Understanding Adaptive Capacity: Sustainable Livelihoods and Food Security in Coastal Bangladesh

Working Paper No. 32

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Helena Wright
Patti Kristjanson
Gopal Bhatta

CGIAR

RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

CCAFS

Working Paper

Understanding Adaptive Capacity: Sustainable Livelihoods and Food Security in Coastal Bangladesh

Working Paper No. 32

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Helena Wright, Patti Kristjanson, Gopal Bhatta

Correct citation:

Wright H, Kristjanson P, Bhatta G. 2012. Understanding Adaptive Capacity: Sustainable Livelihoods and Food Security in Coastal Bangladesh. CCAFS Working Paper No. 32. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

Published by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

CCAFS is a strategic partnership of the CGIAR and the Earth System Science Partnership (ESSP). CGIAR is a global research partnership for a food secure future. The program is supported by the Canadian International Development Agency (CIDA), the Danish International Development Agency (DANIDA), the European Union (EU), and the CGIAR Fund, with technical support from the International Fund for Agricultural Development (IFAD).

Contact:

CCAFS Coordinating Unit - Faculty of Science, Department of Plant and Environmental Sciences, University of Copenhagen, Rolighedsvej 21, DK-1958 Frederiksberg C, Denmark. Tel: +45 35331046; Email: ccafs@cgiar.org

Abstract

This paper analyses data from a household-level survey of 980 agricultural and fishing households in seven sites across southern Bangladesh. We examine the relationship between assets, livelihood strategies, food security and farming practice changes. These households are coping with huge demographic, economic, and environmental changes. The results suggest that the least food secure households are also the least adaptive, and are making few, if any changes, in their agricultural practices. They have relatively few assets, and are producing and selling fewer types of agricultural products than more food secure households. The importance of diversification as a strategy to deal with change is evident - households making more farming practice changes are more diversified in terms of the number of different agricultural outputs produced and sold. Market-related factors are more frequently given as reasons for changes in practices than climate-related factors. We also see a strong relationship between education and adaptability. Households with more educated members are likelier to be introducing new agricultural practices. The often unrecognized, but important role that women play in agricultural production and livelihood strategies in Bangladesh is also evident. This rich dataset (freely available at: www.ccafs.cgiar.org/resources/baseline-surveys) provides insights into the relationship between household food security and the agricultural livelihood changes being made by rural households in southern Bangladesh. The analysis provides relatively rare empirical evidence supporting the use of the Sustainable Livelihoods Framework (SLF) as a conceptual approach for understanding household food security as well as adaptation of agriculture to climate change. This information is critical and timely for ongoing dialogues on appropriate 'climate-resilient' strategies and policies for increasing the adaptive capacity of households under climate change, and enhancing food security at both household and national levels.

Keywords

Climate Change; Agriculture; Livelihoods; Food Security; Adaptive Capacity; Bangladesh

About the authors

Helena Wright is a Doctoral Researcher at the Centre for Environmental Policy, Imperial College London funded by ESRC. Her areas of speciality include climate change and food security. She has experience in climate change policy and finance.

Patti Kristjanson is an agricultural economist and research leader of CCAFS, based at the World Agroforestry Centre in Nairobi. Her expertise includes poverty and livelihood analyses, impact assessment, agricultural system analyses and innovative research approaches for linking knowledge with action. She has 25 years of experience leading and managing multidisciplinary teams from international and national agricultural research centres, in collaboration with universities, donors, private and public sectors across Africa and Asia (p.kristjanson@cgiar.org).

Gopal D. Bhatta is a Science Officer in CCAFS South Asia based in IWMI New Delhi, India. His expertise includes farming system analysis, spatial modeling, consumers' preference analysis and organic agriculture. He has almost 10 years of experience in research and teaching in diverse areas of agriculture and socio-economics of farm-families in South Asia.

Acknowledgements

Special thanks go to the research partners in Bangladesh including Dwijen Mallick and the Bangladesh Centre for Advanced Studies (BCAS) in Dhaka, Bangladesh for their important role in collection and preparation of the household survey data as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Contents

List of Tables and Figures

Acronyms

BCAS	Bangladesh Centre for Advanced Studies
CBO	Community-based Organisation
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
DFID	Department for International Development
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
HYV	High Yield Variety
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
NGO	Non-Governmental Organisation
SLA	Sustainable Livelihoods Approach
SLF	Sustainable Livelihoods Framework
WRI	World Resources Institute

Introduction

The IPCC describes how coastal areas are particularly vulnerable to climate change, and deltaic regions such as Bangladesh have long been recognised as 'hotspots' of vulnerability to climate change and sea level rise due to the low-lying land and dense population (Nicholls et al, 2007). Around 65% of Bangladesh is located in the deltaic plain of the Ganges-Brahmaputra Delta (Alam, 1996). The Ganges-Brahmaputra Delta, spanning an area of 87,300km^2 is the largest mega-delta in the world in terms of population, with 111 million people. It is also the second most densely populated delta in the world, with 1,280 people per square kilometre (Ericson et al, 2006). Bangladesh has been recognised as one of the countries in the world most at risk of climate change (Ali, 1999; World Bank, 2010) and tops the list of the most vulnerable countries in the world compiled by Maplecroft (ADB, 2012). The delta suffers from a range of factors which increase sensitivity to climate impacts, including population pressure, tropical cyclones, and regular flooding. Every 3-5 years, two-thirds of Bangladesh is inundated by floods, and around every 3 years a cyclone hits, causing storm surges in excess of 10 meters (World Bank, 2010). Climate change is expected to lead to sea level rise and sea surface temperature (SST) rise, which is likely to increase the frequency and intensity of tropical cyclones (Khan et al, 2000). Salinity and sea encroachment into groundwater is also likely to impact on the staple rice yield and affect freshwater supplies.

In addition to vulnerability to climate change impacts, parts of Bangladesh already suffer from serious food security issues. Figures from WRI show that 48% of children were underweight between 1995 and 2000 and the average daily per capita calorie intake was 2,201 in 1999 (WRI, 2003). Rice is particularly important for food security in Bangladesh, contributing 63% of calorific intake for urban consumers and over 71% for the rural population (WFP, 2011). Food security has been defined 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" (FAO, 2002). Availability, affordability and access to food have been recognised as crucial. Adaptive capacity is also key for food security (Di Falco et al, 2010), and is defined by the IPCC as "the ability or potential of a system to respond successfully to climate variability and change" (Adger et al, 2007).

At the household level, food security is closely linked to poverty, as people spend a large proportion of their income on food in Bangladesh; a 2005 national household income survey found that food expenditure accounts for nearly 54% of total expenditure on average, and is 60% in rural areas (FAO, 2002). Agriculture is the single largest producing sector of the economy, making up 18% of GDP and employing 45% of the population (CIA, 2012). Bangladesh is in fact the fourth largest rice-producing country in the world (FAO, 2010). As such much of the food security challenge in Bangladesh has historically been closely linked to the production of, and access to, rice at household level. Agricultural development has been important in recent years in reducing poverty and hunger, and the impacts of climate change have been recognised by the Government of Bangladesh as a key threat to national economic development (BCCSAP, 2008).

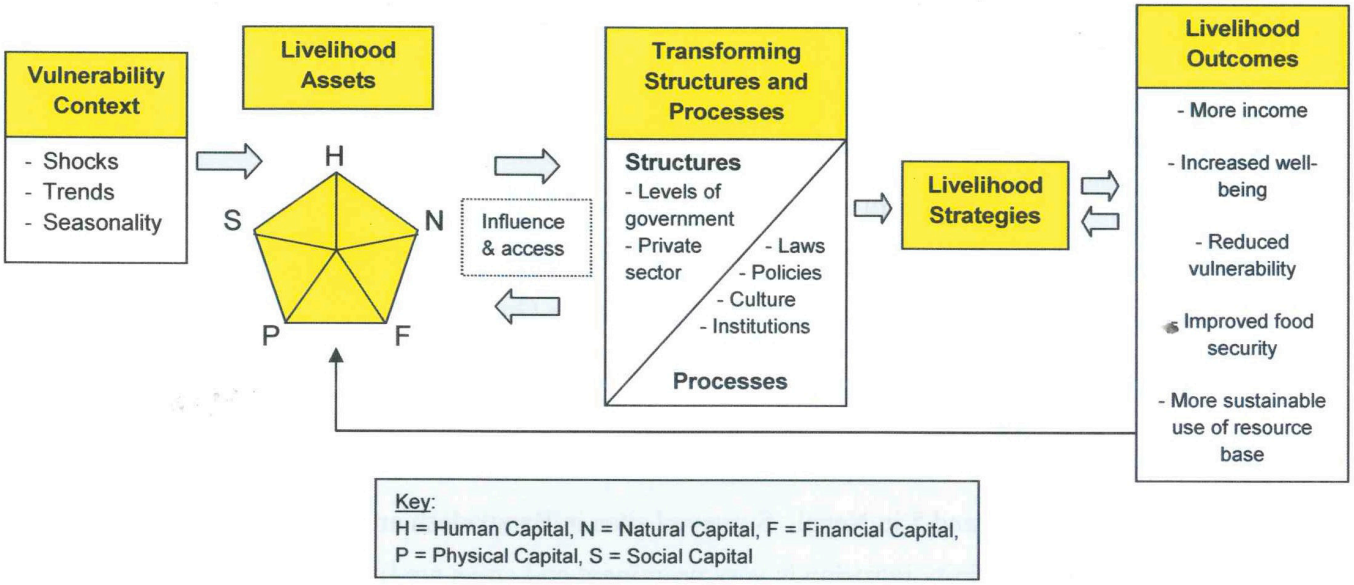
Data Collection and Analysis

The household survey data from Bangladesh was collected as part of the Climate Change, Agriculture and Food Security (CCAFS) research programme, a global ten-year highly collaborative research programme led by the Consultative Group in International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP) (see: www.ccafs.cgiar.org). This baseline survey was carried out with local partners across very diverse rural sites in 12 countries, including 5 sites in West Africa, 5 in East Africa, 7 in Bangladesh, 7 in India and 5 in Nepal. Surveyed sites in Bangladesh are located in the coastal zone, where salinity intrusion is very prominent and crops are frequently lost due to floods or tidal surges. The survey was designed with the intent of developing simple, comparable cross-site household-level indicators, for which changes can be evaluated, of food security, household assets, agricultural production diversity,

agricultural sales diversity, changes to farming practices (adaptation/innovation), mitigation and gender indicators (Kristjanson et al, 2011). The 7 Bangladeshi sites (10kmx 10km blocks were chosen based on certain criteria– see www.ccafs.cgiar.org/where-we-work for a site portfolio document with site descriptions) were selected following a salinity gradient. The sites should not be taken as representative of Bangladesh as a whole as they were selected from the coastal rural areas. A random sample was taken of 20 households within each village, and 7 villages within each of the 7 sites, thus there was a total of 980 (n=980) respondent households in the survey sample (Kristjanson et al, 2010).

This analysis draws from the conceptual framework provided by the sustainable livelihoods approach shown in Figure 1. It shows that, while a households' choice of livelihood strategies influences their levels of food security and income, levels of food security can also influence which livelihood strategies they choose. According to the sustainable livelihoods framework, assets are made up of human, social, natural, physical and financial capital (DFID, 1999).

Figure 1. Sustainable Livelihoods Framework (Source: Adapted from DFID, 1999)



The sustainable livelihoods concept was developed by Robert Chambers and Gordon Conway in 1991 as a basis for conceptualizing development programs and practices. Following on from this work the 'sustainable livelihoods approach' (SLA) was used by DFID and FAO (Solesbury, 2003). Knutson and Ostwald (2006) argue that it has previously primarily been used in a theoretical sense rather than a practical one, where these relationships are tested empirically. The framework suggests that vulnerability context has a direct impact on people's asset status and livelihood options. Climate change can be conceptualized as one aspect of the vulnerability context.

Adaptation to climate change is closely related to agricultural development activities. The IPCC has identified a two-way causality between adaptive capacity and sustainable development (Yohe et al, 2007). This occurs because development influences adaptive capacity, and adaptive capacity also influences the pace and character of development: a lesson applicable to this analysis. Hence development pathways in coastal Bangladesh will likely affect the severity of climate impacts, "not only through changes in exposure and sensitivity, but also through changes in the capacities of systems to adapt" (*ibid).* This paper explores the relationships between assets, livelihoods, adaptive capacity and food security using the CCAFS household baseline survey data.

Food Security, Assets and Livelihood Diversity

In order to meet the multiple purposes of the CCAFS baseline survey, the number of 'food deficit months' was defined as the number of months that a household has difficulty getting food *from any source* during an average year (Kristjanson et al, 2010). This is a crude indicator of a very complex concept that is never easily measured (Migotto et al, 2007), and more in-depth food security studies will be used to complement the baseline data. For the purpose of tracking changes over time (the main objective of the baseline initiative), the households were divided into three categories; those with no food deficit months per year, those with 1-5 food deficit months, and those reporting over 5 food deficit months in the year.

Similarly, a simple wealth proxy, or 'asset indicator', was derived from asking respondents which assets they owned from a list of 21 possibilities. These included assets related to 1) Energy: Generator (electric or diesel), Solar Panel, Biogas Digester, Battery (large, e.g. car battery for power); 2) Information: Television, Cell phone, Internet access, Computer, Radio; 3) Production means: Tractor, Mechanical Plough, Thresher, Mill (for grinding cereals or oilseeds); 4) Transport: Motorbike, Car, Bicycle; 5) Luxury items: Fridge, Air conditioning, Electrical fan, Bank account, Stove (Barahona et al, 2011). To form the Asset Indicator, the households were divided into three categories; those with no assets, those with 1-3 assets, and those with 4 or more assets.

Indicators of the diversity of agricultural production and sales activities were also derived, based on the number of agricultural products being produced on-farm as well as the number of agricultural products being sold by the household (Barahona et al, 2011). Households producing 1 to 4 products were classified as having *low production diversification*, those producing 5 to 8 products were classified as having *medium production diversification*, and households producing 9 or more products were considered as having *high production diversification*. With respect to sales diversification, households selling no products were classified as *subsistence,* 1-5 products as *low market orientation*, and 6 or more as *high market orientation*.

Households were also queried about what changes they had made over the last 10 years with respect to a wide range of practices – relating to crop type, variety type, land use and management practices, and farm animals/fish management practices (59 possibilities in all – see survey for details). The idea here is that households that have already been making changes, and introducing new practices, are likely to be more 'adaptive' to weather-related shocks and long-run changes in weather patterns (i.e. climate), than those that have not been able to make adjustments or introduced any new innovations to date.

This led to an 'adaptability indicator', defined as the following: 0= zero or one change made in farming practices (i.e. crop, livestock, soil, water, land, and/or tree management practices) over last 10 years (low level); 1=2-10 changes made in farming practices (intermediate level); 2=11 or more changes made in farming practices (high level).

Results

The Indicators

Table 1 shows the percentage of surveyed households found in each category with respect to food security, assets, agricultural production diversification, agricultural sales diversification, land ownership and education. Levels of food insecurity are high, with only 44% of households reporting no periods with food shortages during the year, and 15% facing food deficits for over half the year. Many households own only very basic household assets, with 2/3 reporting having three or less. These households vary in their degrees of agricultural production and sales diversification. Farm sizes are very small; only around one-quarter own more than 1 acre of land. One-third of households have little formal education.

Table 1. Food security, assets, diversification, adaptability, land ownership and education indicators

Indicator	Percentage of households (across all 980 households) falling into each category			
Food Security	**No food shortage**	**1-5 months of food deficit/year**	**6+ months of food deficit/ year**	
	44	41	15	
Assets	**Zero assets**	**1-3 assets**	**4+ assets**	
	13	54	33	
Production diversification	**Low (1-4 products)**	**Medium (5-8 products)**	**High (9+ products)**	
	26	41	32	
Sales diversification	**Subsistence level (no products)**	**Low market orientation (1-5 products)**	**High market orientation (6+ products)**	
	19	70	11	
Land Ownership	**No land**	**Low land ownership (<1/2 acre)**	**Medium land ownership (1/2 – 1 acre)**	**High land ownership (>1 acre)**
	2	58	14	27
Education (highest education level in the household)	**No formal education**	**Primary**	**Secondary**	**Post-secondary**
	4	28	40	29
Adaptability	**0-1 changes**	**2-10 changes**	**11+ changes**	
	5	51	45	

Relationship between Food Security and Assets

Given the high levels of food insecurity reported by respondents, we explored the relationship between household food security levels and the number of assets a household owns. Figure 2 suggests that households with higher levels of food insecurity (e.g. 6 months and above per year, in brown) generally had very few of these basic household assets (three or less). Food secure households are the only ones that reported owning 8 or more assets. Thus it appears that having these types of assets helps these rural households in terms of being able to feed their families throughout the year.

Figure 2. Relationship between household asset ownership and food security

Table 2 shows asset ownership by the randomly selected Bangladeshi households surveyed. Cell phones are owned by 70% of households, and almost one-half have fishing nets. Only around a third have bicycles or radios, however. One-quarter own a television or electrical fan. Few (19%) have a bank account.

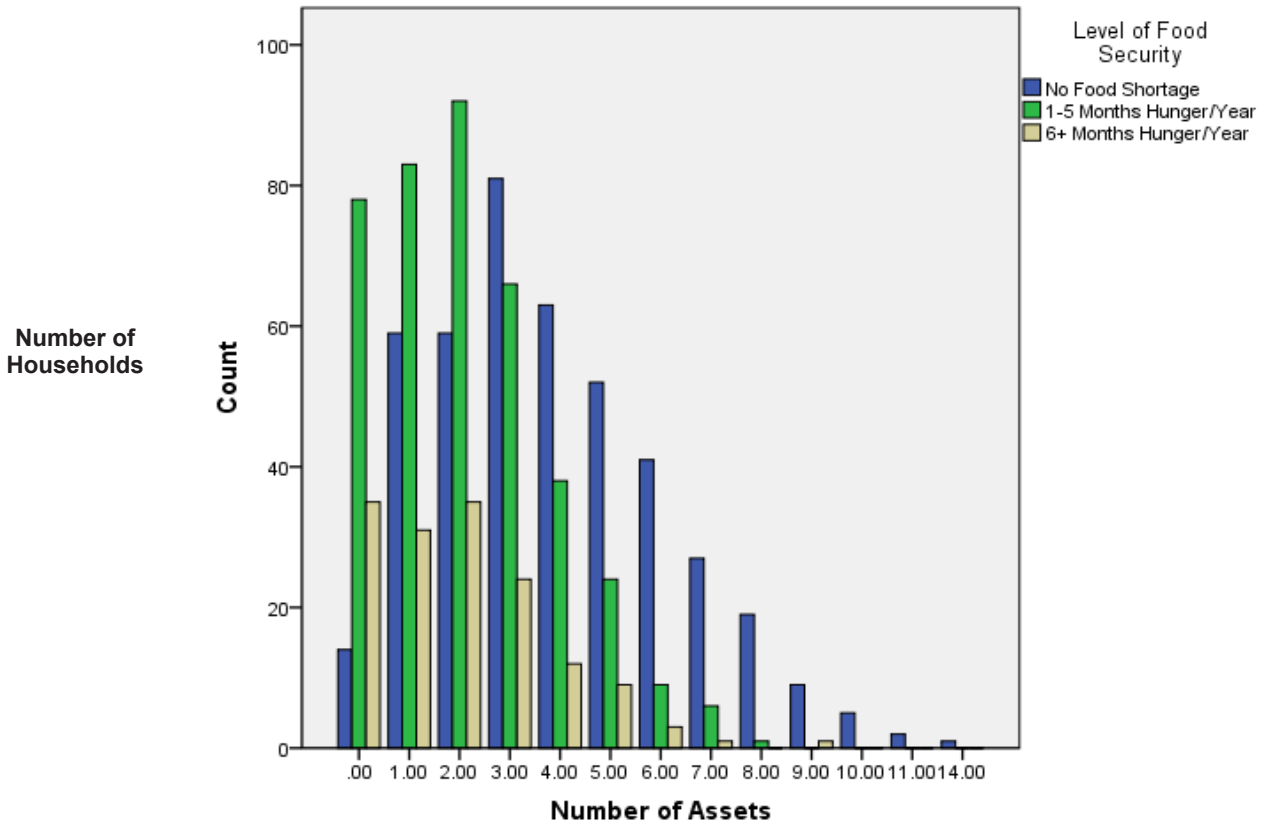


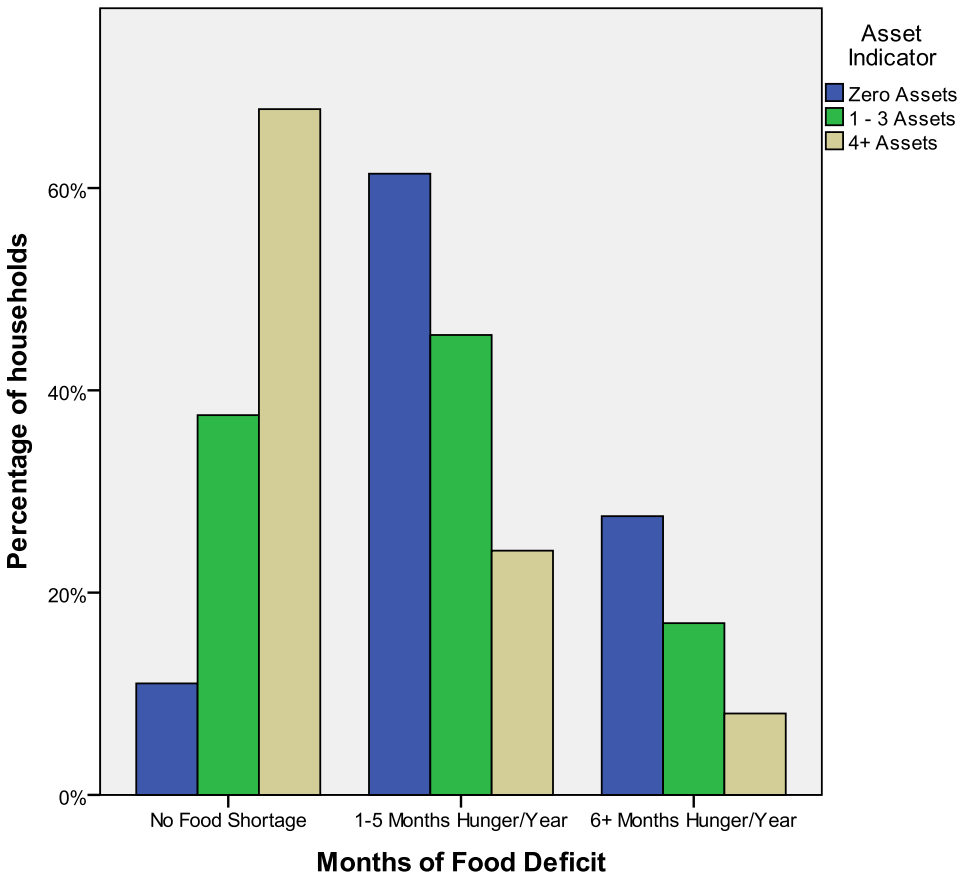
Table 2. Household asset ownership

Asset	Number of households	Percent of households
Cellphone	687	70
Fishing nets	460	47
Bicycle	347	35
Radio	312	32
Television	259	26
Electrical fan	240	24
Bank account	185	19
Solar panel	76	8
Water pump/treadle pump	62	6
Motorcycle	36	4

Boat	33	3
Thresher	22	2
Improved stove	17	2
Mechanical plough	15	2
Computer	9	1
Mill	8	1
Battery (large - e.g. car battery)	8	1
Refrigerator	8	1
Tractor	7	1
Air Conditioning	0	0

We next explored the relationship between asset ownership and the number of food deficit months. As seen in Figure 3, households with four or more assets are generally more food secure (70% of these households are in the no food shortage category), than are those with less assets.

Figure 3. Relationship between Assets and Food Security



A Chi-square statistical test confirms a strong association between the number of assets owned by the household and the level of hunger reported ($chi^2 = 140.5$ (n=980), d.f.=4, $p<0.001$). Households with more assets report fewer food deficit months in a year; the converse is true for households with fewer assets.

As might be expected, households that own higher value assets are more likely to be food secure. 78% of those with a motorcycle, 76% with a solar panel, 73% with a water pump, and 68% that own a television reported no food deficit months. Interestingly, ownership of a boat was not associated with greater food security. In fact, 18% of those who owned a boat reported having more than 6 food deficit months per year. Thus it appears from our data that many households with boats, i.e. likely to be highly dependent on fishing for their livelihoods, are also facing serious food insecurity issues.

Table 3. Structures and Facilities of surveyed households

Household Structures or Facilities	Percent of households
Separate housing for farm animals	61
Improved roofing	42
Electricity from a grid	29
Running water	29
Improved storage for crops	13
Improved housing	13
Well/borehole	10
Water storage tank >500 litres	1

The enumerators asked respondents whether they had any improved household structures, running water or electricity (Table 3). Few reported having electricity (29%) or running water (29%) in their homes. In terms of a relationship between having these facilities and food security, we found that the few (13) households with a water storage tank of a volume of at least 500 litres reported no food shortages. Households with running water or electricity also appear to be more likely to be food secure. Of the households with running water, 59% said they were food secure throughout the year. For those with electricity, 57% reported having no food deficits. This compares an overall average of 44% for food secure households.

Relationship between Production Diversity and Food Security

Rice was by far the most critical crop, with 64% of households saying it was their most important crop (Figure 4). This question was asked in relation to their overall household welfare and not solely in terms of consumption or income, for example. With respect to their reported 'second most' important crop, there were many cited, with coconut, bananas, garlic, papaya, lentils and betel nut being the most frequently mentioned (Figure 5). Betel nut, coconut, garlic and bananas were reported most frequently as the third most important crop.

Figure 4. Households' current 'most important' crop

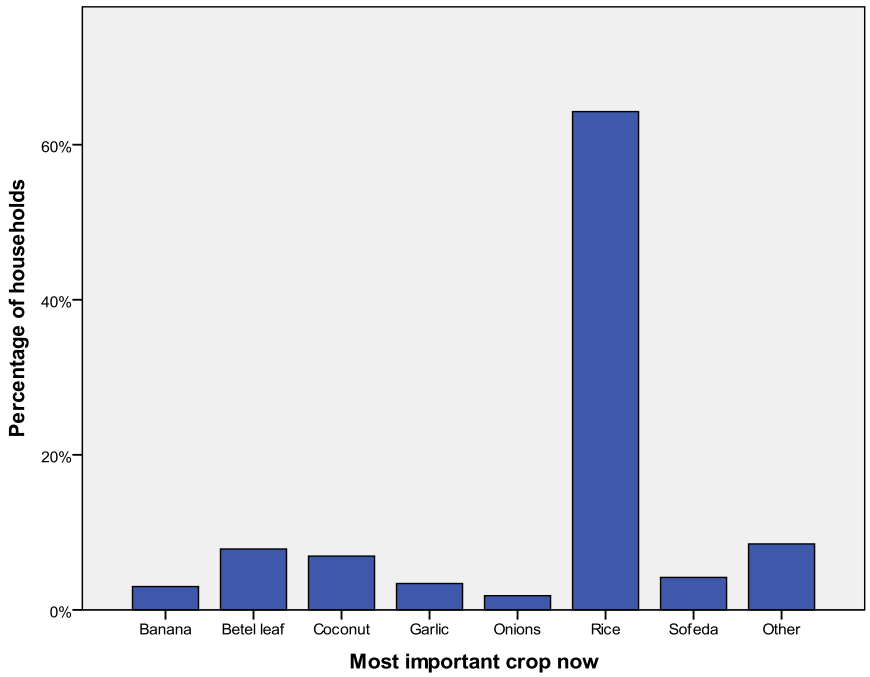
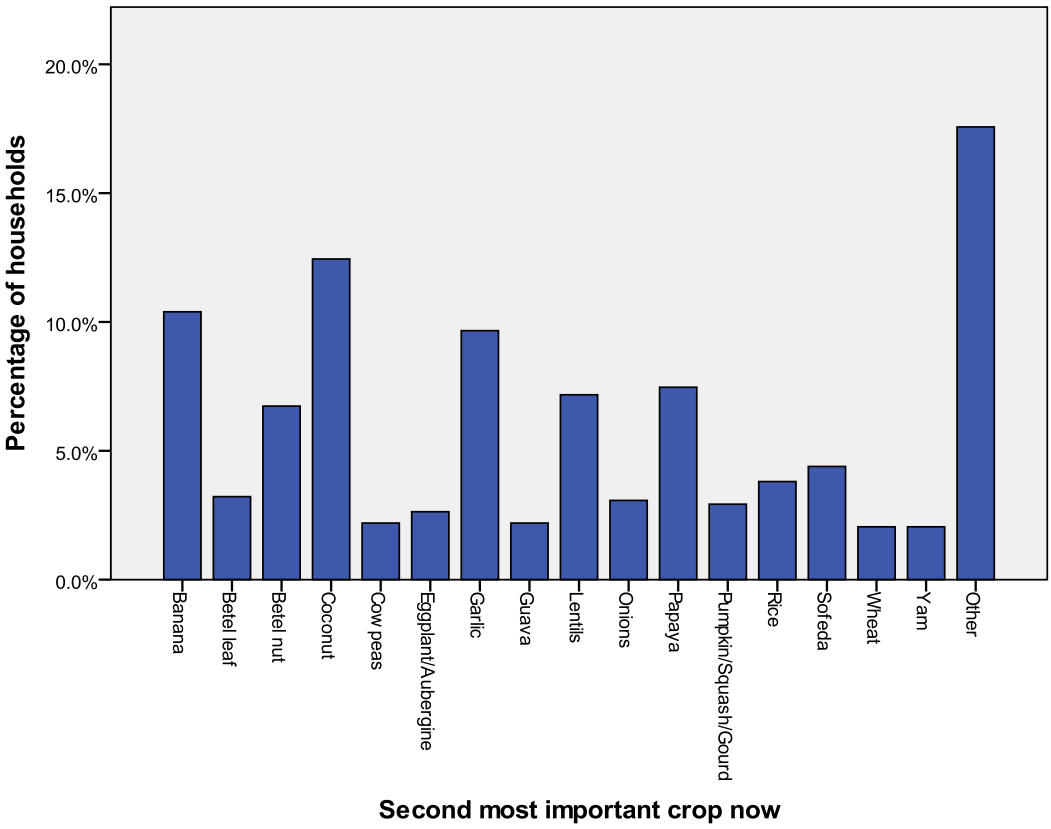
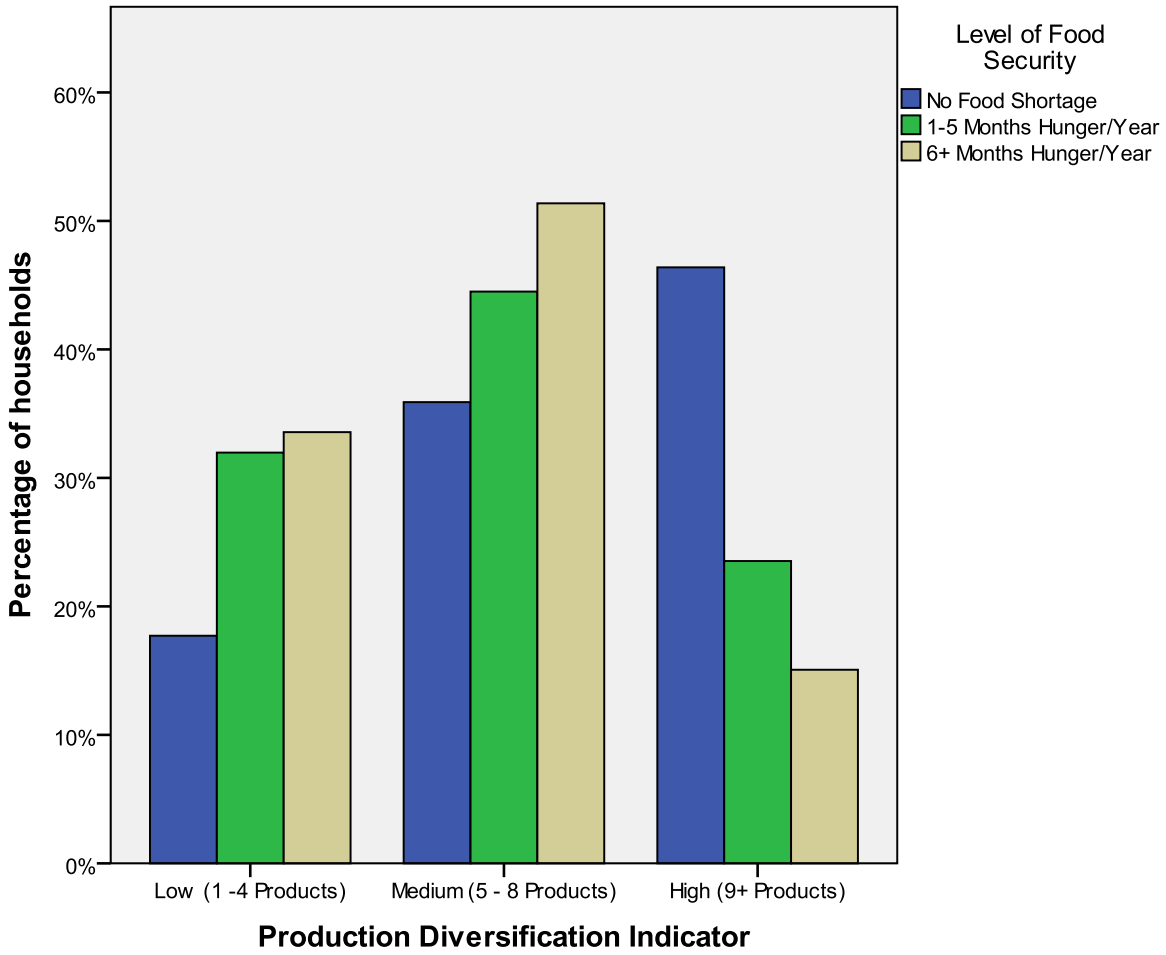


Figure 5. Households' current 'second most important' crop



When the relationship between diversification in agricultural production activities and the level of food security was explored, we found a strong association ($chi^2 = 76.4$, d.f.=4, $p<0.001$). More diversified households had fewer food deficit months in a year; the converse was true for less diversified households (Figure 6). A higher percentage of food secure household (in blue) have highly diversified agricultural strategies than the very food insecure ones (in brown). One-third of extremely food insecure households are involved in very few agriculture-related activities. Figure 6 also suggests that there may be some cause for concern over the fact that more than one-half of households that have more than 6 food deficit months per year fall in the 'medium' diversification category.

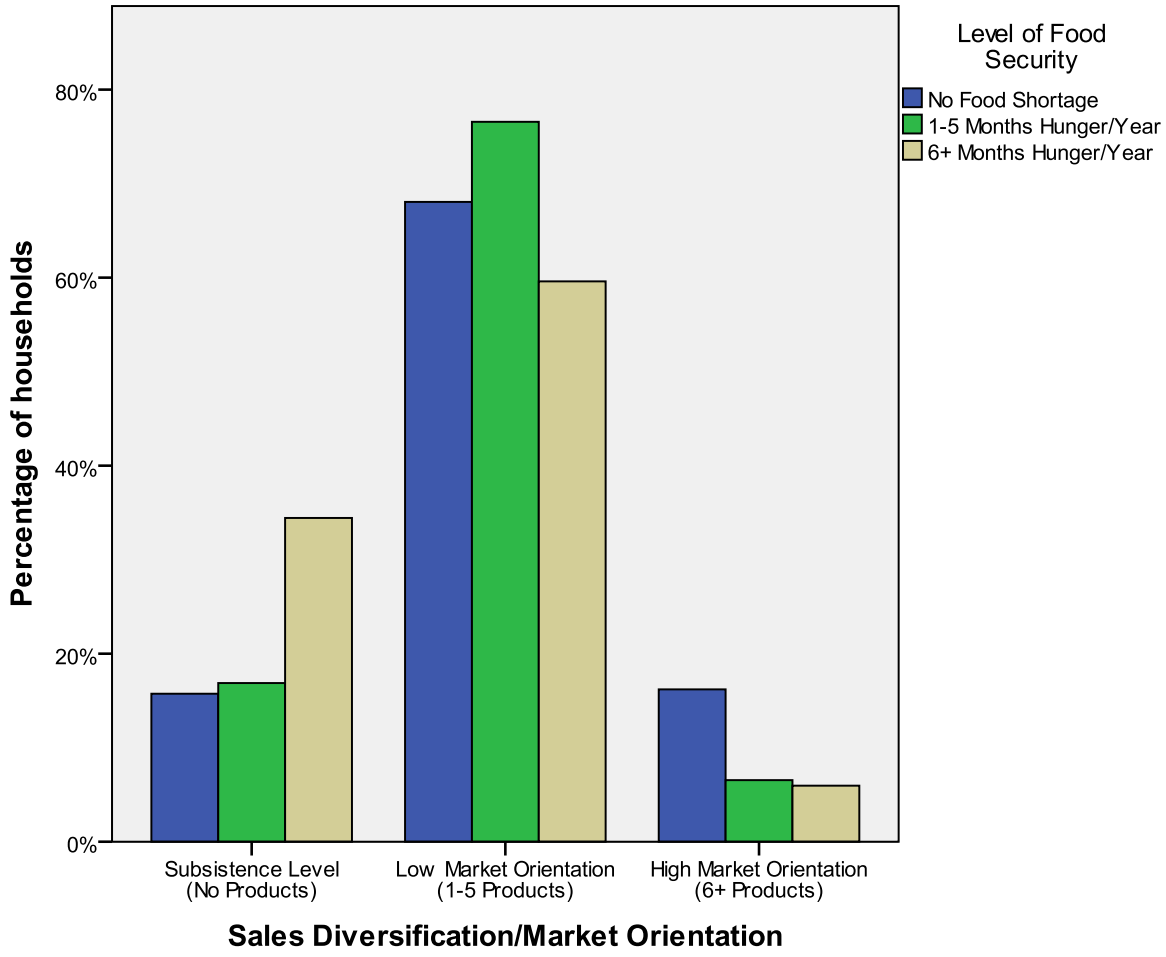
Figure 6. Relationship between Food Security and Production Diversification



Relationship between Agricultural Sales Diversification and Food Security

Figure 7 shows the agricultural sales diversification indicator (which can also be thought of as a market orientation proxy measure), based on the number of different agricultural products produced on-farm and sold. It shows that of the least food secure households, around 35% are selling nothing (subsistence-level), almost 60% sell 1-5 products (low market orientation) and only 5% are selling more than 6 products (high market orientation).

Figure 7. Relationship between Sales Diversification/Market Orientation and Food Security



Indeed, we confirmed there is a strong association between the market orientation of a household and the level of hunger reported (chi² = 48.96, d.f.=4, p<0.001). Households selling a greater range of products reported fewer food deficit months in a year; and the converse was true for households selling fewer products. Out of the 151 households that reported having more than 6 months of hunger per year, 34% reported that they sold no agricultural products (see Figure 7). A further 74% sold only one or two different agricultural products.

Land Ownership and Food Security

Land is considered a form of 'natural capital' under the sustainable livelihoods framework (DFID, 1999b) and is obviously key for sustainable livelihoods and food security. For the purposes of this analysis, households were placed into four categories based on land ownership. Landless households were classified as owning *no land*, households owning <½ acre of land were classified as having *low land ownership,* those with ½ to 1 acre of land were classified as having *medium land ownership* and households owning more than one acre of land were classed as having *high land ownership*[1]. Figure 8 shows the relationship between land ownership and food security.

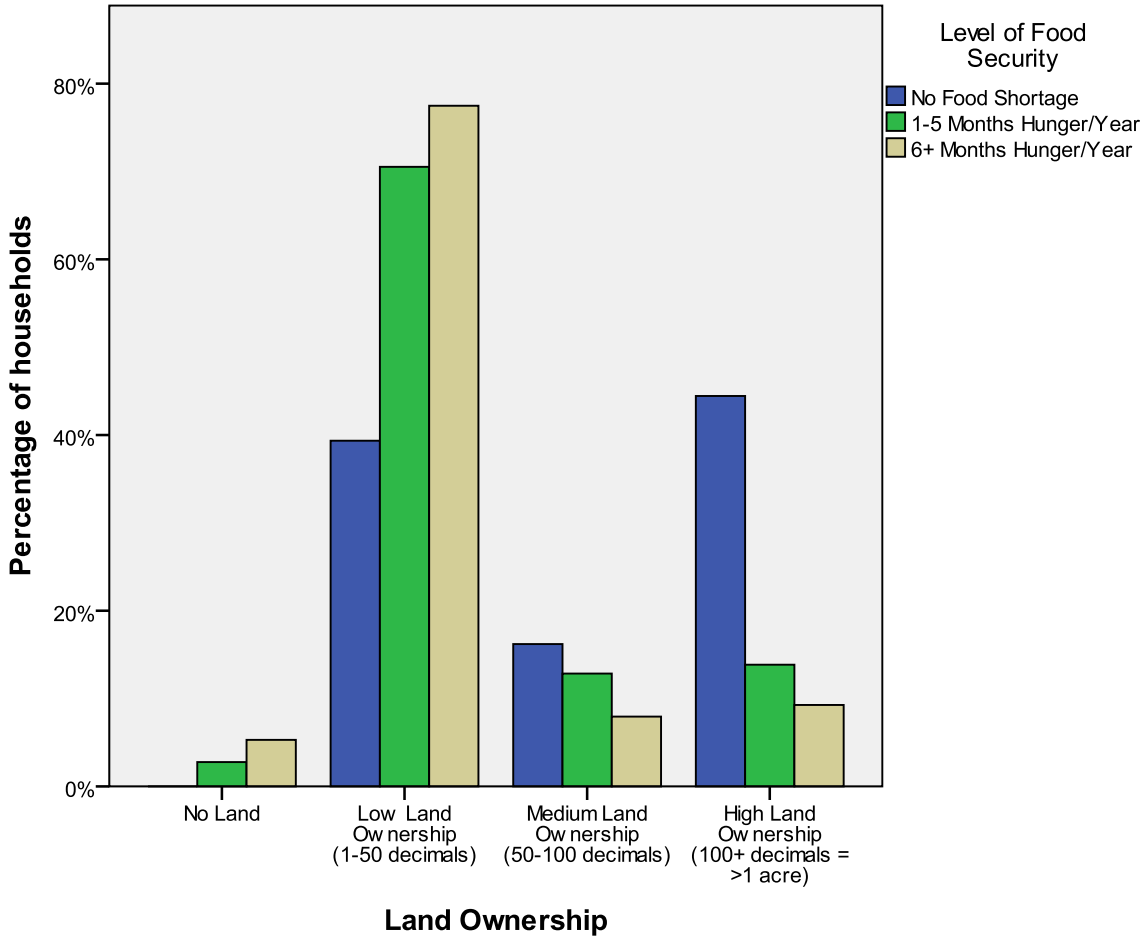
We found a strong and significant negative relationship between the amount of land owned and food security status (chi² = 164, d.f.=6, p<0.001), with less land associated with low food security/ more food deficit months. None of the landless households had sufficient food for their families throughout the year. In fact, of the landless households surveyed, 42% were food deficit for more

1 *Note that 1 acre is the equivalent of 100 decimals of land in Bangladesh. 1 'decimal' is equivalent to 0.01 acre or 0.004047 hectare. (Source: ANGOC, 2009)*

than six months per year (n=19). By contrast, 74% of households (n= 261) that owned more than one acre of land reported having no food shortages at any time of the year. As seen in Figure 8, more than 75% of food insecure households (more than six food deficit months per year) also owned less than ½ acre of land.

The analysis shown in Figure 8 does not include access to or use of rented or communal land. For the surveyed households, we found that 65% of households did not rent any land, and 92% of households reported not making use of communal lands. For those households that did rent some agricultural land, the mean size of rented land was half an acre and the maximum size was reported to be seven acres.

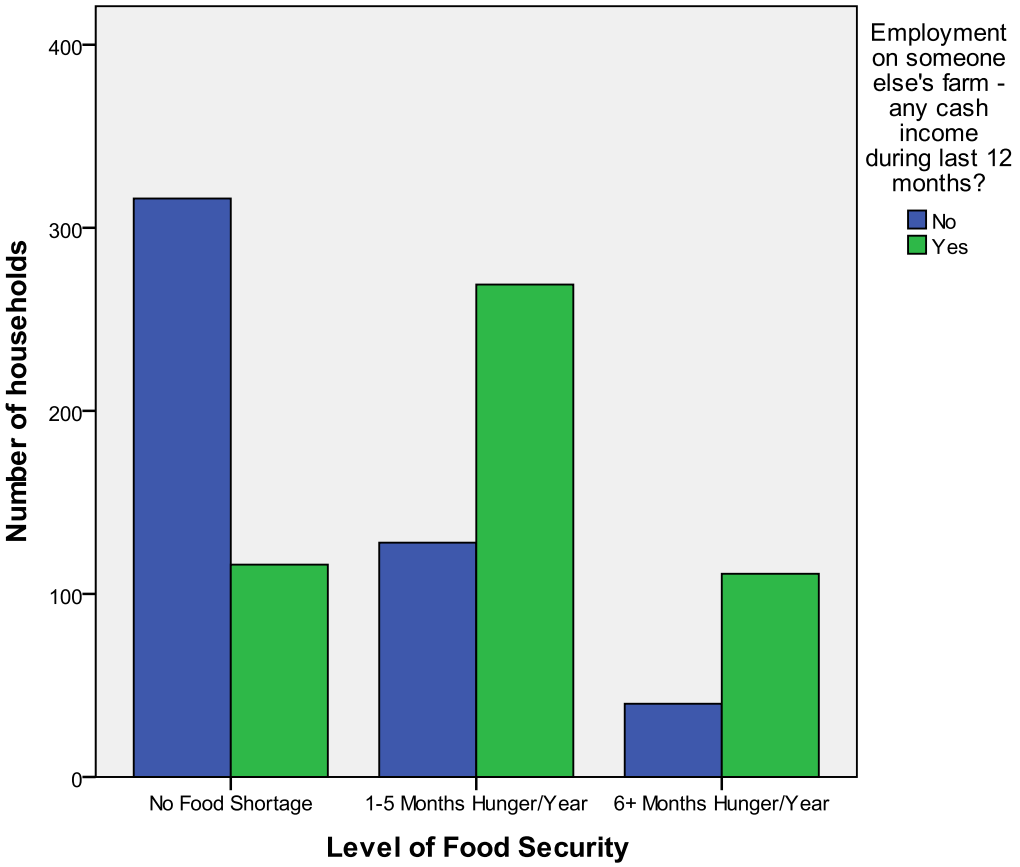
Figure 8. Relationship between Land Ownership and Food Security



Agricultural Labour, Land Tenure and Food Security

With respect to agricultural employment, one-half of surveyed households reported having a member that had earned income working on someone else's farm in the last 12 months. There was a strong association between working on someone else's farm and suffering from food insecurity ($chi^2 = 175$, d.f.=2, $p<0.001$). Of those who reported having six or more food deficit months per year (151 households), three-quarters reported that they had been employed on someone else's farm in the past 12 months (Figure 9). In contrast, virtually the same proportion of food secure households reported earning no such agricultural labour-related income.

Figure 9. Agricultural labour on others' farms and food security



The link between lack of land and employment as agricultural labourers is also clear, as 84% of those with no land (although only 19 households reported being landless), and 64% of those with very little land (567 households had less than half an acre), had a household member working on someone else's farm in the last 12 months. In contrast, of the 261 households that own more than one acre of land, 76% reported no wage earnings from working on others' farms. These households were also less likely to suffer from any food shortage. Agricultural day labour might therefore be seen as a coping strategy for those without any or much land, but it does not appear to be a successful one in terms of ensuring food security.

Fourteen percent of the surveyed households were renting out some of their land. As would be expected, those who were capable of renting out their land were less likely to be food insecure - 69% of those renting out land reported having no food deficit months, compared to 44% of households overall.

Other income sources

One-third of households reported receiving some income from business in the last 12 months. One-fifth received payments from projects or government in the last 12 months. Only 3% reported receiving remittances or gifts in the last year, and only 2% had received any type of payment for environmental services. Seventeen percent received wages from non-agricultural employment in the last year. Therefore, small businesses seem to be a widespread livelihood opportunity for households in these rural coastal areas.

Formal and informal loans as a coping strategy

Almost one-third of households had taken a loan from a bank or formal institution in the last 12 months, and 47% had received cash or received a loan from an informal credit source. Those suffering from food insecurity were slightly more likely to resort to informal sources of credit than other households. Of the 151 households with high levels of food insecurity (reporting six or more months of hunger per year), just over one-half of them (56%) reported accessing cash from informal sources. This compares to 47% of households overall.

Interestingly, not having a bank account does not seem to be a hinderance to accessing formal credit in coastal Bangladesh. Of the 302 households reporting having taken out a loan or receiving credit from a bank or formal institution in the last 12 months, only 64 had a bank account.

Agricultural work, differentiated by gender

In terms of the gender division of labour in agricultural work, the survey revealed that male household members were more likely to be engaged in producing food and cash crops, whereas women were more likely to be responsible for processing food crops. Of the 54% of households producing at least one type of food crop on their own farm, 79% stated that the men do most of the work[2].

Seventeen percent of households reported producing a cash crop on their farms (tea, coffee, sisal, cotton, jute, or sugar cane), and of these households, 83% reported the male members did most of the work.

Just over one-half of households undertook further processing of a crop at home, and 62% of these households said that the women did most of this type of food processing work, with 18% saying the men did most of it, and another 18% saying that several household members shared responsibility for such work.

The work tasks associated with looking after livestock also differed by gender. The vast majority of households reported that women are responsible for most of the work involved in raising small livestock (e.g. sheep, goats, chickens, ducks – found in 89% of households) and producing livestock products such as milk and eggs. For large livestock (cattle and buffalo – found in 44% of surveyed households), one-half of households reported that it was men that do most of the work. Small livestock were likely to be consumed (by 81% of households), and just over one-half reported also selling small animals, but most of the livestock products are being consumed and not sold.

Although 90% of households reported that women do most of the work for small livestock in our study, a recent more in-depth gender survey undertaken across Bangladesh, by the International Food Policy Institute (IFPRI), shows that many women may not control the income from this, or any other, work. Using the 'women's empowerment in agricultural index', the nationally representative study found that 45% of women were not empowered, and lacked access to, or the ability to make decisions about, credit, while 75% lacked control over use of income (IFPRI, 2012).

Fishing was found to be primarily a male activity in coastal Bangladesh. Forty percent of households were producing fish, and 88% said the man did most of the work. Fish is being sold by three-quarters of these fishing households. Harvesting timber is also a task done predominantly by men, as reported by 60% of households.

Collection of fuelwood off-farm, by contrast, was a female-dominated activity, with 69% of households reporting that the woman does most of the work. Virtually all respondents said the fuelwood was used by household members and not sold.

Off-farm activities, differentiated by gender

The survey revealed that most off-farm activities are predominantly activities undertaken by male household members. One-third of households harvest or collect food crops for home consumption, and a similar proportion harvest fruit from areas outside of their farms. Fodder and fish are also frequently harvested or collected off-farm, with 42% of households collecting fodder off-farm, while 49% are fishing outside the farm.

Collection of fuelwood from off-farm sources is something that women frequently are responsible for, however. One-half of households are reportedly collecting fuelwood off-farm, and 48% of these said that women were doing most of this work.

Adapting to Multiple Stressors

Changes in Agriculture from 10 years ago

Respondents were asked to list their three most important crops in terms of household livelihood strategies today versus 10 years ago. Rice was, and still remains, the most important crop (for 78% of households). Farmers today seemed to have shifted away from papaya production, the second most important crop for 16% of households ten years ago and only around 8% now. Coconut, banana, betel nut and garlic were all still being reported as important both 10 years ago and now.

The enumerators were trained to probe about what changes in agricultural practices had been made over the last 10 years (including those related to crop types, crop varieties, livestock types and management, and soil, water, and land management practices), and then record the reasons why those changes had been made. Table 4 shows the type and frequency of the various changes reported.

In terms of changes in practices, the most common ones we see in these Bangladesh households are the introduction of new crops or varieties, and starting to use or increasing usage of chemical fertilizers, pesticides or herbicides. Around one-half of households have switched out of growing a particular crop or variety, and planted higher yielding or better quality varieties.

Table 4. Types and frequencies of agricultural practice changes in the last ten years

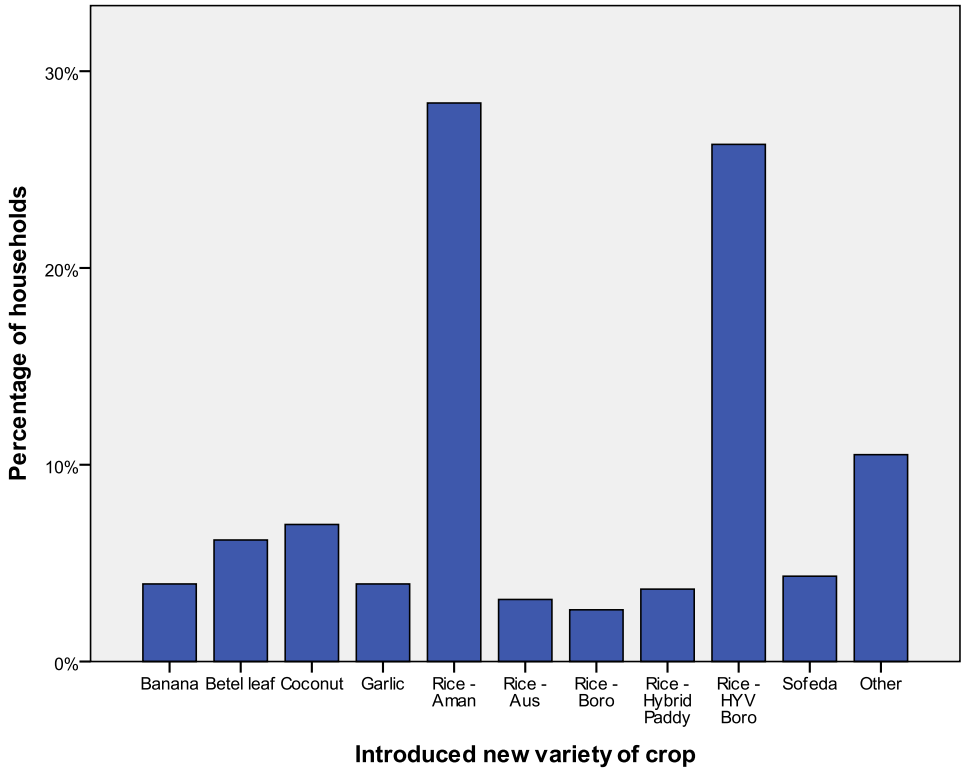
Change Reported in the Past Ten Years	Percent of households (n=980)
Introduced new variety of crop	78
Starting using or using more mineral/chemical fertilisers	61
Stopped growing crop (totally)	52
Stopped using a variety	52
Starting using or using more pesticides/herbicides	51
Introduced new crop	47
Planting higher yielding variety	47
Planting better quality variety	44
Introduced mechanised farming	42
Planting shorter cycle variety	32
Introduced intercropping	28
Started using manure/compost	26

Introduced rotations	21
Started irrigating	20
Expanded area	19
Reduced area	18
Introduced/built ridges or bunds	16
Introduced improved irrigation	13
Planting flood tolerant variety	12
Stopped burning	11

We found that widespread mechanisation has been occurring in the last decade in these areas. In terms of strategies that may be helping households adapt to changing environmental conditions, one-third of households report switching to a shorter-cycle crop variety, and 12% are now planting a flood tolerant variety. One-fifth of households introduced irrigation, and another 13% improved their irrigation practices. Intercropping, rotations and use of manure or compost are also new practices for many. Improved land and soil management practices are also seen, with 16% introducing ridges or bunds.

The main crop varieties that have been introduced are Aman Rice and HYV (High Yield Variety) Boro Rice (Figure 10). The analysis also shows that for those households that had introduced or were using more purchased inputs (mineral or chemical fertiliser, and pesticides or herbicides) than previously, these are the rice crop varieties to which these inputs are predominantly being applied. Overall, rice is the crop that households have been making the most changes to in the past ten years, reflecting its importance in terms of household food security and livelihoods. However, 266 households had stopped growing rice in the past ten years, and 258 households had stopped growing a variety of Aman Rice. For those households who had started using more pesticides or herbicides, these were also commonly applied to Aman Rice and HYV Boro Rice, as well banana, betel leaf, garlic and pumpkins.

Figure 10. Percentage of households introducing new varieties in the past ten years



Climate-related crises and Assistance

In the last five years, virtually all households reported that they had faced a climate-related crisis, but only 36% of them also received some type of assistance to help deal with the crisis. For those that did receive assistance, 84% received support from government agencies, and 44% reported receiving help from NGO's (non-governmental organisations) or CBO's (community-based organisations). One quarter of these households received help from friends, relatives and neighbours. Support from politicians, religious organisations or local community groups was reported by very few.

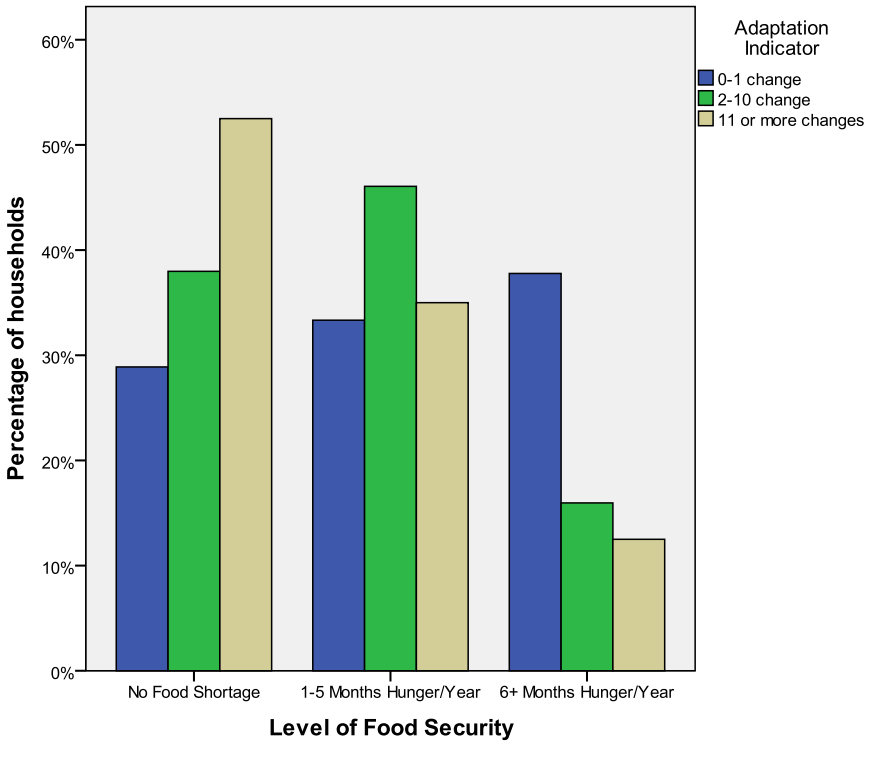
Thus government agencies appear to be active with respect to responding to and providing assistance during climate-related disasters. At the same time, supportive actions by NGO's and CBO's are also recognized by almost half of the surveyed households.

Exploring the relationship between Adaptability and Food Security

A rough proxy for 'adaptability' was derived by adding up the number of all changes that households have made in the last 10 years with respect to their farming practices – this includes any changes made related to crops, livestock, land, water and soil management practices. The assumption here is that households that have made more changes are arguably more adaptive and will likely be in a better position to deal with a changing climate, for example. To allow for an easy comparison and visualisation of the variation of this indicator across households and sites, 3 categories were chosen (Kristjanson et al, 2010). Households that had made 0 or 1 change were classified as having *low adaptability,* those who had made 2 to 10 changes were classified as having *medium adaptability*, and households who had made 11 or more changes were classed as having *high adaptability*.

Are households that are making more changes to their agricultural practices more food secure? As shown in Figure 11, over 50% of the households that had made 11 or more changes to their agricultural practices (in brown) also reported no shortage of food. There is also a strong statistically significant association between the number of changes made in the past ten years by each of the 980 households, and the corresponding number of food deficit months ($chi^2 = 38.4$, d.f.=4, $p<0.001$). Households that had made many changes to their agricultural practices in the past ten years reported fewer months of hunger; and the converse was true for households that had made fewer changes.

Figure 11. Relationship between food security and adaptability

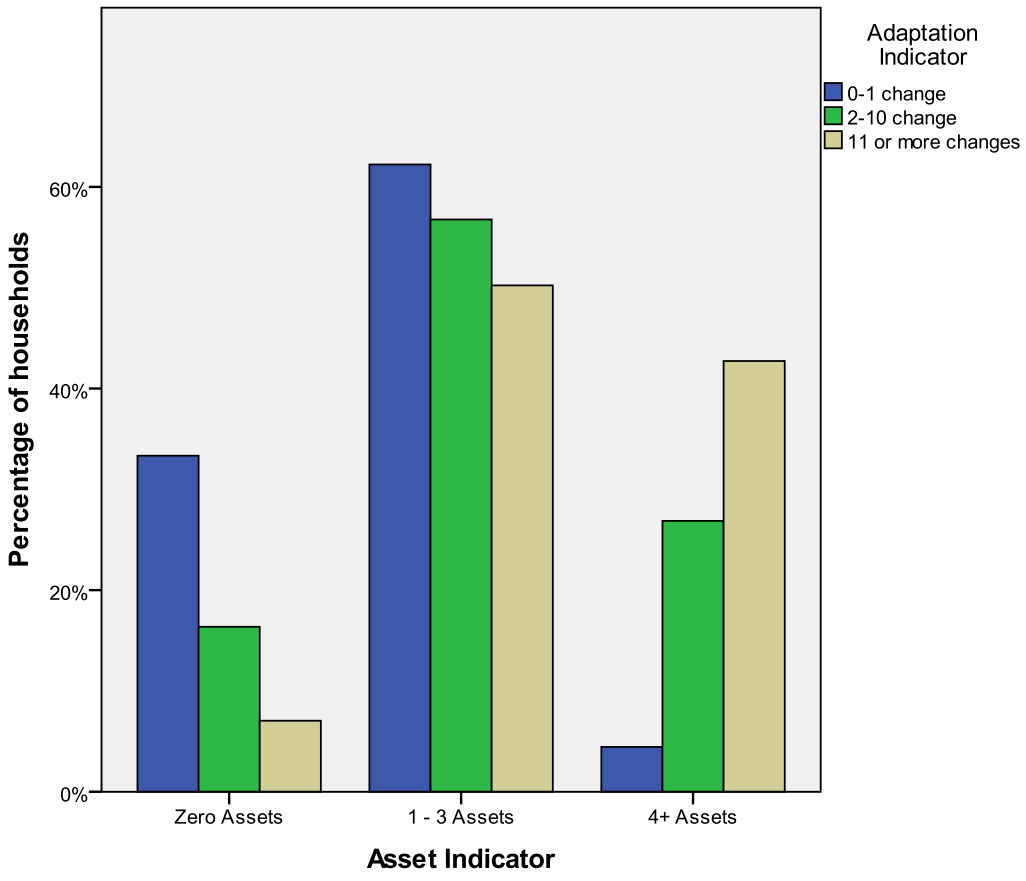


This suggests that households that are pursuing adaptation strategies are enhancing their food security, as proposed by others (e.g. Di Falco et al, 2010). However, this is not a causal analysis, and it is also possible that it is only when households are food secure that they are able to invest in new agricultural practices. A strong and likely two-way relationship between household food security and adaptability was also found in East Africa (Kristjanson et al, 2012).

Assets and Adaptability

The relationship between household asset levels and adaptability was also explored using the baseline data. Using the indicators, we see more high asset households in the higher adaptation category (in brown) (Figure 12). Further analysis confirmed a strong positive association between adaptability (number of changes made in the past ten years) and number of assets ($chi^2 = 62.5$, d.f.=4, $p<0.001$). Households that had made more changes to their agricultural practices in the past ten years tended to have more assets; and those with few assets were farming in much the same manner as they have for many years. However, a small percentage of households that had few assets were making a significant number of changes to their agricultural practices, showing some adaptability by even the poorest households.

Figure 12. Relationship between Assets and Adaptation

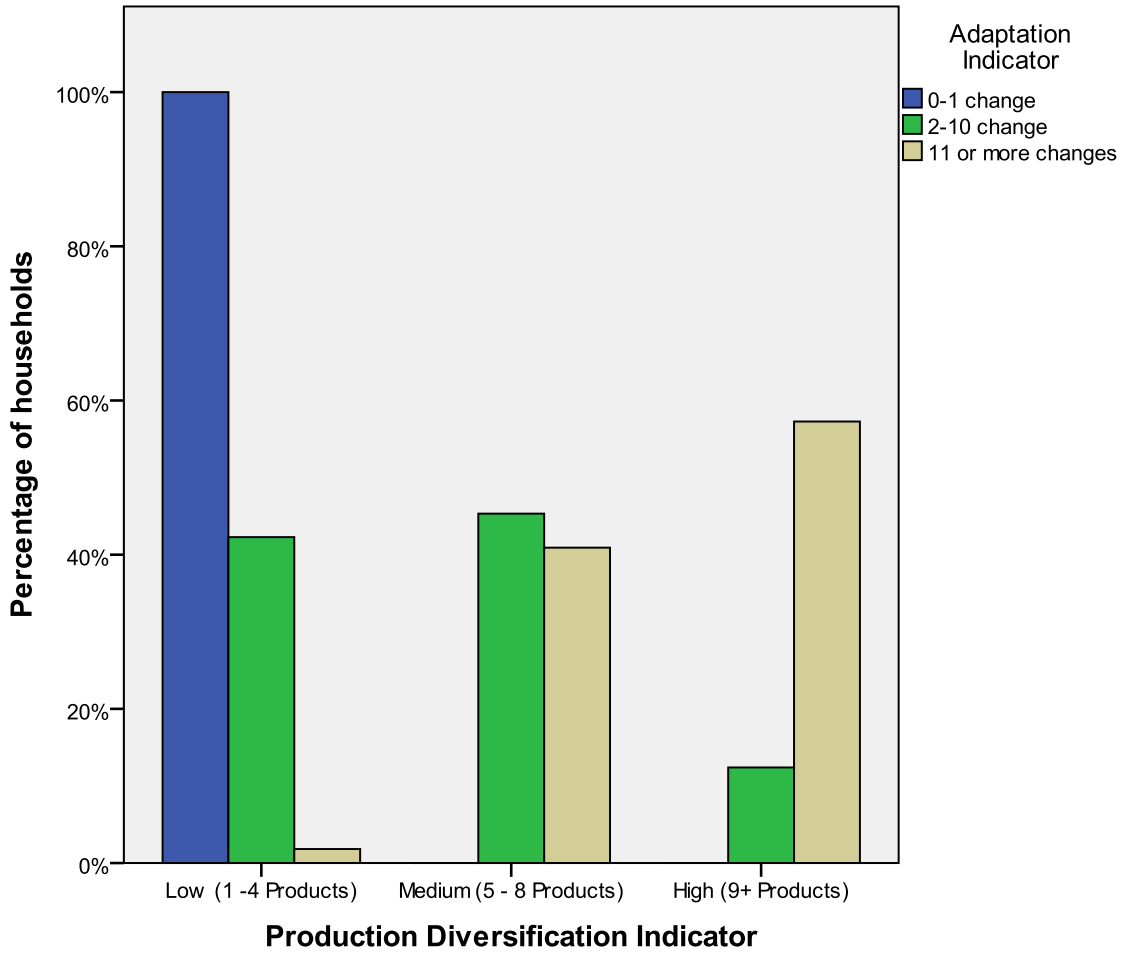


Agricultural Diversification and Adaptability

Are more diversified households, in terms of the number of different agricultural activities being pursued, also the ones that are making more changes in how and what they produce (i.e. more innovative)? It appears so, as shown by Figure 13, since almost 60% of the households with high innovation levels (making more than 11 changes in the last ten years) were also producing 9 or more products. Furthermore, all the households with low innovation levels (i.e. making zero or one change to their farming practices in the past ten years) were producing less than four products.

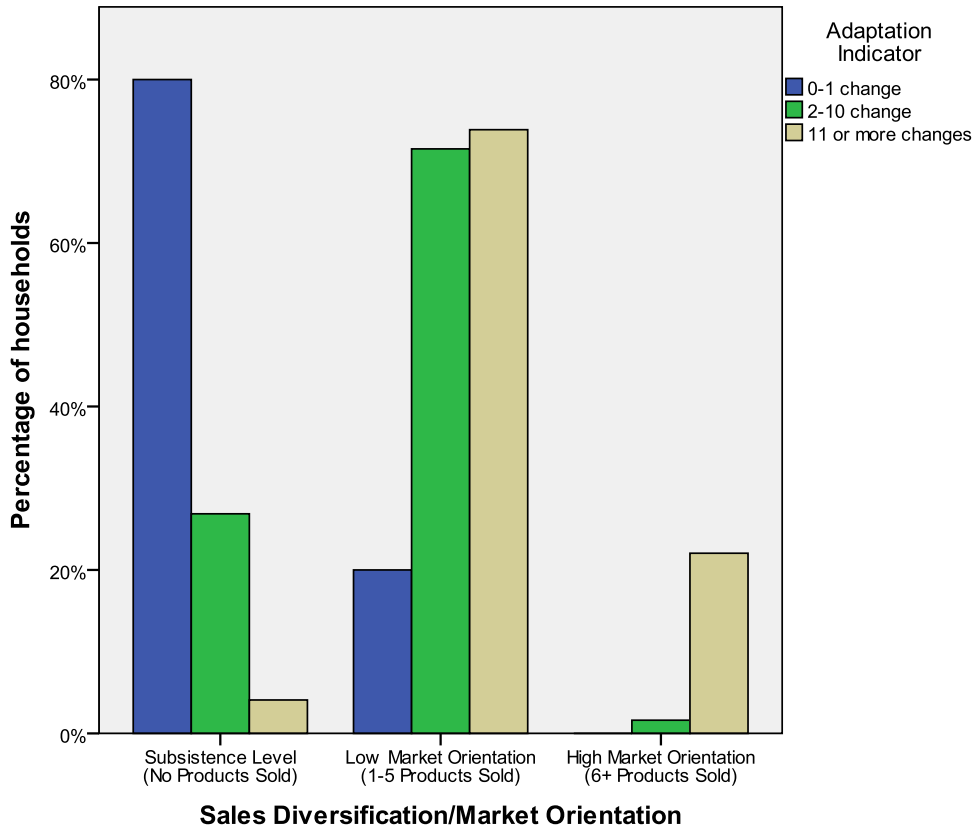
Statistical testing confirms the strong association between the number of changes made in the past ten years and the number of different agricultural activities ($chi^2 = 393.3$, d.f.=4, $p<0.001$). Households that made more changes are also producing a wider range of agricultural products; and conversely, those making few changes tend to be the least diversified households. This is likely to work both ways - the least diversified households are not in a good position to try new things, but low levels of innovation may also mean that households are not able to increase their productivity enough to gain sufficient income to re-invest into producing a variety of products.

Figure 13. Relationship between Agricultural Production Diversification and Adaptability



As can be seen in Figure 14, there is a similarly strong association between adaptability and the indicator of selling diversification, based on the number of different agricultural products sold by the household ($chi^2 = 267.97$, d.f.=4, $p<0.001$).

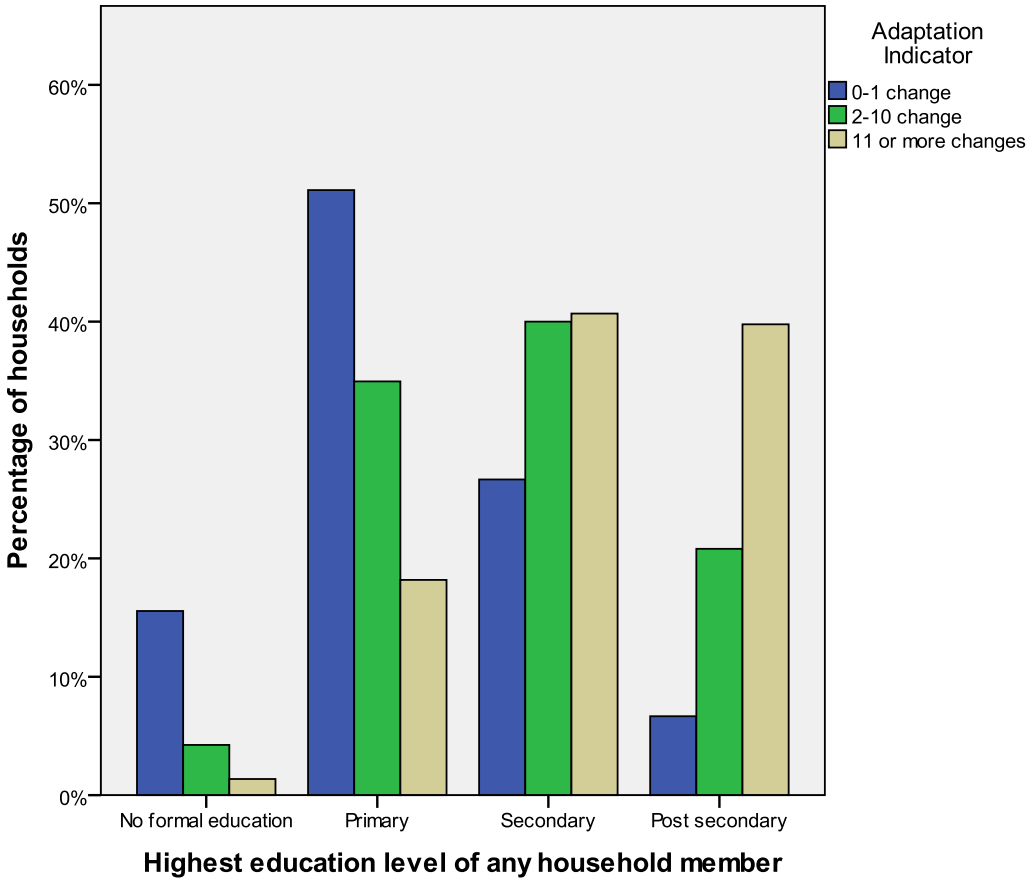
Figure 14. Relationship between Agricultural Sales Diversification and Adaptability



Education levels within the household and adaptability

There was evidence of a strong positive association between adaptability and the highest education level achieved by a household member (chi² = 96.7, d.f.=6, p<0.001), which can also be seen in Figure 15. The majority of households that had made 11 or more changes in agricultural practices in the past ten years had at least one person residing within the household with either a secondary or post-secondary education. Out of the 440 households that had been classified as being *highly adaptable* (in brown), 179 of these had a member with a secondary education (41%) and 175 had someone with a post-secondary education (40%). The link between education levels and the adoption and diffusion of agricultural innovations is discussed by Weir and Knight (2000), who suggest that educated farmers are both better innovators themselves, plus they are better able to copy those who innovate and thus enhance the diffusion of agricultural innovations (*ibid*).

Figure 15. Relationship between Household Education and Adaptation



Group Membership

Collective action around managing the natural resources that rural households rely on (e.g. water, soils) was surprisingly low. The vast majority of respondents were not members of any type of agricultural or natural resource management-related group. Small numbers of households said they were in groups related to one of the following: irrigation, fishing, shrimp ponds, agricultural productivity enhancement, tree nursery/tree planting, or marketing agricultural products.

Fourteen percent of households did report being members of a savings or credit-related group. However, being a member of such a group does not appear to be related to greater household food security. For example, 44% of those in a savings or credit group still suffered from 1 to 5 food deficit months per year, while 12% faced 6 or more hunger months. This was similar to the overall percentages of 41% and 15%, respectively, of all surveyed households.

Reasons for making changes in agricultural practices

Households were asked to give the reasons why they had made the reported changes in agricultural practices (Table 5). These could be related to markets, labour, land, weather/climate or any others they mentioned. With respect to crops, market-related reasons were more frequently given as the reason behind the change in crop practices than weather or climate-related reasons. Better yields and better prices were cited by just over one-half of households, for example.

Climate-related reasons. With respect to environmental or climate-related factors driving adoption of new crops, varieties or crop management practices, higher salinity was mentioned by one-quarter of respondents, and the emergence of new pests and diseases was cited by 21%

of households. Eighteen percent of respondents said the changes were driven by more frequent cyclones, 17% said that floods had become more frequent, and 14% felt that there were more cold spells or foggy days than previously. Perceptions regarding changes in the climate thus appear to have already had a considerable impact on agricultural livelihoods in these parts of coastal Bangladesh. While 11% thought that the overall amount of rain had decreased, 5% perceived it as increasing.

For respondents that mentioned they thought the frequency of floods had increased, 40% said the Aman rice crop had been affected. Similarly, more than 45% of respondents affected by higher salinity said it was in relation to the Aman rice crop. Coconut has reportedly been affected by more frequent cyclones.

Land and labour-related reasons. Changes in availability of land and labour also were perceived by some respondents as a problem (less land and not enough labour). For others, who now had more land (10%) and labour (15%) than previously, these factors created opportunities for adopting new practices. Project or government interventions were seldom mentioned as influencing the changes these farming and fishing households have been making.

Market-related reasons. For many respondents, it was primarily HYV Boro rice that had benefitted from technology and market-related factors, such as a better price, better yields and new opportunities to sell.

Table 5. Reasons for crop-related changes in practices

Reason given for change to crop practices	Number of Households	Percent of Households
Better yield	530	54
Better price	525	54
New Opportunity to Sell	291	30
Higher salinity	249	25
Land is more productive	245	25
Land is less productive	209	21
New pests/diseases have come	203	21
Sufficient labour	183	19
More frequent cyclones	175	18
More frequent floods	163	17
Able to hire labour	142	15
More cold spells or foggy days	132	14
Less land	128	13
More frequent droughts	116	12
More resistant to pests/diseases	114	12
Less overall rainfall	109	11
More land	95	10
More erratic rainfall	68	7
More overall rainfall	49	5
Insufficient labour when needed	38	4
Higher tides (sea level has risen)	36	4
Later start of the rains	35	4
Unable to hire labour (too expensive)	12	1

Earlier start of the rains	11	1
Unable to hire labour (not available)	6	0.6
Government/project told us to	2	0.2
Government/project showed us how	2	0.2
Policy changes	2	0.2
Strong winds	1	0.1
Higher temperatures	1	0.1

With respect to changes in livestock production practices, 93% of households said that they had introduced new farm animals or fish types, and 56% had stopped keeping one or more types of farm animal or fish. Chickens and dairy cows were most commonly stated as being introduced, while other families stated they had stopped keeping dairy cows and goats. As with changes to crop practices, market reasons were the most frequently cited drivers of changes in livestock production practices. Fifty-seven percent of households stated that higher prices were behind their changes in practices, while 43% said that availability of more productive livestock or fish types or breeds were the reason for making a switch. Forty-five percent of households said new diseases are appearing, requiring adaptations, while 17% of households had noticed more salinisation occurring.

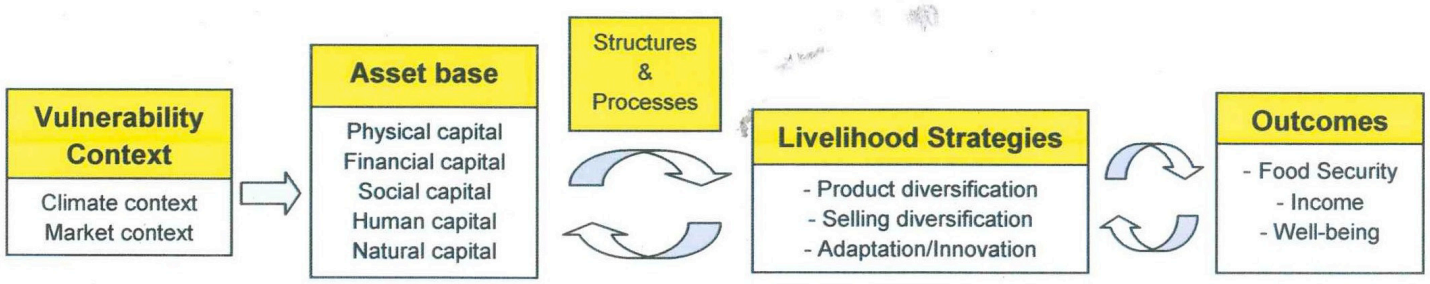
Discussion and Conclusions

This analysis of household survey data from 980 households across coastal Bangladesh supports using the sustainable livelihoods framework as a basis for exploring the many complex factors influencing household food security and adaptive capacity (Haider, 2009). This framework suggests that climate-related, economic and other 'shocks' will have impacts on households' asset base (DFID, 1999b) and livelihood strategies pursued. Different types of livelihood assets (physical, financial, social, human and natural capital) form the basis for households' choices of livelihood strategies, including agricultural practices, which in turn influence their food security status and level of well-being.

We find empirical evidence that land (natural capital) and household asset ownership (physical capital) are positively linked to household food security levels. Education (human capital) is closely associated with the adaptive capacity of these households (proxied by the number of farming practice changes they have already made). The results also show that households that diversify what they choose to produce, as well as to sell, are pursuing key livelihood strategies that make them more food secure, and more able to take up new agricultural practices to deal with changing circumstances.

In the theoretical diagram below, the sustainable livelihood framework has been adapted to highlight the evidence of strong linkages that this analysis shows. As ours was not a causal analysis, the arrows in Figure 16 are likely to go in both directions. We suggest there are multiple 'learning loops' between assets, livelihood strategies and outcomes. In Annex I, we show the strength of the associations we found between the various indicators.

Figure 16. Adaptation to Climate Change in the Sustainable Livelihood's Framework (Source: Authors' interpretation; Adapted from DFID, 1999)



The statistically significant association we found between adaptability and food security supports the view that the poorest households with high levels of food insecurity are less innovative; they are taking up few new agricultural practices. Other researchers have suggested that this is a necessary risk avoidance strategy (Banerjee and Duflo, 2012). In Bangladesh it does appear that food insecure households are simply not in a position to adopt new agricultural strategies in response to climate or market-related changes, thus they are likely stuck in the type of 'poverty traps' discussed by Barrett et al, 2006 and others. It is also probable that this causality goes in both directions in locations such as these where there are few safety nets, i.e. that those that are not changing their agricultural practices are increasingly likely to remain food insecure. Policies that target these food insecure households and provide safety nets in the event of shocks are therefore critical for improved food security. Programs will need to focus on enhancing the food access, availability and affordability situation of the least food secure households, as they are undoubtedly going to be the ones that are the least able to adapt to a changing climate.

This evidence also suggests that it may be worthwhile to explore in more detail the specific changes that food secure households are making, as they are likely the most strategic and feasible ones for 'scaling out' efforts. For example, one-quarter of these households are now using compost or manure, and 16% have introduced flood tolerant varieties. Such practices enhance resilience to a changing climate and likely could benefit many more households.

The data also provide evidence that households with more diversified agricultural portfolios tend to be both more food secure and more adaptable in terms of taking up new agricultural practices (OECD, 2008; Conway, 2010; Clements et al, 2011). However, diversification by itself to date is not solving everyone's food security issues; more than one-half of households that have more than six food deficit months per year are also somewhat diversified.

As the SLF suggests, the viability of adaptation strategies for smallholder farmers will be shaped by the availability of a range of assets. The data show a strong positive relationship between the number of assets owned by a household and the degree to which they are food secure. This indicates that the community-based adaptation to climate change (CBA) approaches being pursued by many development agencies and practitioners may be key to addressing food security issues at the household level, as they are increasingly paying attention to assets and equity, utilizing tools such as participatory community risk assessments (Van Aalst et al, 2008).

A recent study on empowerment of women in agriculture in southwest Bangladesh also found that assets are critical to improved well-being of women and their families (IFPRI, 2012). It found that women in households with higher asset wealth are more empowered than those with few assets, although over one-half of women in the top wealth quintile were not yet empowered (IFPRI, 2012). Since women were found to play an important role in agricultural production in this study, including doing 90% of the work for small livestock farming, this supports the view that gender-sensitive programmes should be included in adaptation strategies and policies.

In the sustainable livelihoods framework (Figure 16), market and climate factors fall in the 'vulnerability context' box. Findings from this analysis suggest that more immediate market and productivity drivers (e.g. higher prices, improved marketing opportunities, higher yielding

varieties) have to date been dominant in shaping these Bangladeshi households' agricultural and adaptation strategies. It makes sense that these more immediate and visible drivers have significantly greater influence on food insecure households than do concerns over long-term changes in the climate. It implies, however, that programs and investments coming from new 'climate change' funds will be most valuable if they do not make the false assumption that rural farming households' behaviour is being significantly influenced by climate factors alone. Such market vulnerability factors that in fact are driving behavioural change are priority areas for more in-depth research that will help identify effective adaptive strategies. This finding also suggests that policies and institutional reforms aimed at reducing market risks for smallholder agriculturalists are as important as those that address climate variability and change.

In terms of changes in practices already underway, the most common ones seen in these households in Bangladesh are the introduction of new crops or varieties, and starting to use, or increasing usage, of chemical fertilizers, pesticides or herbicides. Around one-half of households have switched out of growing a particular crop or variety, and half have planted higher yielding or better quality varieties.

A changing climate is likely already adding, and *will* definitely add, more impetus and need for even greater changes and adaptations in the future. Too many agricultural households are still facing high levels of food insecurity in southern Bangladesh. Two-thirds of the households surveyed reported that they were on their own in a climate-related crisis, receiving no assistance to deal with the outcomes. Clearly, the poorest households with few assets who are already suffering from food insecurity for many months of the year will be increasingly vulnerable to variability in extreme events and average temperature increases. Differences between households in terms of assets, livelihood opportunities and adaptive capacity demonstrate why equity is such an important consideration in research and development efforts focusing on adaptation to climate change (Smit and Pilifosova, 2001).

Although the sustainable livelihoods framework has been shown to be a useful conceptual framework within this analysis, it is also recognised as being limited in so far as it leaves out the role of power, including political power and women's empowerment, and it cannot incorporate historical dimensions or dynamic changes (Adato and Meinzen-Dick, 2002). Power relationships can be conceptualised under the category of 'human capital', but more holistic frameworks incorporating these intangible factors have also been suggested. Jones et al (2010) base their 'local adaptive capacity' framework on five distinct characteristics: the asset base, institutions and entitlements, knowledge and information, innovation, and flexible forward-looking decision-making. The analysis of this household-level data does provide some evidence in support of this 'local adaptive capacity' framework, in particular, showing that assets and innovation (as proxied by our adaptability indicator) are indeed key elements of adaptive capacity, at least in terms of household food security. The analysis does suggest that the Sustainable Livelihoods Approach may be a useful basis for developing such metrics and indicators for adaptation and adaptive capacity. The CCAFS baseline also includes village and institutional-level approaches that attempt to address the institutions and entitlements, knowledge and information, and future visions of different community members, so the linking of results with the baseline research efforts being implemented at the three levels will also contribute to filling the gap in empirical evidence regarding what exactly is meant by adaptive capacity, and how best we go about enhancing it.

Annex I - Associations between Variables

The table below shows a summary of the Chi Square Values obtained through the document and the measure of association in the relationship (using Cramer's V = φc).

Relationship Tested:	**Pearson's Chi Square Value**	**Cramer's V (measure of association)[1]**
Working on someone else's farm (yes, no) and food insecurity (Figure 9)	175.9	0.424
Land ownership and food security status (Figure 8)	164.0	0.289
Asset Indicator and food security status (Figure 3)	140.5	0.268
Production diversification and food security status (Figure 6)	76.4	0.199
Sales diversification and food security status (Figure 7)	49.0	0.158
Adaptability and production diversification (Figure 13)	393.3	0.451
Adaptability and selling diversification (Figure 14)	268.0	0.370
Adaptability and education level (Figure 15)	96.7	0.222
Adaptability and asset indicator (Figure 12)	62.5	0.179
Adaptability and food security status (Figure 11)	38.4	0.140

References

Adato, A., Meinzen-Dick, R. 2002. Assessing the impact of agricultural research of poverty using the sustainable livelihoods framework. FCND Discussion Paper 128, International Food Policy Research Institute. IFPRI, Washington, D.C. http://www.ifpri.org/sites/default/files/publications/fcnbr128.pdf

Adger, W.N., 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: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Eds: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson. Cambridge University Press, Cambridge, UK, 717-743.

ADB (Asian Development Bank). 2012. Addressing climate change and migration in the Asia and the Pacific. Final report. http://beta.adb.org/sites/default/files/pub/2012/addressing-climate-change-migration.pdf

Alam, M. 1996. Subsistence of the Ganges-Brahamaputra Delta of Bangladesh and associated drainage, sedimentation and salinity problems. In: *Sea-level rise and coastal subsidence*. Edited by J.D. Milliman and B.U. Haq. Kluwer Academic Publishers, pp. 169-187.

Ali, A. 1999. Climate Change impacts and adaptation assessment in Bangladesh. Climate Research, Vol 12: 109-116.

ANGOC. 2009. The Backpedalling Stops: Bangladesh Country Paper, Land Watch Asia. Securing the Right to Land (SRL), Asian NGO Coalition (ANGOC). http://www.angoc.org/dmdocuments/SRL_Bangladesh.pdf

Banerjee, A., Duflo, E. 2012. Poor Economics: Barefoot Hedge-fund managers, DIY Doctors and the surprising truth about life on less than $1 a day. Penguin Publishers.

Barahona, C., Fairbanks, H., Garlick, C., Grove, P. 2011. CCAFS Baseline Household Level Survey – Analysis Plan. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), January 2011. [Online] Available at: ccafs.cgiar.org/resources/baseline-surveys

Barrett CB, McPeak JG. 2006. "Poverty Traps and Safety Nets," in Alain de Janvry and Ravi Kanbur, editors, *Poverty, Inequality and Development: Essays in Honor of Erik Thorbecke.* Amsterdam: Kluwer Academic Publishers.

BCAS. 2011. Summary of Baseline Survey Results: Paikgacha, Khulna, Bangladesh. Research Report. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). [Online] Available at: ccafs.cgiar.org/resources/baseline-surveys

BCCSAP. 2008. Bangladesh Climate Change Strategy and Action Plan 2008. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh [Online] http://www.sdnbd.org/moef.pdf

Below, T., Matubazi, K., Kirschke, D., Franke, C., Sieber, S., Siebert, R., Tscherning, K. 2012. Can farmer's adaptation to climate change be explained by socio-economic household-level variables? Global Environmental Change 22 (1): 223 – 235.

CIA. 2012. World Factbook: Bangladesh https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html

Clements, R., J. Haggar, A. Quezada, and J. Torres. 2011. Technologies for Climate Change Adaptation – Agriculture Sector. X. Zhu (Ed.). UNEP Risø Centre, Roskilde, 201

Conway, G., Waage, J. 2010. *Science and Innovation for Development.* Published by UKCDS, January 2010.

Di Falco, S., Veronesi, M., Yesuf, M. 2010. Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. Grantham Research Institute on Climate Change and Environment, Working Paper No. 19.

DFID. 1999. Sustainable Livelihoods Guidance Sheets, April 1999 [Accessed 2/2/12] http://www.eldis.org/vfile/upload/1/document/0901/section1.pdf

DFID. 1999b. Sustainable Livelihoods Guidance Sheets: Introduction [Accessed 2/2/12] http://www.eldis.org/vfile/upload/1/document/0901/section2.pdf

Ericson, J.P., C.J. Vorosmarty, S.L. Dingman, L.G.Ward and M. Meybeck. 2006. Effective sea-level rise and deltas: causes of change and human dimension implications. *Global Planet Change* 50:63-82. http://www.hzg.de/imperia/md/content/dahlem/ericson_et_al__2006_.pdf

FAO. 2002. *The State of Food Insecurity in the World 2001*. Rome pp. 4-7.

FAO. 2005. *Rural women and food security in Asia and the Pacific: Prospects and paradoxes*. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

FAO, 2010. FAOSTAT, 2010. http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Gylfason, T. 2001. Natural resources, education and economic development. *European Economic Review*, Volume 45, Issues 4-6: 847 – 859.

Haider, M. 2009. Sustainable Livelihood Approaches: the Framework, Lessons Learnt from Practice and Policy Recommendations. Economic and Social Commission for Western Asia (ESCWA), UNDP.. [Online] http://css.escwa.org.lb/SDPD/1125/UNDP.pdf

Kent, G. 1997. Fisheries, food security, and the poor. *Food Policy* 22 (5): 393-404.

Khan, T.M.A., O.P. Singh and M.D. Sazedur Rahman. 2000. Recent sea level and sea surface temperature trends along the Bangladesh coast in relation to the frequency of intense cyclones. Marine Geodesy (23): 103-116.

Knutsson, P., and Ostwald, M. 2006. A process-orientated sustainable livelihoods approach – a tool for increased understanding of vulnerability, adaptation and resilience. Mitigation and adaptation Strategies for Global Change, May 2006, DOI: 10.1007/s11027-006-4421-9

Kristjanson P, Neufeldt H, Gassner A, Mango J, Kyazze F, Desta S, Sayula G, Thiede B, Förch W, Thornton PK, Coe R. 2012. Are food insecure smallholder households making changes in their farming practices? Evidence from East Africa. *Food Security* Published Online May 25, 2012. DOI 10.1007/s12571-012-0194-z. http://www.springerlink.com/content/1876-4517/ (Open Access).

Kristjanson P, Förch, W., Barahona, C., Garlick, C., Thornton, P. 2010. CCAFS Baseline Household Level Survey – Manual for Survey Sites. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). [Online] Available at: ccafs.cgiar.org/resources/baseline-surveys

Kristjanson P, Garlick C, Ochieng S, Förch W, Thornton PK. 2011. Global Summary of Baseline Household Survey Results, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), November 2011 [Online] Available at: http://ccafs.cgiar.org/sites/default/files/assets/docs/summary_of_households_baseline_studies_all_sites_report_final30-11-11.pdf

IFPRI. 2012. Women's Empowerment in Agriculture Index. USAID, IFPRI, OPHI [Online] http://www.ifpri.org/sites/default/files/publications/weai_brochure.pdf

Jones, L., Ludi, E., Levine, S. 2010. Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level. ODI Background Note, December 2010. [Online] http://www.odi.org.uk/resources/docs/6353.pdf

Migotto, M., David, B., Carletto G., Beegle, K. 2007. Measuring food security using respondents perceptions of food consumption adequacy. Chapter 2 In *Food Security: Indicators, measurement and the impact of trade openness*, Guha-Khasnobis, Basudeb et al, Oxford University Press, 2007.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe. 2007. Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.

OECD. 2008. *Economic Aspects of Adaptation to Climate change: Costs, benefits and Policy Instruments*. Agrawala, S., Fankhauser, S. (Eds) Organisation for Economic Cooperation and Development.

Smit, B., Pilifosova, O. 2001. "Adaptation to Climate Change in the Context of Sustainable Development and Equity" in J.J. McCarthy, et al. (eds), Climate Change 2001: Impacts, Adaptation and Vulnerability (Cambridge, MA: Cambridge University Press).

Solesbury, W. 2003. Sustainable Livelihoods: A Case Study of the Evolution of DFID Policy. ODI Working Paper 217 [Online] http://www.odi.org.uk/resources/docs/172.pdf

Van Aalst, M., Cannon, T., and Burton, I., 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. Global Environmental Change 18 (1): 165-179.

Weir, S., Knight, J. 2000. "Adoption and diffusion of agricultural innovations in Ethiopia: the role of Education". The Centre for the Study of African Economies Working Paper Series. Working Paper 115. http://www.bepress.com/csae/paper115

WFP. 2011. World Food Programme Report: Agricultural Production and National Food Balance, Bangladesh. http://www.foodsecurityatlas.org/bgd/country/availability/agricultural-production

World Bank. 2010. Economics of Adaptation to Climate Change (EACC) Report, Bangladesh, 2010. http://climatechange.worldbank.org/sites/default/files/documents/EACC_Bangladesh.pdf

WRI. 2003. World Resources Institute. http://earthtrends.wri.org/pdf_library/country_profiles/agr_cou_050.pdf

Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez. 2007. Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841.

(Footnotes)

1 Cramer's V varies from 0 (corresponding to no association between the variables) to 1 (complete association). A figure of above 0.25 indicates a very strong relationship, and a value between 0.15 and 0.25 indicates a strong relationship.

CGIAR

RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

CCAFS

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic initiative of CGIAR and the Earth System Science Partnership (ESSP), led by the International Center for Tropical Agriculture (CIAT). CCAFS is the world's most comprehensive global research program to examine and address the critical interactions between climate change, agriculture and food security.

For more information, visit www.ccafs.cgiar.org

Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

European Commission

IFAD

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
Consultative Group on International Agricultural Research