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Increasing Biodiversity in the Coastal Belt of Bangladesh during Climate Change to Enhance Environmental Sustainability

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Authors' contributions

This work was carried out in collaboration between all authors. Author AR was the second Dhaka based project coordinator of the project and the manuscript is written by her. Author MSR was the field based project coordinator of the project and provided information for the manuscript. Author LR provided intellectual guidance and overall supervision of the project. All authors read and approved the final manuscript.

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ABSTRACT

The impacts of climate change in Bangladesh's coastal belt are on increase in temperature, changes in cropping, irregular rainfall and increased salinity. The coastal belt farmers are usually following single cropping with rice in rainy season. This has lead to decrease in biodiversity, loss of soil fertility and increased use of crop care products. This action Research was conceptualized as a Lab to Land activities with 3200 farm families over a period of two years in 8 locations of Patuakhali, Barisal and Borguna. The aim behind the research was to bring changes in the cropping practices, which would tackle climate change enhance their livelihood. Each family comprised of a male and a female farmer. It aimed at increasing biodiversity through cultivation of cereals, vegetables, pulses and oilseeds apart from rice. The women members were trained for cultivation of vegetables through year round homestead gardening. This increase in biodiversity through rotation of crops adaptive to climate changes will lead to better use of the soil, retain fertility and the water table. Biodiversity has already started increasing, since the participatory farmers

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have begun to realize the importance of crop rotation and a healthy cropping pattern. For example, crops which are less water consuming than Boro rice are being cultivated. Mung bean cultivation has increased along with total available nitrogen. In conclusion a diverse climate smart cropping pattern will emerge and may lead to environmental sustainability.

Keywords: Cropping pattern; nutrition; homestead gardening.

1. INTRODUCTION

Bangladesh is one of the largest deltas in the world which is highly vulnerable to Natural Disasters because of its Geographical location, flat and low-lying landscape, population density, poverty, illiteracy, lack of Institutional setup etc [1]. The country experiences different types of Natural Disasters almost every year because of Climate Change impacts such as floods, flash floods, cyclones, storm surges, salinity intrusion, extreme temperature and drought [2]. For a country, where two thirds of the population is engaged directly or indirectly on agriculture, change in climate has a wide spread effect on their livelihoods and the country's economy [3].

The most devastating impacts can be seen in the areas surrounding the coastal belt leading to decline in crop yields. Season shifts have taken place in the coastal belt compared to the rest of the country [4]. Due to this reason irregular rainfall and mono cropping have lead to decrease soil fertility and increase in salinity intrusion. Thus farmers have started to leave land fallow and only cultivate rice during the *Transplant Aman (T. Aman)* season when water is available [5]. Mono cropping or continuous rice cultivation will have a negative impact on the water table and eventually the soil [6]. This loss of arable land will lead to a further loss in biodiversity.

At the moment efforts are being made by various projects of the government, donor agencies and private organizations through Public Private Partnership to increase the biodiversity of the Coastal Areas of Bangladesh which will lead to Environmental Sustainability. The aim of this project was to bring about changes in the cropping practices of the coastal belt population to tackle climate change and enhance their livelihood. The information generated through use of the model followed by the Advanced Seed Research and Biotech Centre in collaboration with the Innovation Against Poverty, Swedish International Development Corporation for a jointly funded project with ACI Limited is explained in details in this paper.

2. HYPOTHESIS

Appropriate implementation of the project would meet the food demands at nutritional level of the beneficiaries who will be participating in the project. This is in addition to the over brim effect of the activities and the motivations in the area will satisfy the change in crop diversity, cropping pattern with new crop varieties having nutrient rich crops/varieties. The action research project would improve the income of the Participating Farm Families (PFF) and ensure maintenance of biodiversity in the area.

3. METHODOLOGY

3.1 Selection of Location

The first step towards project initiation was to select the Barisal, Barguna and Patuakhali as the districts for project implementation. Out of these 3 districts, 8 locations including Bauphal, Bakerganj, Patuakhali Sadar, Golachipa, Amtoli, Dumki, Kalapara and Babuganj were chosen for farmer selection based on the size of the Upazilla and accessibility and the need for intervention.

3.2 Selection of Participatory Farm Families

The project was carried out for two years and each year 1600 Participatory Farm Families (PFFs) were chosen based on their capacity to grow field crops as well as homestead gardens. In each family two members were chosen- one male and one female. The male member carried out the field crop cultivation, while the female carried out homestead gardening of vegetables. The 3200 PFFs were divided into groups of 40. Each group had a Lead Farmer (LF) who was selected based on influence over the rest of the members and his/her acceptability as leader in respect of knowledge and collaboration attitude. The groups were supervised by 8 Field Officers, who in turn was managed by a Project Coordinator.

3.3 Surveys Conducted Throughout the Project

Two benchmark surveys were conducted during year 1 and year 2, each addressing the new PFFs. The surveys were done to have a clear understanding of the socio-economic conditions of the PFFs along with their knowledge as well as skills in agricultural practices. The surveys also provided insight in the seasons in the locations along with the highest cultivated crops and the stresses which need to be addressed. Data such as family size along with age distribution, education, earning status, land ownership, monthly expenditure pattern, investment in farming, farm land utilization, access to nursery and access to agri info. The survey was carried out by an outsourced third party, who then analyzed the data and presented as a final report. Data for this paper has been taken from the report submitted to the project.

A market survey was done to understand the commercial aspect of the crops being proposed for production in the project. This was done from the farmer's point of view. Data was collected on accessibility to market along with medium of transport, yield of the most common crops grown in the past year, channels for marketing surplus, market prices after harvest for the past year and problems with the marketing. This survey was done by a contracted consultant. Raw data collected was analyzed and the analysis was incorporated in the report. Information from the submitted report has been used in this paper.

A midterm impact survey was done by the project team to understand if the interventions are beginning to cause positive effects, after the end of year 1. This was based on the PFFs adopting the new practices taught to them after they were withdrawn from the project.

3.4 Field Crop and New Cropping Pattern Intervention

As mentioned before, the common cropping pattern in the coastal belt is that of monocrop-*T. Aman* rice (66%). The remaining time land is left fallow. A more environment friendly, commercially valuable cropping pattern was demonstrated and motivated for adoption among PFFs. Apart from *T. Aman* rice, the crops encouraged were sunflower, mung bean, relay khesari, potato, maize, brinjal, watermelon, bottle gourd, bitter gourd, sponge gourd, snake gourd, okra, chilli, mustard, groundnut, tomato, cauliflower, cabbage, knolkhol, papaya and *Transplant Aus (T. Aus)* rice. By growing these crops the PFFs would be able to crop for at least 2 seasons minimum if not 3.

3.5 Homestead Gardening as a Source of Nutrition

The PFFs of the project are 50% female and if they are not field farmers, were encouraged to carryout homestead gardening. Most of the female beneficiaries either did not carry out homestead gardening or did not know the proper agriculture management to reap benefits from the gardens. Each female were given mini sachets of 5 types of vegetable seeds; where applicable seedlings were distributed. Model gardeners were also given watering cans, since the common complaint in the coastal areas is insufficient access to water. They were taught and supervised to grow the vegetable crops in rows and also given money for crop care products. The intention was to provide nutritional diet for the families and the selling the surplus in the local market, thus adding to the household income.

3.6 Strengthening the Service of Local Nurseries

One nursery in each of the eight locations was chosen to support the PFFs of the area. This was necessary for both the field farmers as well as homestead gardeners. Growing seedlings for vegetables such as brinjal and tomato for example were difficult for the PFFs since care and time is required. It is easier to purchase the seedlings from the local nurseries and transplanting them. Nurseries were already present in the areas but through the project support they were strengthened and connected with the PFFs. It also helped nurseries to diversify by raising other seedling varieties and increasing income. Availability of water is also a common problem for the nurserymen during the hot summer months. Techniques were taught on how to grow seedlings during those times by the field officers.

3.7 Training Classes for the Field Officers and Participatory Farm Families

The recruited field officers for the project had to undergo training before they were sent to their field stations. They were trained on the concept

of the project and the eventual goal. Product managers of ACI Seed trained them on agronomic management of the crops which will be introduced in the project locations and their benefits. A refresher course was given before the second year of the project and also feedback on their experiences were noted for future modifications of the program.

Training classes for the PFFs were arranged at the local agricultural extension offices in groups of 40-60 persons. The trainers comprised of nearby university professors, government agricultural extension officers, ACI's marketing officers, special invited guests and the project coordinator. Multimedia presentations were given where possible and the medium of the classes were in Bangla. The training document was developed by an expert also included in the project. The knowledge disseminated was on the agronomic management of the new crops being introduced, their uses and their benefits.

3.8 Demonstrations of Introduced Crops

As mentioned previously multiple cropping patterns were introduced in the project locations. Demonstrations of the cropping patterns were showcased in land leased from 200 farmers and a 5 acre plot leased specifically for this purpose.

4. RESULTS

The findings and effects of each class of activities carried out through the program are given below.

4.1 Surveys Conducted

The surveys conducted gave clear information on the reality of the environmental and socio economic situation in the locations. Through the benchmark survey it was found that the average family size comprises of 5.2 members as opposed to the national average of 4.4 members. 50% of the family has one earning member. The cropping intensity of the area is 159, which is also much lower than the national average of 177-200 meaning the arable land is used only for 1.59 times in a year. On the other hand homestead gardening using private sector seeds more than for field cultivation, where the choice is more traditional. Fig. 1 illustrates that 89% of the land is used for *Transplant Aman* rice cultivation, while 66% cultivate other cereals only leaving the land fallow for the rest of the year. The survey also identified that only 2% of the land utilized for Mung Bean is covered by company seed, while that of oilseed is even lower even though farmers had shown interest. Maximum farmers in the sample size did carryout homestead gardening to a certain level but only 51% had access to nursery and that too for wood and fruit trees only. It was also revealed there is a shift in season in the coastal belt compared to the rest of the country due to heavy rainfall, tidal flood and water logging.

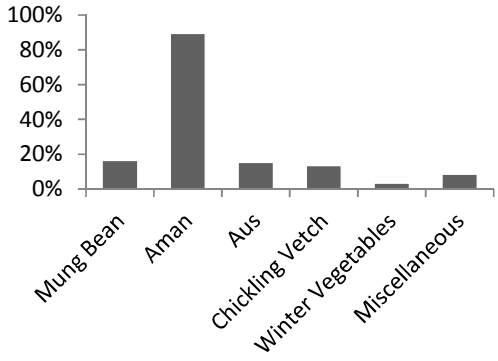

Fig. 1. 94% land utilization of major crops over three farming seasons is divided Aman rice, Mung Bean, Aus rice, Chickling Vetch, Winter Vegetables while smaller percentages include boro rice, green chilies, sweet potato, lentil, potato, watermelon, wheat, groundnut and hybrid maize

The market survey was done with a sample size of 160 farm families from all 8 locations of the project. 46.25% of the PFFs in the sample size were marginal farmers, while 39.37% were small farmers. The study was close to the end of the first year of project intervention; hence an increase in double cropped and triple cropped areas could be seen. It was also determined that the beneficiaries in most of the locations have convenient access to market through various channels the exceptions being Kalapara and Amtoli. Fig. 2 illustrates percentages of crops being sold in the market. The most common reasons behind marketing problems were determined as low price during harvest, credit sales to middlemen and transport in places like Kalapara and Amtoli.

The midterm impact survey done suggested that farmers have started adopting the new crops demonstrated to them throughout the project. This was determined by the increase in demand for the crop seeds. Demand for cereal seeds increased by more than 42%, vegetable seeds

by 26%, oilseeds by 50%, potato by 100%, pulse by 35% and fruit by 55%. Fig. 3 illustrates these findings and Table 1 shows the percentage increase of specific crop varieties mentioned in the latter groups.

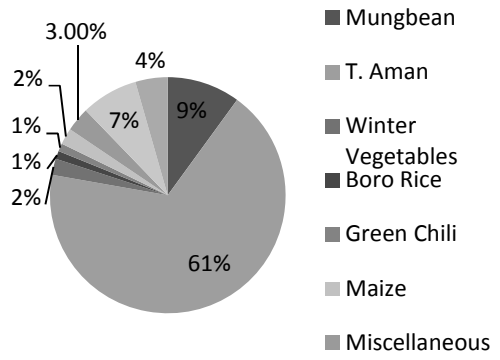

Fig. 2. About 89% of total earning from farming is from the 15 major crops. 71% come from cereals, 13.5% from pulses, both oilseed and winter vegetables have 2% share each, chilies and water melon have 1% and 0.5% share respectively

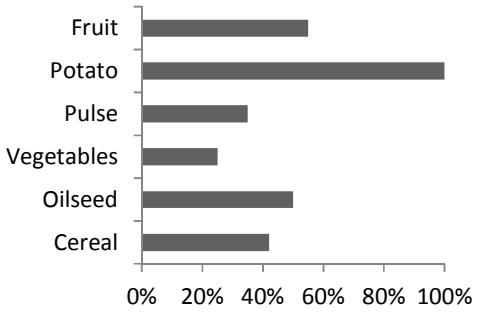

Fig. 3. Percentage of seed demand created after crop interventions through this project for fruit, potato, pulse, vegetables, oilseed, and cereals. The percentage increase for each category of crop is shown in the shown in the bar chart

4.2 Homestead Gardening

Women carried out homestead gardening using the crops- Carrots, Tomato, Papaya, Red Amaranth, Stem Amaranth, Kangkong, Indian Spinach, Yard Long Bean, Cucumber, Knolkhol, Cabbage, Caulifower, Raddish, Brinjal and Spinach all year round. By growing the crops in rows, providing proper irrigation and harvesting at the right time along with application of optimum level of crop care products; the beneficiaries achieved higher yields. This was found to be accurate even for beneficiaries who had previous experience in carrying out homestead gardening as well as new gardeners. Nurseries were linked with homestead gardening for easy access to raised seedlings which were transplanted to the gardens. 13.5% motivated indirect women beneficiaries have entered into this practice.

Table 1. List of cultivated crops and the percentage increase in seed demand due to the project activities

Sl. No.	Crop	% increase
1	Aus rice (HYV)	20
2	Maize	50
3	Wheat	55
4	Potato	100
5	Watermelon	55
6	Sunflower	100
7	Groundnut	10
8	Sesame	40
9	Mung Bean	35
10	Tomato	50
11	Cauliflower	10
12	Cabbage	10
13	Knolkhol	30
14	Brinjal	20
15	Bottle gourd	50
16	Bitter gourd	40
17	Ridge gourd	10
18	Snake gourd	20
19	Sponge gourd	10
20	Cucumber	10
21	Okra	40
22	Chili	40
23	Yard long bean	20
24	Pumpkin	20

4.3 Provision of Nursery Services

Seven local nurseries were developed and one was strengthened through project support in the intervening locations. Seedlings were raised in these nurseries and which were purchased not only by the PFFs but also others in the area. The nurserymen also motivated the farmers towards purchasing the vegetable seedlings, hence increasing the sales and use. During the hot and dry seasons, mulching was done to prevent surface moisture from evaporating.

4.4 New Cropping Patterns

A number of crops along with cropping patterns were introduced to the farmers. This included patterns including 2 crops, 3 crops and 4 crops. Table 2 shows the preferred patterns by the farmers ranked from 1-10 in a descending order. Partially the patterns were chosen based on marketability of the new crops in the local market based on customer choice.

4.5 Demonstrations of Crops

Around 20 crops were introduced to the farmers participating in this project. They were Aus Rice, Aman Rice, Mung Bean, Sunflower, Potato, Tomato, Maize, Wheat, Water Melon, Cauliflower, Cabbage, Knolkhol, Indian Spinach, Snake Gourd, Ridge Gourd, Bottle Gourd, Sweet Gourd, Ground Nut and Chili. Some of the crops were being cultivated by farmers before ACI-IAP-SIDA intervention, but through the project replacement varieties of better qualities such as short duration were introduced. About 11% motivated indirect farmer beneficiaries were influenced by 629 crop demonstrations carried out in farmer fields. 45 Field days were carried out for the crops and around 2300 invited farmers were invited to see crop performance first hand.

5. DISCUSSION

The seasonal shift in the coastal belt of Bangladesh due to prolonged rainfall leading to submergence and flood related problems has an impact on the annual cropping seasons. The primary crop for the region, *T. Aman* rice [7] is transplanted late and harvested later than the rest of the country [4]. This shortens the *Rabi* season (winter) which means a number of crops cannot be cultivated unless they are of short duration [8]. For this reason the farmers were introduced to crops like Mung Bean and potato, which can be grown after late *T. Aman* rice harvest. In fact introduction of these two crops also meant it is possible for farmers to grow 4 crops in one year if necessary. A typical cropping pattern for that would be T. Aman-Potato-Mung Bean-Aus. 4 crop patterns were also introduced through the program, but they were less popular than the 3 crop patterns.

Since the farming practice depended mostly on rice, a diverse collection of crops were introduced in the Rabi season. This was to lower the pressure on the water table, since rice is a water-loving crop [9]. Also cultivating the same crop continuously leads to soil loss and infertility. *Boro* rice is grown during the winter seasons when rainfall is low. Also this type of rice is harvested during summer, when the soil is drier. Hence cultivating rice during this time lowers the water table and increases the growing problem of salinity in the region [8]. Low water sensitive crops such as wheat and maize have the ability to replace rice [10]. Other crops such as Mung Bean has the ability to restore soil nutrient, hence help in restoration. Cash crops such as potato and winter vegetables also increase crop diversity in the coastal region.

Biodiversity in the coastal region is further increased through Homestead Gardening. Here the women of the participatory farm families are involved. Through the program they have grown vegetables which they had never grown before such as carrots and tomatoes. With proper agriculture management the yield from the gardens were high enough to be consumed and sold in the local market. This added much needed nutrition to their diets and increased family income. The increase in yield was found to be accurate even in the gardens of the women who carried out homestead gardening before, but in a disorganized way.

Table 2. Preferred cropping pattern for 3 crops in descending order

Sl. No.	Kharif II	Rabi	Kharif I
1	T. Aman	Mungbean	T. Aus
2	T. Aman	Chickling Vetch	T. Aus
3	T. Aman	Sunflower	T. Aus
4	T. Aman	Chili	T. Aus
5	T. Aman	Winter Vegetables	Jute
6	T. Aman	Wheat/Maize	T. Aus
7	T. Aman	Watermelon	T. Aus
8	T. Aman	Potato/Sweet potato	T. Aus
9	T. Aman	Groundnut	T. Aus
10	T. Aman	Mustard/Lentil	Jute

Further increase in crop biodiversity was complemented by the linkage between nurseries and homestead gardeners and farmers growing vegetables in the fields. As mentioned before that local nurseries mostly grew wood and fruit trees, but through the project seasonal nurseries were set up where farmers also became nurserymen and raised seedling of vegetables. Raising seedlings is a difficulty faced by the homestead growers and farmers due to lack of time and space. Linking them with each other has reduced this problem. Throughout the project duration, not only the participatory farm families but also non-beneficiaries availed their services.

The local dealer and retailers saw an increase in demand for certain vegetable seeds due to the interventions through this program. Farmers shifted from using low yielding, disease susceptible, local varieties to high yielding hybrids. The performance for these vegetables was vetted by beneficiary and non-beneficiary farmers during the field days held after the demonstrations. Some of the crops which performed well during the project and gained popularity were Bottle Gourd, Bitter Gourd, Snake Gourd, Cucumber, Okra, Chili and Red Amaranth. Another crop which saw a stark rise in demand for seeds was an indigenous potato variety. The potato variety was grown for the first time in the coastal belt, which is thought to be a non-potato region using 0.6 tons of seed the first year of the program. The success of the low input and water sensitive crop increased the demand for seeds to 7 tons the next season.

Local agricultural extension officers and active academics from the local university were also incorporated in the program during training sessions and field days since. The familiarity of their faces and the trust in them were transferred to the program field officers, enabling the ACI-IAP-SIDA project to reach its scope.

Some of these success stories were also location specific. For example, increase in demand for potato seeds were not seen in all project locations. The reason behind this was the lack of market for the crop. Hence farmers are willing to adopt crop varieties, provided it is acceptable to the local consumers.

6. ASSURANCE OF SUSTAINABILITY IN THE FUTURE

The exit plan of the project was drafted with the idea of sustainability. To make the project sustainable, the biodiversity has to be maintained and the farmers have to continue using the environment friendly cropping patterns. For these reasons, seeds of the introduced crops were bought for the seasons after end of project duration until the last season of the year. This was to show the farmers that even though the project has ended, they were not left alone. Land has been leased for the next 7 years in Patuakhali, so that demonstrations and field research of crop varieties tailored to tackle the climate change problems in the coastal belt can be carried out. Experts in the field are advocating to the local persons of influence from the government agriculture extension and university to continue promoting the positive activities of the program and support development of logistic support to the farmers. More programs in collaboration with international donor agencies have been drafted and will be implemented so that the activities mentioned here can be scaled up and replicated in other locations in the coastal belt.

7. CONCLUSION

The two year project was a pilot for the model mentioned before and has been found to effective. The coastal belt of Bangladesh is affected severely by climate change and the rural population of the region involved in agriculture is unaware of how to tackle the problems. Through this program varieties suitable for the coastal belt were introduced to farm families with activities which would ensure sustainability. Biodiversity of the project locations have been increased through introduction of environment friendly cropping patterns. This also promoted arable soil management. Sustainability of such introductions largely depends on adoption by farmers. This requires a change in habit and attitude. For that, they need to be continuously attached with initiatives such as this program.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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