

ADAPTATION TO CLIMATE CHANGE IN COASTAL SALINE AREA OF SOUTH-WESTERN REGION OF BANGLADESH

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ABSTRACT

An adaptation research under Food and Agriculture Organization (FAO) funded LACC-II project started at coastal saline area of Laudove, Dakope upzila in Khulna district of Bangladesh through on-farm research division of Bangladesh Agricultural Research Institute (BARI), Khulna Bangladesh during May-June 2008 to May-June 2009. It aimed to find out the appropriate adaptation measures against salinity problem. After selection of adaptation options through three focus group discussions (FGD), homestead vegetable production started immediately with saline/excess soil moisture tolerant vegetables for coastal area. In coastal area several homestead vegetables were successfully produced through scientific management like making ridge and furrowing of bed. There was large participation of women in all the activities of home gardening from land preparation to marketing at Laudove. Through utilization of different niches of homestead farm family succeeded to increase their vegetable consumption three to five folds more from the bench mark, though intake was below recommended level. Economically homestead vegetable production was quite lucrative. Also social relationship of the farm family was improved with neighbors and relatives through free distribution of vegetables. Short duration T. aman rice variety (cv. BINAdhan 4) was tested at Laudove for facilitating timely planting of rabi crops. It gave better yield and one month shortening of field duration was possible. Farmers kept most of the produced seed for next year cultivation. In post-rainy season (Rabi) different field crops were tested, such as relaying (for timely planting and avoiding of increased soil salinity) of mustard, wheat, cowpea and later on creeping crops like watermelon and sweet gourd. Among them cowpea, water melon and sweet gourd proved to be promising.

Keywords: Adaptation, Salinity, FGD, Vegetable and Short duration.

INTRODUCTION

Bangladesh, a flood plain delta, is a land of rivers and canals (Sarwar, 2005). The country is sloping gently from the North to the South, meeting the Bay of Bengal at the southern end. The whole coast runs parallel to the Bay of Bengal, forming 710 km long coastline (CZPo, 2005). The coastal zone covers 19 out of 64 districts facing or in proximity to, the Bay of Bengal, encompassing 153 upazilas (MoWR, 2006). Out of these 19 districts, only 12 districts directly meet the sea or lower estuary. A total of 48 upazilas/thanas of these districts are considered as ‘exposed’ directly to vulnerabilities from natural disasters (CZPo, 2005). Bangladesh occupies a unique geographic location spanning a relatively short stretch of land between the mighty Himalayan mountain chain and the open ocean. It is virtually the only drainage outlet for a vast river basin complex made up of the Ganges, Brahmaputra and Meghna rivers and their network of tributaries. These rivers, which cause almost regular and serious floods over much of the country during the summer monsoons, are reduced seriously during the dry winter months (NAP, 2006). BARC (2001) reported that Bangladesh has a total land surface of 12.31 million hectares, of which presently 7.85 million hectares are under agriculture (NAP, 2006). About 30 % area of Bangladesh belongs to coastal area, which is regularly and recurrently battered by calamities like, cyclone, tidal bore/surge, inundation, intrusion of saline water etc. costing thousands of lives and huge amount of properties (Amin *et al.*, 2008). Three indicators have been considered for determining the landward boundaries of the coastal zone of Bangladesh. These are influence of tidal waters, salinity intrusion and cyclones/storm surges (CZPo, 2005). Nineteen districts near the coastal boundary of the country are being affected directly or indirectly by some of these phenomena. In Bangladesh, salinization is one of the major natural hazards hampering

crop production. About 53% of coastal area is affected by different degrees of salinity (Islam, 2004). According to BARC (1999), light 0.29, moderate 0.43 and high 0.12 million hectares land salinization was observed in Bangladesh which cost 586.75 million USD per year (NAP, 2006). Bangladesh is the nation most vulnerable (CRI rank 1, 1991-2010) to global climate change in the world, according to German Watch Global Climate Risk Index (CRI) of 2013 (Harmeling and Eckstein, 2013). Salinity affected soil increase 21% in last three decades in this region (Salaudinand and Ashikuzzaman, 2012). Future changes of temperature and rainfall are estimated for Bangladesh and it was found from the observed data that the temperature is generally increasing in the monsoon season (June-August) (IPCC, 2007). Over the years (1973-2000), salinity of cultivable land of Khulna increased by 21% (Islam *et al.*, 2008) mainly due to three reasons, viz. i) drastic deduction of sweet water flow from upstream in dry season, i.e. from the Padma (Ganges) and its tributaries, because of water diversion by India through *Farakka* barrage, ii) breaching of embankment by recurrent tidal surge/cyclone, iii) Secondary salinity: it is the artificial intrusion of saline water for shrimp cultivation by big fisherman cum trader in the cultivable land, popularly called “Gher”. This situation is changing the biodiversity of the vast area including crops and cropping patterns, trees, grasses etc., rendering a devastating impacts on health, livelihoods, and income of the farmers. The resource poor farmers and fishermen are affected the most. Thus coping with the changing climate is important through modern technology, crops/trees/ varieties/cropping systems/farming systems for the overall livelihoods improvements of farm community, particularly for the resource-poor. IPCC (2001) define adaptation as adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability (Lisa, 2007). In this context this study has been undertaken to identify the potential adaptation measures with the farming community of Dakope under Khulna district to understand the farmers’ behaviors and outcomes.

METHODOLOGY

This study under LACC-II project started at coastal saline area of Laudove, Dakope upzila under Khulna district of Bangladesh through On-Farm Research Division of Bangladesh Agricultural Research Institute, Khulna during May-June 2008 to May-June 2009 funded by FAO. An array of adaptation measures were formulated on the basis of three focus group discussion with the participation of farmers, concerned researchers, extension worker (GO and NGO) and other stakeholders. There were fifty variables. Data were collected from ten selected farmers out of thirty. Each farmer was considering as experimental unit. Homestead data were collected weekly. Field crop data were collected periodically. Data collected by research assistant under the supervision of researcher. Land owners are male. Females act as implementer and manager in absence of male. Male as well as female was the primary decision maker. Homestead profit goes to female but field crops to both. Knolkhol, beet, spinach, tomato, kangkong, okra, Indian spinach, stem amaranth, BINAdhan 4, traditional T.aman BR 23, cowpea (BARI Falon-1), wheat (var. Sourov), watermelon and sweet gourd crops were considered for adaptation. At first we allocated these crops according to soil suitability and then farmers’ choice. The adaptation measures were (i) cultivation of different saline and excess water tolerant vegetables under different ecosystem, (ii). saline tolerant short duration T. Aman rice variety and (iii). different saline and rot tolerant fruits, vegetables and field crops. Several key problems and issues were identified and action research programs were chalked out through careful review of available secondary information and previous experimental results of different saline zones. The adaptation options were experimented in a participatory manner in the farmer’s homestead and field of Laudove, Dakope, Khulna representing coastal/saline area. Homestead is the raised land where farmers live after making his dwelling house, cattle shade, pond, open space etc. Field data were taken from ten farmers for each variable. Only vegetables produced in bed (niche: open space) were systematically produced by 10 household and regular data recording was possible. Soil salinity analyzed by digital EC meter. The data on different parameters were statistically analyzed by “SPSS” software.

RESULTS AND DISCUSSION

Adaptation in homestead of coastal area

Adaptation to climate change is considered especially relevant for developing countries, where societies are already struggling to meet the challenges posed by existing climate variability (Yamin *et al.*, 2005; Adger *et al.*, 2003; Handmer, 2003; Kates, 2000; Watson and Ackerman, 2000) and are therefore expected to be the most adversely affected by climate change (McCarthy *et al.*, 2001). The recent Intergovernmental Panel on Climate Change Fourth Assessment Report makes clear that “adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions” (IPCC, 2007). As such, it supports adaptation as a complimentary response strategy to mitigation (Lisa, 2007). In context of crop adaptation, no previous research and development work on salinity was done. As a consequence only T. aman is growing in monsoon and the most of the time the land remain fallow. It was possible to grow one or two more crops on these lands particularly rabi season. It implies that after proper investigation different saline tolerant vegetable and field crops could be grown in this area with the active participation of community members. It could help to improve their food security and overall livelihood. Adaptation should be introduced in agriculture including crop changes and resource substitutions (IPCC, 2001b). So, on the basis of crop suitability against salinity in Rabi (Mid October- Mid March) and Kharif-I (Mid March- Mid July) seasons, excess soil moisture in Kharif-II (Mid July- Mid October) season and farmer’s preference, the following year round homestead vegetable model was tested and recommended. Women farmer’s choice was also considered, such as Tankuni (*Centella asiatica*, a medicinal plant cum vegetable)/Helencha (*Enhydra fructuans*) was accommodated in the model for partially shady area cum excess moisture conditions. For open sunny space those rabi vegetables were selected which are tolerant at 4-6 dS/m salinity such as knolkhol/kholrabi (*Brassica oleracea*), beet (*Beta vulgaris*), spinach (*Beta bengalensis*) and tomato (*Lycopersicon esculentum*) (Tisdale *et al.*, 1997). In general salinity in homestead is low because of raised and modified soils. Commonly eight niches were observed in homestead area of Laudove, though some small homestead has less number of niches. Farmers were largely successful in producing both kharif and rabi vegetables (Table 1).

Table 1. Average production and disposal pattern of rabi and kharif season vegetable per homestead at study area.

Season	Total production in 240 days (kg)	Total own consumption (kg)	Own* consumption (g/head/day)	Free distribution (kg)	Sold (kg)	Total cash income (Tk) [†]
Kharif	40.17 (3.52)	27.4 (5.87)	45.66 (9.78)	6.77 (2.90)	6.0 (4.58)	37.22 (29.13)
Rabi	120.1 (11.65)	55.20 (14.54)	92.00 (24.24)	22.30 (8.07)	42.6 (13.4)	405.4 (113.66)

Figure in parenthesis indicates Standard Deviation. * Five members in family were considered.

Table 2. Average intake of homestead vegetables of 10 farmers in kharif and rabi seasons at study area.

Season	Before intervention (g/head/day)	After intervention (g/head/day)
Kharif	8 (3.56)	45.66 (9.78)
Rabi	32 (9.51)	92 (24.24)

Figure in parenthesis indicates Standard Deviation. *Considering only own production from homestead

Production per homestead was three times more (120 kg) in rabi season than kharif (40 kg) because kharif-II production started late. Moreover, kharif production was affected by excessive rainfall. Among the produced vegetables, farmers consumed 52%, free distributed 18% among relative and neighbor and sold 30 % for cash income, which they need for purchasing small items including children’s book, pencil and other items. Most of the earned money was hold by women. There was significant improvement in kharif season vegetable intake (Table 2) more than five times (46g/head/day) from the bench mark (8 g/head/day). Because of excessive soil moisture farmers produced only some creepers like ash gourd on roof top. But now through making ridged bed drainage of water has improved and farmers were able to

[†] US dollar (\$) 1 = Taka (Tk) 79

produce vegetables like amaranth, kangkong and Indian spinach. In rabi season also consumption of vegetable increased almost three times (92 g/head/day) from the base (32 g/head/day). On the average of 240 days, vegetable intake has increased more than three times (69 g/head/day) from the bench mark (20 g/head/day) through vegetable gardening, though it was far less than recommended requirement of 200 g/head/day for an adult. However, it is also a marked improvement for this remotely situated calamity affected island's poor people alongside Sunderban (mangrove forest) where this type of endeavor is probably rare. In this island female has contributed more in homestead vegetable production (Table 3) from land preparation to intercultural managements except marketing. Because most of male partners are out of home for their livelihoods like fishing, Sunderban forest related business and other off/nonfarm activities. Economic analysis (Table 4) clearly showed that vegetable gardening is quite profitable bringing a gross margin of Tk. 1135/homestead costing only Tk. 250/homestead (without family labor) with 4.54 benefits cost ratio (BCR). The amount of profit might be small but homestead vegetable gardening has a profound impact on family members' food habit, nutrition, consuming balanced diet in a carbohydrate (rice) dominated society (Table 5). Vegetable purchasing cost was reduced. It paved the path of obtaining safe vegetable at own homestead, as most of the commercially produced vegetable is sprayed with excessive systemic (long lasting effect) insecticides. Actually the program opened the path of major women participation in all activities including meeting, training, field day and home gardening and field works (Table 3). However, there are some limitations such as acute crisis of sweet water for vegetable cultivation in kharif-I season (February to May) and unavailability of quality seeds/seedlings. It may be mentioned that in homestead vegetable model "open space" is the most productive niche due to maximum availability of sunlight. Other niches were utilized by few farmers, and data recording was also not possible. So, in this report only data of open space is furnished.

Laudove Homestead Vegetable Model (for saline area of Khulna)

Niche 1: Sunny land (open space)

- Bed 1: Knolkhol-Kangkong-Kangkong
- Bed 2: Beet-Ladysfinger+ Red amaranth-Ladysfinger
- Bed 3: Spinach-Indian spinach- Indian spinach
- Bed 4: Tomato-Stem amaranth-Stem amaranth

Niche 2: On-roof

- Roof-1: Bottle gourd-White gourd- White gourd
- Roof-2: Sweet gourd-White gourd- White gourd

Niche 3: Trellis

- Trellis-1: Bottle gourd-White gourd-Sponge gourd
- Trellis-2: Country bean-Bitter gourd- Snake gourd

Niche 4: Partially shady area

- CP-1: MoulaviKaclu (aroid)- MoulaviKaclu (aroid)- MoulaviKaclu (aroid)
- CP-2: Thankuni/Helencha- Thankuni/Helencha- Thankuni/Helencha

Niche 5: Marshy area

- Panikachu (aroid)-Panikachu (aroid)-Panikachu (aroid)

Niche 6: On-tree support

- Potato yam/Choi jhal- Potato yam/Choi jhal- Potato yam/Choi jhal

Niche 7: Home boundary/backyard

- Local banana/Moringa- Local banana/Moringa- Local banana/Moringa

Niche 8: Home boundary fence

- Country bean-Yard long bean- Sponge gourd

The vegetable crops selected were largely adapted to local saline and excessive soil moisture (in monsoon) environments. It contributed to food and nutrition security of household members through intake in daily meal. Though round the year vegetable cultivation CO₂ was used and O₂ was released which helped to reduce greenhouse gas (GHG). So the selected vegetable crops are potential for resilience against climate change effect.

Table 3. Average work distribution among the family members for the homestead vegetable production at study area.

Name of practice	Male (%)	Female and children (%)
Land preparation	49	51
Sowing/planting	40	60
Irrigation	19	81
Intercultural operation (Pest management, Weeding etc.)	25	75
Harvesting	21	79
Marketing	70	30

Table 4. Economic return per homestead (240 days) at Laudove, Dakope, Khulna, 2008-2009.

Vegetable name	Average total production/ bed (kg)	Vegetable price (Tk/kg)	Gross return (Tk/bed)	Average production cost in Tk./ homestead (Without family labor)	Gross margin/ homestead (Tk.)	Benefit cost ratio (BCR)
Knolkhol	26.8	10	268			
Beet	25	11	275			
Spinach	19	6	114			
Tomato	49.3	9.50	468	250	1135	4.54
Kangkong	12.55	7	88			
Okra	4.7	10	47			
Indian spinach	11.22	6	67			
Stem amaranth	11.7	5	58			
Total	160.27	-	1385			

Table 5. Visual impact of the vegetable gardening (not quantified for qualitative data) and field crops on the cooperating household members, Laudove, Dakope, Khulna, 2008-2009.

Sl. no.	Area of consideration	Impacts created
01.	Income and cost reduction	Cash income increased though small amount but cost of vegetable purchasing was reduced significantly
02.	Family nutrition and health	- Consumption of vegetables increased - Positive change of consumption habit - Reduced disease infestation - No or less constipation - Visually health improved due to higher consumption of pest-free vegetable
03.	Resource use pattern	- Successful adaptation of new crops in saline environment - Homestead area utilized properly both kharif and rabi season - Farmers utilized all the available niches for vegetable production - Use of farm yard wastage
04.	Education and knowledge	- Increased knowledge of family members regarding vegetable cultivation and nutrition - Cultivation of vegetable in bed helped to reduce salinity and drainage in kharif season
05.	Social status	- Social status increased - Improved mental strength - Increased acceptability to people due to free distribution of vegetable among neighbor/relative
06.	Micro environment	- Household waste used for composting - New plantation improved environment
07.	Others	Increased utilization of family labor
08.	Women empowerment	Active participation by women. In general women kept the sell proceeds of vegetable selling

Adaptation in crop field of coastal area

T.aman: T.aman variety BR23 is the major crop in Bangladesh. It is a photosensitive and long duration variety it took around 160 days. Its harvested in early December, thus timely planting/sowing of rabi crops like mustard, wheat are delayed. Moreover yield level of BR23 is also comparatively low (400 kg/Bigha or 3 ton per hectore). To facilitate the timely planting of succeeding rabi crops T.aman variety BINAdhan4 was introduced for the first time. It was harvested on 5 November and grain yield (468 kg/bigha or 3.5 t/ha) was 500 kg/ha higher than BR23 (Table 6). It would also probably helps to avoid

Table 6. Yield and yield attributing characters of T.aman rice at Laudove, Dakope, Khulna, during kharif season 2008.

Crop	Field duration (days)	Plant ht. (cm)	Tillers/hill (No.)	Panicle length (cm)	Grains/panicle (No.)	1000-grain weight (gm)	Grain yield (kg/bigha)	Straw yield (kg/bigha)
T.aman (BINAdhan-4)	130 (4.24)	115 (2.58)	18 (1.7)	24 (0.91)	120 (2.83)	26 (1.29)	468 (6.28)	428 (2.89)
Traditional T.aman BR 23	162 (4.47)	-	-	-	-	-	401 (4.63)	-

seasonal cyclone/tidal bore which generally happened during mid-late November. But after the harvest of T.aman, planting/ relaying of mustard/cowpea/maize/wheat was not possible due to excessive water in the field. As there was enough rainfall in October, 2008 (Fig 1), so relaying was possible in late November. But mustard was seriously affected by fog and aphid attack, producing zero yields. While maize growth was hampered by growing salinity during February -April (Fig 1), it gave very small cobs and some plants also died.

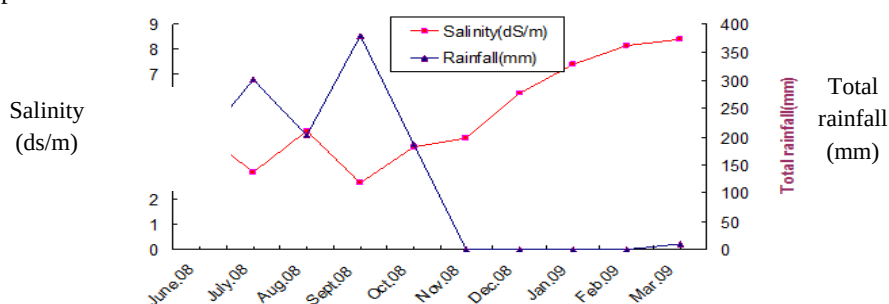


Fig.1. Relationship between salinity and rainfall during June, 2008 to March, 2009 at the study area.

Cowpea: Cowpea (*Vigna unguiculata*) is one of the most important foods in the semiarid tropics. It has the ability to fix atmospheric nitrogen through its root nodules. It is drought tolerant and can be used as fodder as well as food. Cowpea had a very good germination and later stage growth was stunted due to excessive soil moisture. Observing this situation soil was opened with a spade to reduce soil moisture content. This operation works, and cowpea gave a reasonable yield (134 kg/bigha or 1t/ha) also it fetched good economic return (Table 8).

Table 7. Yield and yield attributing characters of zero-tillage cowpea after T.aman rice at Laudove, Dakope, Khulna, a coastal saline area of Bangladesh during rabi season 2008-2009.

Crop	Plants m ⁻²	Plant height (cm)	Pod/plant	Seed/pod	1000 grain weight (g)	Seed yield (kg/bigha)
Cowpea (BARI Falon-1)	16 (1.15)	70 (4.22)	9.00 (1.25)	9.00 (0.47)	80(1.47)	134 (1.64)

Table 8. Economic return from different rabi field crops after T.aman rice at Laudove, Dakope, Khulna during rabi 2008-2009.

Crops	Production cost (Tk/Bigha)	Gross return (Tk/bigha)	Gross margin (Tk/bigha)	BCR
Cowpea	1200 (75.31)	3350 (41.1)	2150 (97.65)	2.79 (0.20)
Wheat	3400 (219.86)	4005 (68.26)	605 (194.97)	1.17 (0.07)

Wheat: Wheat germination was good, but growth was less due to excessive soil moisture, however it gave a reasonable yield (267 kg/Bigha or 2 t/ha) under zero tillage condition (Table 9), but its economic return (Table 8) was not so encouraging (only 605 Tk. gross margin/Bigha with 1.17 benefit cost ratio).

Table 9. Yield and yield attributing characters of zero-tillage wheat after T.aman at Laudove, Dakope, Khulna, during rabi season 2008-2009.

Crop	Days to heading	Days to maturity	Spike /m ²	Plant ht. (cm)	Spike length (cm)	Grains/spike (No.)	1000-grain weight (g)	Grain yield (kg/ bigha)	Straw yield (kg/ bigha)
Wheat	66 (2)	105 (2.79)	207 (2.67)	69 (2.7)	9.38(0.50)	31 (3.2)	36 (0.9)	267 (4.55)	309 (4.57)

Crops such as sesame and mungbean were also tested but serious drought along with increase of soil salinity reduced its population below threshold level. It may be mentioned that relationship between rainfall and salinity is opposite (Fig. 1). It was also not possible to irrigate as sweet water source within polder was dried (pond/canal) due to long winter drought, on the other hand outside polder pond and river water was critically salty.

Watermelon and sweet gourd: Two creepers water melon and sweet gourd were also plated in January. It survived well, also produced fruit (Table 10). Watermelon yielded 586 kg/Bigha (5.12 t/ha) fruit while sweet gourd yielded 557 kg/Bigha fruit (4.15 t/ha). Both water melon and sweet gourd has market in the locality. Water melon is exported to main land and brings cash income. Along with selling

Table 10. Yield and economic return from watermelon and sweet gourd after T.aman rice at Laudove, Dakope, Khulna, 2009

Crop	Area (Bigha)	Fruit yield (kg/Bigha)	Production cost (Tk/Bigha)	Gross return (Tk/Bigha)	Gross margin(Tk/Bigha)	BCR
Watermelon	0.5 (0.165)	685 (9.06)	2672 (38.31)	4112 (47.15)	1440 (47.14)	1.54 (0.02)
Sweet gourd	0.5 (0.165)	557 (7.87)	2405 (39.58)	3343 (45.04)	938 (18.06)	1.39 (0.009)

sweet gourd is used as rainy season vegetable security, because it could be stored in house easily. Market price of both water melon and sweet gourd was a bit low due to late harvest, but it could be advanced by planting one month poly bag raised seedling. Both water melon and sweet gourd creeping vines and leaves worked as soil mulch which could effectively reduce soil evaporation and prevent rising of soil salinity. It needs small amount of water only in its base, which could be possible to supply from mini pond/Kuni or small canal within the polder. Thus making small pond at one side of a big plot is important to produce commercially viable crop like water melon. But it needs some investment. Different adaptation options were evaluated by a good number of women farmers and other stakeholders. They opined that homestead gardening could be regarded as a successful avenue through scientific management and selection of appropriate vegetables. However, for success field crops more attention would be given to small scale water harvest through digging pond, canal etc. They were optimistic about short duration T.aman rice BINADhan 4. The selected field crops were well adapted to local saline, excessive soil moisture (in monsoon) and drought environment. It enhanced food, feed and nutrition security along with good cash income. Resilience against climate change is enhanced by reducing salinity and drought through its vigorous canopy. It used CO₂ and produced O₂. Therefore, GHG emission was seems to be reduced.

CONCLUSION

Firstly the whole motivation, training and action programs helped the men and women farmers to get the information of scientific adaptation measures at their door step. It has improved their social status through close and frequent interactions with public institution researchers and change agent. Empowerment of women farmers occurred along with gaining of knowledge as they actively participated in the entire program. Through increased production of vegetables and field crops farmers increased their income which helped to improve their overall livelihoods. Homestead vegetable gardening should be up-scaled in community basis following Laudove model. For field crops in rabi season; cowpea, watermelon and sweet gourd should be promoted with full packages of technology. Small scale pond/kuni excavation should be

promoted to produce economic crop like watermelon along with small scale fish culture in rainy season. The experimentation suggests that cowpea, water melon and sweet gourd could be a viable adaptation options in post rainy season. However, testing of other field crops would continue with saline tolerant varieties along with appropriate management options for reducing soil salinity and drought. Homestead vegetable is a viable option for resilience against climatic change.

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