extension, and lack of access to get information on weather and climate prediction. These obstacles basically boil down to the main incentive of farmers' decisions in adopting adaptation practices i.e. the availability of climate change information and farmers' access to this information (Table 8).

Regardless of the order of importance, constraints on adaptation to climate change actually consist of several groups, namely financial, technological, institutional, socio-cultural, and informational constraints. One of key constraints in implementing climate change adaptation options are financial constraints. These include lack of working capital, lack of availability and access of credit facilities, high interest of loans from money-lender, and no clear-cut subsidy. Some farmers indicate that they keep using their own saved seeds because financial constraints have

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prevented them to purchase improved crop varieties that are more suitable to be used for adapting to climate change.

Table 8. Rank of importance of adaptation constraints as perceived by respondents

Adaptation Constraints)	Average of rank value	Rank of importance
Financial constraints		
• Unavailabilty of cheap and easily accessed agricultural credits	3.70909	XII
• Increasing cost of production	4.00000	II
Technological constraints		
• Difficult to obtain specific technologies designed to adapt to climate change	3.98182	IV
• Unavailability of specific technologies designed to adapt to climate change	3.99091	III
• Difficult to obtain varieties specifically designed for climate change adaptation	3.87273	VIII
• Unavailability of varieties specifically designed for climate change adaptation	3.93182	VII
• High crop failure risks of adaptation strategy	3.86818	IX
Institutional constraints		
• The existing land tenurial system that positions farmers to keep moving	2.68636	XVI
• Ineffective services of agricultural extension	3.95455	V
• Weak agricultural institutions, especially farmer-group and cooperative	3.84545	XI
• Low attention and weak government policies regarding climate change problems	4.24545	I
Socio-cultural constraints		
• Ineffective local indigenous strategy	3.00000	XIV
• Beliefs/conventional practices that hinder the implementation of adaptation strategy	2.98182	XV
Information constraints		
• Lack of access to obtain information on climate prediction	3.93636	VI
• General low famers' awareness to climate change	3.60000	XIII
• Limited knowledge of adaptation strategy	3.86818	X

Generating new crop varieties adapted to climatic variability and uncertainty, more efficient irrigation and drainage techniques, and other climate smart agricultural technologies are critically needed by farmers. Limited availability and access to new relevant climate change technologies has made farmers to merely depend on their own indigenous technologies in ensuring and securing their household's incomes. This may imply an additional burden for farmers to confront climatic problems in their livelihoods.

The coping capacity of farmers with climate variability could be strengthened when institutions are able to provide mechanisms in building the interactions within society to influence the focus of climate change adaptation strategies. Weak reinforcement of central government driven adaptation policies has often constrained the implementation of adaptive strategies at the regional and local levels. Lack of funding on agriculture and climate change studies has caused the relevant technologies are unavailable and/or inaccessible by farmers. In the meantime, the extension workers that supposed to bridge the scientific community and farmers through the dissemination of innovative technologies seems to be overburdened by the administrative works. Hence, the lack of information on adaptation options, weak institutional capacity, and the lack of explicit adaptive policies may pose a threat on food security and even on the well-being of farm households and communities.

Socio-cultural constraints should be well recognized because otherwise they may have dramatic consequences for farmers' capacity in confronting impacts. It is understandable that socio-cultural norms and rules will shape farmers' action and behavior. Therefore, logical behavior responding to climate change impacts may not always go along with the development of adaptation policy even though supported by adequate knowledge and awareness. Socio-cultural constraints may present serious barrier to any intervention to strengthen farmers' adaptive capacity. Accordingly, in addressing substantive limitations caused by socio-cultural barriers, interventions should be executed in such a way that is complementary and respectful to the local context of social and cultural environment.

Most farmers perceive that a lack of climate change information is a critical barrier to successful adaptation,

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especially when farmers consider that their traditional knowledge is no longer sufficient to deal with climate variability and uncertainties. Minimum information on the frequency and intensity of extreme events, and poor predictive capacity to respond at local level are often cited as barriers to adaptation strategies. Information on the beginning of rainy season and distribution of rainfalls during crop growing season is very important for farmers to plan their strategies, such as changing the time of planting and some adjustments that follow. Lack of response to changing climate signals is most probably occurred because farmers heavily rely on their own agro-ecological knowledge and experience. It is also quite unfortunate that when such information are available, farmers often have lack of access to obtain it.

IV. CONCLUSIONS

With regards to weather and climatic uncertainties, farmers consider the three most important climate change impacts are erratic rainfall, increased temperature, and unusually earlier rainy season. In the meantime, farmers indicate that the three most important negative impacts on the farm are a higher risk of crop failure, a higher risk of farm-business loss, and increased pest/disease incidence.

Various adaptation options that are implemented by a larger proportion of respondents are changing planting dates and making some adjustments in planting time, promptly carrying out the planting at the beginning of rainy season, carrying out time adjustments in land preparation, starting to practice minimum tillage, preparing better seeds or seedlings, sowing the seeds a bit deeper, using recommended planting distance, applying more manure or compost, still using chemical pesticides but start reducing farm-use of chemical inputs, increasing weeding intensity, practicing water-use conservation, using better irrigation - drainage systems, avoiding growing crops in a row in the same field, applying inter-cropping or relay cropping systems, using multiple cropping or crop diversification systems, carrying out adjustments in harvesting time, and practicing post-harvest handling that minimizes yield-loss.

Meanwhile, various adaptation options that are implemented by a smaller and/or similar proportion of respondents are using plastic mulch, early harvest variety, pest/disease resistant variety, drought tolerant variety, heat tolerant variety, salinity tolerant variety, natural/bio-pesticides. In addition, smaller proportion of respondents are also using crop-livestock systems, reducing land size, increasing land size, moving out from risky location, changing employment from farmer to trader, changing from growing vegetables to food crops or raising livestock, and looking for part-time off-farm employment as options to adapt. Other than that, further analysis is needed to explain why only few farmers are willing to look for complete information on climate change as an adaptation option.

Educational background significantly influences most of selected adaptation strategies that are used by respondents to adapt. This suggests that farmers with higher education are more knowledgeable and have more capacity to access information concerning climate change adaptation strategies. Meanwhile, from attitudinal perspectives, the higher the approval level of farmers toward the need for more attention (from government and society in general) to climate change also significantly affects farmer's decision to choose adaptation options.

Constraints to adaptation do not act in isolation but interact each other at different levels to hinder farmers' adaptive capacity. For example, informational constraints (lack of access to available climate change information) are related to technological constraints (limited availability and access to new relevant climate change technologies) and institutional constraints (weak government policies regarding climate change and ineffective services of agricultural extension). Financial constraints (unavailability of cheap and easily accessed agricultural credits) may also correlate with technological constraints (difficult access to obtain improved crop varieties). Considering that these constraints act interdependently to restrict the ability of farmers to adapt, coordinated and concerted efforts from policy makers are critically needed in to overcome many of these interrelated constraints. Therefore, it is recommended that policymakers and all stakeholders start to seriously and appropriately integrate local agro-ecological knowledge with scientific-based findings in designing, formulating and implementing adaptation strategies to climate change.

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