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Salinity effects on food habits in three coastal, rural villages in Bangladesh

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Abstract

Since shrimp farming started in Bangladesh in the 1970s, it has spread throughout the coastal region, increasing soil and water salinity levels. The water salinity in 2005 in the coastal districts of Khulna, Bagherat and Satkhira ranged from 0.3 to 20.7, 0.4 to 27.1 and 0.7 to 24.8 dS m^{-1}, respectively, whereby it was highly saline for several months of the year. Water salinity above 2.5 dS m^{-1} is not suitable for irrigation, and may cause animal health problems. Irrigation with saline water may cause ion toxicity and osmotic stress, reducing plant growth and yield. Salinity has reduced the agro-biodiversity in the coastal regions of Bangladesh, and this paper investigates how these changes have impacted human food habits in the three coastal, rural villages Putia (Satkhira district), Srifaltala (Bagerhat district) and Hogolbunia (Khulna district). Fieldwork was conducted from July to December 2006 and Participatory Rural Appraisal methods including transect walks, key informant interviews, group discussions and personal interviews were carried out. In total, 121 respondents were interviewed and historical data from 1975 to 2006 were collected. For historical data, respondents aged above 50 years were sampled, but additional criteria such as socio-economic condition and farm location were applied to assure a sample representative for the population of the coastal areas. The sampled households had characteristics similar to the major part of Bangladeshi households (rural, agrarian based, regarding family size and food habits), and were thus representative of a broader cross-section of households in Bangladesh. As all sampled villages faced increasing salinity and spread of shrimp farming, they were representative of villages in the coastal areas. When salinity increased, the production of vegetables, seasonal fruits, animal species, eggs and milk declined. As the price of the mentioned animal commodities rose, cheaper commodities such as broilers, exotic and marine fish species and exotic oils were introduced. The decision on what to cultivate was also influenced by non-residents converting the farmers' land into shrimp ponds, increasing the salinity in the surroundings and killing the farmers' ducks. These agro-biodiversity changes caused reduced frequency of consumption of beef, goat, native chicken, egg, local freshwater fish, seasonal fruits, vegetables and milk, while broilers, exotic fish, exotic oils and marine fish species were increasingly consumed. Still, the total fish consumption declined. These changed food habits may lead to considerable negative health consequences for the rural, coastal populations.

Key words: agro-biodiversity change, Bangladesh, coastal area, food habits, salinity, shrimp aquaculture

Introduction

Food is being used to satisfy hunger and meet nutritional needs, it is also used as a gift and to show hospitality in order to create and maintain social relations. Food can denote ethnic, regional and national identity and it is an important part of holidays, celebrations and special family occasions.[1,2]. Foods have symbolic meanings in religious rituals and beliefs and can be used to show status, make one feel secure, express feelings and emotions, to relieve tension, stress or boredom[1,2]. Cultural values influence how people use food and eating cultures, varying among regions and within societies, are influenced by class, age and gender[3]. The developed attitude toward food evolves from learned experiences, often influenced by cultures and traditional practices, and food is used for self-expression

and/or showing group membership[4,5]. Food habits may be described as 'the culturally standardized set of behaviors in regard to food manifested by individuals who have been reared within a given cultural tradition,[6,21] and food habits are continually changing as they adapt to travel, immigration and the socioeconomic environment[1,2,7,8]. Food preferences indicate the amount of satisfaction an individual anticipates from eating food[9]. Preferences are a factor of physiological and psychological development as well as social experiences, and are related to the degree of liking food. Liked foods are familiar, considered pleasant and more frequently eaten, while disliked foods are rejected as they are considered unpleasant or unfamiliar. Taste is considered the most important sensory attribute to food selection, but texture, color, shape, form, size of pieces and temperature are also important factors[9]. While familiarity is one of the most important factors of child and adult preferences[10–12], the liking for bitter or strong-tasting foods increases with the age[13]. Also, socioeconomic environment influences culture and food habits[1,7,8].

In Bangladesh, rice is the staple food and is often consumed thrice daily. Traditionally, it was common to raise cattle, chicken, ducks and goats for meat and milk, and to grow vegetables as well as plants for oil extraction in the homesteads. The majority of the rural households owned cattle, had income from selling calves, milk and cow dung for fuel, and animals were available for sacrifice in holy festivals[14]. Poultry were kept by many families and women had supplementary income from selling chickens and eggs[14]. Rural households used to cultivate vegetables and sell the surplus after meeting household needs[15]. Shrimp farming, which started in Bangladesh in the 1970s, has spread to many coastal districts[16,17], and although it is important for the national economy[18,19], it has made the environment in the shrimp-producing areas increasingly saline[20]. The Bangladeshi coastal area has great potential for agricultural development, but salinity is the main limiting factor[21]. Salinity is divided into the following categories: non-saline (0–1.9 dS m^{-1}), slightly saline (2–4 dS m^{-1}), moderately saline (4.1–8 dS m^{-1}), saline (8.8–16 dS m^{-1}) and highly saline (>16 dS m^{-1})[22]. Soil and water salinity in Bangladesh varies throughout the year and is generally high in the dry season, January to July, and lower during the heavy rainfall, August to December[23]. The yearly average soil salinity in the coastal sub-districts Batiaghata and Rampal increased from 1.4 to 6.9 dS $m^{-1}$and from 3.7 to 8.8 dS m^{-1}, respectively, from 1990 to 2005. In the same period, the average yearly water salinity in Kazibachha River in Batiaghata and Rampal River in Rampal increased from 2.7 to 7.6 dS m^{-1} and from 4.5 to 8.7 dS m^{-1}, respectively. The average yearly water salinity in Kakshiali River in Kaliganj increased from 9.2 to 10 dS m^{-1} from 1995 to 2005[23]. Water with electrical conductivity (EC) above 2.5 dS m^{-1} is not suitable for irrigation[24] as it may cause ion toxicity and osmotic stress, reducing plant growth and yield[25]. Poultry and pigs should not drink water with EC above 6 dS m^{-1}, as even salinity above 2.5 dS m^{-1} may cause health problems for animals and EC above 4 dS m^{-1} may cause shell cracking in laying hens[26]. Although beef cattle are able to drink water up to 17 dS m^{-1}, even lower EC levels may contain unacceptable concentrations of particular ions[24]. Increased salinity has caused agro-biodiversity changes such as reductions in cattle, buffalo, goats, ducks and chickens[27–29] and rice production as well as crop extinctions and a shift from native to high-yielding varieties[26,30–32]. The species diversity and production of certain vegetables have declined and half of the 32 crop species grown in Satkhira in 1985 were extinct by 2000 due to salinity[15,30,33]. Farmers in shrimp-producing, coastal areas used to grow pulses, oil seeds and vegetables, but now there are no longer any winter crops[34,35]. Salinity has caused a reduction in fruit trees[28,29,36,37] and while indigenous fish varieties disappear, exotic and marine species become dominant[38].

With declining yields and disappearance of species, the rising food prices[39] may further reduce the availability of food and have negative effects on the nutritional status and health of vulnerable populations[40]. In Bangladesh, nearly half of the population is poor[41] and food insecure, and use coping strategies such as starving 1–2 times a day (54%) and reducing the intake of favorite foods (49%)[42]. Nationally, a high proportion of children under 5 years are underweight and stunted (40 and 46% respectively), a scenario similar for Khulna (35 and 44%) and Chittagong division (40 and 52%)[43]. Consumption of seeds and legumes, yellow and orange fruits, vegetables, root crops and green leafy vegetables can prevent micronutrient malnutrition[44], and thus a diverse diet is essential to ensure the intake of the 17 minerals and 15 vitamins needed for good health[45]. However, the Bangladeshi average daily intake of vegetables and fruits is 179.5 g[46], which is far below the World Health Organization recommendation of 400 g[47]. The Bangladeshi government and NGOs have thus launched large-scale food and nutrition programs, including direct food and nutrient supply, school feeding, home gardening and health advice, to combat and prevent nutrient deficits[48,49]. For advice to have any impact, it is important to know which factors influence the people's food habits and food choices[50]. The salinity increase in the Bangladeshi coastal areas has degraded the environment and caused a decline in agro-biodiversity, with various species lost. This research examines how the salinity-induced changes in agro-biodiversity (here crops, fruit trees and livestock) have affected the people's food habits in the villages Putia, Srifaltala and Hogolbunia in the coastal area of Bangladesh.

Materials and Methods

The three villages in this study, Putia in Kaliganj sub-district of Satkhira district, Srifaltala in Rampal sub-district of Bagerhat district and Hogolbunia in Batiaghata sub-district of Khulna district in Khulna division in Bangladesh, were selected based on their farming systems and salinity

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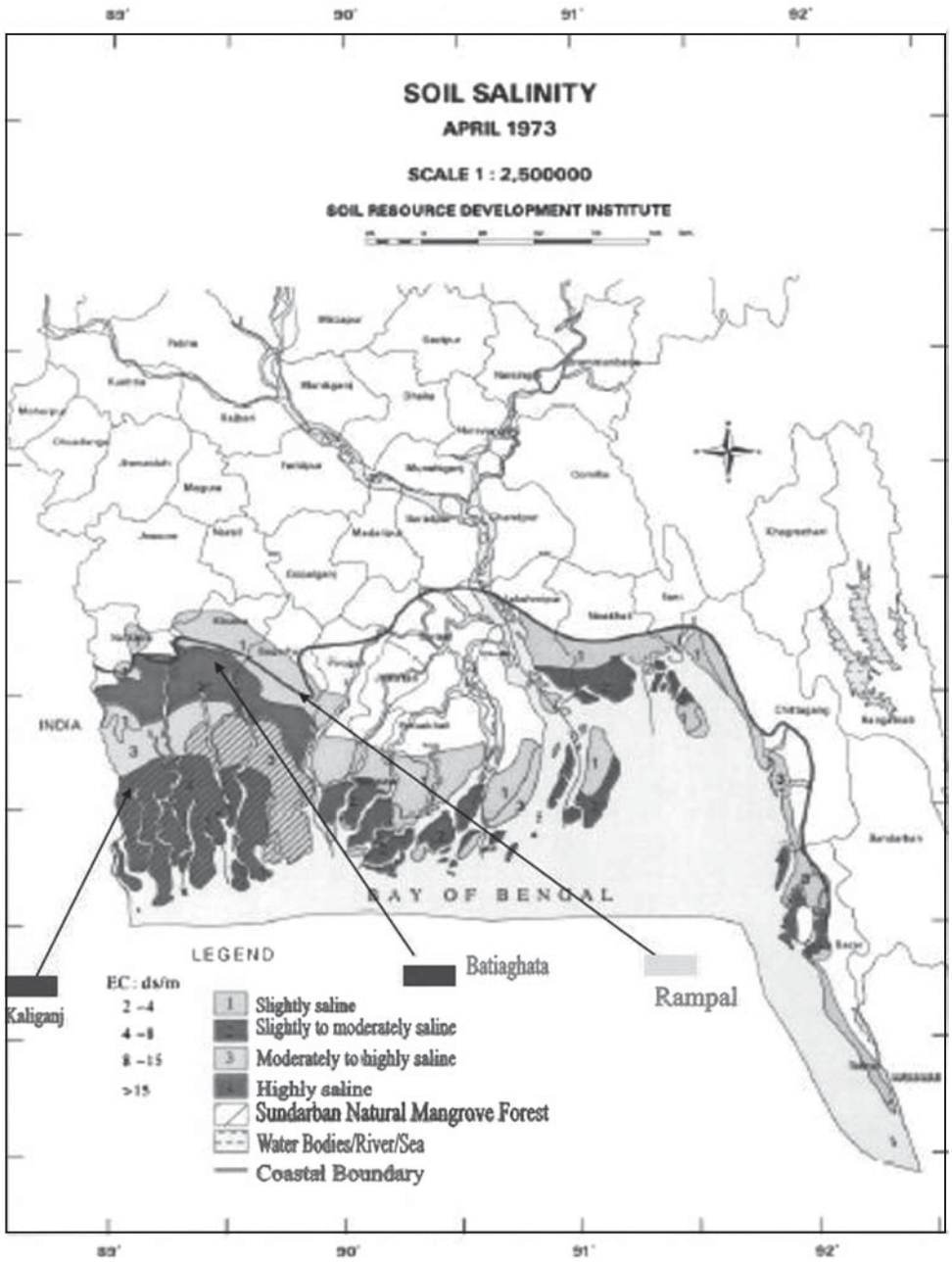

Figure 1. Salinity-affected areas in Bangladesh, 1973, including study areas.

levels (Figs. 1 and 2). Participatory rural appraisal (PRA) was used to assure wide participation of the communities and obtain more accurate data[51]. The PRA tools included transect walks, personal interviews with farmers, focus group discussions and key informant interviews. To obtain preliminary information about the study sites, salinity, livelihood, cropping pattern and food habits, each study area was visited for 10 days in July and data collected from local teachers, experienced farmers and officers of sub-district Agriculture, Fisheries and Livestock. Additional information on cultivated species was collected from five teachers at Khulna University (specialized in agriculture, forestry, soil science and fisheries) who had grown up in the study areas. A transect walk was done in each study area to cross-check information and the questionnaires were pre-tested on local farmers.

For personal interviews, a sample of 34 farmers in Putia, 43 in Hogolbunia and 44 in Srifaltala were selected. The sample sizes, based on the number of agricultural households in the sampled villages, were calculated with 95% confidence ($z = 1.96$) and 10% error margin ($e = 0.1$) by the following equation[52]:

$$n_o = z^2 p\ (1-p)/e^2, \quad (1)$$

where n_o is the sample size not corrected with the finite household correction factor, z is the level of confidence, p is

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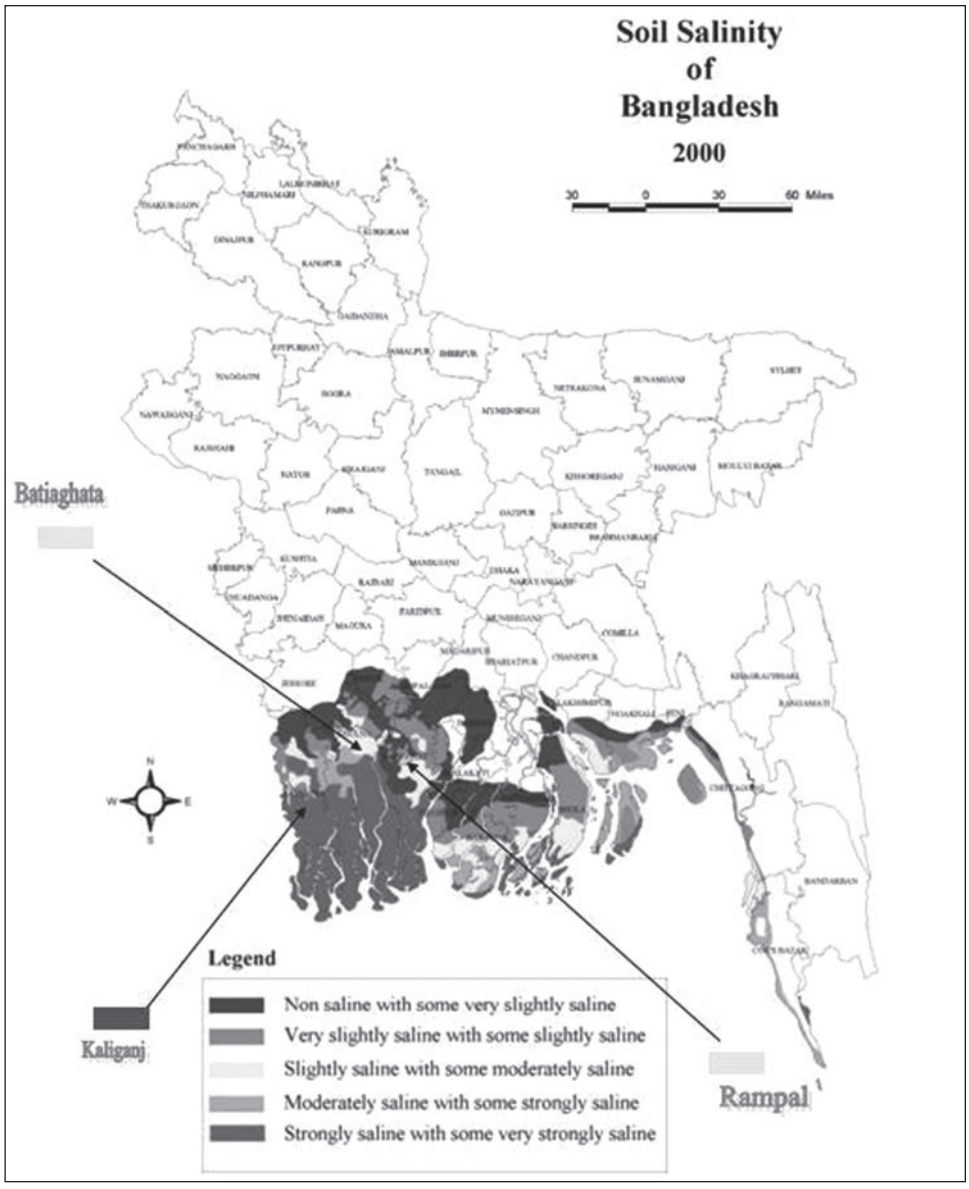

Figure 2. Salinity-affected areas in Bangladesh, 2000, including study areas.

the proportion of the households and e is the accepted sampling error.

Then the finite correction factor was applied to correct the calculated sample size[52]:

$$n = n_o N/(n_o + (N-1)), \quad (2)$$

where n is the sample size considering the finite household correction factor and N is the total number of households in the study area.

To obtain historical data from 1975 to 2006, purposive sampling was used to select respondents aged above 50 years, who had been living and engaged in farming in the area since 1975. To assure a representative sample and capture diverse views, additional selection criteria were socioeconomic condition and farm location. All respondents for the personal interviews were men. As Bangladeshi women move to their husbands' home area upon marriage, the women in the study areas could not provide historical data for that area, so to capture the women's views they were instead sampled for group discussions. All personal interviews were conducted individually in the respondents' homes, enabling observation and data verification. Semi-structured questionnaires covering the topics, cropping practices, livelihood, food habits in 1975, 1990 and 2006, and reasons for change in food habits, were used. A checklist covering livelihood situation and challenges; environment, cropping patterns and species cultivated in 1975, 1990 and 2006; perception of salinity levels; salinity effects and management; main income sources; comparison between rice and shrimp cultivation and conflicts due to shrimp farming was used for the key informant interviews and group discussions. In each study area, key informant interviews with 18 local people, including six experienced farmers, 10 school teachers, four officers of the sub-district

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Forestry, Agriculture, Fisheries and Livestock, the local leader and one imam were conducted. Six group discussions, separately for men and women, were conducted in each study area, including two mixed group discussions with 10 young and 10 elderly farmers, two with 10 elderly farmers (above 40 years) and two with 10 young farmers (20–40 years) to avoid influence from one age group on the other and cross-check information. In Hogolbunia and Srifaltala, the key informants and group discussion participants were different from the personal interview sample. However, in Putia, the entire population of elderly farmers was sampled for personal interviews, and so key informants and elderly farmers in the group discussions were the same as those for personal interviews.

The respondents perceived that the salinization in their areas started in 1975 and shrimp cultivation in 1990. The selected base year for comparison of change in salinity was thus 1975. As 15 years is considered to be a sufficiently long time interval to observe substantial changes in environmental parameters, 1990 and 2006 were selected to obtain information about the salinity-induced changes. As 1975 was close to the year of independence (1971) and there was a conflict between the people of Bangladesh and the military government in 1990, both years are thus memorable for the respondents and made it easier for them to remember historical data. Data from the individual interviews were analyzed by Excel.

Description of Respondents and Study Areas

The entire coastal area in Bangladesh, which comprises the divisions of Chittagong and Khulna, is affected by salinity (Figs. 1 and 2). This salinity increase is partly caused by shrimp farming, which has spread throughout the coastal region[53], reduced rice production and limited livestock and poultry rearing[53]. Shrimp cultivation covered 33% of the total land in Bagerhat, 19% in Satkhira and 24% in Khulna in 1994[54], and from 1975 to 1999, the area under rice production in Rampal decreased from 80% to less than 20%[55]. Of the 156 million people in Bangladesh, 38.5 million live in the coastal areas and 14.5 million live in Khulna division. The majority of the households in Bangladesh (88%) as well as in the coastal areas (91 and 88% in Khulna and Chittagong, respectively), are rural based and engaged in agriculture (64, 56 and 57% in Khulna, Chittagong and nationally, respectively). For about a third of the households in Bangladesh (38, 27 and 31% in Khulna, Chittagong and nationally, respectively), agriculture is the main income source[56]. The population of the study areas was 3000, 6116 and 2700 in Hogolbunia, Srifaltala and Putia, respectively. All the respondents were farmers born in the study areas, with mean ages from 61 to 63, and the average family sizes (5.8, 5.2 and 5.4 in Hogolbunia, Srifaltala and Putia, respectively) were similar to the national average (5.8)[57]. In Hogolbunia, the majority of the respondents (60%) were subsistence farmers, 35% also had small-scale commercial rice production and 5% got their main income from teaching or shrimp production. The majority of the respondents in Hogolbunia (70%) were only sharecropping; some (21%) owned land in addition to sharecropping and very few (9%) only cultivated their own land. In addition, all rented public land close to the river for small-scale, non-intensive shrimp production. In Srifaltala, all respondents cultivated rice intensively, commercially. A proportion of 95% had additional, intensive, commercial shrimp production, whereas 5% were day laborers and teachers. All the respondents in Srifaltala owned land and only 5% rented additional land. All the respondents in Putia had intensive, commercial shrimp and rice production, 21% also had small businesses and the rest worked as teachers, laborers, doctors and cycle/van drivers in addition to the farming. The respondents' average years of education (four in Hogolbunia and Srifaltala and six in Putia) was lower than the national average of eight[43]. In Srifaltala and Putia, the majority of the respondents (93 and 82%, respectively) were Muslim and the rest were Hindu, values that are close to the national proportions (90% Muslim and the rest mainly Hindu)[57]. In Hogolbunia, all the respondents were Hindu.

The main source of income in the study area was from shrimp cultivation related livelihood activities based on wild shrimp larvae from the rivers. The shrimp farms were mainly surrounded by low earthen dikes with small wooden sluices, which were opened from February to April to allow the entry of saline water with post-larvae shrimp and fish. In June/July, when the water in the shrimp pond reduced, the majority of the shrimps and fish were harvested and rice was planted. In Putia, which had the highest salinity level of the three villages (>15 $dS\,m^{-1}$ from March to July), the water salinity in the shrimp farms and Putia river was so high that it was used to produce salt. In Srifaltala, the salinity was high (8.1–16 $dS\,m^{-1}$ from March to May), but it was even higher at the sub-district level (14–25 $dS\,m^{-1}$). Farmers in Putia and Srifaltala cultivated shrimp and fish intensively in large farms, and in Putia they added extra salt to their shrimp/fish ponds to increase the salinity. Most of those farmers cultivate rice in separate fields allocated close to the shrimp farms. While it was common to have an additional field only for rice in Putia, this was not common in Srifaltala. Although Hogolbunia had the lowest salinity level (2–4 $dS\,m^{-1}$ from March to April) of the three villages, the salinity at the sub-district level (15–17 $dS\,m^{-1}$) was higher than in Hogulbunia village[23]. In Hogulbunia, some rice was grown together with the shrimp, and in addition there were separate fields for intensive rice cultivation. Large barriers were erected between the shrimp pond and the rice field to prevent river water from entering the fields. In all three villages, farmers grew vegetables in elevated land in their homestead close to the shrimp farm, and irrigated with brackish well water. Homestead production is common throughout Bangladesh[58], and the large species variety is vital for the livelihoods[59,60]. Despite the

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Table 1. Changes in the consumption of goat and beef meat in the study areas. P, Putia; S, Srifaltala; H, Hogolbunia.

	Goat meat									Beef					
	1975			1990			2006			1975		1990		2006	
Days/ month	P	S	H	P	S	H	P	S	H	P	S	P	S	P	S
	Respondents (%)														
0	12	2	0	15	7	2	88	80	81	15	11	15	11	77	20
1–5	65	9	98	82	55	95	12	20	16	62	60	71	64	21	20
6–10	24	50	0	3	36	0	0	0	3	24	13	15	18	0	51
11–15	0	32	2	0	2	2	0	0	0	0	9	0	7	0	7
16–20	0	5	0	0	0	0	0	0	0	0	4	0	0	0	2
21–25	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
26–29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

common practice of cultivating homesteads on elevated land, salinity still reduces the production[59,60].

Results and Discussion

Food habits

All the respondents' food habits had changed from 1975 to 2006 due to salinity increase, shrimp farming, introduction of new foods and increased income and population. Despite changing food habits, the respondents cultivated rice as the staple food and continued eating it thrice daily, as they felt a meal was incomplete without rice. The concept and daily number of meals are among the most difficult aspects of food habits to change[50], and as rice is among the cheapest sources of calories in Bangladesh, rural people first satisfy their need for rice and only buy vegetables, meat and fish with the remaining money[61]. As rice is a staple food, the increasing machine polishing, removing the protein-rich outer layer, is alarming[62]. Bangladeshi consumers prefer the non-sticky and small-grain rice varieties, without regarding the nutritive value[62]. Gender also impacts the food preferences and habits, as in the Biodiversity Use and Conservation in Asia (BUCAP) conservation project of local rice varieties where women emphasized on aroma and good eating quality while men preferred high yields[63].

Beef and goat meat

In 1975, beef was the most consumed meat in Putia and Srifaltala, eaten on average 4 and 6 days per month, respectively (Table 1). From 1990 to 2006, the proportion of respondents who did not eat any beef monthly increased from 15 to 77% in Putia and from 11 to 20% in Srifaltala. The people still consuming beef ate it when visiting rich relatives or attending ceremonies. When grazing land was converted into shrimp ponds, shortage of fodder for cattle arose and led many farmers to sell off their cattle. In addition, salinity-induced diseases made cattle rearing and beef meat expensive. As the farmers in Srifaltala cultivated their own land, they could afford to buy beef and were thus not so much affected by the shortage of cattle as in the other study areas. In Putia, the farmers did not cultivate their own land due to insecurity and lack of capital. They preferred to lease their land instead of risking that the owners of the large shrimp farms would take it by force. The farmers only received about US$60 per 2000 m^2 per year and thus could not afford to buy beef. Most people in Hogolbunia had cattle, but did not eat beef for religious reasons.

The frequency of eating goat meat declined from an average of 4 (Putia and Hogolbunia) and 11 days per month (Srifaltala) in 1975 to 1 day per month in all the study areas in 2006 (Table 1). In the same period, the proportion of respondents who did not eat goat meat monthly increased from none to 81% in Hogolbunia, from 2 to 80% in Srifaltala and from 12 to 88% in Putia. The reasons for this decrease were salinity-induced unavailability of goat meat and related high prices, as explained by a farmer in Hogolbunia: 'We used to eat goat until 1990, but now people prefer the cheaper broiler and pork. People have goats, but due to high prices they rather sell it. In 1975 people had goat meat in every ceremony, but now goat meat is rare in parties. People also eat less goat meat due to larger family size and joint families. In 1975, one kilo goat meat was sufficient for three meals, but now two kilos are not sufficient for one meal'.

In Bangladesh, farmers use rice straw, hay, bran and husks as livestock fodder, but increased salinity has reduced rice cultivation and thus also livestock production[31,64]. Also flooding, which has reduced the available grazing land and fodder[64–66], and salinization of water have caused increased livestock mortality[14]. Consequently, salinity-induced cattle diseases have led farmers in Putia and Srifaltala to sell off their cattle[27]. The total cattle production in Bangladesh has decreased[21], especially in the shrimp farming areas, where the number of households keeping cattle yearly reduced by 9% from 1990 to 1995[29,55,67–69], and many sold their cattle to invest in shrimp aquaculture[17,66]. The reduction in grazing land has

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Table 2. Changes in the consumption of milk and egg in the study areas. P, Putia; S, Srifaltala; H, Hogolbunia.

	Egg									Milk								
	1975			1990			2006			1975			1990			2006		
Days/month	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H
	Respondents (%)																	
0	0	0	0	0	7	0	6	41	0	3	0	0	3	0	0	74	91	94
1–5	9	2	0	9	11	0	71	45	23	3	2	0	3	2	0	15	7	5
6–10	3	9	0	18	16	40	15	14	74	0	0	0	0	5	0	6	2	0
11–15	15	25	23	32	21	42	3	0	2	0	0	0	0	2	0	0	0	0
16–20	21	32	72	27	30	16	6	0	0	6	0	2	15	2	12	3	0	2
21–25	21	9	2	9	5	2	0	0	0	3	0	14	3	0	7	0	0	0
26–29	0	2	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
30	32	21	2	6	11	0	0	0	0	85	98	81	77	89	79	3	0	0

caused a decline in the number of goats[55]. Deb[64] confirms that if local peasants in the coastal areas refuse to lease their land to the socially and politically powerful and wealthy shrimp farm owners, the latter inundate the land with brackish water, increasing saline water intrusion into nearby paddy fields. The subsequent losses in rice production force the peasants to lease their land to the shrimp farm owners on the latter's conditions[64].

Milk

The respondents liked milk, but monthly average consumption declined from 27 (Putia) and 29 days per month (Hogolbunia and Srifaltala) (Table 2) in 1975 to 2 (Putia) and 1 (Hogolbunia and Srifaltala) in 2006. According to nearly all the respondents (93, 91 and 74% in Hogolbunia, Srifaltala and Putia, respectively), the reason was unavailability of cattle, as described by a farmer in Srifaltala: 'In 1975 the average household had seven, eight cows and people drank milk twice or thrice daily. Due to shrimp farming there is shortage of grazing land and fodder, and fewer cattle. People have money, but as milk is not available, only rich people with cattle farms, still drink it'. Shortage of milk and cattle in the coastal areas is also documented in other studies[19]. As reduced intake of milk, which is rich in vitamin A, may cause nutrient deficiencies[19,44], the reduced cattle-raising in Bangladesh has had serious economic and nutritional consequences[34,35], especially for the children[14,15,70].

Native chicken, egg and broilers

All the study areas experienced a decline in the consumption of native chicken from 1975 to 2006 (Tables 3 and 4). From 1990 to 2006 the proportion of respondents not eating native chicken monthly increased from 6 to 82% in Putia and from 11 to 84% in Srifaltala. While all respondents in Hogolbunia still raised native chicken, very few in Srifaltala and Putia did. Some farmers in Putia and Srifaltala still reared duck after 1990, but many stopped as the shrimp owners killed the ducks because they ate the shrimp larvae. The high salinity levels in Putia and Srifaltala caused poultry diseases, watery droppings and high mortality, making native chicken rearing difficult. According to the respondents, the native chicken did not catch diseases so frequently prior to the introduction of shrimp farming. From 1975 to 2006 all study areas experienced a large decline in the consumption of eggs, which dropped from an average of 23 (Putia) and 20 (Srifaltala and Hogolbunia) days per month to 3 days per month in Putia, 1 in Srifaltala and 11 in Hogolbunia (Table 3). Salinity-induced stomach diseases, mortality and reduced growth rate and consumption of chicken is widely documented[36,55,58,71,72]. About 80% of the households in shrimp farming areas of Khulna and Satkhira faced large declines in poultry production[21,68], and the number of native chicken in Dacope, near Hogolbunia, decreased by 90% from 1995 to 2001 due to salinity-induced diseases and drinking water scarcity[69]. Large declines in the number of ducks in Srifaltala[55] and the shrimp farmers' practice of banning ducks[14,15,55] have also been documented elsewhere.

Commercial broiler production was introduced to the rural areas of Bangladesh in 1990[26], and in 2006 the respondents ate broiler on average 4 (Putia), 5 (Hogolbunia) and 8 (Srifaltala) days per month (Table 3). Most of the respondents preferred the cheap broiler to the expensive and unavailable native chicken. In Hogolbunia, the increased broiler consumption was due to lack of alternative meat sources, as goat and native chicken were expensive and beef was not consumed. A farmer in Putia said: 'People prefer to rear broiler rather than native chicken due to profits and because native chicken catch diseases when they go to the shrimp farms, drink saline water and eat harmful waste material, while broilers are reared in protected rooms.' However, the average days per month consuming poultry were stable or increased in the study areas.

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Table 3. Change in the respondents' consumption of certain foods.

	Putia			Srifaltala			Hogolbunia		
	Mean days of consumption per month								
	1975–1990	1990–2006	1975–2006	1975–1990	1990–2006	1975–2006	1975–1990	1990–2006	1975–2006
Beef	-1^{1}	-3^{1}	-4^{1}	-1^{ns}	$+2^{10}$	$+1^{ns}$	No	No	No
Goat	-1^{1}	-2^{1}	-3^{1}	-6^{1}	-5^{1}	-11^{1}	-2^{1}	-2^{1}	-4^{1}
Native chicken	-1^{1}	-2^{1}	-3^{1}	-4^{1}	-4^{1}	-8^{1}	-6^{1}	-5^{1}	-11^{1}
Milk	-1^{10}	-24^{1}	-25^{1}	-2^{ns}	-27^{1}	-29^{1}	-1^{ns}	-28^{1}	-29^{1}
Egg	-6^{1}	-12^{1}	-18^{1}	-4^{1}	-13^{1}	-17^{1}	-5^{1}	-6^{1}	-11^{1}
Fresh water fish	-3^{1}	-21^{1}	-25^{1}	-0.4^{ns}	-29^{1}	-29^{1}	-21^{1}	-18^{1}	-21^{1}
Marine fish	$+0.4^{5}$	$+17^{1}$	$+17^{1}$	$+6^{1}$	$+19^{1}$	$+24^{1}$	$+7^{1}$	$+13^{1}$	$+20^{1}$
Native oil	0^{ns}	-30^{1}	-30^{1}	-1^{ns}	V30^{1}	-30^{1}	-1^{ns}	-30^{1}	-29^{1}
Seasonal fruits	-3^{1}	-6^{1}	-10^{1}	-4^{1}	-14^{1}	-18^{1}	-6^{1}	-8^{1}	-14^{1}
Winter vegetables	-3^{1}	-13^{1}	-16^{1}	-3^{1}	-10^{1}	-13^{1}	-6^{1}	-6^{1}	-11^{1}
Summer vegetables	-4^{1}	-12^{1}	-17^{1}	-1^{1}	-3^{1}	-4^{1}	-5^{1}	-5^{1}	-10^{1}

1 = significant at 1%, 5 = significant at 5%, 10 = significant at 10%, ns = not significant, No = respondents do not consume beef.
− = reduced consumption, + = increased consumption.

Fish

Fish, a staple food in Bangladesh, is consumed by literally all people, and from 1975 to 1990 the respondents mainly depended on freshwater fish, but prices increased after the introduction of shrimp cultivation and exotic fish species. Due to larger family sizes, people could no longer afford freshwater fish and the monthly average days of eating local freshwater fish dropped significantly (Table 4) from 26 to 1 in Putia and Hogolbunia from 1975 to 2006. In 2006, the majority of respondents in Putia (88%), Srifaltala (86%) and Hogolbunia (81%) did not eat freshwater fish monthly. A farmer in Srifaltala explained: 'As local freshwater fish was abundant in 1975, people ate it thrice daily, but now people mainly produce exotic fish due to high growth rates. Shrimp farming and increased salinity have made freshwater fish rare and increased their value so only rich people can afford it. Thus if people catch freshwater fish they rather sell than eat them'. While the average monthly intake of marine fish in 1975 was close to zero in all study areas, it increased by 13, 17 and 19 days in Hogolbunia, Putia and Srifaltala, respectively, from 1990 to 2006. Exotic fish species were introduced in the study areas in 1990, before that none of the respondents ate exotic fish, but in 2006 they were consumed on average 8 (Srifaltala) and 15 (Hogolbunia and Putia) days per month.

The salinity-induced decrease in indigenous and increase in marine and exotic fish species in the coastal areas[73], partly explains the respondents' shift in food habits regarding fish. However, the total fish consumption in the study areas had declined. Fish is the major source of animal protein in Bangladesh, contributing to about 60% of per capita intake[19], and although animals and fish contribute small proportions of total iron intake (4–8%), their high bioavailability contribute to better iron uptake than that from plants[61]. Small fish species are key suppliers of crucial nutrients, such as calcium, minerals, fatty acids, vitamins[74], phosphorus, iron and zinc[75], and vitamin A, especially, from these species is important for children and lactating mothers to avoid child blindness and reduce infant mortality[75]. Thus, the decrease in consumption of small fish species is serious[74], especially considering that the current annual per capita fish consumption is 4 kg below the recommended minimum (18 kg year^{-1})[41]. The sharp decrease (90%) in natural fish catch the last 20 years[76] together with fish's increased market value[77], reduces poor people's protein availability[31], with possible serious nutritional impacts[74].

Native and exotic oils

In all the study areas, people used native oils from sesame, linseed, mustard and coconut for cooking from 1975 to 1990 (Table 3). In Hogolbunia, people were self-sufficient with sesame in 1975, but saline soil and water logging decreased the yield to the extent that most had stopped cultivating it by year 2000, as explained by a farmer: 'Sesame and mustard oil were used for cooking before 1990, and although soy and palm oil were available, people preferred the sesame oil they produced. Now, water logging and salinity make sesame and mustard cultivation nearly impossible'. The native oils, used daily by nearly all respondents in 1975, increased in price partly due to salinity-induced production decrease. In 2006, native oils had been substituted by cheaper exotic oils, i.e. soybean, which were consumed on average 29 (Putia) and 30 (Hogolbunia and Srifaltala) days per month.

Vegetables and seasonal fruits

From 1990 to 2006, the average monthly consumption of winter vegetables in Hogolbunia, Srifaltala and Putia declined by 6, 10 and 13 days, respectively, and by 5, 3 and 12 days, respectively, for summer vegetables (Tables 5

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Table 4. Change in consumption of native chicken and broiler in the study areas.

Days/ month	Native chicken									Broiler								
	1975			1990			2006			1975			1990			2006		
	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H
	Respondents (%)																	
0	3	0	0	6	0	2	82	84	2	100	100	100	100	100	100	3	0	0
1–5	91	39	0	94	0	95	18	16	58	0	0	0	0	0	0	85	16	5
6–10	6	41	0	0	4	0	0	0	40	0	0	0	0	0	0	12	66	5
11–15	0	16	74	0	19	2	0	0	0	0	0	0	0	0	0	0	18	84
16–20	0	5	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
21–25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26–29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5. Change in consumption of vegetables in the study areas.

Days/ month	Summer vegetables									Winter vegetables								
	1975			1990			2006			1975			1990			2006		
	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H	P	S	H
	Respondents (%)																	
0	0	7	0	0	7	0	9	11	2	0	0	0	0	0	0	0	0	2
1–5	6	7	0	15	7	5	44	16	28	3	2	0	9	2	5	34	0	35
6–10	3	30	7	15	39	40	29	50	65	3	2	7	15	14	47	36	2	60
11–15	18	36	37	15	43	40	15	18	5	18	11	42	9	20	30	11	0	2
16–20	12	20	47	9	5	16	3	5	0	12	21	37	12	21	16	5	0	0
21–25	15	0	7	15	0	0	0	0	0	12	11	7	26	5	0	2	0	0
26–29	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
30	47	0	2	32	0	0	0	0	0	47	52	7	29	39	2	11	98	0

and 3). The respondents in Srifaltala did not grow many winter vegetables, but bought them. According to a farmer in Putia: 'People used to cultivate vegetables commercially, but crop failures due to increased salinity and lack of freshwater for irrigation made most farmers stop commercial winter vegetable production'. Fruit trees were abundant in the study areas in 1975, but most were salt sensitive. From 1975 to 2006, the frequency of eating seasonal fruits declined by 10, 14 and 18 days in Putia, Srifaltala and Hogolbunia, respectively, and in 2006, 21% of the respondents in Putia and 37% in Srifaltala did not eat seasonal fruits monthly. As explained by a farmer in Srifaltala: 'People ate seasonal fruits daily around 1971, but now most people do not as the fruit trees' yield and quality is very low due to shrimp farming'.

Rural people in Bangladesh get 90% of their vitamin A from vegetables and fruits[78] and 50% of their iron from non-staple plants[61], thus the decreasing consumption of these commodities is alarming. Vitamin A deficiency is a public health problem, and the coverage of the government-distributed capsules to vulnerable people is not complete[16]. Thus, home gardening has been promoted[16], and this has lowered the incidences of child blindness[79]. While a home garden project in Bangladesh demonstrated a positive relation between participants' increased knowledge about vegetables' nutritional value and their vegetable production[80], people have to be made aware about their own consumption to consider health promotion messages personally relevant[81]. Thus, lack of nutrition knowledge maybe an additional reason for the respondents' declining fruit and vegetable consumption, and also cultural preferences and habits, such as palatability, cooking properties, food storage and preparation methods, influence people's choices of food plants[82].

From 1991 to 2000, Bangladesh's food production and the national average food intake increased, but the diet of the rural and urban poor did not improve. The urban population's demand for high-protein items draws produce to the market where animal products are too expensive for the poor. Thus, the diet of the poor is becoming less diverse, with less fish, meat, fruits and vegetables, and increasingly rice-dominated. Farmers, who were once

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self-sufficient in most commodities are becoming increasingly dependent on the market, and people in rural areas currently only produce 25% of what they consume[83]. The typical, rural, Bangladeshi diet is not well balanced as it mainly comprises rice (62%), some vegetables and pulses and less than 10% is protein and micronutrient-rich foods such as fish, egg, meat, milk, fats and oils[84]. Meat and milk are only consumed occasionally and in very small amounts, fish only when available and the consumption of fruits and vegetables is declining[84]. Thus, the respondents' changing food habits in Srifaltala, Putia and Hogolbunia, as well as the factors driving the changes, resembles the national scenario for rural residents in Bangladesh.

The reduced consumption of meat, milk, eggs, fish and vegetables by rural people in shrimp farming areas has serious implications for their health[14,34,86], and reduction in cattle dung for fuel has decreased the frequency of boiling water, thus increasing incidents of water-borne diseases[14]. As the lack of homestead vegetables decreases food security, nutrition and income generation[15], shrimp farming has increased the risk of food shortage and poverty by degrading soil qualities, and threatening the rice ecosystem[31]. Aquaculture products have become more expensive, and so if farmers catch high-value species (which are good protein sources), they sell them and buy cheaper products for their own consumption[86]. Food habits include foods for specific ceremonies, often to build social relations, and the availability of sacrificial animals for the Muslim Eid-ul-Azha festival is reportedly reduced[15].

Due to shrimp aquaculture's negative impacts on livelihood and environment in the coastal areas, it is increasing demands on the government to regulate this production[64] and to impose regulations for rural land-use planning together with local communities, ensuring their economic well-being and food security[31]. Alternative production systems improving soil fertility, increasing production, food consumption and income may be integrated rice/prawn cultures[87–89]. Adding the fish mola to this culture may further increase production[90], and farmers in Bagerhat practicing this system have increased their daily number of meals and intake of food like fish, eggs, meat, milk, fruits and vegetables[75].

Conclusions

The changes in agro-biodiversity, caused by salinity increase in the three study area, had a significant impact on the people's food habits. Shortage of cattle, goats, native chickens and freshwater fish species led to a price increase and reduced the consumption of these salinity-sensitive animal species. Consumption of milk and eggs decreased due to the shortage of cattle and chickens. Broilers, exotic and marine fish species and exotic oils were cheaper than the local equivalents and thus increasingly consumed by the respondents. The consumption of vegetables and seasonal fruits also declined due to lower production in saline conditions. Apart from a possible lack of sufficient amounts of food, these changed food habits may have serious nutritional impacts and increase vulnerability to diseases.

The decisions concerning which livestock, crops and fruit trees to produce do not depend entirely on the farmers. As seen in Putia, the farmers are forced to lease their land to the shrimp owners, and in both Putia and Srifaltala the farmers' ducks were killed by the shrimp owners. Salinity increases, owners of the shrimp farms and economic motives have directly and indirectly changed the farmers' food habits and may cause negative health impacts. The situation is especially serious for the subsistence farmers, i.e., in Putia, who faced reduced production and could not afford to buy food. The lack of certain foods may also have cultural and social impacts as people may lack the food needed for ceremonies used to build social relations among village members. The entire coastal area is facing increasing salinity, partly from the expansion of shrimp farming, causing a change and decrease in livestock, fish, vegetables and fruit trees produced. As documented in this study, the salinity-induced changes in agro-biodiversity indirectly changes people's food habits. Thus, if salinity continues to increase in Bangladesh, it is likely that similar changes in food habits (as outlined in this study), with possible serious nutritional and health consequences for vulnerable people, will spread.

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