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Climatic Stress, Structural Change and Farm and Non-Farm Enterprise Uptake by Farmers in India and Bangladesh

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2 Executive summary

The aim of the project is to explore the key factors that affect farmers' decisions to take up entrepreneurial ventures and to understand how climate change related water scarcity and shocks influence such decisions.

Specifically, we intend to identify interactions among households' natural, physical, human, financial and institutional capital bases and how these could influence the uptake, competitiveness and profitability of their entrepreneurial activities. It is to be noted that apart from farm and non-farm entrepreneurship, migration and wage based incomes also serve as significant sources of livelihood incomes for the farming households. Therefore, the propensity to rely upon entrepreneurial incomes and its prospects cannot be studied in isolation of these alternate livelihood options. In this context, the three key objectives of the project are:

- To identify key determinants of farmers' decisions related to entrepreneurial activity, particularly in the face of declining natural resource base and climatic stress.
- To identify interactions among natural, human, financial and institutional capitals and their influence on the competitiveness and profitability of entrepreneurial activities.
- To understand the determinants of the right set of institutional, policy and market linkages that lead to a high capital-intensive, diverse and profitable non-farm sector.

In order to accomplish the above objectives, we identify specific questions and hypotheses that are tested in this study:

1. To what extent is non-farm enterprise uptake affected by water scarcity or salinity challenges?
2. To what extent is migration uptake by farming households driven by water stress or salinity?
3. Are migrating households better off compared to those who prefer to take up enterprises or to those who just concentrate on farming?
4. How do household, community, regional and geographical characteristics determine the likelihood of occupational choices for water starved farmers?
5. What are the challenges and determinants of entrepreneurial success for those who start businesses in nearby towns? What lessons could be derived from their experience for the rural entrepreneurs?
6. Is there a significant difference in the risk attitudes of the water stressed farmers compared to those with assured water supply?
7. How do higher measures of risk attitudes, such as prudence and temperance, vary across farming households?

In order to achieve the project objectives and answer the research questions we identified three water stressed districts in the states of Bihar and West Bengal in India and three salinity stressed districts in the South-western region of Bangladesh. We conducted an extensive survey of households and businesses (totalling about 3000) in the rural areas and towns of these districts. In addition, we conducted a series of behavioural experiments on a sub-sample of farmers in order to assess their risk aversion, loss aversion, and higher order risk preferences. These experiments were conducted in the Nalhati region of West Bengal.

Research Findings for India

Impact of Water Scarcity on Enterprise Uptake and other Livelihood Choices

- The level of cropping intensity is positively associated with enterprise uptake probability. Higher cropping intensity is also positively associated with urban migration decision. It is possible that those who migrate are able to bring back

savings that allow them to buffer losses in farming as well as to improve farm productivity through higher investments in tools and better farming practices.
- Contrary to the case of urban migration, the probability of rural labour supply declines for those with higher cropping intensity.
- Water buyers are less likely to start an enterprise.

Impact of other Factors on Enterprise Uptake

- There is a negative association between the probability of starting an enterprise and stated drought resilience[1] of farmers. The level of crop income of the farming household has a negative impact on their enterprise uptake probability.
- Some minimum level of education (secondary or higher secondary level) is found necessary for households to take up an enterprise.
- Households with more non-agricultural assets are more likely to start an enterprise. Households that own high value livestock assets are less likely to take up enterprises.
- Households with Self Help Group (SHG) memberships increase their probability of starting an enterprise. Also, higher loan amounts held and higher borrowing capability of the households increase their probability of enterprise uptake.

Impact of Livelihood Choices on Households' Incomes

- The contribution of enterprise to total household income is found to be negative. This suggests that households would have been better off had they not taken up a particular enterprise. This could be because the enterprises that the households are involved in are typically conventional and low-return ones.
- Urban Migration contributes far more towards augmenting household incomes as compared to business enterprises.
- Households that supply rural labour have lower total household incomes as compared to those that do not supply rural labour. Labor supplying households could have earned more had they opted for other livelihood options such as urban migration. Despite such a negative impact of labour supply on household incomes, we find that almost half the sample in our study area (in India) is engaged in rural labour supply.

Policy Recommendations for India

- Invest more towards creation of water supply augmentation infrastructure, such as check dams and watershed areas, in order to enhance crop productivity. This type of infrastructure will help with improving drought resilience of the households and also their cropping intensities. Both these factors, in our study, are found to influence household incomes in a positive way.
- Provide support through local NGOs and government banks towards setting up of value-added farm enterprises by farmers. The current set of enterprises taken up by households, such as small grocery shops, vegetable vending, sweet shops, etc., do not seem to provide high returns and the households could have earned more by taking up alternate livelihood options.
- Shift policy intervention to the category of farmers who are participating in rural labour supply and create alternative livelihood opportunities for them. Induce farmers to take up skill enhancement programs.

Research Findings for Bangladesh

[1] *Drought resilience is defined as the number of years of repeated droughts the household would be able to survive.*

Impact of Salinity on Enterprise Uptake and other Livelihood Choices

- Salinity poses serious challenges to the livelihoods of rural households in Bangladesh, particularly to those who are still into crop farming. The ultimate outcomes are a very low level of crop diversification and a significant crop loss.
- Those who have exited crop farming or reduced their reliance upon crop farming as a means of livelihood can, in fact, benefit from salinity if they have the requisite resources to invest into fisheries.
- For those who are unable to take up saline water fishery businesses, due to geographical or infrastructural issues, tend to rely upon cash crops using traditional varieties on a limited scale, which fails to have any significant impact on their total household incomes.

Impact of other Factors on Enterprise Uptake

- Education plays a decisive role in explaining households' involvement with different livelihood options. Those household heads who have higher secondary or above level of education are more likely to take up enterprises.
- Level of education of the household head does not seem to play any role in determining the ability to start a fishery based enterprise (unlike other livelihood options such as labour supply, enterprise uptake or salaried employment).

Impact of Livelihood Choices on Households' Incomes

- Those taking to enterprises earn significantly higher incomes compared to those who are not into enterprises. Similarly, labour supply and fishery based enterprises are also lucrative, though their contribution to household incomes is lower (as compared to those who do not take to these professions).
- Doing crop farming reduces household incomes significantly, whereas salaried employed tend to do the best with highest contribution to household incomes.
- Migration, whether stress driven or not, contributes significantly towards annual household incomes.

Policy Recommendations for Bangladesh

- Invest in infrastructure that creates better supply chain opportunities for shrimp and crab farming. Create markets to facilitate production and marketing by landless and marginal farmers.
- Strengthen research-extension linkages to invent and help adoption of high yielding, stress tolerant varieties, particularly for the variety which is sown during spring and harvested during/after summer rain.

3 Introduction and Background

Introduction

It is generally acknowledged that as economies grow, the contribution of agriculture to their GDPs tends to decline. This has been true for most developing countries in South Asia. From around 30% in 1990s, agriculture now contributes to just 16% and 18% of GDPs of Bangladesh[2] and India[3] respectively. Despite this decline in the agricultural sector's contributions to the GDP, the share of population employed in agriculture has remained relatively high in these economies (i.e. 47% in both India[4] and Bangladesh[5]). Yet, this is a significant reduction from a very high share of around 60% in the early 1990s.

However, the rate of decline in the share of agricultural contribution to the GDPs in India and Bangladesh has been much faster than the rate of decline in the populations employed within agriculture. This phenomenon, termed as structural stagnation, leads to reduced productivity as well as disguised unemployment[6]. The situation has been further exacerbated by the fact that the average land sizes in these countries are getting smaller. More than 85% of the farms are less than 1 ha size in both the countries, and the average operated area is 1.15 ha in India[7] and 0.62 ha in Bangladesh[8].

Given this context, it turns out that farming alone is insufficient to provide sustenance for rural households, and such households are increasingly forced to look for opportunities in the non-farm sector[9].The major challenge faced by these countries is to help a large majority of their rural populations transition or diversify out of farming into more profitable and sustainable non-farm activities or urban employment. This challenge is further exacerbated by climatic changes[10] and differences in inter-generational occupational preferences within a rural household (Ranjan, 2015a and 2015b)[11]. Yet, the role of climatic stress and natural resource base depletion in this structural transformation process has not received enough attention in the literature thus far.

Non-farm expansion has become noticeable in India and Bangladesh in the past two decades and almost 50% of farming household incomes are derived through non-farm based sources. However, most of these incomes have been generated through activities involving casual labour based employment and less through nonfarm businesses or regular salaried employment (Jha, 2011; Himanshu, 2013; Ranganathan, 2015a)[12]. In reality, among farm based households in India, non-farm businesses contributed only 8% towards

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[2] *http://www.mof.gov.bd/en/budget/14_15/ber/en/Ch-02%20(English-2014)_Final_Draft.pdf*

[3] *http://www.pib.nic.in/budget2015/english/EconomicSurvey_Appendix.pdf*

[4] *http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS*

[5] *http://www.mof.gov.bd/en/budget/14_15/ber/en/Ch-03%20(English-2013)_Final_Draft.pdf*

[6] *Binswanger-Mkhize, H. P. (2012): India 1960-2010: Structural Change, The Rural Non-Farm Sector, and the Prospects for Agriculture, Centre for food Security and the Environment, url: https://woods.stanford.edu/sites/default/files/files/India1960-2010.pdf*

[7] *http://agcensus.nic.in/document/agcensus2010/completereport.pdf*

[8] *http://203.112.218.65/userfiles/Image/ArgYearBook11/Chapter-7.pdf*

[9] *http://www.financialexpress.com/article/fe-columnist/from-plate-to-plough-a-wake-up-call-from-the-farms/67093/*

[10] *http://www.business-standard.com/article/specials/for-india-s-farmers-harder-life-ahead-find-latest-studies-115042900153_1.html*

[11] *Ranjan, R. (2015a): Adapting to Catastrophic Water Scarcity in Agriculture through Social Networking and Inter-generational Occupational Transitioning, Natural Resource Policy Research, vol. 7, pp. 71-92.*

Ranjan, R. (2015b): Rural Entrepreneurism and Developmental Outcomes under Climate Change Threats, Climate and Development, 7(4), pp. 353-366.

[12] *http://www.livemint.com/Opinion/Dk2OPASLtOibQTCI2gK13M/The-livelihood-question.html*

households' incomes in 2012-13 as compared to 11% in 2002-03 (Ranganathan, 2015b). This seems to indicate farming populations may not be trained in skills required to exploit the non-farm business opportunities[13]. Despite this, the fact is that currently 6 out of 10 jobs in the rural sector are created in the non-farm sector and it has 'emerged as the largest source of new jobs in the Indian Economy' (Binswanger 2012). Other studies have also noted an increase in the rate of livelihood diversification into non-farm sectors in India in the recent past as well as its correlation with a decline in the poverty levels.[14]

In order to help farmers move out of poverty and reduce their vulnerability to future climatic stress, there has also been an emphasis on promoting crop diversification as well as enhancing the marketability of the crops through promoting better supply chains and increasing the uptake of farming technologies. However, there are limits to relying upon increasing profitability of agriculture given marginalization of land and the presence of climatic and groundwater stresses. In this context, there is a need to enhance the scope of entrepreneurial ventures in rural areas and learn from countries that have been successful at it[15]. China's experience over the past two decades in this regard sets an example.

China's non-farm employment (through its private rural enterprises as well as through Township Village Enterprise systems) has not only increased rapidly, it has also seen an increase in capital intensity as well as complexity of economic activity (Zhang and Scott Rozelle 2005)[16]. With respect to the rate and extent of structural transformation in agriculture across India and China, Binswanger (2012) points out that in the case of India, a high population growth rate (of 1.6 percent) and low rural to urban migration stands in stark contrast to China's zero population growth rate and rural to urban migration of close to 220 million workers (over the last 20 years).

The challenges faced by Bangladesh are similar in many ways to India. However, both these countries have moved differently in some aspects in the recent years. Though India has shown a higher economic growth compared to Bangladesh in recent years, Bangladesh has shown a significant improvement in human capital outcomes as compared to India (Dreze and Sen, 2013). This is likely to pose different sets of constraints to these two economies. The similarity of challenges and differences in constraints provides with an opportunity to understand the issue from a broader perspective.

For Bangladesh, during the 6th Five Year Plan period (2011-15), the agricultural growth rate in the country was below the set target. Further challenges await the sector due to declining trend in the availability and quality of natural resources such groundwater and soil. Farmers periodically lose 12–36% of their harvest due to natural hazards such as flooding (Thomas et al., 2012). A World Bank (2010) report predicted that agricultural GDP in Bangladesh will be 3.1 percent lower each year as a result of climate change. Non-agricultural sectors, whereas, have much more potential to contribute. The fishing industry, in particular, fuelled by increasing shrimp exports, holds great promise. It employed roughly 10 percent of its labour force and accounted for 6 percent of its GDP in 2006[17].

In short, future flooding, droughts, irregular rainfalls, temperature and increasing salinity levels due to sea water intrusion will further challenge the livelihoods of poor rural farmers. Given such challenges, non-farm enterprises in India and Bangladesh could play a vital role

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[13] *http://indianexpress.com/article/opinion/columns/untie-the-farmer/99/*

[14] *Himanshu, P. Lanjouw, A. Mukhopadhyay and R. Murgai (2011): Non-Farm Diversification and Rural Poverty Decline: A Perspective from Indian Sample Survey and Village Survey Data, LSE Asia Research Centre Working Paper, url: http://www.lse.ac.uk/asiaResearchCentre/_files/ARCWP44-HimanshuLanjouwMukhopadhyayMurgai.pdf*

[15] *Ranjan, R. (2015): How Prolonged Droughts and Farm Subsidies Influence Entrepreneurial Ventures by Farmers, Journal of Developmental Entrepreneurship, vol. 20(4)*

[16] *http://aciar.gov.au/files/node/642/MN116%20Part%202.pdf*

[17] *Bangladesh Integrated Water Resources Assessment: Final Report, CSIRO Water for a Healthy Country Flagship Report Series ISSN: 1835-095X*

in pulling a significant rural mass out of poverty and making them resilient to natural hazards.

Though the promise of nonfarm enterprises is prominent in both India and Bangladesh, there has not been enough policy initiatives to encourage farm households to move into such activities. In the Indian case, we observe that there has actually been a decline in importance of these sectors for farm households. It is important to understand why this has been so and what could be done to promote enterprise uptake. A crucial component in understanding these aspects is the challenge posed by current and future climatic stress, and our study aims to explore this role explicitly.

Brief Review of the Literature

There exists an extensive literature on the challenges and opportunities presented by non-farm enterprises globally. Nagler and Naude (2014)[18], using data for six African countries (from 2005-2012), find that non-farm enterprises there tend to be small in size and mainly serve local economies. These businesses are also often interrupted during the farming season. In the case of Rwanda, Abbott et al. (2012) [19]observe that enterprising households can be classified as 'survivalist', 'steady employment types' and 'entrepreneurial'. While the last category is mainly found in urban areas, the first category mainly in the rural areas (and is afflicted by poverty), the middle category could be found in both regions. Owoo and Naude (2014)[20], explore whether productivity in rural entrepreneurship exhibits any kind of spatial autocorrelation. They find that, in Ethiopia, places where farm productivity is lower also have higher non-farm enterprise productivity. Also, individual traits such as education pay a crucial role in enhancing productivity.

When the right set of conditions are present, opportunistic and skilled farmers would be the first ones to start a nonfarm business. We may consider such category of farmers as being influenced by the 'pull' effect of profitable opportunities outside farming. However, even when lacking in necessary skills and human/financial capital, a significant rural population would be compelled to follow suit into entrepreneurial activity (EA) if the natural resource base that previously sustained their livelihood in agriculture is now threatened. For instance, declining groundwater levels[21] in agriculture could trigger mass scale farming exodus. Some of these farmers would be forced to diversify or venture into non-farm related EA. It is normally observed that farming households typically venture into petty trade (small retails shops, petty roadside shops) or transport and motel businesses. These sectors generally provide low profitability, which further declines when many rural households venture into same/similar substitutable activities. This kind of stress induced entrepreneurial shift is 'push' related and generally more vulnerable to failure as well as could lead to significant burden on the local and central governments' finances and other resources.

Despite there being an extensive literature on the topic of rural entrepreneurship, very little is understood over the nature of factors that compel (or attract) different types of farmers to try business ventures. It may very well happen that EA becomes a disguising tool to hide a large number of farm-rejects and this sector would suffer from low capital intensity, productivity and high failure rates in the future.

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[18] *Non-farm Entrepreneurship in Rural Africa: Patterns and Determinants, IZA Working paper no. 8008. url: http://ftp.iza.org/dp8008.pdf*

[19] *Abbott, P., I. Murenzi and S. Musana (2012): The Role of Non-farm Household Enterprises in Poverty Reduction, Employment Creation and Economic Growth in Rwanda, Rwanda Journal 26, Series B, Social Sciences, url: http://www.ajol.info/index.php/rj/article/viewFile/78925/69243*

[20] *Non-Farm Enterprise Performance and Spatial Auto-correlation in Rural Africa: Evidence from Ethiopia and Nigeria, url: http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/Africa/afr-nkechi-owoo.pdf*

[21] *http://www.livemint.com/Opinion/97fuaF2aQkO9IjPiPAjMyL/Six-charts-that-explain-Indias-water-crisis.html*

http://www.livemint.com/Opinion/v4nXpXNxSJtxQNlEbvtJFL/Indias-groundwater-crisis.html

In some instances, geographical factors such as proximity to bigger markets may promote uptake and success in EA. Such beneficial effects are likely to be non-existent or weak the farther the villages are from big towns or main markets. However, clustering of businesses can exist even in remote areas, thereby attracting further entrepreneurial ventures. There are several benefits of clustering, such as reduction of costs through sharing of labour pool and other resources, reduction in costs to provide transportation and energy infrastructure, as well as productivity gains through knowledge spill over amongst competing businesses. Examples of such clustering based gains for micro-enterprises have been noted in the case of the Handloom sector in Ethiopia[22].

Another crucial factor that affects EA uptake is the risk faced by farmers, both within farming as well as in the particular EA. Objective as well as subjective perceptions of risks influence investment into non-farm enterprises. The literature holds conflicting theories on their roles, however. One line of thought argues that when farmers face risk of low productivity in farming (say due to reduced rainfall), they would diversify their portfolio by starting non-farm enterprises[23]. However, there also exists evidence that risk in agriculture can deter investment into non-farmer enterprises when productivity shocks co-vary with profits in non-farm enterprises. This could occur when lower agricultural output reduces incomes of the population and dampens demand for consumption goods which are produced by non-farm enterprises (Rijkers 2013)[24]. Finally, even if some households would like to diversify their livelihood portfolio when one particular source of income becomes risky (such as farming), they may not be able to do so if there exist constraints to their abilities to diversify into more productive and less risky avenues. This point has been highlighted by Dercon and Krishnan (1996), using the case of rural households in Ethiopia and Tanzania. They demonstrate that while ownership of livestock was considered desirable by the households, due to the safety it offered in lean farming periods, not all households were able to own livestock due to low wealth or problems with accessing common pool resources[25].

Risk also affects farmers' decisions related to diversification into other livelihood options, such as through wage based labour income or migration income. The literature is largely unanimous in the observation that an increase in income shocks or risks (either ex-ante or ex-post) leads to households increasing their labour supply (Bardhan 1983, Saha 1994 and Rose 2001)[26]. However, there could be factors other than risk which could also influence households' labour supply decisions. These may include, poverty, lack of productivity in farming, landlessness, etc. A study by DFID[27] (2006) conducted on the 'role of migration and remittances in promoting rural livelihoods' finds that migration in Bihar has substantially increased, especially amongst lower caste communities, and despite its risks and hardships, offers upward mobility to migrating households. Migrants bring back valuable skills as well as savings to finance agricultural assets. Additionally, they also acquire new skills in the urban areas that help them diversify into more secure and better paying jobs

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[22]Ali, M. and J. Peerlings (2001): Value Added of Cluster Membership for Micro Enterprises of the Handloom Sector in Ethiopia, World Development, 39 (3), pp. 363-374.

[23]Rosenzwieg, R. and H. Binswanger (1993): Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments, The Economic Journal, 103(41), pp. 56-78

[24]The effects of risks and shocks on non-farm enterprise development in rural Ethiopia, World Development, 45, pp. 119-136, url:http://www.sciencedirect.com/science/article/pii/S0305750X12002574

[25]Dercon, S. and P. Krishnan (1996): Income Portfolios in Rural Ethiopia and Tanzania: Choices and Constraints, Journal of Development Studies, pp. 850-875, url:http://www.tandfonline.com/doi/pdf/10.1080/00220389608422443

[26]Rose, E. (2001): Ex ante and ex Post Labor Supply Response to Risk in Low-Income Area, Journal of Development Economics, 64, pp. 371-388.

Sha, A. (1994): A Two-Season Agricultural Household Model of Output and Price Uncertainty: Journal of Development Economics, 45, pp. 245-269.

Bardhan, P. (1983): Labor Tying in a Poor Agrarian Economy: A Theoretical and Empirical Analysis, Quarterly Journal of Economics, 98(3), pp. 501-514.

[27] Deshingkar, P. S. Kumar, H.K. Chobey and D. Kumar (2006): The Role of Migration and Remittances in Promoting Livelihoods in Bihar, url: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/2354.pdf

(DFID 2006). Similarly, for those unable to migrate, wage based labour provides supplementary sources of income. Very often such earnings could exceed the expected earnings if they were to start an enterprise according to their capabilities and assets.

In summary, it is not clear whether (and which category of) farmers would take to different livelihood avenues based upon opportunistic reasons or through sheer compulsion. Nevertheless, understanding the key pull and push related determinants of rural enterprises would help with targeting policy measures that can mitigate resource scarcity related mass scale exodus and crowding into already saturated entrepreneurial options. By quickly identifying the key triggers for farmers' EA, and linking them with available opportunities, it would become possible to ensure a rapid and successful transition for most.

4 Objectives

The aim of the project is to explore the key factors that affect farmers' decisions to take up entrepreneurial ventures and to understand how climate change related resource scarcity and shocks influence such decisions.

Specifically, we intend to identify interactions among households' natural, physical, human, financial and institutional capital bases and how these could influence the uptake, competitiveness and profitability of their entrepreneurial activities.

It is to be noted that apart from farm and non-farm entrepreneurship, migration and wage based incomes also serve as significant sources of livelihood incomes for the farming households. Therefore, the propensity to rely upon entrepreneurial incomes and its prospects cannot be studied in isolation of these alternate livelihood options. It may very well be true that migration and wage based non-farm incomes are still heavily relied upon and preferred by a majority of rural households.

Therefore, one of the main objectives of this project is to compare and understand the opportunities offered by non-farm business enterprises in the context of alternate livelihood options such as migration and wage based earnings. Further, from a policy perspective, our goal is to understand what household characteristics (along with community and geographical ones) determine that farmers would make a particular livelihood choice and would be successful in it. This is an important policy concern as these decisions determine their future resilience and vulnerability to climatic and structural shocks. Therefore, the context of water scarcity in India (and salinity in the case of Bangladesh) is given special consideration in our research objectives.

To recap, the three key objectives of the project are:

- To identify key determinants of farmers' decisions related to entrepreneurial activity, particularly in the face of declining natural base and climatic stress.
- To identify interactions among natural, human, financial and institutional capitals and their on influence the competitiveness and profitability of entrepreneurial activities.
- To understand the determinants of the right set of institutional, policy and market linkages that lead to a high capital-intensive, diverse and profitable non-farm sector.

In order to accomplish the above objectives, we identify specific questions and hypotheses that are tested in this study:

1. To what extent is non-farm enterprise uptake affected by water scarcity or salinity challenges?
2. To what extent is migration uptake by farming households driven by water stress or salinity?
3. Are migrating households better off compared to those who prefer to take up enterprises or those who just concentrate on farming?
4. How do household, community, regional and geographical characteristics determine the likelihood of occupational choices for water starved farmers?
5. What are the challenges and determinants of entrepreneurial success for those who start businesses in nearby towns? What lessons could be derived from their experience for the rural entrepreneurs?
6. Is there a significant difference in the risk attitudes of the water stressed farmers compared to those with assured water supply?
7. How do higher measures of risk attitudes, such as prudence and temperance, vary across farming households?

5 Methodology

A brief description of the study areas is presented in appendix 11.1. Below we present the research strategy, sampling strategy and details of the econometric analysis.

In order to achieve the project objectives and answer the research questions, we identified three water stressed districts in the states of Bihar and West Bengal in India and three salinity stressed districts in the South-western region of Bangladesh. We conducted an extensive survey of households and businesses (totalling about 3000) in the rural areas and towns of these districts. The collected data was analysed through descriptive statistics and advanced econometric methods which generated insights over the livelihoods decisions made by households and the impacts of such decisions on their total incomes. First, the demographic characteristics of households, their land ownership, agricultural and non-agricultural assets ownership, details related to debt and social capital were summarized. Next, we explored the various dimensions along which climatic stress was reflected among the sampled households. We also summarized how households responded to climatic stress. Then, we looked at the livelihood patterns of the households with respect to the number and types of activities undertaken, incomes from these activities and the shares of household incomes from such activities.

The purpose of the econometric analysis was to understand three key aspects – the influence of water scarcity on livelihood activities, the impact of other factors on livelihood activities and finally the impact of participation in any particular livelihood activity on households' total incomes. Specifically, we first used a probit model to predict the uptake of enterprises as well as other livelihood activities (such as rural labour supply, migration and salaried employment). Next, we used OLS, Tobit and Cragg models (wherever appropriate) to explore the impact of livelihood choices on total household incomes. Finally, we used endogenous switching models to further control for the possibility of biases in livelihood choices made by households (see Pradhan and Ranjan (2016) for reference)[28]. Robustness checks were performed with respect to regional fixed effects as well as with respect to the choice of instruments.

In addition, we conducted a series of behavioural experiments on a sub-sample of farmers in order to assess their risk aversion, loss aversion, and higher order risk attitudes. These experiments were conducted in the Nalhati region of West Bengal.

Sampling Description for India

The household survey comprised a sample of 1600 households. 500 households were selected in Birbhum and Purulia districts each, while 600 households were surveyed in Nalanda district of Bihar. The household survey collected information related to farming, entrepreneurial activities, migration, labour supply along with an extensive set of standard relevant questions related to socio-economic and climatic stresses faced by households.

Along with 1600 farming households, 200 town based enterprises were also surveyed in the Birbhum and Purulia districts of West Bengal (combined), while 120 town based enterprises were surveyed in the Nalanda district of Bihar. A slight oversampling of 20% was done in Nalanda district as we were surveying only one district in Bihar against two in West Bengal.

The households and enterprises in these districts were selected from two contrasting blocks (varying in level of water scarcity). In each block villages/village clusters were selected

[28] *Pradhan, D. and Ranjan, R. (2016): Achieving Sustainability and Development through Collective Action? An Empirical Analysis of the Impact of the Bore Pool Sharing Program on Farm Incomes and Crop Choices, World Development, vol. 88, pp. 152-174.*

based on heterogeneity in distance from the nearest town. Effort was made to select some villages that were nearer to the town and some that were farther away from the town. Only villages or village clusters that had a population of more than 500 households and had diverse caste groups were considered for sampling.

Sampling Description for Bangladesh

A multi-stage sampling procedure combining both purposive and random sampling methods was followed. The regions were selected purposively, whereas respondents at the village level were selected randomly.

In Bangladesh, 18 districts are affected by salinity. Among these, survey was conducted in three of the most severely salinity affected districts, namely Patuakhali, Satkhira and Khulna. Next, from within each district two sub-districts, severely affected by salinity, were selected. Severity was identified as area affected by saline water intrusion. The selected sub-districts were: Galachipa and Kalapara from Patuakhali; Shyamnagar and Ashashuni from Satkhira; and Paikgacha and Dumuria from Khulna district.

In the next stage, from within each sub-district, two unions based on low and high levels of salinity were selected. Then, two villages from each union were selected based on their proximity to the district headquarters. Proximity was measured not only by distance, but also by time taken to travel. The nearest and the most distant villages were selected. For information regarding unions and villages, consultations were made with the respective sub-district government offices (e.g. UNO office and agricultural office). Finally, at the village level, Rapid Rural Appraisal (RRA) method was applied to make proper listing of the households. Then, the identified households were classified into five categories based on their major income sources. These categories were: crop farmer, livestock/poultry practicing household, households with fisheries as their main occupation, business doing households, casual labour and migration dependent groups. Finally, from the above list, 40 households were randomly chosen for interview. Here proportional representation of the different professional categories was ensured. Thus, 960 farm households belonging to 24 villages from 12 unions under 6 sub-districts from the 3 districts in southern Bangladesh were identified and interviewed.

Data Analysis

We used the probit model to predict households' propensity to take up various livelihood activities. For identifying correlates with household incomes, we used ordinary least squares (OLS), Tobit, and Cragg models. To identify the impact of livelihood choices on total household incomes, we first generated water scarcity and salinity indices. Next, we used endogenous switching regression models (specifically, ivtreatreg in STATA) to control for selection biases and measure the impact of livelihood choices on household incomes. We conducted experiments on a subset of sampled farmers in West Bengal to measure their loss aversion, risk aversion, disaster aversion, prudence and temperance.

Table 5.1 summarizes the key models tested through econometric analysis and the appropriate estimation techniques used.

Table 5.1. Models and Estimation Methods

Models Tested for India Region	Models Tested for Bangladesh Region	Estimation Methods
Explaining determinants of enterprise uptake by farming households	Explaining the determinants of enterprise uptake	Probit Model
Explaining household income variation with respect to enterprise uptake	Determinants of income from entrepreneurship	OLS*, Tobit** and Cragg** Ivtreatreg (for endogenous switching models)
Explaining determinants of migration uptake and its impact on household incomes	Explaining the determinants of rural labour supply	Probit Model
Explaining determinants of rural labour supply and its impact on household incomes	Explaining the contribution of rural labour supply to total household income	OLS*, Tobit** and Cragg** Ivtreatreg (for endogenous switching models)*
	Explaining the determinants of fisheries based enterprise uptake	Probit
Determinants of profitability of enterprises located in nearby towns (close to the sampled rural households)	Explaining the contributions of fisheries based enterprise in income	OLS*, Tobit** and Cragg**
Explaining the contributions of various livelihoods options to total household income	Explaining the contributions of various livelihoods options to total household income	OLS
behavioural experiments conducted on West Bengal farmers		Field experiments and probit analysis of data

Note: * Method used for India Model only. ** Method used for Bangladesh model only

6 Achievements against activities and outputs/milestones

We had originally identified three key objectives aimed at enhancing our understanding of the rural non-farm sector's role in climate stressed areas. During the project execution stage, we expanded upon these objectives to further include exploring the determinants and profitability of other alternate livelihood activities such as migration, rural labour supply and salaried employment. This helped us create a better picture of the livelihood opportunities and challenges present in the climate stressed areas and to present the findings related to non-farm enterprise uptake and profitability in the broader context. Table 6.1 presents the mapping of activities and outcomes from these activities.

Table 6.1. Mapping Activities and Outcomes

Sr. no.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Activity 1 Identifying the portfolio of EA in the study areas through existing literature as well as through meetings with relevant government and non-government officials	Ethics application, Literature review, Meetings with GOs and NGOs in study areas and development of preliminary report that will feed into the survey design process	Jun-Aug 2015	We identified the portfolio of entrepreneurial activities for each area and used this portfolio for sampling of enterprises in the towns. We held meetings with ministry of agriculture officials in Delhi and Dhaka as well as with several NGOs to understand key livelihood options present in the study regions.
1.2	Activity 2 To map the competitiveness, profitability and constraints imposed by capital (human/natural/social/financial) requirements for different EA identified in the region	Converting meeting insights into testable hypotheses	Sept 1, 2015	We identified key issues faced by climate stressed households through meetings held with relevant stakeholders (including farmers, policy makers, NGOs). This formed the basis for the design of an extensive household level survey that would later allow for mapping of capital endowments to livelihoods responses

1.3	Activity 3 To identify the portfolio of possible future EA feasible in the study region and understand potential constraints for establishment of the sector in the region.	Converting meeting insights into testable hypothesis	Oct 15, 2015	Testable models were developed based upon modified research questions. These models formed the basis for the survey questionnaire. We designed an extensive household level survey for 3,000 households (including a small sample of local town businesses) in India and Bangladesh study regions.
1.4	Activity 4 Finalising the scope and study areas for study.	A final list of villages, districts to survey and a list of testable models and hypotheses.	Oct 30, 2015	We conducted a number of field trips and organized meetings with govt. officials and NGOs in the potential districts and blocks to acquire an understanding of the suitability of the study area. This, along with an analysis of secondary data related to climatic stress, formed the basis on which finalized list of villages and blocks were selected.
1.5	Activity 5 Conducting focus group discussions (FGD) with farm households in the region	A pilot survey comprising data from study areas. Analysis of weaknesses and strengths of the questionnaire. Preparation of the final survey questionnaire	Nov 15, 2015	We held several meetings with the affected farmers in the regions in the period preceding the survey. These meetings helped revise and refine the survey questionnaire.

1.6	Activity 6 Administering pilot and household survey in the study regions and data entry	Generation of the data set needed for analysis	Nov 30, 2015-Feb 1, 2016	We hired one survey firm for India and one for Bangladesh. In addition, we hired two monitoring firms in India and local researchers at BSMRAU in Bangladesh for ensuring survey quality. Survey firms and monitors were provided intensive training before starting survey work and were periodically monitored and given feedback during the survey process. We surveyed about 2000 farm households (including 320 town entrepreneurs) in the districts of Nalanda, Birbhum and Purulia in India and about 1000 households in the districts of Patuakhali, Satkhira, and Khulna in South west Bangladesh.
1.7	Activity 7 Analysis of data and interpretation of findings	Generation of research findings and research papers	Feb-Apr 2016	We performed data analysis through generation of an extensive descriptive statistics and through the use of advanced econometric tools. We also conducted a series of experiments on farmers in the Nalhati region of West Bengal to understand higher measures of risk preferences of farmers.

1.8	Activity 8 Communicating findings to fellow academics, policy makers and ACIAR in seminar/workshops and through submission to academic peer reviewed journals	Communication of the results to the stakeholders	April 12, 2016	We organized a workshop, in Delhi at the Institute of Economic Growth on April 12, 2016, to present preliminary findings. Various academics as well as policy makers from GOI attended this meeting and provided feedback. This feedback was used to revise the analysis and prepare the final reports. Another round of communication of project findings was held in September 2016 in Delhi. We met with members of agricultural ministry, Govt. of India, NITI, and researchers at IFPRI, CYMMIT and PUSA University. A final copy of the report was shared with several stakeholders. In case of Bangladesh, a final copy of the project findings relevant to Bangladesh study was shared with various stakeholders. A number of manuscripts are currently under preparation for submission to peer reviewed journals.
1.9	Activity 9 Final Report preparation for ACIAR	Submission of Final report	July 2016	We submitted the final reports in Nov 2016

1.10	Activity 10 Determining scope for future work and identifying areas that need policy targeting based upon findings	Submission of a new proposal	Aug-Sep 31, 2016	Scope for future work has been determined through meetings with policy makers in Delhi in September 2016. Specifically, project leaders held discussions with members of the govt. (Agricultural Ministry and NITI) and with researchers at IFPRI, CYMMIT, PUSA University. Based upon the outcomes of this project and through the feedback received from the above mentioned stakeholders we have identified the following work for future research: Migration has become a major source of livelihood for many marginal and landless farmers in water stressed regions of Bihar, West Bengal in India as well as in Nepal where similar challenges force seasonal migrants into bigger cities such as Kathmandu or into India. In Bangladesh, seasonal migration is a significant source of income for climate-stressed households. It is important to understand how migrants use their extra incomes and savings (compared to equally stressed but non-migrating households) to enhance their resilience to future climate shocks. In future research, we plan to analyse the impact of interventions involving improved agricultural technologies and information on food security and livelihoods of rural households in India, Bangladesh and Nepal. We also plan to estimate the impact of interventions on migration and its subsequent impact on incomes, savings, investment, food and nutritional security of the households.

7 Key results and discussion

We present the results on the basis of descriptive statistics as well as econometric analysis. A detailed report containing descriptive statistics and econometric analysis can be found at: https://www.researchgate.net/project/Climatic-Stress-Structural-Change-and-Farm-and-Non-farm-Enterprise-Uptake-by-Farmers-in-India-and-Bangladesh

Below we present the essence of the descriptive statistics and the econometric analysis.

Essence of descriptive statistics from sampled households in India Study Region

There are a number of important features of the sampled households in the study areas that are worth noting. The dependency ratio (based upon ratio of non-working to working) is very high at 0.54 for the overall sample. 15 percent of sampled households are illiterate, whereas close to 45 percent have secondary education. Only 7 percent of the sampled households had any members that were graduates. Also, about 65 percent of the sampled households came from the non-general category (that is comprising SC, ST and OBC). Therefore, we are considering the implications of water scarcity in regions where households may not have decent opportunities for urban employment or salaried employment.

Average land holding of the households is 2.1 acres, with SC and ST categories holding 1.8 acres, OBCs holding 2.17 acres, and forward castes holding 2.3 acres. Fifty percent of households owned cows and the average value of livestock in the entire sample was 22,509 INR. There is not much evidence of technology based farming in the sample, as only 2.8 percent of overall sample owned a tractor, less than 4 percent owned a submersible pump, less than 7 percent owned electric motors and less than 13 percent owned sprayers.

In terms of non-agricultural assets, more than 90 percent owned a mobile, 40 percent owned a TV, 80 percent owned a cycle, but only 13 percent had a bike or a scooter. Average value of non-agricultural assets was 35,000 INR. Only 25 percent of sampled houses were pucca. 83 percent households had access to electricity. 20 percent of sampled households held bank loans, 50 percent held loans from any source.

99 percent of households cultivated in the Kharif season, whereas only 56 percent did so in the Rabi season. Only 2 percent of households cultivated more than one crop in the kharif season, whereas 30 percent households cultivated more than one crop in the Rabi season. The perceived average optimal number of irrigations in the Kharif season was 5.2, whereas the actual applied was 3.2. Average cropping intensity was 140 percent. Water scarcity index for kharif season was 42 percent, whereas it was 51 percent for the Rabi season.

Average yield was 10.5 Qtls./acre of paddy in kharif and 10.9 Qtls./acre of wheat in Rabi. 45 percent of households reported to have suffered crop losses of more than 3 times in the past 5 years.

Almost 100 percent of sampled households were engaged in farming. About 24 percent were doing dairy/poultry fishing, 37 percent were supplying agricultural labour, 66 percent were into casual labour supply, 23 percent were opting for urban migration based earnings, 12 percent were salaried employed, 16 percent took to enterprises and 15 percent had earnings from other income sources.

Only 3.5 percent of households relied upon just one form of livelihood, 68 percent had 2 or 3 forms of livelihood activities and 21 percent had 4 sources of livelihood earnings. On average, a household engaged in 3 forms of livelihood activities.

Total income of an average household was 105,000 INR, of which 20,000 INR came through cultivation, 18,000 INR through migration, 25,000 came through casual labour supply and only 6,500 INR through enterprise uptake.

Essence of econometric analysis for India study region

Explaining determinants of enterprise uptake by farming households

Using a probit model to explain the probability of enterprise uptake, it is found that the cropping intensity is positively related to enterprise uptake probability (increases uptake by about 8 percent, keeping other things constant), whereas a marginal increase in water scarcity in the Kharif season has a negative and significant impact (of about 9 percent) on enterprise uptake probability. Also, household crop income is negatively associated with enterprise uptake. That is, those households that face significant water scarcity and have low crop incomes are less likely to start an enterprise. The intuition behind this result could be that frequent disruptions in income due to adverse impacts of water scarcity on crop productivity leave little resources for these households to accumulate necessary capital (financial, human or other) for enterprise uptake. Households that stated a higher 'minimum drought resilience' (stated by the respondent as the number of months that the household could survive in a drought-like situation with only their current income. See Ranjan (2013a, 2013b, 2014a & 2014b) for application of the concept[29]) were also less likely to start an enterprise. This gives an indication that for a majority of households, the decision to start an enterprise could be more of 'push' or distress related one. Households from the ST community and other backward caste category were relatively less likely to start an enterprise compared to scheduled caste households.

Households, that had a head with secondary and higher secondary education, were also more likely to start an enterprise as compared to those with illiterate household heads (by about 5 and 7 percent respectively). Those with a higher level of education, such as diplomas or graduates, were also more likely to start an enterprise. The propensity to start an enterprise does not seem to be influenced by the size of the land holdings of the farmers, nor is it influenced by the value of their agricultural assets. However, the value of non-agricultural assets is positively and significantly associated with the probability of starting an enterprise. The marginal probability being about 2 percent, that is, a unit increase in the value of non-agricultural assets leads to an increase in 2 percent probability of starting an enterprise. It also suggests that (when accounting for endogeneity) those who take to enterprises are able to shift their focus away from accumulating farming assets and towards accumulating non-agricultural assets. Total value of livestock has a negative influence on the probability of starting an enterprise, suggesting that those with more livestock cope better with low crop incomes and water scarcity without needing to start any enterprise. It could also be that maintaining livestock may not allow them time to engage in any enterprise activity.

Ability to borrow money from their social networks or being a part of the SHG is positively associated with enterprise uptake. Similarly, those households that stated their preference for enterprise as compared to migration and agriculture as livelihood avenues were also more likely to take to enterprise. Considering district level fixed effects, relative to Birbhum in West Bengal, households in Purulia (which is the most water scarce of the three districts)

[29] *Ranjan, R. (2013a): Mathematical Modeling of Drought Resilience in Agriculture, Natural Resource Modeling, vol. 26, pp. 237-258.*
Ranjan, R. (2013b): The Role of Credit in Enhancing Drought Resilience in Agriculture, Journal of Environmental Economics and Policy, vol. 2, pp. 303-327.
Ranjan, R. (2014a): Technology Adoption for Long-Term Drought Resilience, Water Resources Planning and Management, vol. 140, pp. 384-392.
Ranjan, R. (2014b): Combining Social Capital and Technology for Drought Resilience in Agriculture, Natural Resource Modeling, vol. 27, pp. 104-127.

were less likely to start an enterprise whereas those in Nalanda in Bihar were more likely to start an enterprise.

Explaining household income variation with respect to enterprise uptake

Once a household has taken up an enterprise, their challenges do not necessarily get reduced. An ordinary least squares analysis suggests that those households with an enterprise have their incomes higher by 10 percent compared to non-entrepreneurial households. However, when we control for selection bias (using an endogenous switching regression model), the contribution of enterprise to total household income turns out negative. This suggests that households may be better off not taking up such enterprises. Alternatively, households currently into enterprises would earn more if they took an alternative profession.

Explaining determinants of migration uptake and its impact on household incomes

Irrespective of the merits of the business enterprises in enhancing households' incomes, not every household would possess the inclination or the means to do business. For the educated households, it may not even be considered prestigious. On the other extreme, are the most illiterate households who do not have the acumen or the resources to take to business. In our study, we find that migration contributes far more towards augmenting household incomes as compared to business enterprises. While higher cropping intensity was found positively associated with household income and the decision to start and enterprise, it was also positively associated with urban migration decision. It is possible that those who migrate are able to remit savings that allow them to buffer losses in farming as well as invest in farm productivity through higher investments in tools and through better farming practices. That is, urban migration could be distress driven, just as enterprise uptake, however, it still allows farming households to continue in farming and even increases its intensity. Contrary to those taking to enterprise, the probability of a household member migrating declines significantly with higher educated members in the households. That is, migration is mostly preferred by households with lower levels of literacy, as this livelihood option suits that category of human capital endowments. It is also worth noting that the decision to migrate to urban areas is not influenced by water scarcity in our models. Neither is it found to be a caste specific phenomenon. That is, migration may have become a necessity for a large number of poor households in our study area due to lack of incomes and employment opportunities locally. However, not all households may be able to migrate. Having more household members helps with migration decision, whereas, having more dependents within the household becomes a constraint. But for those households, who are able to migrate (to urban areas), their household income is higher by at least 25 percent as compared to non-migrating households. This finding is robust even after controlling for selection biases.

Explaining determinants of rural labour supply and its impact on household incomes

For those households who are not able to migrate, the alternative is to supplement their incomes through rural labour. Contrary to the case of urban migration, the probability of rural migration declines by about 13 percent for those with higher cropping intensity. Those who are growing crops throughout the year would have less time to participate in the labour market. Such labour supplying households tend to have lower value of non-agricultural assets, and they also do not participate in SHGs. They also have lower value of agricultural assets and are highly likely to be illiterate. Just as the decision to migrate to urban areas cannot be explained as being effected by water scarcity, we also do not find any association between rural labour supply and water scarcity. What makes the story alarming is that we find that those who supply rural labour have total household incomes lower by at least 15

percent compared to those households who do not supply rural labour. While controlling for selection bias, this percentage becomes 80 to 90 percent. Despite such a lower impact of labour supply on household incomes, we find that almost half the sample in our study area is engaged in this livelihood activity. This finding suggests high levels of stress currently faced by low and small land holding farming households.

Explaining income variations as a function of livelihood profiles of the households

So far we have considered the impact of various livelihood activities of the households on the incomes individually. That is, we have asked how enterprise uptake affects household income or how urban migration affects the same. In reality, most households engage in multiple livelihood avenues to supplement their incomes as well as to minimize risk of sectoral shocks through diversification. In this section, we classify the entire sample based upon their detailed livelihood profile and then run an OLS of total household income to delineate the effect of various livelihood profiles on income. Households have been classified based on their livelihood diversification into the following 8 categories:

P0--Base category (Household involved only in agricultural activities – crop cultivation and livestock). This category of household does not participate in labour supply (total number of households in this category=92 households).

There are seven other categories, which engage in some kind of labour based work but do not earn salaried employment. They are generally involved in agriculture as well. These profiles (P1-P7) are as follows:

P1 - offering rural labour only (and no salaried employment) (774 households)

P2 - offering urban migration only (and no salaried employment) (127 households)

P3 – engaged in enterprise only (and no salaried employment) (53 households)

P4 – offering rural labour and urban migration (and no salaried employment)

(166 households)

P5 –offering rural labour and working on an enterprise (and no salaried employment)

(139 households)

P6 – (urban migration and enterprise) (and no salaried employment) (26 households)

P7-having salaried employment (including any other livelihood sources) (180)

Results confirm the earlier outcomes when we assessed the role of rural labour on household income (without considering other livelihood profiles), and the impact was surprisingly negative. In the current model, including all livelihood profiles together in a model, we still find that P1 (rural labour) category is the only category that shows no significant contribution to total household income. Considering that this profile is nearly half of the entire sample spanning the three districts, this is a troublesome finding, as this suggests high level of economic stress faced by a majority of the households. In contrast, all households that are engaging in urban migration either as a sole livelihood avenue or when combined with enterprise or labour supply are doing much better. For instance P2 category households have their total household incomes about 36 percent higher, whereas, P4 and P5 category households have their incomes higher by roughly 50 percent compared to the base group. Salary based livelihood earners are doing the best of all categories, with their household income being 80 percent higher than the base group.

Determinants of profitability of enterprises located in nearby towns (close to the sampled rural households)

We also performed a regression analysis of determinants of enterprise profitability on a smaller sample size of 320 businesses, which were sampled from local towns nearby the study area villages. Findings suggest that those running enterprises armed with higher secondary education or graduate level education are found to have a higher income (by about 15 percent) compared to those with less than or equal to secondary education. Age of enterprise or its location does not seem to influence its profitability. Nor is the level of initial investment a factor. Those using internet for running their enterprise are found to have 50 percent higher incomes as compared to those running an enterprise without internet. While, most entrepreneurs may be making little use of internet based information for running their day to day business, this perhaps reflects the higher education of the entrepreneurs using internet as well as their unobservable traits such as better understanding of the markets, higher skills sets, higher ability to compete with other businesses, etc. Similarly, those who stated that they try to innovate in their business, for improving quality, marketing and reducing costs, also had 20 percent higher incomes compared to those who did not. Those who took to business because they could not find other jobs had relatively lower profits. Also, those who took to businesses which required lower capital had lower profits.

Results from the series of behavioural experiments conducted on West Bengal farmers

We conducted behavioural experiments on a sub-sample of farmers to measure their risk aversion, loss aversion and higher order risk preferences, such as prudence and temperance, with the goal of being able to relate their risk taking behaviour to their household characteristics as well climatic stress faced by them. Higher order risk preferences remain relatively unexplored in the case of farmers. The general assumption in the literature is that education is linked positively with prudent and temperate behaviour. However, probit analysis of the experimental data suggested that education and precautionary saving/prudent behaviour are not linked positively. Considering that our experiments exclusively dealt with farmers, we consistently find that more educated farmers are more likely to take risks at low levels of income or when background risks are present, as compared to illiterate farmers. Whereas, we also find that more educated farmers show a positive association with disaster risk aversion as compared to illiterate farmers. In general, individuals were found to be more loss averse than risk averse. Medium size farmers were found to be not prudent as well as having a negative association with disaster risk aversion. These farmers had the most land of all the participants and their ability to ignore disaster risks in experimental settings or to be less prudent presents interesting scope for further comparisons with their real life decisions.

Enterprising households seemed less likely to be averse toward ambiguity, that is, in ambiguous conditions they are more likely to invest. Though statistically insignificant, individuals from households with enterprises seem to be less likely to be averse to loss and disasters and more likely to be prudent and temperate.

Water buyers and sellers are both found to be negatively associated with temperate behaviour. Farmers in water scarce situations normally buy water to ensure a minimum amount of crop yield. Yet, it is not a risk-free decision as in the absence of an optimal amount of irrigation, their crops could fail nevertheless. Therefore, it is likely that those who buy or sell water are taking a measured risk when faced with a number of background risks. The same risk taking behaviour could be reflected in their higher observed intemperance in the experimental setting.

Essence of descriptive statistics from sampled households in Bangladesh Study Region

Appendix 11.2 presents some key descriptive statistics. Here we present some notable aspects[30]. Khulna, Satkhira and Patuakhali are the three highest salinity affected areas in South-Western district of Bangladesh (in terms of number of affected acres). Further, these districts have shown a persistent trend of salinity increase over the last 3 decades. The average dependency ratio (work wise) is close to 70 percent in the three districts. A quarter of the sampled households were illiterate. Given the high level of salinity in these regions, cropping was the main occupation for only 13 percent of the overall sampled households and it was only 3 percent for Satkhira. Nearly 50 percent of the sampled households took to day labour as their main occupation, whereas only 14 percent were into any type of enterprise. 11 percent of the sampled households took to livestock, poultry and fisheries as their main occupation. The severity of salt water intrusion can be gauged from the fact that in a number of villages from the three districts, almost all households had to buy drinking water for 4 to 6 months a year. Around 16% of the households had to purchase drinking water at for least some months in a year.

Nearly 50 percent of the sampled households were landless farmers. In high saline areas, farmers owned 92.97 decimal of land, which was valued at 754,463 tk (Bangladeshi currency valued at about 80 tk per USD). Their counterparts in less saline areas had 54.64 decimal of land, which they could sell at 558,051 tk. Four in every five households sampled, live in mud houses. In Khulna, Patuakhali and Satkhira districts, 68.75%, 89.06% and 76.56% had mud houses respectively. Only 10 percent of the sampled farmers had brick houses. Among the sampled households, close to 80 percent had electricity connection.

On average, the owner households had 13 poultry birds worth 2,527 tk. Compared to the households in low saline areas, both the number as well as the value of poultry birds were higher for households living in high salinity affected areas, except for Patuakhali. But the difference was significant only in Satkhira. On average, a household owned around 2 animals worth 19,126 tk. It is interesting to note that the value of animals held by an average household in the sample was around 7 times higher than that for poultry. Households would be expected to own more cattle as a risk hedging measure, more so in high salinity areas. However, even though the households in highly saline areas had more livestock than their counterparts in less saline areas, the value of livestock was higher for households in less saline areas.

In terms of asset ownership, mobile phones were owned by 94.48% of the households, by-cycles by about 30 percent, tube wells were owned by 20 percent and television sets by 18 percent of the households. Motorcycles were owned only by 6.25% households. Average value of tube wells owned in less saline areas was 1.5 times higher than that in high saline areas. Only 5 percent of sampled households owned diesel engines, less than 3 percent owned electric motors, less than 5 percent owned sprayers, whereas close to 60 percent owned fishing nets. 10 percent of the sampled households owned boats.

Landless and marginal farmers owned about 8,000tk worth of agricultural assets, whereas small farmers owned 12,000tk worth of assets and medium and large category farmers owned 20,000tk worth of farm assets.

On average, farmers lost nearly 30 percent of paddy in the Rabi season and 20 percent in the kharif season due to salinity. Sampled farmers practiced very little crop diversification. Nearly 60 percent of surveyed farmers believed that increased salinity was caused by sea

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30 For detailed descriptive statistics refer to the report: https://www.researchgate.net/project/Climatic-Stress-Structural-Change-and-Farm-and-Non-farm-Enterprise-Uptake-by-Farmers-in-India-and-Bangladesh

level rise, whereas 30 percent attributed it to mismanagement of the polder gates that allowed sea water to intrude inland.

Essence of econometric analysis of Bangladesh sampled household data

Explaining the determinants of enterprise uptake

We first analyse different socio-economic, demographic, salinity related and locational factors that may influence a household's involvement in the major income generating activities. We use probit model to predict livelihood participation and Tobit and Cragg models to predict impact of a particular enterprise uptake on incomes.

The main livelihood activities include enterprise ownership, casual labour and fisheries. Salinity poses serious challenges to the livelihoods of rural households in Bangladesh, particularly to those who are still into farming. Those who have exited farming or reduced their reliance upon farming as a means of livelihood can in fact benefit from higher salinity levels if they have the requisite resources to invest into fisheries. Our analysis suggests that farmers face few alternative livelihood options in these areas, comprising labour supply, enterprise uptake and fisheries. Those who take to enterprise tend to have higher secondary or above level of education and also own less land compared to those who do not take to enterprise. For landed farmers, enterprise may not be the first choice. Ironically, those households who face higher periods of saline intrusion in a year are less likely to do business. This could be because, higher salinity adversely impacts on their capability to accumulate the required financial capital to start an enterprise. Therefore, even as salinity pushes households out of their traditional livelihood means, it punishes those with lesser means to adapt. Those who have better access to loans are more likely to start an enterprise. The probability of taking an enterprise is lower for households who participate in labour supply or have salaried employed members or own more livestock. This suggests that labour supply, salaried employment and owing more livestock offer alternate opportunities for livelihood sustenance and may be incompatible with doing an enterprise as a side activity for most households. Enterprise uptake is higher in Satkhira and Khulna districts and also higher in more salinity affected villages.

Determinants of income from entrepreneurship

In terms of reward from entrepreneurial activity, those with secondary education or higher tend to generate 60 percent more incomes compared to illiterate households. Despite higher enterprise uptake in Khulna and Satkhira, the profits of entrepreneurs are lower compared to Patuakhali district, suggesting higher level of distressed enterprise uptake. Remote village area entrepreneurs tend to make lower incomes due to lack of demand or other distance related constraining factors.

Explaining the determinants of rural labour supply

Compared to enterprise uptake, labour supply seems to be very sensitive to the frequency with which households had to purchase drinking water. This signifies the presence of most vulnerable groups of household in the labour supplying category. A higher level of salinity also increases the chances for such vulnerable households to take to labour supply. This form of livelihood tends to draw from the illiterate group of households and the probability of participation in those households with educated members goes down significantly. Those having more family members are more likely to participate in labour supply for the obvious advantages of more earning hands within the family and also for the obvious disadvantages of more mouths to feed. Having more land or being into alternate livelihood categories such as enterprise, fisheries or salaried employment reduces the likelihood of labour supply.

Being a member of the NGO groups also marginally lowers the probability of labour supply, indicating possibility of effective poverty mitigation roles played by such agencies. Again, Satkhira and Khulna districts draw more households into labour supply suggesting higher level of salinity stress faced by these districts.

Explaining the contribution of rural labour supply to total household income

Amongst those who take to labour supply, those who face higher frequency of salinity tend to earn significantly more through labour income, suggesting higher willingness to migrate farther and seek better labour incomes given water stress in hometowns or villages. In contrast, those with more dependents tend to have lower incomes suggesting exactly the opposite—reduced ability to migrate farther or lower flexibility to take up roles that would take them away from dependents for sustained time periods. Having extra family members obviously leads to higher total incomes. Being a part of the NGO group also assists in some inexplicable way to higher labour income. Perhaps through better connections that ensure higher frequency of works. However, similar to earlier findings, households from Satkhira and Khulna make lower labour based incomes as compared to those from Patuakhali. Remote area labour workers make significantly less, suggesting constraints in migrating to more attractive areas in terms of higher wages offered.

Explaining the determinants of fisheries based enterprise uptake

Those households which took to saltwater fishery based livelihoods were more likely to come from villages far from district headquarters that were also prone to higher frequency of saline intrusion. Remote area villages with suitable resources are more likely to switch to fisheries if they have the required resources such as more land, more family members, and also hold a higher perception of salinity rise over the years. This is specially observed in Khulna and Satkhira, where the probability of fishery based enterprise uptake is 30 to 40 percent higher as compared to Patuakhali district. Level of education of the household does not seem to play a role in determining the ability to start a fishery based enterprise (unlike other livelihood options such as labour supply, enterprise uptake or salaried employment). This suggests, ease of access to know-how as well as willingness of households to take to this form of livelihood if they had the required resources. Also, doing a fishery based business is uncorrelated with any other form of livelihood, except farming. This suggests that fishery based livelihood could be providing sufficient incomes to these households, and also it could be drawing all households members into it, thereby leaving little opportunity or need to take up enterprises or salaried employment.

Explaining the contribution of fisheries based enterprise on income

Amongst, those who take to fishery based livelihood, those in high salinity affected areas tend to earn less suggesting the presence of adverse effects of high saline water on fishery health. Therefore, high salinity acts as a double edged sword that compels households to switch to fisheries (given that salinity adversely affects paddy output by 30-40 percent) and reduces their fishery based incomes. This calls for government intervention to better manage saline water intrusion in the low lying areas given the increasing reliance of households on fisheries. Compared to saline fisheries, which is largely prevalent in Satkhira district, Patuakhali and Khulna district residents are more likely to go for fresh water fisheries. Also, fresh water fisheries tend to attract more educated households.

Explaining the contributions of various livelihoods options on total household income

If we compare the impact of various livelihood activities on the total income of these households, those taking to enterprise have their incomes higher by 100 percent compared to those who are not into enterprise. Similarly, labour supply and fishery based enterprises are also lucrative, though their contribution to household income is lower at 85 and 60 percent respectively (as compared to those who do not take to these professions). Doing crop farming reduces household incomes by 40 percent, whereas salaried employed tend to do the best with highest contribution to household incomes. Those in Khulna and Satkhira and those in remote and high saline areas tend to have lower total household incomes. These results are largely robust even when controlling for selection bias.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The findings from this study will be submitted to peer reviewed journals in the field of agricultural and development economics. It is hoped that these findings will generate further research in the coming years to understand institutional, socio-economic and behavioural challenges to the uptake and success of non-farm enterprises in rural areas. Particularly, we posit significant impact of climatic stress on not just farming, but various livelihood activities for farm households in India and Bangladesh. As these two economies are undergoing structural transformation, it is important to understand the impact of climatic stress on this transformation. Our research lays foundation for wider research on this topic at this important juncture.

In our study, a small sub-sample of farmers were also subjected to a series of experiments in order to assess their higher order risk preference measures. While it may be too early to derive inferences about their real life risk taking behaviour based upon these experimental findings, further application of such methods holds promise towards enhancing our understanding of how households' decisions and risk preferences are altered when faced with climatic stress.

This research has several innovative aspects. First, the research question itself is novel as it relates to the impact climate related stress could have on livelihood choices of farmers. A better understanding of the households' responses to climatic stress in terms of their livelihood decisions can help policy makers focus their livelihood augmenting interventions. Second, an understanding of livelihood choices also helps present a clearer picture over the extent of future structural transformation in the farm sector in the background of climate change impacts. Third, the methodology adopted in this research allows for comparing entrepreneurial incomes in the context of incomes available through other key livelihood options for farmers, and therefore, puts in perspective whether such decisions are stress driven or opportunistic. Further research will be needed to confirm the findings on a larger regional scale, however, our research takes an important step in this direction.

Experimental methods are important towards understanding actual decision making of farmers facing risky situations. In fact, our innovation involves testing for decision making by climatic stressed farmers in presence of background risks. Background risks are a reality for farm households, and our work is an improvement over similar methods employed previously.

8.2 Capacity impacts – now and in 5 years

A number of researchers were trained as a part of this project. Two PhD students at Macquarie University were trained in design, handling and analysis of large household level datasets. Of the two, one PhD student was also trained in conducting field experiments in West Bengal, where a series of experiments were run on a sub-sample of farmers to measure their risk aversion and higher order risk characteristics. Two research assistants were provided training in field level data generation related activities including training and monitoring of surveyors. The project country leaders applied for various ACIAR fellowships (including John Dillon fellowship) to visit Australian partnering institutions. Collaborating researchers at IEG and BSMRAU benefitted through enhanced skills in policy analysis, use of advanced econometric methods and handling and analysis of large scale household level data. The researchers at IEG and BSMRAU also developed capabilities related to field survey for a large sample. Additionally, they got an opportunity to try innovative experimental methods on the field, which will help them with future research in this area. Finally, the project also helped improve the linkages between IEG and BSMRAU researchers and various regional stakeholders such as governments and NGOs.

8.3 Community impacts – now and in 5 years

Key findings from the study will indirectly benefit the community through enhancing the understanding of various stakeholders with respect to challenges and determinants of enterprise uptake by climate stressed farmers. The findings derived through this study are significantly detailed in nature as they provide analysis for various livelihood profiles of farmers and therefore make possible targeting of specific household types for policy interventions. For instance, we have created eight categories of farm households (for the case of India) depending upon their livelihood activities. This includes households engaged only in rural labour supply or only in urban migration or only in entrepreneurial activity or only in salaried employment and those households who were engaged in various combinations of these four key categories. Policy implications for entrepreneurial households would vary significantly for those engaged in rural labour supply. For instance, we find that households engaged in rural labour supply earn significantly less than those engaged in urban migration. Further, both types of households have lower levels of literacy as compared to households that take up enterprises. Yet, urban migrants tend to earn significantly more than rural labour supplying households as well as those who take to enterprises. Despite this, not all stressed households may be able to migrate, as factors such as number of dependents and numbers of family members significantly influence their migration decisions. Similarly, those taking to rural labour supply appear to be the most vulnerable group in our study and would require immediate attention as compared to other categories of households.

Findings from this study are also applicable outside of the study areas which face similar climatic stresses.

8.3.1 Economic impacts

The economic impacts of this study materialize through adding further policy insights to a cumulative body of literature that has analysed various aspects of livelihood decision making and outcomes in the climate stressed regions. The study areas we selected are relatively poorer and see significant push related livelihood choice, including migration and labour supply. Most households in our study areas were found to be relying on 3 or more livelihood activities in order to supplement their incomes, and analysing these livelihood choices in the background of water scarcity, salinity stress and the various capital endowments presents with an opportunity to make efficacious policy interventions.

We also established that policies that improve cropping intensity and drought resilience will not only improve crop incomes of the households but also help with taking up other livelihood options which provide higher returns. Even during the phase of structural transformation and movement of people out of agriculture into profitable nonfarm avenues, there is a need for policies that enhance water security. The focus on agriculture should not be just for agricultural growth, but also for the positive linkages it establishes with other sectors.

Therefore, this project makes an important policy contribution by providing evidence over the linkages between agricultural incomes and the ability of farmers to make alternate livelihood choices. The additional employment opportunities generated through targeted intervention policies in farming will boost economic activity in the water stressed regions, and will ultimately bring poorer households out of poverty as well as assist with the process of structural transformation at macro levels.

8.3.2 Social impacts

Any social impacts from this project are invariably linked to the economic impacts. For instance, creation of better livelihood opportunities could lead to a higher rate of employment among households and also positively impact on their consumption patterns, child education and health. Interventions promoting adoption of entrepreneurial activities will reduce distressed labour supply and migration and will improve their wellbeing.

8.3.3 Environmental impacts

Water scarcity and salinity driven livelihood choices can adversely impact on the environment. For instance, while shrimp farming leads to better livelihood outcomes for households in salinity affected areas in Bangladesh, it also threatens to adversely impact on the ecology of the region through increasing the concentration of nutrients in water bodies as well as through increasing disease incidences and vulnerability. Similarly, excessive reliance upon groundwater in water stressed areas, will have implications for environmental water supply. Our study did not directly address the environmental aspects of climate stress, and it is not clear how improving (or the failure to improve) the livelihoods of the climate stressed farmers will impact on future environment. Further study will be needed to address this aspect.

8.4 Communication and dissemination activities

Project findings were communicated through a workshop organized at the institute of economic growth, Delhi, in April 2016. Various stakeholders including researchers, funding agencies and government ministry representatives participated in this workshop. Additionally, policy briefs were prepared and shared with ACIAR and country leaders for further dissemination. Additional meetings with stakeholders were also conducted. Finally, the main report containing detailed analysis was made available on the internet for receiving further feedback and for dissemination of findings. This report is available at:

https://www.researchgate.net/project/Climatic-Stress-Structural-Change-and-Farm-and-Non-farm-Enterprise-Uptake-by-Farmers-in-India-and-Bangladesh

9 Conclusion and Recommendations

9.1 Conclusions

Based upon the findings from this project, some key conclusions are offered for the two countries:

Key Conclusions from Research in India Study Region

- Even as water scarcity in farming pushes households to seek alternative livelihood avenues, it also makes it harder for them to take up enterprises. This is confirmed through the finding that those who face significant water scarcity in the kharif season are less likely to start an enterprise. High water scarcity can adversely affect the capability of farmers to accumulate significant capital needed for starting enterprises.
- Migration contributes far more towards augmenting household incomes as compared to business enterprises. For those who cannot migrate, the alternative is to take to rural labour supply. However, rural labour supplying households have much lower incomes.
- Half the sample in our study area is engaged in rural supply, which indicates high level of stress currently faced by low and small land holding farming households.

Key Conclusions from Research in Bangladesh Study Region

- Saline water fisheries is a lucrative business, however, marginal and landless farmers are left out due to lack of resources.
- A higher level of salinity increases the chances for vulnerable households to take to labour supply. This form of livelihood tends to draw mostly from the illiterate group of households.
- Those taking to enterprises have their incomes higher by 100 percent compared to those who are not into enterprises. Similarly, labour supply and fishery based enterprises are also lucrative, though their contribution to household incomes is lower at 85 and 60 percent respectively (as compared to those who do not take to these professions).

9.2 Recommendations

Policy Recommendations for India Study Region

Our study hardly found any evidence of farmers exiting farming despite facing significant water stress and declining productivity in farming. Instead, they took to multiple livelihood activities to supplement their incomes. The most common livelihood profiles observed in our study areas were rural labour supply, urban migration, and entrepreneurial activities including farm and non-farm enterprises. Despite covering three districts in the two Sates of Bihar and West Bengal and gathering a reasonably sized sample of 2000 households, we did not find much evidence of government intervention programs (apart from NREGA) that were aimed at enhancing farm productivity or improving water supply and demand management. Therefore, our **first policy recommendation is to invest more towards creation of water supply augmentation infrastructures such as check dams and watershed areas**. This would enhance crop productivity and would reduce distress related migration.

A majority of those who took to migration reported that migration was stressful and risky. Some felt that migration would harm their children's futures. One of the key insights from

the study is that farmers would prefer to stay into farming and supplement their incomes rather than exit farming. They strive to attain this objective through taking up other livelihood activities. Policy interventions that improve crop incomes would reduce the stress and hardship that follows with taking up forced livelihood alternatives such as migration and labour supply. Therefore, our **second policy recommendation is to provide support through local NGOs and government banks towards setting up of value-added farm enterprises by farmers.**

The main focus of this study was on evaluating the role of farm and non-farm enterprises in improving farmers' livelihoods. In this regard, our key finding suggests that farmers' uptake of such enterprises is primarily stress driven as crop productivity is not enough to sustain rural livelihoods in water stressed areas. We find that entrepreneurial ventures undertaken by farmers provide them with very little incomes and had they been not doing such businesses (and taken to other occupations), their household income could in in fact have been higher. Based upon this finding our **third policy recommendation calls for external intervention to create infrastructure that aid in profitable entrepreneurial ventures using non-traditional and technology driven enterprises.** This recommendation is further bolstered by a supplementary finding using township enterprises data (of 320 firms) which revealed that businesses using internet were making significantly higher incomes compared to those who weren't. In contrast, rural enterprises were largely concentrated into traditional sectors such as grocery stores and shops that offered little scope for future growth. There is tremendous scope to get local NGOs involved in providing entrepreneurial skills and government banks in providing the finances to help toward this goal. We found at least two cases of local NGO based interventions that were yielding tangible outcomes for the rural participants. Such interventions are further encouraged.

We also found that farmers who were taking to migration were able to enhance their household incomes significantly compared to those who weren't, whereas those farmers who were participating in rural labour supply had much lower incomes compared to those who weren't going for wage based labour. Our finding suggests that this group of farmers, which makes up almost half of our sample is significant in size in the two states. This is a sign that significant livelihood stress is faced by small and marginal farmers who comprise a majority of the rural population and are taking to wage based labour to supplement their incomes. Therefore, **our forth recommendation is to shift policy intervention to this category of farmers (those who are participating in rural labour supply) and create alternate livelihood opportunities for them.** While NREGA based interventions are largely catering to the same category of farmers, it is obvious from our findings that better long term livelihood opportunities need to be created for them.

It was also amply clear from our analysis that very few households were relying on just one form of livelihood for their sustenance. Only 3.5 percent of households relied upon just one form of livelihood, 68 percent had 2 or 3 forms of livelihood activities and 21 percent had 4 sources of livelihood earnings. On average, a household engaged in 3 forms of livelihood activities. Therefore, it provides support to the hypothesis that when faced with climatic stress, farmers are willing to diversify into alternative means of livelihoods if opportunities exist. **Our fifth recommendation is that government agencies should take up skill enhancement programs actively and support setting up livelihood diversification projects in such areas.**

Policy Recommendations for Bangladesh Study Region

The south-western parts of Bangladesh are significantly affected by salinity caused due to sea water intrusion. The fact that this problem is only projected to get exacerbated in the future, due to climate change related sea level rise and increased frequency of cyclones, should be alarming for policy makers concerned about the livelihoods of the populations

living in these areas. While salinity has significantly reduced crop productivity and driven farmers out of agriculture, it has also created opportunities for larger farmers who own land in saline areas to take up profitable fishery based enterprises. Given that such opportunities are not available to smaller farmers, a majority of whom are forced to take up wage based labour supply, our **first policy recommendation is to invest in infrastructure that creates better supply chain opportunities for shrimp and crab farming and which can get the landless and marginal farmers involved in the marketing and production phases.** This could be accomplished through creation of better roads and shipping lanes as well as cold storage facilities that could help with keeping the produce fresh for longer as well as ensure quicker transportation. This type of infrastructure is essential for catering to the international market. One of the side effects of high salinity is that it also destroys the roads and makes transportation costlier. Despite this, we also found that fishery based households in remote areas were actually earning higher incomes compared to their counterparts closer to district centres. Therefore, there is potential to create and support local markets that could absorb a significant proportion of migrating and labour supplying workers.

While fishery based enterprises benefitted from such ventures, we also found that their incomes went down with an increase in salinity. That is, while salinity is good for fish farming, too much of it is harmful. Given, that salinity also adversely affects crop productivity, **our second recommendation is to create robust infrastructure at the inlets that prevents and controls intrusion of seawater in inland areas.** The better the control the government exercises on saline intrusion, the more prepared it can be to future risks of sea level rises. This would also allow more time for affected households to adapt to the impact of higher salinity on their livelihoods.

In terms of entrepreneurial opportunities, we find that educated households taking to enterprise earn significantly more than illiterate households in the same profession. Also, among all livelihood opportunities, entrepreneurs earned the most. Yet, more landed farmers are less likely to take to enterprises. Enterprise uptake is also positively correlated with availability of credit facilities. Therefore, **our third recommendation is to invest in policy measures that promote higher rate of enterprise uptake.** This will prevent quick saturation of the shrimp and fishing sectors as well as reduce vulnerability through higher livelihood diversification, as shrimp fishing industry could suffer losses from future climatic events (or due to export demand related shocks). However, it needs to be pointed out that stress driven enterprise uptake may not be sustainable in the long run. Therefore, it would be desirable for government, the NGOs and the development organizations to collaborate in order to offer large scale entrepreneurial skills based training.

Many farmers in the salinity areas suffered negative net returns from cropping due to high salinity. Further research is needed for developing new saline-tolerant varieties. Very few farmers in the study areas were found to be adopting modern varieties, despite the proven performances of the same under controlled environments. Lack of their adoption could be due to lack of information at the farm gate. High risk-aversion could also explain lack of adoption of modern varieties, which keeps farmers stuck in a low cost and low return trap. Given this situation, farmers may find casual labour and enterprises as more lucrative livelihood options.

As there remains very low potential for growing winter paddy in the regions, the government should explore potential for the *aus paddy* (sown during summer) in the region. The *aus paddy*, which is basically a traditional strain and not high-yielding, is sown in March or April and harvested during summer, utilizing the April and May rains. Traditionally, *aus paddy* used to be grown in Bangladesh before the green revolution took place, to make up for production shortfall in the monsoon season. It seems to be back in the government's priority list. However, production of *aus paddy* is constrained by irregular rainfalls, particularly less rainfall during the seedling preparation stage and from excess rainfall during harvesting stage. In addition, in coastal areas, there are challenges associated with salinity. Therefore, there is a need to focus on developing better drought and saline tolerant varieties. Making

such seedlings available to the farmers during periods of insufficient rainfalls can help towards mitigating some of the adverse effects from future climatic stresses. **Therefore, our fourth recommendation is to strengthen research-extension linkages and to invent and help adoption of high yielding, stress tolerant varieties, particularly for that variety sown during spring and harvested after summer rain (*aus*). Government procurement programs that purchase directly from all categories of farmers could also be very crucial towards alleviating farmers' risk aversion related to the demand side of production, and would go a long way in alleviating poverty.**

About 30% of the sampled households were found to be receiving support from different social safety net programmes. Educational subsidy was the most common form of support received. Other programs offered relief and financial/food assistance in exchange for work. In monetary terms, this support may not be much, but is still meaningful for distressed households in times of need. **Our fifth recommendation is for provision of more intensive support services in seasons when much work is not available in the locality.** As winter is the lean season for farming, government interventions are needed more in this season. Another season requiring intervention is monsoon, where due to heavy rains, people's movement and scope of work gets constrained.

10 References

10.1 References cited in report

References are embedded within the footnotes.

10.2 List of publications produced by project

Ranjan, R**. (2015): How Prolonged Droughts and Farm Subsidies Influence Entrepreneurial Ventures by Farmers, *Journal of Developmental Entrepreneurship*.**

11 Appendixes

11.1 Appendix 1: Description of Study Areas in India and Bangladesh

Brief Description of Study Regions in India

Two states within India, Bihar and West Bengal, were selected for our study. Three districts were selected from within these two states. Birbhum and Purulia districts from West Bengal and Nalanda district in Bihar are crucial districts facing varying levels of water scarcity. Nalanda has a population of roughly 2.8 million and an area of about 2400 square kms. It has a forest area of 47 sq. km., a cultivable area of 2000 sq. km. and a net sown area of 1600 sq. km. Major soil types are clay loam, fine loam, coarse loam and loam[31]. There are 114,000 tube wells, 4,000 tanks and 16,000 canals in the district. Groundwater is the main source of irrigation, however, average groundwater utilization is only 65% indicating much scope for further exploitation.[32] The average rainfall is about 1000 mm. Main crops grown in Nalanda are paddy, potatoes and onions. The region has seen farm productivity improvement in the recent past owing to adoption of better technology and practices. Some crops such as bitter gourd and onions are being exported to Bangladesh and Nepal[33].

Birbhum district in West Bengal has a total area of 4500 sq. km. and a population of roughly 3.5 million. It has a forest area of 160 sq. km. and about 75 percent of population is farming dependent. It has a number of cottage industries including textile. Average annual rainfall is roughly 1400mm. Paddy, oilseeds, wheat and pulses are major crops grown in the district. Nearly 75 percent of the land is owned by small and marginal farmers, with average landholding being 1 ha.[34] In contrast to Nalanda, groundwater is over-exploited and groundwater levels are declining rapidly.

Purulia district in West Bengal has a total area of about 6500 sq. km. with a population of about 3 million. It is the most drought prone and driest of the three districts chosen for our study. Average rainfall received is 1300mm. Paddy is the main crop grown in the district. It has an undulating topography which is not conducive for groundwater recharge.

Bangladesh Study Area Description

The Bangladesh study area selection is based on climate change induced salinity problem in agriculture. Table 11.1 presents salinity status and changes in salinity levels in the 18 salinity affected coastal districts of Bangladesh. In a span of past four decades the area affected by salinity has increased from 833.45 thousand ha to 1,056.26 thousand ha. Except for three districts, salinity levels have increased in the remaining fifteen districts. Increase in salinity is more severe in the western part as compared to the eastern part.

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[31] *http://www.cgwb.gov.in/District_Profile/Bihar/Nalanda.pdf*

[32] *http://www.cgwb.gov.in/District_Profile/Bihar/Nalanda.pdf*

[33] *http://timesofindia.indiatimes.com/city/patna/Nalanda-emerges-as-export-hub-of-agriculture-products/articleshow/13281568.cms*

[34] *http://www.birbhum.gov.in/DDAgri/PAO.htm*

Table 11.1. Changes in salinity status in different districts of Bangladesh in terms of hectares affected

District	Salinity affected areas (000 ha)			Salinity change between 1973-2009 (000 ha)
	1973	2000	2009	
South-Western Districts				
Khulna	120.04	145.25	147.96	27.92
Bagerhat	107.98	125.13	131.12	23.14
Satkhira	146.35	147.08	153.11	6.76
Jessore	0	10.86	14.99	14.99
Narail	0	16.05	18.71	18.71
Pirojpur	21.30	28.64	35.83	14.53
Jhalakathi	0	3.52	4.69	4.69
Barishal	0	10.82	13.96	13.96
Bhola	40.33	93.64	94.57	54.24
Patuakhali	115.40	139.35	155.18	39.78
Borguna	103.55	104.22	95.62	-7.93
Gopalganj	0	10.20	6.27	6.27
Madaripur	0	1.19	0.72	0.72
South-Eastern Districts				
Laxmipur	19.30	17.50	18.43	-0.87
Feni	9.50	7.30	5.75	-3.75
Noakhali	49.60	53.54	52.52	2.92
Chittagong	45.70	46.50	51.48	5.78
Cox's Bazar	54.40	59.96	55.35	0.95
Grand Total	833.45	1020.75	1056.26	222.81

Source: SRDI 2010

Most of the coastal parts in Bangladesh are affected by salinity. Compared to the south-western coastal region, salinity is less severe in the south-eastern coastal region. Most of south-western coastal districts are low-lying and surrounded by hundreds of rivers and canals carrying salty water to the land from the adjacent sea. Salinity in the area is closely related with season and polder (dike) management. Saline water intrusion gets exacerbated during the dry season (winter season) when water flow is low from the upstream. The low flows allow saline water to travel up the distributaries of the western part of the delta in southwest Bangladesh and ultimately thousands of hectares of lands are rendered unproductive during the season.

These coastal polders, with sluice gates for controlling river flows and to protect low-lying agricultural lands from tidal inundation and saline water intrusion, were built during the 1960s. The gates are supposed to be closed during mid-November and again opened in

May when the monsoon begins. In the monsoon, accelerated water flow in upstream rivers and heavy rainfall makes water in surrounding canals fresh; whereas in winter, as rainfall and upstream water flow reduces, sea water enters the locality.

Salinity in groundwater is a major problem in the coastal region, particularly in the dry season. Inability to cultivate paddy in the winter season, forces farmers to look for alternative crops, particularly crops with lower water requirements. Farmers cultivate different types of pulses and nuts. Of these, some common ones are mung, sesame, groundnut, cowpea, sunflower, etc. Mainly, the traditional varieties are cultivated. They do practice modern varieties, but only when input packages (or subsidies) are provided by the agricultural department or NGOs. They are not very much familiar with the modern varieties, neither are these varieties widely available in the local markets. Even those farmers who have knowledge of modern varieties, do not prefer them over the traditional varieties, as the latter require less capital and labour. For some crops, the traditional ones have a higher market price, though they provide a lower yield. But in areas where shrimp and other saline water fisheries are possible, farmers are unwilling to go for crop farming.

Basically, farmers do farming in those areas where shrimp farming is not possible. In Bangladesh, vegetables are mostly grown during the winter season. Most of the vegetables are saline intolerant and hence cannot be grown in saline areas during the winter season. In summer and in monsoon, options are relatively fewer and limited to local varieties. Moreover, as paddy is grown only once in a year in the saline areas, farmers prioritize paddy over vegetables. Homestead gardening is practiced in the high lands, though to a very limited extent. In the low lying areas, due to water logging, homestead gardening in monsoon is not possible. Homestead gardening is gaining popularity in these areas following interventions from NGOs and the extension department. Sack gardening could be another appropriate technology in the water logged areas, however, it is yet to be widely tested.

11.2 Appendix 2: Some Key Descriptive Statistics for the Sampled Households in India and Bangladesh

Some Key Descriptive Statistics of the Sampled Households in India

In all, 1604 households were surveyed across the three districts in India for the present study. Out of these, 47 samples were omitted owing to inconsistency in the data. The remaining 1,557 households were used for the analysis. Table 11.2.1 provides the characteristics of the overall sample surveyed in our study.

Table 11.2.1. Characteristics of the Sampled Households

Religion	
Hindu	87.6%
Muslim	12.3%
Christian	0.1%
Caste	
SC	24.2%
ST	6.4%
OBC	34.7%
Forward	34.6%

Household Size (number of members)	5.9
Dependency Ratio (age)—defined according to working age	0.27
Dependency Ratio (work)—defined on whether working	0.54
Age of the Household Head	50.6
Gender of the Household Head	
Male	95.2%
Female	4.8%
Education of the Household Head	
Illiterate	15.1%
Informally Literate	3.7%
Primary	20.6%
Secondary	44.3%
Higher Secondary	9.6%
Graduate	6.8%
N (number of observations)	1557

In the sample, around 88% households were Hindus and 12% were Muslims. In terms of caste wise distribution, around 25% of the households belonged to Scheduled Castes (SCs), 6% belonged to scheduled tribes (STs), and around 35% belonged to Other Backward Castes (OBCs) and 35% belonged to forward castes.

The average household size in the sample was 5.9. The average dependency ratio, defined as ratio of number of working age (15-59 years) members in the household to the total number of members in the households, was 0.27. So, roughly one in four members of a household was dependent on the other three working age members of the households. We also calculated an alternative dependency ratio, defined as the ratio of number of members who were not working to the total number of members in the households. The average of this ratio was double that of dependency ratio based on working age (0.54). We find that slightly more than one in two persons in the household are dependent on working members of the household.

The average age of the household head was 50 years. More than 95% of the households had a male household head. Around two-thirds of the household heads were educated at primary and secondary levels. 15% of the household heads were illiterate. Around 16% of the household heads were educated at the level of higher secondary and above.

Table 11.2.2 presents how different Quintiles derive their incomes relying upon various livelihood sources

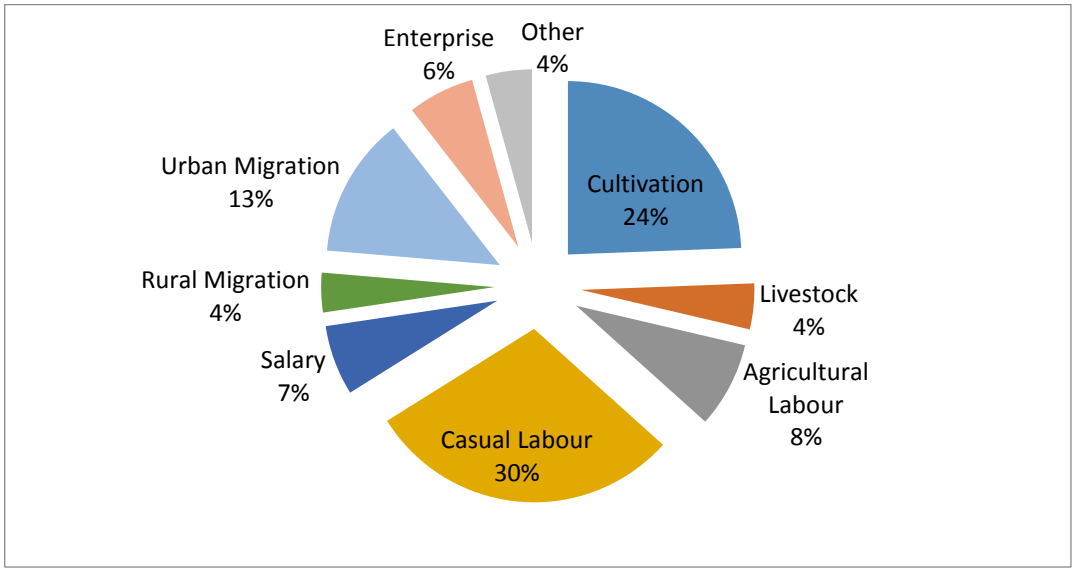
Table 11.2.2. Annual Income Distribution across Quintiles

Quintiles	Cultivation Income	Livestock Income	Agricultural Labour Income	Casual Labour Income	Salaried Income	Rural Migration Income	Urban Migration Income	Enterprise Income	Other Income	Total Income
Q1	1893	836	4130	19070	583	2064	1577	2298	763	33213
Q2	7290	1695	6066	25085	897	2779	5129	3971	1621	54534
Q3	12989	4552	5882	24404	2801	3803	10977	6888	1285	73581
Q4	23233	5964	5988	27061	7148	2844	19648	7952	5016	104855
Q5	50802	8648	5094	28016	77262	3806	49191	10952	21817	255588

Q5/Q1	26.8	10.4	1.2	1.5	132.4	1.8	31.2	4.8	28.6	7.7

From table 11.2.2, we can observe that the income of the households belonging to fifth quintile is around 8 times the income of the households in the first quintile. Among different sources of income, the difference is most stark in salaried income category where the households in fifth quintile earn 132 times that of the incomes in the first quintile. Income from urban migration for the fifth quintile was 31 times the same for the first quintile, and cultivation income of the fifth quintile was 27 times that of first quintile. The inter-quintile ratios for livestock income, enterprise income, rural migration, casual labour and agricultural labour income were 10.4, 4.8, 1.8, 1.5 and 1.2 respectively.

Figure 11.2.1. Income Diversification Pattern of Households



From figure 11.2.1, we observe that the most important source of income for the sampled households is casual labour, which, on average, contributes 30% of the household income. Crop cultivation contributes 24% of the household income. Urban migration contributes 13% towards household income. Agricultural labour, salary and enterprise contribute 8%, 7% and 6% to household income respectively. Rural migration, livestock incomes and other income, on average, each contribute 4% towards household income.

Some Key Descriptive Statistics of the Sampled Households in Bangladesh

Table 11.2.3 presents socio-economic and demographic characteristics of the households. On an average, a household has 4.47 members. Among the household members, 51% are male. Average family size and gender composition of the family members is almost identical across districts.

The average age of the household members is 30.5 years. Patuakhali has relatively the lowest average age (27.7 years) and Khulna has the highest average age (33.8 years) among the three districts. Dependency ratios have been estimated based on household members' age and occupation. The estimated dependency ratio using age implies that 30% of the total household members belong to the dependent age group (age group of below 15 years and above 65 years). The other estimated dependency ratio (using work) means that 68.2% of the members are not involved in any income generating activities, i.e., they are mostly students, or retired professionals, or unemployed and involved in household activities which do not yield any cash returns.

Almost all the households have male heads (97.3%).The head's average age is around 45 years. Compared to the national level statistics, the heads have better literacy rate. In

Bangladesh, 57.91% of the population at 7 years and above have literacy (HIES, 2010)[35], whereas among the heads, 74.7% are literate. On an average, a household head has studied up to the primary level. Around 36% of the educated household heads studied up to the primary level, whereas another 32.4% have formal education up to the secondary level. Hardly any of the heads have studied beyond the secondary level. Among the three districts, heads in Khulna have better educational status. In Khulna, relatively lower proportion of the heads are illiterate and higher proportion of the heads have studied above the primary level. The average schooling for the heads is primary level.

Casual labour supply in agriculture and/or outside agriculture is the main occupation for almost half (47.8%) of the household heads. Compared to the other two districts, in Khulna relatively lower proportion of the heads (39.7%) indicated casual labour supply as their main occupation. In other two districts, at least half of the heads indicated casual labour participation. Involvement in business or entrepreneurial activities as main income source is mentioned by 14% households. Satkhira has relatively higher proportion of heads (17.19%) into business, whereas in other two districts the proportions are almost similar. Almost one out of every four heads (24.3%) reported agriculture as the main income source. Crop farming is the main occupation for 12.8% of the heads, whereas another 11.5% reported non-crop farming.

Table 11.2.3. Socio-economic and Demographic Profile of the Surveyed Households

	Khulna	Patuakhali	Satkhira	All
Household Characteristics				
Gender Composition of the household Members (%)				
Male	0.52	0.50	0.52	0.51
Female	0.48	0.50	0.48	0.49
Average Household Size (no.)	4.18	4.65	4.58	4.47
Average Age of the Household Members	33.8	27.7	29.9	30.5
Dependency Ratio (age)	25.4%	34.8%	29.9%	30.0%
Dependency Ratio (work)	66.2%	67.5%	70.8%	68.2%
Head's Characteristics				
Age of the Household Head	46.2	42.4	45.7	44.8
Gender of the Household Head				
Male	96.6%	96.6%	98.8%	97.3%
Female	3.4%	3.4%	1.3%	2.7%
Education of the Household Head				
Illiterate	19.1%	27.5%	29.4%	25.3%
Primary	30.3%	46.6%	30.9%	35.9%
Secondary	40.0%	24.7%	32.5%	32.4%
Higher Secondary & above	10.6%	1.3%	7.2%	6.4%
Average Year of Schooling	5.62	3.92	4.58	4.70

[35] *HIES (2010). Household Income and Expenditure Survey 2010. Bangladesh Bureau of Statistics. Dhaka.*

Main Occupation of the Head				
Crop Farming	15.3%	20.3%	2.81%	12.8%
Non-crop Farming (Livestock, Poultry & Fisheries)	18.4%	2.8%	13.13%	11.5%
Business	12.2%	12.5%	17.19%	14.0%
Service	5.3%	5.0%	5.31%	5.2%
Day Labour	39.7%	50.0%	53.75%	47.8%
Others	9.1%	9.4%	7.81%	8.8%

Table 11.2.4 presents landholdings across farming populations. Among the sampled farmers, nearly half (48.68%) were landless. In less saline areas, 53.98% of the farmers were landless, whereas the proportion was 38.20% in high saline areas. Among the three districts, Satkhira had the highest proportion (70.59%) of landless farmers. In Khulna and Patuakhali, proportions of farmers are almost identically distributed across different categories. This is a well acknowledged fact, as these two districts are geographically adjacent. Surprisingly, in Satkhira, only around 2% (of the sample) were small farmers whereas around 10% were medium & large farmers. In less saline areas, comparatively higher proportion of farmers fall in the landless and marginal farmers groups, whereas in high saline areas, proportions of small and medium & large farmers were around thrice and twice the same in less saline areas.

Table 11.2.4. Proportion of Farmers Belonging to Different Categories across Regions

Farmers' Category	Districts			Salinity Level		All
	Khulna	Patuakhali	Satkhira	Less	High	
Landless	40.45%	45.60%	70.59%	53.98%	38.20%	48.68%
Marginal	37.08%	35.20%	17.65%	34.09%	29.21%	32.45%
Small	13.48%	13.60%	1.96%	6.82%	20.22%	11.32%
Medium & Large	8.99%	5.60%	9.80%	5.11%	12.36%	7.55%

Table 11.2.5 shows proportion of households involved in different types of income generating activities. Casual labour supply (67.1%) followed by poultry farming (50.2%) were the two most common income sources for the households. In high saline areas, relatively higher proportion of the households (70.6%) were involved in casual labour supply as compared to the less saline areas (63.5%), particularly in Khulna and Patuakhali districts. In Patuakhali district, as opposed to 59.4% in less saline areas, 80.6% households in high saline areas were supplying casual labour. Except Satkhira, in the other two districts, relatively higher proportion of the households had earnings from poultry farming. Another 15.9% of the households made some earnings from livestock through milk selling and beef fattening, with relatively more proportion of households involved in such activities in the less saline areas.

Around 28% of the households were involved in crop farming. Similar proportion was involved in fisheries. According to national statistics, 54.5% of the rural population are

involved in agriculture, forestry and fisheries (BBS, 2011)[36]. Quite noticeably, compared to high saline areas, almost twice the proportion of households in less saline areas were involved in crop farming. The difference is most notable in Satkhira where around 3% and 29% in high and less saline areas were into farming.

Among the three districts, Khulna had the highest proportion of households (estimated at 45.6%) involved in fisheries against the sample average of 27.8%. The households in Khulna and Satkhira appear to have taken advantage of the highly saline water and taken to cultivating shrimp and other saline water fishes. But, as the practice of turning crop fields into fish ponds is not excessively prominent in Patuakhali, very low proportion of households (6.3%) in high saline areas were found to be doing fisheries. In less saline areas of Patuakhali, 23.8% of the households, which is comparable to the proportion in Satkhira, were involved in fisheries. Fish collected from open water bodies contributed to 16.6% of the household's earnings.

For the entire sample, 15.3% households were involved with businesses or enterprises. In Khulna and Satkhira districts, almost similar proportions of households had some kind of enterprises, whereas in Patuakhali the proportion was relatively lower. Involvement with enterprises did not vary with salinity levels.

31% of the sampled households got some financial assistance from different social safety net programmes, mostly in the form of educational stipends and relief. Around 10% of households had members into salaried jobs. At least one out of every ten households had income from other sources that included remittances, forestry, rents, gardening, tree selling, pension, asset selling, etc. Here it is noteworthy mentioning that compared to households in less saline areas, very few households in high saline areas were involved with activities such as gardening and tree selling. Alternatively, collection of wood, honey, leaf from forest as income sources was popular only with high saline area residents of Satkhira, who live near the Sundarbans forests.

Table 11.2.5. Proportion of Households Involved in Different Income Generating Activities

Income Generating Activities	Khulna			Patuakhali			Satkhira			All		
	Low	High	All	Low	High	All	Low	High	All	Low	High	All
Crop Farming	32.5 %	23.1 %	27.8 %	48.8 %	29.4 %	39.1 %	28.8 %	3.1 %	15.9 %	36.7 %	18.5 %	27.6 %
Poultry	50.6 %	41.3 %	45.9 %	52.5 %	46.3 %	49.4 %	55.6 %	55.0 %	55.3 %	52.9 %	47.5 %	50.2 %
Livestock Rearing	20.6 %	12.5 %	16.6 %	17.5 %	20.0 %	18.8 %	21.3 %	3.8 %	12.5 %	19.8 %	12.1 %	15.9 %
Fisheries	48.1 %	43.1 %	45.6 %	23.8 %	6.3 %	15.0 %	18.1 %	27.5 %	22.8 %	30.0 %	25.6 %	27.8 %
Fish Collection	25.0 %	10.0 %	17.5 %	15.6 %	16.3 %	15.9 %	8.8 %	23.8 %	16.3 %	16.5 %	16.7 %	16.6 %
Enterprise	16.9 %	14.4 %	15.6 %	9.4 %	15.6 %	12.5 %	18.8 %	16.9 %	17.8 %	15.0 %	15.6 %	15.3 %
Salaried Job	10.6 %	10.6 %	10.6 %	13.8 %	8.8 %	11.3 %	10.0 %	7.5 %	8.8 %	11.5 %	9.0 %	10.2 %
Casual Labour	58.8 %	63.8 %	61.3 %	59.4 %	80.6 %	70.0 %	72.5 %	67.5 %	70.0 %	63.5 %	70.6 %	67.1 %

[36] *BBS (2011). Report on Labour Force Survey 2010. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.*

Migration	12.5 %	19.4 %	15.9 %	5.6 %	5.6 %	5.6 %	18.8 %	13.8 %	16.3 %	12.3 %	12.9 %	12.6 %
SSNP	14.4 %	15.6 %	15.0 %	42.5 %	30.6 %	36.6 %	37.5 %	45.6 %	41.6 %	31.5 %	30.6 %	31.0 %
Other	24.4 %	1.9 %	13.1 %	9.4 %	0.6 %	5.0 %	17.5 %	15.6 %	16.6 %	17.1 %	6.0 %	11.6 %

Table 11.2.6 presents annual income distribution of the households across the five quintiles. The highest income quintile earned around 11 times higher than the lowest income quintile. The income for the top and bottom income quintiles are 208,080 tk and 20,074 tk respectively. Compared to the fourth income quintile, the top income quintile earned more than double. Entrepreneurship activities made the difference between top and other quintiles. From enterprises, the households in the top quintile earned 41,595 tk, which is around 3.6 times and 22.5 times higher than the income of the fourth and first quintile from the same livelihood category. From fisheries, fish collection and other sources, the households in top quintile earned around 3.5 times higher than their preceding quintile. From casual labour supply and social safety net programs, the households in Q5 earned less than the Q4 quintile.

Table 11.2.6. Annual Income Distribution across Income Quintiles

Income Sources	Income Quintiles				
	Q1	Q2	Q3	Q4	Q5
Crop Farming	-2664	522	-36	1029	2735
Livestock & Poultry	2949	2023	3932	4401	6955
Fish Farming	-611	5539	5602	14274	49396
Fish Collection	275	740	2347	3673	12797
Salary & Pension	1563	1024	5427	11063	31717
Casual Labour	14474	41192	48795	52601	50413
Enterprise	1848	2328	7288	11484	41595
SSNP	620	709	565	864	591
Other	1621	1618	1911	3367	11881
Total Income	20074	55696	75832	102755	208080