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Impacts of Climatic Changes on Food Security and Adaptation Strategies among Rural Paddy Farmers: Situational Comparison in 2011 and 2012

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ABSTRACT

Food security is directly linked with the people's ability of consuming foods. The specific objective of this study is to identify the level of food security among rural paddy farmers caused by the climatic changes during the period of 2011 and 2012 in Kurunegala District. Ibbagamuwa, Galgamuwa and Maho Divisional Secretaries were selected based on highly paddy growing and highly climatic variant areas in Kurunegala District. Multiple stage sampling was used to select 60 rural paddy farmers from selected Divisional Secretaries in 2 states as Grama Niladari divisions, and finally paddy farmers. The data were collected by directing questionnaire based personal interviews among paddy farmers during January to March 2013. Principal Component Analysis was applied to make indicators into uncorrelated factors. Indices were calculated for each dimension of food security for both years. Those dimensions were included in to four categories namely most secure, more secure, less secure and least secure. Results revealed that for all three dimensions in 2012 index values are lower than 2011. Food Security Index was calculated for both years by taking the average index values of each dimension. It exhibits that 2011 was more secure concerning 2012 which was least secure for food security. One of the reasons behind this insecurity is due to climatic impact on agriculture. Improvements of micro finance projects within the rural community, implementation of food assistance programs aimed at reducing food insecurity of rural paddy farmers in Kurunegala is needed for successful endurance.

KEYWORDS: Adaptation strategies, Food security, Vulnerability

INTRODUCTION

The Food and Agriculture Organization (FAO) defines food security as a "situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This definition comprises several dimensions of food supplies; as food availability, accessibility and utilization. Food security is not only affected by climatic changes but also affected by income distribution of the community and also socio economic aspects of the community (Francesco et al., 2007). Achieving sustainable food security in a world of growing population and changing diets is a major challenge under climate change.

Climate change can refer to long-term changes in average weather conditions, all changes in the climate system, including the drivers of change, the changes themselves and their effects. Year to year variability in climate already contributes to rural poverty where exposure is high and adaptive capacity is low.

Climate change is already being felt in terms of gradual increases in temperature, increased variability in annual rainfall regimes and a greater prevalence of extreme events such as drought and floods. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows (Rosenzweig *et al.*, 2002). Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns.

Kurunegala district covers an area of 4816km^2, which is 7% of the total area of Sri Lanka and 61% of the province. Of this 4624km^2 is land and 192km^2 is water bodies. Kurunegala district covers part of the dry zone and the intermediate zone. The dry zone receives a mean annual rainfall of less than 1750mm. Kurunegala falling into the Low Country with an elevation below 300m. Above mentioned categories further divided into 24 agro ecological zones. Under the major irrigation paddy cultivated extent is 15% from the total and under minor irrigation scheme the paddy cultivated extent is 46%, while the rest is cultivated as rain fed conditions (Anon. (2012a).

The objective of this study is to assess the vulnerability for food security concerning all dimensions of food security and investigates the level of food security in year 2011 and 2012; where 2012 considering as highly climatic variations year due to drought condition takes place.

METHODOLOGY

Data Collection and Analysis

Ibbagamuwa, Galgamuwa and Maho Divisional Secretaries (DS) were selected based on highly paddy growing and highly climatic variant areas in Kurunegala District. Multiple stage sampling was used to select 60 rural paddy farmers from selected DS in 2 states as Grama Niladari divisions (GN), and finally paddy farmers.

Primary Data were collected with face to face interviews directed by structured questionnaire during the period of January to March 2013. The proxy variables were used to measure food availability, accessibility and utilization across the years 2011 and 2012.

In this study Knowledge Based Scoring method (KBS) was applied to assess the food security levels separately in 2011 and 2012 using 25 indicators related to food security. Scoring was used on a categorical scale of 1 to 5. For some indicators where 1 indicates very common, 2 indicates common, 3 indicates average, 4 indicates rare and 5 indicates very rare. For others most appropriate measurements were used (Table 1).

Table 1. Indicators selected for food security dimensions

	Availability of Food
i.	Paddy cultivation losses due to rain fall
ii.	Paddy cultivation losses due to drought
iii.	Non availability of other foods
iv.	Income Shocks
v.	Difficult to reach prefer foods in the market
vi.	No prefer foods grown in own lands
vii.	Home garden cultivation
viii.	Seed shortages
ix.	Marker proximity
	Access to food
i.	Home productions
ii.	Stocks
iii.	Purchases
iv.	Barters
v.	Borrowings
vi.	Food aids
vii.	Seasonal job migrations
viii.	High Market price on food items
ix.	Poor road conditions and transport facilities
x.	Availability of safe drinking water
	Food Utilization
i.	Quality
ii.	Food preparation methods
iii.	Storage
iv.	Nutritional knowledge
v.	Feeding practices
vi.	Health Status of individuals

Weightage by Principle Component Analysis

Some of these indicators were correlated. Therefore vulnerability for food security among rural paddy farmers were calculated by taking the linear combination of the indicators after making them into uncorrelated factors using Principal Component Analysis (PCA).

Let $x_1, x_2, x_3, \ldots, x_p$ are indicators under study, then first principal component may be defined as;

$$P_1 = a_{11} x_1 + a_{12} x_2 + \ldots\ldots + a_{1p}x_p$$

Such that variance of P_1 is as large as possible subject to the condition that;

$$a_{11}^2 + a_{12}^2 + \ldots\ldots + a_{1p}^2 = 1$$

This constraint is introduced because if this is not done, then Var (P_1) can be increased simply by multiplying any a_{1j}^s by a constant factor.

The second principal component is defined as;

$$P_2 = a_{21} x_1 + a_{22} x_2 + \ldots\ldots + a_{2p}x_p$$

Such that Var (P_2) is as large as possible next to Var (P_1) subject to the constraint that

$a_{21}^2 + a_{22}^2 + \ldots\ldots + a_{2p}^2 = 1$ and

cov (P_1, P_2) = 0 and so on.

It is quite likely that first few principal components account for most of the variability in the original data. If so, these few principal components can then replace the initial p variables in subsequent analysis, thus, reducing the effective dimensionality of the problem.

PCA was applied for the data set of year 2011 and 2012 separately as well as for each dimension of food security by using Minitab.

Computation of Indices

Food Availability (FA), Food Accessibility (FAC), and Food Utilization (FU) indices were constructed after performing PCA separately for each food security dimensions. For the construction of indices, Eigen values (λ_i) greater than 1 as well as contribution to the total variation more than 75% were combined into indices as weighted averages of *n* principle components, where the weights are the Eigen values of the correlation Matrix R. indices were constructed as follows:

$$\begin{Bmatrix} FAI_i \\ FACI_i \\ FU_i \end{Bmatrix} = \frac{\sum_{i=1}^{n} P_i \lambda_i}{\sum_{i=1}^{n} \lambda_i}$$

Where,

FAI_i, $FACI_i$, FU_i= Food Availability (FA), Food Accessibility (FAC), and Food Utilization (FU) indices for i^{th} farmer respectively

$P_i = i^{th}$ Principal Component of each category

λ_i = Eigen Value for i th principal component

n = number of farmers

Food Security Index for each framer was calculated by averaging the FAI_i, $FACI_i$, *and* FU_i indices.

$$FSI_i = \sum_{i=1}^{n} \frac{FAI_i + FACI_i + FUI_i}{3}$$

Finally, overall Food Security Index (*FSI*) was performed for the year 2011 and 2012 separately.

Normalization of Indices

Values of the indices were normalized in order to bring it into one and zero range to assess the level of food security easily, by using following equation.

$$FSI_{i\ nor} = \frac{FSI_i - FSI_{\min}}{FSI_{\max} - FSI_{\min}}$$

Where,

$FSI_{i\ nor}$= Normalized food security index for i^{th} farmer

FSI_{Min}= Minimum value *FSI* of farmers

FSI_{Max} = Maximum value *FSI* of farmers

The indices were used to compare the food security conditions for the years 2011 and 2012 separately. All the farmers were then classified into four categories according to the scores of the FAI_i , $FACI_i$, *and* FU_i namely most Securer (>0.75), more Securer (0.5-0.75) less Securer (0.25-0.5), least Securer (<0.25) for each food security dimensions, of Accessibility, Availability and Utilization severalty for year 2011 and 2012.

RESULTS AND DISCUSSION

Overview of the Sample of Paddy Farmers

Of the total respondent 85% having at least secondary Education (Grade 6-13). Average family size of the respondent was 4 members. The monthly per capita income of most of the respondents (52%) were between Rs.20,000 and 30,000. Monthly Expenditure for foods of majority of the farmer family (42%) was in between Rs.6,000 and 9,000.But monthly budgetary allocation for foods by majority of the respondents (60%) was lesser than the actual expenditure and it was in between Rs.4,000 and 6, 000 (Table 2). Most of the respondents (32%) were resided in Kurunegala district over the duration of 40-50 years. All the farmers engaged in paddy cultivation for both seasons in year 2011 and 2012. Rain was the major source of water for agriculture. All the paddy farmers in study area were self-sufficient in paddy for their annual consumption and sell surplus to the market.

Table 2. Socio economic variables

Parameter	Percentage (%)
Profession	
Farming	65
Non farming	35
Education	
Primary (Grade 1-5)	13
Secondary (Grade 6-13)	85
Tertiary (>Grade 13)	2
Age	
30-50	32
50-70	64
>70	4
PCI (Rs)	
<20000	39
20000-30000	52
>30000	9
PCCE (Rs)	
<6000	32
6000-9000	42
9000-12000	8
>12000	18
PCBA (Rs)	
<4000	22
4000-6000	60
>6000	18

PCI-Per Capita Income; PCCE-Per Capita Consumption Expenditure; PCBA-Per Capita Budgetary Allocation for foods

Results of Climatic Data Analysis in Year 2011 and 2012

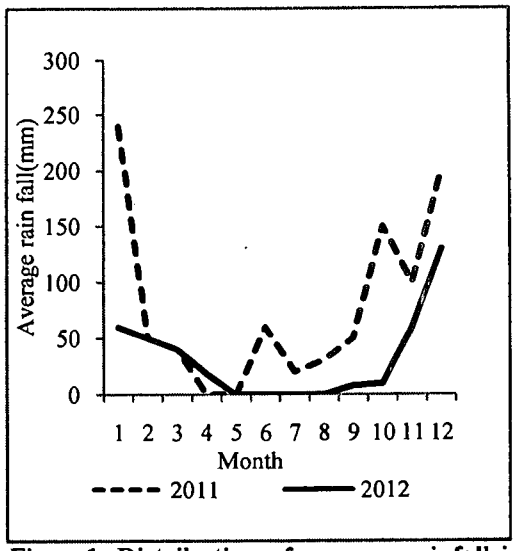

Figure1. Distribution of average rainfall in years 2011 and 2012

Rainfall distribution of year 2011 and 2012 is presented in the Figure 1. It can be clearly seen that year 2012 there was a significant decrease of average rainfall in Yala season.

The wind speed was gradually decreased during the period of 6 to 8 months (yala season) in year 2011. But there was a significant increase in wind speed in yala 2012

due to drought condition, which leads to shoot damages of the rice plant, flower and fruit shedding, water lodging condition and poor areation condition(Figure2).

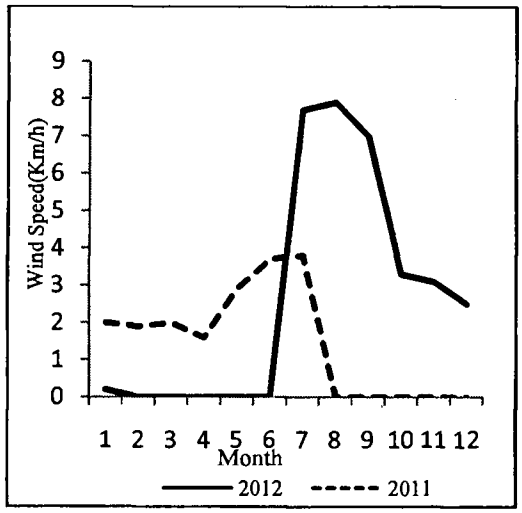

Figure 2. Change of wind speed in years 2011 and 2012

Overview of the Rice Production in 2011 and 2012

Generally in Kurunegala district Maha yield is greater than Yala yield (per Ha) (Anon. 2011-2012). For both seasons in year 2012; sold portion, obtained income from selling the surplus, consumable period of harvest is comparatively lower than the year 2011 since the cultivation of paddy was done under the effect of drought condition(Table 3).

Interpretation of Food Vulnerability Index Values

Consequently this study assessed each dimensions of food security using the indices developed for the years 2011 and 2012. According to the indices constructed by the study, lower index value impresses the lower vulnerability and higher value impress higher vulnerability for food security. Therefore, these indices would serve as a tool to measure food security status of paddy farmers in both considered year 2011 and 2012.

In the case of food availability among rural paddy farmers year 2011 reported higher *FAI* value (0.576) while year 2012 reported lower *FAI* (0.029). These figures shows that, there is a vide variation in vulnerability for food availability in year 2011 and 2012. Main reasons for this gap may be due to the drought prevailing in 2012. Due to drought, farmers have suffered from unavailability of other food products, income shocks, lack of home garden cultivation, and water shortages, leading to the unavailability of food.

Table 3. Summary of rice production and income in Yala and Maha in 2011 and 2012

Season	variables	2011	2012
Yala	Yield (Kg/Ha)	3967	1455
	Sold portion (Kg/Ha)	990	200
	Obtained income (Rs/Ha)	34650	7000
	Expected Income (Rs/Ha)	45000	30000
	Consumable Period (Month/Ha)	7	3
Maha	Yield (Kg/Ha)	4145	3591
	Sold portion (Kg/Ha)	1036	900
	Obtained income (Rs/Ha)	36260	33200
	Expected Income (Rs/Ha)	47500	51200
	Consumable Period (Month/Ha)	6	5

Food Accessibility Index (*FACI*) obtained for the area is higher in 2011 (0.948) with compare to the 2012 (0.399). Similarly, Food Utilization Index (*FUI*) also higher in 2011 (0.691) than 2012 (0.206).

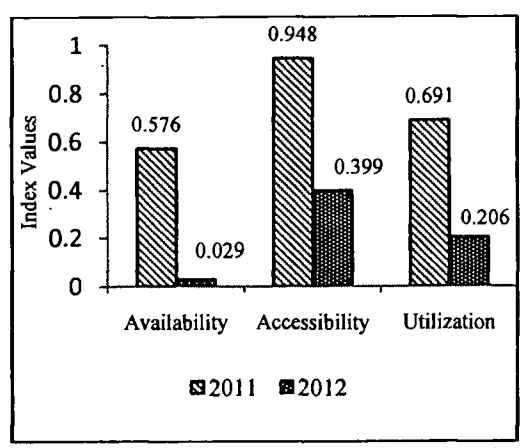

Figure 3. Index values for food security dimensions

Results indicated that values of indices of food security dimensions obtained for paddy farmers in Kurunegala district in year 2012 was relatively lower than the year 2011 due to the impacts of climatic changes. Food Security Index (*FSI*) was performed after getting the average of *FSI* for each farmer, for the year 2011 and 2012. Results revealed that *FSI* for 2011was higher (0.738) than in the year 2012 (0.211) (Figure 4). One of the reasons behind this insecurity due to climatic impact on agriculture.

Table 4. Classification of dimensions

Year	Most Secure >0.75	More Secure 0.5-0.75	Less Secure 0.25-0.5	Least Secure <0.25
2011	Food accessibility	Food availability Food utilization		
2012			Food accessibility	Food availability Food utilization

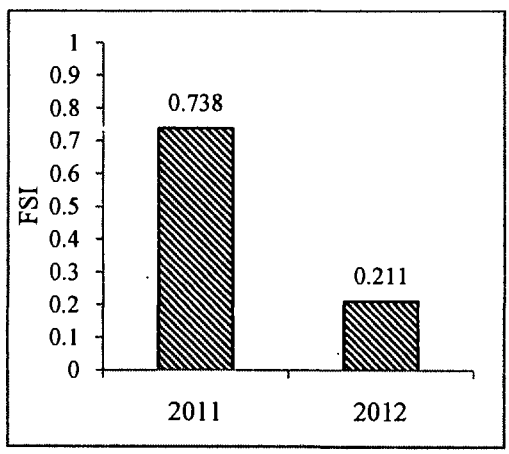

Figure 4. FSI for 2011 and 2012

Grouping of Dimensions using Food Security Index

After observing the index values obtained for each food security distributions for year 2011 and 2012, it was categorized into 4 groups as Most secure (>0.75), More secure (0.5-0.75), less secure (0.25-0.5) and least secure(<0.25).

According to the food availability and food utilization, farmers were more secure in year 2011. But in year 2012 they were least secure. For the food accessibility, farmers were less secure in 2012 (Table 4). All these collective information shows that 2012 was least secure year for food security due to the drought.

CONCLUSIONS

The study developed different indices for food security dimension and used them as a tool to measure the food security level of the study area in 2011 and 2012. The index vales clearly shows that, 2012 is the unsecured year with respect to food security compare to 2011. Study linked those information with climatic changes in those area and it revealed that the one of the reasons behind this insecurity due to climatic impact on agriculture. However this is a good starting point for the policy makers to concern on the implementation of adaptation strategies such as launching irrigation schemes, considerable improvements of micro finance projects within the rural community in order to enhance the paddy cultivation to reduce the food insecurity during the adverse climatic periods.

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REFERENCES

Anon. (2011-2012). Department of Census and Statistics available from: http://www.statistics.gov.lk/agriculture/Paddy%20 Statistics (Accessed 25 February 2013).

Anon. (2012a). Central Bank Annual report. Central Bank of Sri Lanka, Colombo.

Anon. (2012b). Climate view, The World Climate Available from: http://ds.data.jma.go.jp/gmd/tcc/climatview/obsmonth.jsp?n=43441&dt=2011-09-30 (Accessed 28 February 2013).

Food and Agriculture Organization (2002) The State of Food Insecurity in the World 2001 (Food and Agriculture Organization, Rome).

Rosenzweig C, Tubiello F.N, Goldberg R.A, Mills E, Bloomfield J. (2002) Global Environment Change **12**: 197–202.

Francesco N.T., Schmidhuber,J. (2007).*Global food security under climate change.* International Center for Climate Systems Research, Columbia University, New York.