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Perception-driven Coping Strategies for Climate Change by Smallholder Farmers in Sri Lanka: A Case Study in *Hakwatuna-oya* Major Irrigation Scheme

D.M.N. Diyawadana, S. Pathmarajah[1] and E.R.N. Gunawardena[1]

Postgraduate Institute of Agriculture
University of Peradeniya
Sri Lanka

ABSTRACT: *Adaptation to the negative impacts of climate changes by farmers is often autonomous. Perception on climate change is an important aspect that determines the coping strategies adapted by farmers to the impacts of climate change. Therefore, identifying the perception of smallholder farmers on climate change is important to understand their adaptation strategies to climate change and support them in their initiatives. Therefore, this study was conducted to identify the perceptions and adaptations of smallholder farmers to climate change, and to study the factors influencing the climate change perceptions and adaptations in Hakwatuna-oya Major Irrigation Scheme in the Kurunegala district of Sri Lanka. Primary and secondary data were collected by surveying 298 households from all the 17 GN divisions in the scheme. Data were filtered based on the size of land cultivated (less than 2 ac.) and the main income source (agricultural) to identify smallholder farmers. Statistical analysis was performed using SPSS software. Sixty one percent (61%) of the households in Hakwatuna-oya scheme are smallholder farmers. About 89% of the smallholder farmers have observed that climate change in terms of increased temperature, decreased rainfall, increased extreme rainfall events, increased drought incidents or unpredictability of rainfall have occurred over the past 10 years. About 84% of the smallholder farmers have identified crop failure as the main impact of climate change and 61% have carried some form of adaptation measures to climate change impacts. Perception has significant correlation with adaptation of smallholder farmer to climate change impacts. Perception and adaptations to climate change have significant correlations with socio-economic, demographic and government interventions. Therefore, any action towards building adaptive capacity and resilience to climate change impacts must consider these aspects for the interventions to be effective.*

Keywords: *Adaptation, climate change, perception, major irrigation scheme, smallholder farmers*

INTRODUCTION

Climate is a main factor that affects the environment, economy and the social impacts. Rural smallholder farmers who depend on natural resources for their livelihood are affected more by climate change or variability (ICIMOD, 2009). The adverse impacts of climate changes or increased variability make farmers more aware on these changes (Nyanga, 2011). Rainfall

[1] Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka.
[*] Corresponding author: maheshdmn@gmail.com

and the temperature are the major attributes of climate and changes of these factors will affect more on farmers (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn 2006). Therefore, farmers perceive the changes of these climate factors much stronger than others who do not have to depend more on the climate. Rainfall is the major factor that decides the commencement of cultivation season, crop variety to be cultivated and the extent to be cultivated.

Adaptation to the negative impacts of climate changes is a must and it is automatically developed by the farmers. It is influenced by factors such as socio-economic, cultural, political, institutional, geographical and ecological situations (Eriksen *et al*., 2011). Further the perception of farmers on climate change or variability is very important for adapting to the impacts of climate change or variability (Smithers and Smit, 1997). If the farmers have identified the changes, they tend to cope with those changes and reduce negative impacts. However, farmers are not in a position to distinguish between climate change and climate variability where the former is a long term phenomenon. Identifying the perception of smallholder farmers on climate change is important to understand their adaptation strategies to climate change and support them in their initiatives. Therefore, this study was conducted to identify perceptions and adaptations of smallholder farmers to climate change and variability together and to study the factors influencing the climate change perceptions and adaptations in *Hakwatuna-oya* Major Irrigation Scheme in the Kurunegala district of Sri Lanka.

METHODOLOGY

Selection of sample

Hakwatuna-oya major irrigation scheme was selected for the study. The scheme is situated within the *Daduru oya* river basin and within the Divisional Secretariat of Polpithigama in the Kurunegala district. It has 3020 farm families distributed over 17 *Grama Niladhari* (GN) administrative divisions. Primary and secondary data were collected in all the 17 GN divisions. The population was stratified based on GN divisions and stratified random sampling technique was used to identify the number of households to be surveyed in each GN division. Table 1 shows the distribution of sample units in each GN division. Individuals for interviewing were selected randomly within the GN division.

Data collection

Primary data were collected through semi-structured questionnaire, key informant interviews and field observations. Semi-structured questionnaire was developed to gather data on five themes, namely socioeconomic characteristics of farmers, cultivation information, perception to the climate variability, adaptation measures for climate variability and government policy interventions. Recall questions were used to get information about the farmers' perception and adaptation on climate variability. Questionnaire survey was conducted in every GN division. Only the households who are doing paddy cultivation as a primary or secondary income source were interviewed without considering the scale of the farming. Altogether, 298 households were surveyed.

Table 1. Selection of sample at GN division level for household survey

	GN division	GN Code	Land area	No. of farm families	Sample size
1	Agare	373	185	113	11
2	Balagolla	368	612	254	25
3	Bogolla	352	399	350	35
4	Dagama	370	313	145	14
5	Elagamuwa	398	332	191	19
6	Galtanwawa	366	291	308	31
7	Hakwatunawa	395	220	195	19
8	Indigolla	367	502	244	24
9	Koruwawa	365	345	220	22
10	Maeliya Dakuna	372	352	216	21
11	Maeliya Uthura	371	252	135	13
12	Rambe	374	85	83	8
13	Rawaela	369	122	60	6
14	Siyambalawewa	396	133	234	23
15	Thalkolawawa	397	130	81	8
16	Thalwahara	392	51	30	3
17	Thambuwa	387	169	160	16
	Total			**3019**	**298**

Data analysis

Analysis was done with Microsoft EXCEL and SPSS software. Collected data were first filtered based on the land area cultivated (less than 2 ac.) and main income source (agricultural) to identify smallholder farmers. Descriptive and inferential statistical methods were used to analyze data.

RESULTS AND DISCUSSIONS

Of the 298 households surveyed, 89% were male headed households and 11% were female headed households. According to Department of Census and Statistics (2001), percentage of female headed households was 20.8% in Kurunegala District. The education level of 33% of the household heads is below grade 5 and 67% is above grade 5. Average number of household members is 4. Of the households surveyed, 89% is living in comparatively well built houses. All of them have access to electricity and water supply. The main source of drinking water is domestic well.

In this study, smallholder farmers are identified as the farmers cultivating less than 2 acres of lowlands and whose main income source is crop farming. All the farmers do not have their own lands, though they are involved in cultivation. Only 82% of the farmers own their cultivation lands and the rest of the farmers (18%) do not own lands for cultivation. These 18% farmers cultivate in rented or mortgaged lands, or shared lands with others. Of the households interviewed, 86% owns less than 2 acre of lowland. Accordingly, of the 298 households interviewed, 61% cultivate less than 2 acres of lowlands and having crop farming

as their main income source. Therefore, 61% of the households in *Hakwatuna-oya* scheme could be considered as smallholder farmers.

Smallholder farmers' perception on temperature changes

Temperature increase is a main effect of climate change. Temperature changes are readily sensed by farmers due to its effect on water availability and crop production. When interviewing the farmers, they were asked about the changes in temperature within the last 5 to 10 year period. About 67% farmers perceived that temperature is changing in the area. About 25 % expressed that there is no change in temperature and 8% do not have enough knowledge or evidence to express temperature has changed or not. According to the data collected, most of the farmers who have said there is no change and there is not enough knowledge on changes have their income contributed more from non-agricultural sources such as businesses and salaried employments. This could be the reason for them focusing less on the climatic changes in the area.

Considerable percentage of smallholder farmers (63%) perceived that temperature is increasing and only 3% have expressed that the temperature is decreasing (Fig. 1). Accordingly, most of the farmers have perceived that the temperature is increasing.

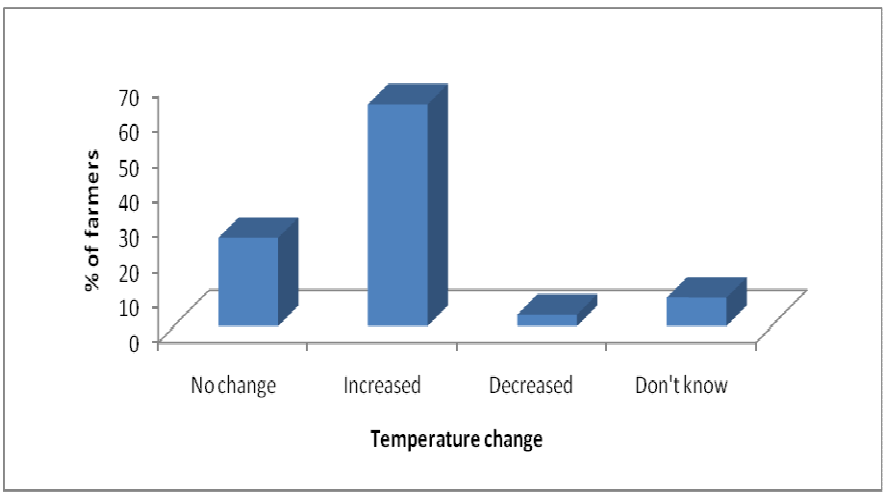

Fig. 1. Farmers' perception on temperature change

Smallholder farmers' perception on rainfall changes

Changes in rainfall have become the main impact of climate change. Climate change leads to change in rainfall amount, increase in extreme rainfall events and increase in the rainfall intensity and the duration of dry periods. All these changes will adversely affect agricultural activities. Because rainfall is a main factor in agricultural activities, farmers are very sensitive to rainfall changes. In the questionnaire survey, farmers were asked whether they felt any change in the amount of rainfall, unpredictability of rainfall and increase in the number of extreme events of rainfall within the last 5 to 10 year period; 83% of farmers observed that rainfall has changed with time. Fifteen percent (15%) of the farmers have expressed that there is no change in rainfall with time and 4% do not have any idea, whether

the rainfall changed or not (Fig. 2). Farmers whose educational level is low are found to be poor in perceiving rainfall changes or unconcerned about the changes. The highest percentage of farmers (32%) observed that the rainfall is decreasing with time and 23% have observed that the extreme rainfall events have increased. Fourteen percent (14%) have expressed that the rainfall becomes unpredictable in terms of amount, rainfall duration and onset of rainfall while 13% have expressed that the rainfall is increasing. Therefore, most of the smallholder farmers in *Hakwatuna-oya* scheme have perceived that rainfall is decreasing with time and extreme rainfall events are increasing. Further, they have perceived that unpredictability of the rainfall events also increased with time.

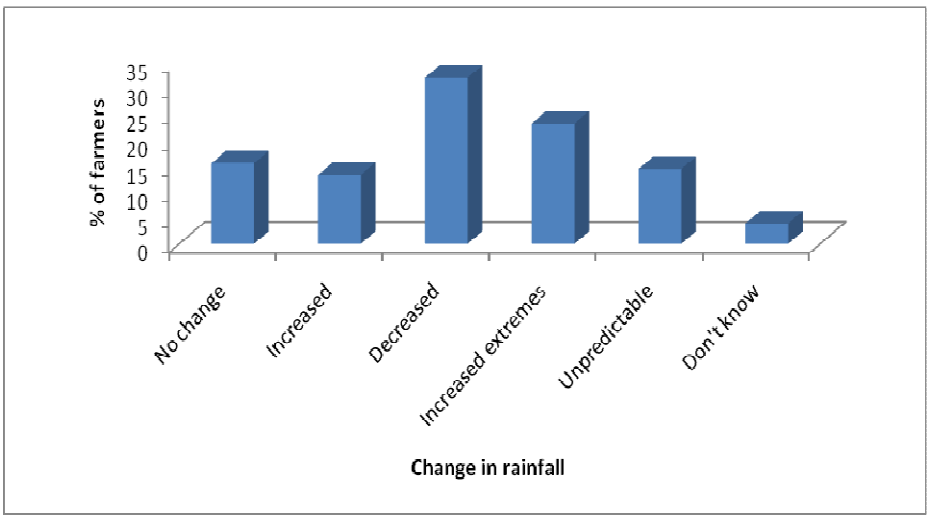

Fig. 2. Farmers' perception on change in rainfall

Seasonal changes and unpredictability of rainfall

In the past, the farmers were able to predict the onset of rainfall. But in recent years farmers face difficulty to start paddy cultivation at the exact time as the onset of rainfall has become unpredictable. Farmers perceive these changes better, because the onset of rainfall and unpredictability makes cultivation more difficult for farmers particularly in deciding the timing of cultivation using their traditional knowledge. Eighty six percent (86%) of smallholder farmers in *Hakwatuna-oya* scheme perceived that rainfall seasons have changed with time (Fig. 3).

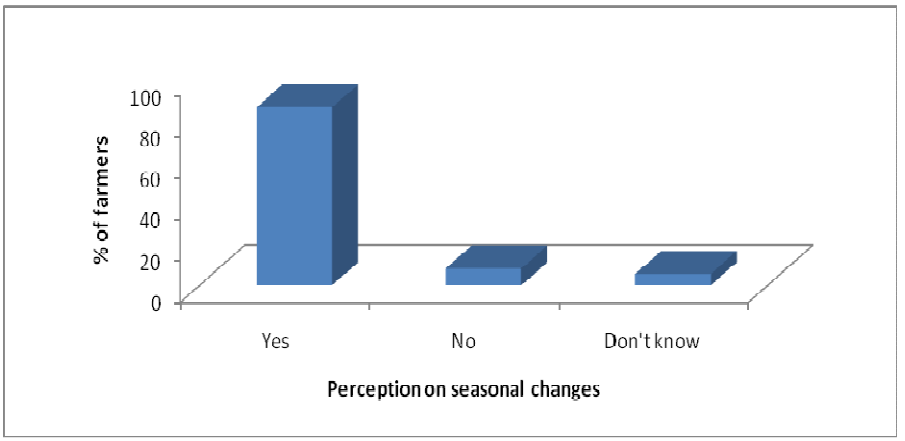

Fig. 3. Smallholder farmers' perception on seasonal changes

Changes in droughts, floods and cyclones

Climate change is a major cause to increase droughts, floods and cyclones. It increases the severity and the duration of drought events. In *Hakwatuna-oya* scheme, 69% of the farmers have perceived that drought incidents have increased in the area with time (Fig. 4). Seventeen percent (17%) of the farmers have said that drought incidents have not changed with time. This shows that majority of the farmers have perceived that droughts have increased. During the past 10 years, floods and cyclones are very rare in the area and farmers have not experienced floods or cyclones in the area in the past and at present.

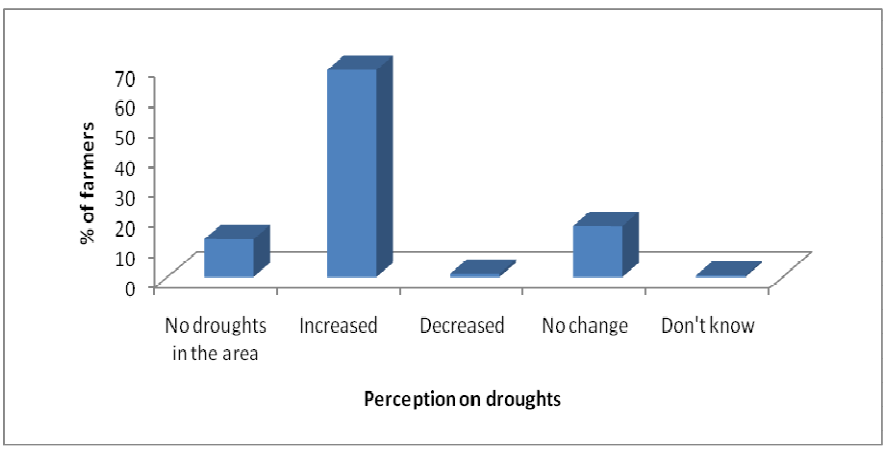

Fig. 4. Smallholder farmers' perception on droughts

Impacts of climate change on smallholder farmers

Perceived impacts of the climate changes were identified using the questionnaire survey. In this study, information was received on six impacts that could affect agriculture practices. Most of the farmers observed crop failure (84%) as the main impact of climate change. Increasing temperature, decreasing rainfall and increasing drought incidences reduce the water availability and cause increasing crop failure. Fig. 5, shows that 45% of farmers observed that the pests and diseases have increased with the changing weather conditions. They have observed it after high rainfall events and also with the temperature increase. Crop failure has direct implications on food shortage. However, only 12% of the farmers have reported food shortage. Most of the farmers keep the whole or part of their paddy harvest for their consumption. Most of the time, this quantity of paddy is enough for them to survive for a year. They sell the extra quantity of paddy only when they are getting the yield from the next season. Therefore, if they could not cultivate the next season, they rarely feel the food shortage. This is clearly visible in Fig. 5. Further, they have observed damage to the livestock farming, pest and disease outbreak in livestock as other impacts.

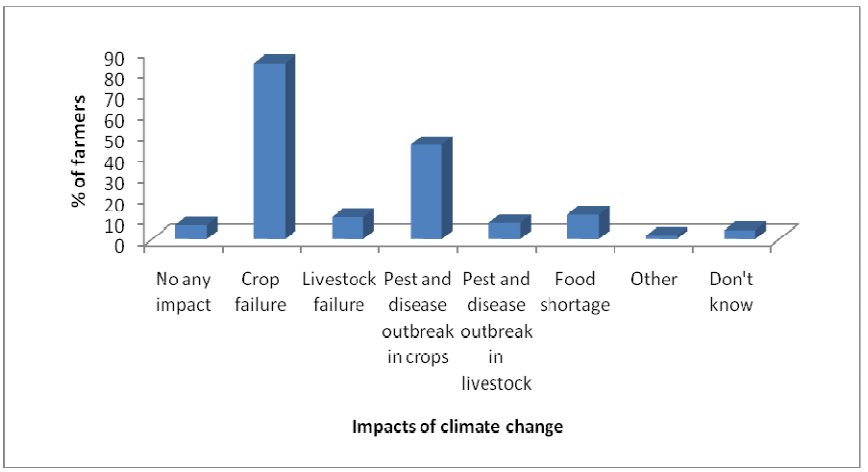

Fig. 5. Perceived impacts of climate change

Adaptations of smallholder farmers to climate change impacts

Adaptation to climate change is a two-step process. The first step is the perception to climate change. The second step is the adaptation practices as the responses to perceived climate changes (Apata, 2011).

Autonomous adaptation measures by farmers were identified using the questionnaire survey. Farmers were asked whether they have made any changes to cropping patterns or crop varieties that they have been cultivating during the past 5 to 10 years. According to the questionnaire survey, 37% of the farmers did not change any cultivation practice with time and therefore, they do not have any adaptation measures in use (Fig. 6). Thirty two percent (32%) of the farmers have avoided some seasons from cultivation. Most of the farmers avoided cultivation in *Yala* season because of inadequate irrigation water and lack of rainfall. Twenty six percent (26%) of the farmers increased cultivation of short duration crops. Especially they are cultivating short duration paddy varieties to reduce the risk from sudden

dry spells or shortage of irrigation water. It is decided collectively at the seasonal meeting (*kanna* meeting) where farmers and officials of different institutions gather before the cultivation starts. In the past, they have cultivated long duration rice varieties. But, almost all the farmers now cultivate short duration rice varieties. Twelve percent (12%) of farmers increased the cultivation of drought resistant upland crops such as green gram, soya and sesame. Notably, they are cultivating these crops on the same lowland during *Yala* season. Farmers have to use more agrochemicals such as fertilizer, pesticide and disease preventing agro-chemicals to maintain the crop healthy, so that it will withstand any climate adversity. It is visible in Fig. 6 that 21% of the farmers have increased agrochemical usage. With temperature increases and increased humidity following higher rainfall events, disease outbreak can be visible. Therefore, they use high amount of plant protection chemicals. With the uncertainty of water availability, they have to get the crops maturated soon into a certain stage that can resist the bad situation. Therefore, they use more fertilizers for their cultivation. Around 2% of the farmers use multi-cropping as an adaptation measure and very few farmers use some other types of adaptation measures. Further, 2% of the farmers do not have an opinion on adaptation measure on cultivation. Overall, 61% of the farmers have carried some adaptation measures to the climate change.

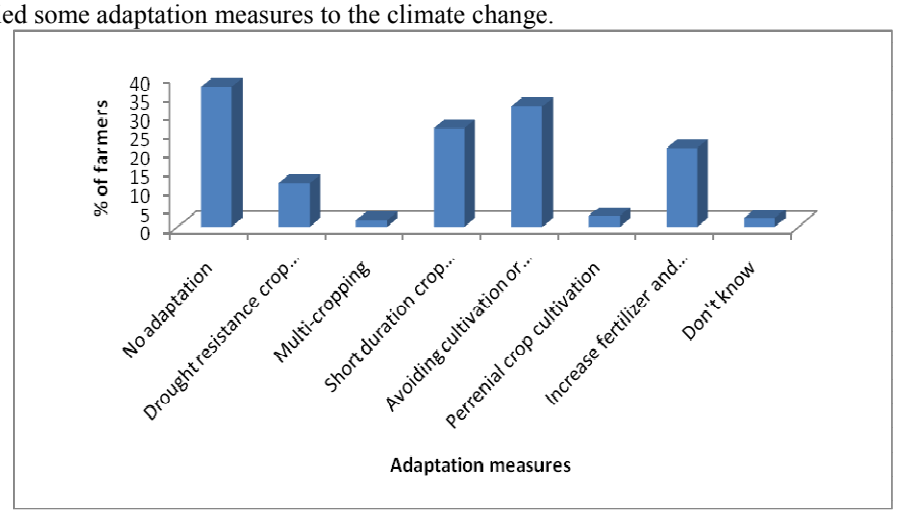

Fig. 6. Adaptation measures practicing by farmers

Though farmers perceive that there is a change in climate and there are negative impacts for their livelihoods, they are unable to come up with sufficient adaptation measures. As shown in Fig. 5, though more than 80% of the farmers face crop failure due to climate change, there are around 39% of the farmers who still do not practise any adaptation measures (Fig. 6). Also the farmers, who have developed some adaptation measures, have not been able to cope with the negative impacts considerably. It indicates that there is room for improvement in adaptation measures undertaken by the farmers.

Most of the farmers (71%) indicated lack of irrigation water as the main difficulty in adapting to climate change (Fig. 7). If they do not receive enough or manageable amount of water to their fields throughout the season, crop will definitely fail because other water sources are only complementary to irrigation water. Therefore, the main barrier to the adaptation is not receiving the least required water amount to their field, particularly in the dry season. Therefore, farmers avoid cultivation in dry season rather than looking into other adaptation measures.

If farmers have enough information on climate change and the adaptation measures that they can use, it will be very useful for them to successfully implement suitable adaptation measure. Therefore, Fig. 7 shows that 24% of the farmers have identified lack of knowledge as a barrier for proper adaptation.

Smallholder farmers are not much financially sound. They always face financial crisis in their day-to-day life. This is a barrier for adaptation because they have lack of resources and it is risky for them to try innovations. Fig. 7 shows that around 23% of farmers have expressed financial difficulties as their difficulty to move on with adaptation practices. Around 12% of the farmers expressed that less profit from agriculture is a barrier to implement adaptation measurers. With less profit from agriculture, they try to work as labour or engage in other kind of employment for their livelihood. This leads them to focus less on adaptations with agricultural practices.

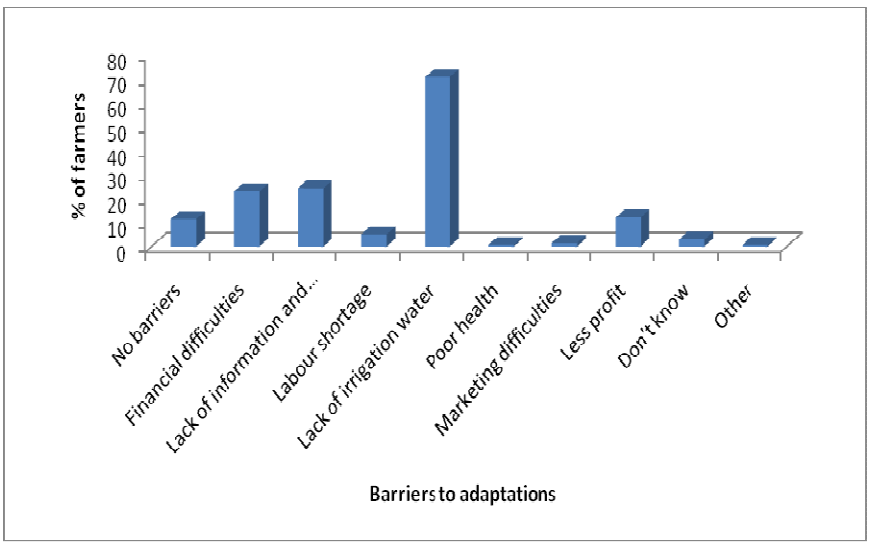

Fig. 7. Barriers to adaptations

Factors affecting perceptions and adaptations to climate change

Number of years that farmers are living in the area, gender, income from crop farming activities, employment status of household head , number of extension services, and education level of other household members have significant correlation with perception on climate change (Annex I). Therefore, these factors could be identified as the factors influencing the perception on climate change. Number of extension service providers and the education of other household members are the most sensitive factors for perception. Location of the field in relation to left and right bank irrigation canals, age of farmer, number of household members, extent of land owned by the farmers, extent of lowland cultivated, total income of the household, income from paddy cultivation and education level of household head are not having significant relationship with perception to climate change.

Perception of farmers leads to adaptation. If they perceived more, then they will adapt quickly and more. Table 2 shows that there is a significant correlation between perception and adaptation of the farmers in *Hakwatuna-oya* scheme. Correlation between perception of

rainfall changes and adaptation is significant at P<0.05 level. Correlation between perception of drought changes and adaptation is highly significant at P<0.01. Further, the climate change impacts lead to adaptation. Table 2 shows that impacts have highly significant (P<0.01) correlation with the adaptations.

Table 2. Correlation of perception to adaptation

		Perception of any rainfall changes	Rain fall is decreased	Perception on seasonal changes	Perception of any changes of drought incidents	Drought incidents are increased	Farmers impacted by climate change or variability
Farmers adaptation to climate change or variability	Chi-square value	6.299*	.026	.398	30.389**	30.595**	18.551**
	df	1	1	1	1	1	1
	Significance	.012	.871	.528	.000	.000	.000
	N	183	183	183	183	183	183

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

Table 3. Correlation between adaptation and socio-economic factors

Factor	Farmers adaptation to climate change or variability			
	Chi-square value	df	Significance	N
Area cultivated by left and right irrigation canal	13.441**	1	.000	183
Number of years that farmers living in the area	8.223*	3	0.042	183
Gender	3.362	1	.067	183
Age	9.520*	4	0.049	183
No of household members	6.221	6	.399	183
Size of lowland owned	2.351	3	0.503	183
Extent of lowland cultivating	6.546	3	0.088	183
Total household income	12.705*	5	0.026	183
Income from paddy farming	9.146*	3	0.027	183
Income from crop farming	10.497*	4	0.033	183
Whether household head is employed or not	.345	1	.557	183
Number of extension services	15.181**	3	0.002	183
Education of household head above O/L	5.123	4	.275	183
Education of other members of the household above O/L	9.749*	4	.045	183

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

Adaptation of the farmers to climate change is influenced by many factors. Socio-economic factors, cultivation practices and government institutional support are the main factors influencing adaptation. Location of the field in relation to left and right irrigation canals and

number of extension service providers to the farmers have highly significant correlation ($P<0.01$) with adaptation (Table 3). Farmers are receiving information on cultivation from several sources. Officers of the Department of Agrarian Development (DoAD), Department of Agriculture (DoA), Non-governmental organizations, inputs suppliers and fellow farmers are some of the sources of information. Extension services provide climate related details and possible adaptation strategies to farmers. This shows the importance of extension services in adaptation to climate change.

Total household income, income from paddy farming and income from all the crop cultivation activities have a significant correlation with adaptation. This shows that smallholder farmers are adapting less because smallholder farmers' income is always less.

Number of years that farmers have been living in the area and age of the farmers have a significant correlation ($P<0.05$) with adaptation. Secondary education level of the members of the household has significant correlation ($P<0.05$) with adaptations. This shows that the household members' educational level has an influence on adaptation.

CONCLUSIONS

Most of the farmers (63%) perceived that temperature is increasing and rainfall is decreasing in the area. Further, they have perceived the seasonal changes and unpredictability of rainfall as the major impacts of climate change while accepting occurrence of drought also has increased in the area. No incidents of floods and cyclone were reported by the farmers during the past 10 years in the area. Most of the farmers perceived crop failure and pest and disease outbreak (84% and 45%, respectively) as the indirect impacts of climate change. The farmers have developed adaptation practices on agricultural activities with time. Cultivating drought resistant crops, short duration rice varieties and increasing fertilizer and pesticides were the main adaptation measures. In severe cases, they avoid cultivation and go for non-agricultural sources of income. Severe shortage of water is the main barrier for adaptation. Financial difficulties of smallholder farmers, less profit from cultivation due to smallholdings and lack of information and trainings on agricultural activities related to climate change are the other barriers reported.

Main factors affecting smallholder farmers' perception on climate change are the number of years that farmers lived in the area, gender, income from crop farming, number of extension services, employment status of household head and education level of other household members.

Adaptation is highly influenced by the perception of the smallholder farmers. Number of years that farmers have been living in the area, age, total household income, income from paddy farming, income from all the crop farming, education of household members and number of extension services are the main factors affecting smallholder farmers in adapting to climate change.

Providing farmers with adequate awareness on climate change and providing some kind of early warnings or forecasting of weather pattern will support autonomous adaptation to climate change. The support could be further strengthened through appropriate policy interventions focusing on crop improvements for drought resistance, development of short duration crops, introduction of new cultivation practices such as aerobic paddy cultivation and improved extension services. Policies have to be focused on livelihood diversification

programs, credit facilities and crop insurance systems to strengthen the farmers socio-economically to increase resilience to climate change.

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ANNEX I

Correlation of perceptions and socio-economic factors

Factor		Perception on any changes of temperature	Temperature is increased	Perception on any changes of rainfall	Rainfall is decreased	Perception on seasonal changes	Perception on any changes of drought	Drought incidents are increased
Area cultivated by left and right irrigation canal	Chi-square value	.026	.359	.441	.028	.515	1.623	1.605
	df	1	1	1	1	1	1	1
	Significance	.873	.549	.507	.868	.473	.203	.205
Number of years that farmers living in the area	Chi-square value	5.421	2.470	4.726	19.459**	4.419	3.400	3.018
	df	3	3	3	3	3	3	3
	Significance	.143	.481	.193	.000	.220	.334	.389
Gender	Chi-square value	2.368	1.238	.020	.029	10.276**	.025	.053
	df	1	1	1	1	1	1	1
	Significance	.124	.266	.887	.864	.001	.875	.818
Age	Chi-square value	6.238	5.220	5.497	3.651	1.498	5.020	5.002
	df	4	4	4	4	4	4	4
	Significance	.182	.266	.240	.455	.827	.285	.287
No of household members	Chi-square value	4.828	2.429	4.954	2.529	3.116	3.418	3.146
	df	6	6	6	6	6	6	6
	Significance	.566	.876	.550	.865	.794	.755	.790
Size of lowland owned	Chi-square value	1.519	2.327	6.552	3.640	1.756	1.001	1.106
	df	3	3	3	3	3	3	3
	Significance	.678	.507	.088	.303	.625	.801	.776
Extent of lowland cultivating	Chi-square value	1.812	4.027	6.755	6.870	1.008	5.356	5.245
	df	3	3	3	3	3	3	3
	Significance	.612	.259	.080	.076	.799	.148	.155
Total household income	Chi-square value	6.046	5.560	3.976	6.657	5.161	6.994	6.900
	df	5	5	5	5	5	5	5
	Significance	.302	.351	.553	.247	.396	.221	.228
Income	Chi-	1.447	.958	4.835	5.991	4.698	1.317	1.528

from paddy farming	square value							
	df	3	3	3	3	3	3	3
	Significance	.695	.812	.184	.112	.195	.725	.676
Income from crop farming	Chi-square value	2.839	2.379	16.824**	7.732	4.314	2.030	2.328
	df	4	4	4	4	4	4	4
	Significance	.585	.666	.002	.102	.365	.730	.676
Whether household head is employed or not	Chi-square value	6.226*	.199	.685	.668	.190	.509	.613
	df	1	1	1	1	1	1	1
	Significance	.013	.655	.408	.414	.663	.476	.434
Number of extension services	Chi-square value	20.321**	15.258**	21.058**	18.777**	6.172	29.953**	32.657**
	df	3	3	3	3	3	3	3
	Significance	.000	.002	.000	.000	.104	.000	.000
Education of household head above O/L	Chi-square value	2.527	2.392	1.416	.119	.483	.702	.920
	df	1	1	1	1	1	1	1
	Significance	.112	.122	.234	.730	.487	.402	.337
Education of other members of the household above O/L	Chi-square value	8.597**	5.417*	2.123	.352	2.037	10.921**	13.524**
	df	1	1	1	1	1	1	1
	Significance	.003	.020	.145	.553	.153	.001	.000

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).