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# Spiny coriander (*Eryngium foetidum* L.) cultivation in the Chittagong Hill Tracts of Bangladesh: Sustainable agricultural innovation by indigenous communities

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Spiny coriander (*Eryngium foetidum* L.) is a shade tolerant plant suited to climatic conditions found in the Chittagong Hill Tracts (CHT) of Bangladesh and which is intrinsically linked to the culture and traditions of indigenous communities who live in the region. This study, carried out in two villages in the CHT, examined cultivation techniques, productivity, contribution to household income and its role in supporting resilience to climate change. The study adopted a participatory rural appraisal approach; data was collected through focus group discussions, structured interviews and field observation. Sixty five per cent of farmers in the two villages cultivate spiny coriander; the mean plot size was 0.12 ha. The cropping cycle starts in January and continues until October. Production averaged 59, 219 kg per hectare with a net benefit of about US$51,212/ha/yr. Eighty six percent of farmers who cultivate the crop do so solely for the purposes of income generation. Good market demand for the crop means that farmers obtain substantial economic benefit from its cultivation. It also has the potential to build the climate change resilience of marginal farmers. The findings suggest that policies to support the development of this crop have the potential to enhance marginal farmers' financial capability and climate resilience.

**Keywords:** Cultivation techniques, Market potentiality, Shifting cultivation, *Jhum*, Underutilized crop, Livelihood

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The Chittagong Hill Tracts (CHT) covers about 10% (13,295 km$^2$) of the land area of Bangladesh. They are mainly composed of high hills (70%) ranging from 200-1000 m above mean sea level with hills of lower elevation hills, ranging from 15-200 m above mean sea level[1] making up the remainder (30%). In this hilly terrain a traditional cultivation system, *jhump* has long been practiced by local indigenous groups to meet household food needs. Historically this involves shifting slash and burn cultivation with a 4-5 yrs fallow period. In the last three decades, the population in CHT has more than doubled, substantially increasing pressure on land resources. As a consequence the *jhum* fallow period has been reduced to 1-2 yrs[2,3] and also there is permanent culture of some areas. Repeated cultivation of land due to the shortening of the fallow period has resulted in land degradation, soil fertility loss and severe soil erosion[4]. The continuance of *jhum* within this shorter cycle has also contributed to indiscriminate destruction of forests resulting in wider ecological degradation and loss in eco-system service[5,6]. As a result, meeting household needs in the marginal landscapes of the CHT has become more challenging. These factors alongside the intrusion of the market economy has led local indigenous communities towards the wider cultivation of, cash crops such as; *Ada* (*Zingiber officinale* Roscoe), *Halud* (*Curcuma longa* L.), *Katchu* [*Colocasia esculenta* (L.) Schott]**,** *Pape* (*Carica papaya* L.) and high value vegetables which yield better economic return either in *jhum* or permanent agriculture[7].However, it has been reported that the cultivation of crops such as *Ada*, *Halud* and others on the hill slopes causes severe soil erosion, further degrading the land and causing yield decline[4]. Furthermore, their production is believed to be affected by changes in the rainfall regime, micro-climate, and hampered ecosystem functioning due to deforestation which has occurred over the past decade. For this reason, high yielding hybrids and varieties of major crops, e.g. *Tomato* (*Lycopersicon esculentum* Mill.), *Begun* (*Solanum melongena* L.), *Pape* (*Carica papaya* L.), *Puishak* (*Basella alba* L.), *Bhuttra* (*Zea mays* L.), *Mula* (*Raphanus sativus* L.), etc., are now receiving even greater priority amongst

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farmers driven by the widely held view that such hybrids are more productive and provide better returns in terms of both cash and food than traditional crops[8]. This further contributes to the cycle of land degradation, imposing evermore pressure on the resource base of the CHT. In addition it undermines the areas historical agro biodiversity. Local crops and varieties which were traditionally grown in the area are becoming underutilized. However, amid increasing evidence of the negative environmental impact arising from the use of high yielding hybrids, and the accompanying adverse long term economic consequences this has for local communities the potential role of these traditional local crops should be given more attention. Savitha & Kumari (2016) also urged the conservation of local varieties that are fast disappearing under the pressure of hybrids[9]. Traditional crops are familiar to local communities and adapted to local agro-ecological conditions, placing less demand on the land resulting in less environmental deterioration. They play a great role in socio-economic development, nutritional and livelihood security of the local farmers and dwellers as a whole[10]. Moreover, the indigenous techniques employed in cultivating local crops in developing countries, are gaining recognition within scientific circles as offering the basis of more sustainable production in environmentally sensitive and economically marginal areas[11].These indigenous techniques might have developed through practices of indigenous communities over many years but are diminishing gradually due to modernization and overall development trends[12]. Thus an exploration of the potential of these underutilized crops in terms of climate resilience, yield, economic and nutritional value[13,14] may offer indigenous smallholder communities the basis of a more sustainable alternative than the adoption of major crops.

Spiny coriander is an example of one such underutilized crop with significant economic potential. It is a culinary, spice and medicinal leafy herb mostly grown in tropical Africa, South Asia and warmer southern parts of Europe[15]. In India, it is grown in the Northeastern states (Mizoram, Manipur, Nagaland, Assam and Tripura), Andaman & Nicobar Islands, and parts of Tamil Nadu, Kerala and Karnataka[16]. Information on the nutritional content, bio-chemical, ethno-medicinal and pharmaceutical composition of spiny coriander is well known[17,18,19]. The leaves of the plant contain 63 chemical components important for the pharmaceutical industry[16]. The crop also has many localized ethno-medicinal uses including treatment for burns, earache, fevers, hypertension, constipation, fits, asthma, stomach ache, worms, infertility complications, snake bites, diarrhea and malaria[18]. In the CHT the crop is cultivated on hill slopes and plains by indigenous smallholder communities in some areas. While scholars have begun to recognize the importance of local knowledge in the development of low cost, site specific and appropriate farming techniques for smallholders[20] specific studies remain thin on the ground. In the case of spiny coriander, although it has been cultivated by indigenous communities in the CHT for many years little research has so far been conducted on its production or associated cultivation and market practices. This study explores the cultivation techniques currently employed by indigenous communities. In addition the study also examines its productivity, market potential and socio-economic value in the livelihood practices of the indigenous communities which currently cultivate it. By doing so the study hopes to increase understanding of spiny coriander cultivation in the CHT and outline some recommendations to maintain its use in sustainable agriculture in the CHT.

## Methodology

### Study area

The study was carried out in two villages; Choto Pagli (22°35'40.70"N latitude to 92°6'25.48"E longitude) and Shapchari (22°39'27.64"N latitude to 92°7'35.43"E longitude) located in the CHT. Both areas are of hilly topography consisting of valley plains in between hills. The villages are surrounded by remnants of tropical semi-evergreen forests on which the inhabitants are partially dependent for bamboo, fuel wood, timber, tubers, and other resources. About 1570 people belonging to 304 households live in the two villages. Agriculture is the main economic activity in both areas, consisting mainly of *jhum* and rainfed agriculture.

### Field survey

The study was intended to explore the way in which underutilized crops are cultivated, used and valued within local livelihoods. In order to do so the study employed a participatory rural appraisal approach in order to gain an understanding of how members of both communities conceptualize and incorporate different crops into their livelihoods. The methods of data collection occurred in two phases, a short Focus Group Discussion (FGD) followed by twenty semi-structured household interviews in each village. A total of 14 farmers (12 male and 2 female) participated in the FGD at Chotopagli whereas 16 farmers (11 male and 5 female) participated at Shapchari. Cultivation techniques practiced by the smallholders for different crops including spiny coriander, as well as market demand, income, and the challenges smallholders faced were discussed in the FGD. The preliminary observations revealed that farmers cultivated spiny coriander on areas ranging between 0.004 ha to 0.25 ha and hence farmers were divided into three farm size categories (small, medium and large) in order to correlate production with varying farm size. Following the FGD's 40 randomly selected households were then interviewed, 20 in each village using a semi-structured survey questionnaire consisting of both closed and open questions in order to collect data on crop composition, farmers' crop preference, cultivation techniques, seed sources and associated networks, market potentialities, productivity, and contribution to household income. A crop chart was employed to document when and how farmers cultivated spiny coriander and other crops. The questionnaire also sought information on environmental issues including rainfall, temperature and drought that influence crop production as well as perceptions of change.

## Data analysis

Collected data were compiled and analyzed using SPSS to find out percentages, averages and standard deviations (Table 1). Pearson's correlation was conducted to find out the association between farm sizes, production, cost and benefit.

## Results and discussion

### Commercial orientation of spiny coriander in the CHT

Spiny coriander is commonly known as *Bilatidhonia* in Bengali and *Tanchangya* and *Chakma,* ethnic communities of the CHT call it *Borpata* and *Bagur*, respectively. It is an annual crop with a cropping cycle of 8-10 months. It is a traditional component crop of *jhum.* Historically farmers grow it along with many other crops for their household consumption only. Farmers rarely sold it in the market. In the last few years farmers in the studied communities reported that they noticed that buyers from neighboring regions were interested in purchasing coriander. Subsequently, reasonable market price and year-round demand encouraged them to expand its commercial cultivation. Presently farmers cultivate it on separate plots both on hill slopes and plains land. The study found that the majority of farmers (86%) preferred to cultivate spiny coriander, followed by *Ada* (*Zingiber officinale* Roscoe, 60%), *Halud* (*Curcuma longa* L., 50%), *Dhan* (*Oryza sativa* L., 50%), *Morich* (*Capsicum frutescens* L., 45%), *Begun* (*Solanum melongena* L., 43%), *Bilatisim* (*Phaseolus vulgaris* L.,40%), *Puishak* (*Basella alba* L.,35%) and *Pape* (*Carica papaya* L., 35%) (Table 1). They allocate a dedicated plot of a mean size of about 0.12 ha for spiny coriander. The FGD also showed that 100% of spiny coriander cultivators grow the crop to sell in the market in order to generate income. Only a very small fraction (<1% or 7 - 8 kg annually) of spiny coriander leaf production is used as a spice within the regular family diet.

### Seed sources and associated networks

There is no formal seed source for spiny coriander and hence informal seed networks meet the seed demands of farmers. The majority of farmers (96%) buy in formally sourced seeds from the local market, while only a small number (4%) collect seeds from their own harvest. Seed collection is done from selected vigorous and healthy spiny coriander plants which are left to maturation. After maturation of the seeds during the months of October to December the plants are harvested by uprooting or cutting at the collar region. The harvested plants are then dried in the Sun on a mat and threshed to collect seeds (Fig. 1). Seeds collected through this procedure are regarded as being of good quality and are sold in the local market. Farmers, sometimes, collect seeds from neighboring farmers. Saved seeds are stored in dry conditions using gunny bags. The seeds are then broadcast in the next sowing season (January-February).

### Cultivation techniques

Farmers usually start land preparation for spiny coriander cultivation in January. Farmers plough the land three times then level the soil after mixing with manure (cow-dung, Triple Super Phosphate (TSP) and Muriate of Potash (MOP)) before broadcasting seed. Farmers reported that they broadcast about 49 kg of seed per hectare. Dry straw is used as mulch after seed broadcasting. Other cultivation practices including weeding, fertilizing, watering and harvesting are

Table 1—Crops with their number of farmers and cultivated area in the smallholders' farmlands of the studied villages of CHT, Bangladesh (*contd.*)

| SN | Scientific name and local name | Farmers cultivating the crop (%) | Cultivated area per HH (dec.) | Percent of total cultivated area of the study area (%) |
|---|---|---|---|---|
| 1 | *Zingiber officinale* Rosc.; *Ada* | 60 | 38.0 | 16.26 |
| 2 | *Saccharum officinarum* L.; *Akh* | 8 | 5.0 | 0.27 |
| 3 | *Solanum tuberosum* L.; *Alu* | 8 | 12.0 | 0.64 |
| 4 | *Hibiscus sabdariffa* L.; *Amila* | 50 | 1.1 | 0.12 |
| 5 | *Cajanus cajan* (L.) Millsp.; *Arhor* | 30 | 1.0 | 0.02 |
| 6 | *Brassica oleracea* L. var. *capitata* L. f. alba DC.; *Badha kopi* | 5 | 5.5 | 0.20 |
| 7 | *Chenopodium album* L.; *Battashak* | 5 | 0.5 | 0.02 |
| 8 | *Solanum melongena* L.; *Begun* | 43 | 11.9 | 3.38 |
| 9 | *Zea mays* L.; *Bhuttra* | 8 | 11.0 | 0.59 |
| 10 | *Eryngium foetidum* L.; *Bilatidhonia* | 86 | 27.2 | 12.60 |
| 11 | *Phaseolus vulgaris* L.; *Bilatisim* | 40 | 8.3 | 2.35 |
| 12 | *Vigna sesquipedalis* (L.) Fruwirth; *Borboti* | 13 | 21.9 | 1.95 |
| 13 | *Psophocarpus tetragonolobus* (L.) D.C.; *Charkonisim* | 3 | 0.5 | 0.01 |
| 14 | *Trichosanthes cucumerina* L.; *Chichinga* | 5 | 22.5 | 0.80 |
| 15 | *Oryza sativa* L.; *Dhan* | 50 | 114.9 | 30.04 |
| 16 | *Coriandrum* sp.; *Fuji* | 5 | 0.5 | 0.02 |
| 17 | *Daucus carota* subsp. *sativus* (Hoffm.) Schübl. & G. Martens; *Gajor* | 3 | 1.0 | 0.02 |
| 18 | *Curcuma longa* L.; *Halud* | 50 | 24.6 | 8.76 |
| 19 | *Sorghum bicolor* (L.) Moench; *Jadena* | 3 | 2.0 | 0.04 |
| 20 | *Luffa acutangula* (L.) Roxb.; *Jhinga* | 5 | 2.0 | 0.07 |
| 21 | *Colocasia esculenta* (L.) Schott; *Katchu* | 18 | 29.8 | 3.03 |
| 22 | *Pennisetum glaucum* (L.)R.Br.; *Kaunchal* | 2.5 | 2.0 | 0.04 |
| 23 | *Ipomoea aquatica* Forssk.; *Kolmishak* | 3 | 0.5 | 0.01 |
| 24 | *Lagenaria siceraria* (Molina) Standl.; *Lau* | | | |
| 25 | *Cucumis sativus* L.; *Marfa* | 13 | 6.9 | 0.61 |
| 26 | *Lens culinaris* Medikus; *Masur* | 3 | 2.0 | 0.04 |
| 27 | *Pisum sativum* L.; *Mator* | 13 | 6.8 | 0.61 |
| 28 | *Ipomoea batatas* (L.) Lam.; *Mistialu* | 9 | 5.3 | 0.28 |
| 29 | *Cucurbita maxima* Duch. *ex* Lam.; *Mistikumra* | 25 | 5.3 | 1.23 |
| 30 | *Capsicum frutescens* L.; *Morich* | 45 | 4.3 | 1.39 |
| 31 | *Raphanus sativus* L.; *Mula* | 18 | 5.9 | 0.73 |
| 32 | *Carica papaya* L.; *Pape* | 35 | 21.6 | 5.40 |
| 33 | *Corchorus capsularis* L.; *Pat shak* | 5 | 0.8 | 0.03 |
| 34 | *Basella alba* L.; *Puishak* | 35 | 19.8 | 4.93 |
| 35 | *Allium sativum* L.; *Rasun* | 3 | 0.5 | 0.01 |
| 36 | *Ocimum basilicum* L.; *Sabarang* | 15 | 1.6 | 0.17 |
| 37 | *Anethum graveolens* L.; *Sakkabahor* | 3 | 1.0 | 0.02 |
| 38 | *Manihot esculenta* Crantz; *Shimulalu* | 5 | 0.8 | 0.03 |
| 39 | *Lablab purpureus* (L.) Sweet; *Sim* | 10 | 5.8 | 0.41 |
| 40 | *Brassica juncea* (L.) Czern.; *Sorisa* | 28 | 3.6 | 0.70 |

(*contd.*)

Table 1—Crops with their number of farmers and cultivated area in the smallholders' farmlands of the studied villages of CHT, Bangladesh

| SN | Scientific name and local name | Farmers cultivating the crop (%) | Cultivated area per HH (dec.) | Percent of total cultivated area of the study area (%) |
|---|---|---|---|---|
| 41 | *Sesamum indicum* L.; *Til* | 3 | 0.5 | 0.01 |
| 42 | *Momordica charantia* L.; *Tit Korolla* | 13 | 13.4 | 1.19 |
| 43 | *Lycopersicon esculentum* Mill.; *Tomato* | 20 | 6.3 | 0.89 |
| 44 | *Abelmoschus esculentus* (L.) Moench; *Vendi* | 3 | 3.0 | 0.05 |

Fig. 1—Drying of harvested spiny coriander plant for seed collection

subsequently undertaken (Fig. 2 and Table 2). A temporary structure (Fig. 2b) made of bamboo and wooden poles is placed over the plot to provide partial shade, this promotes vegetative growth[16] and suppresses weed growth. The soil is kept wet with regular irrigation as spiny coriander grows well in moist soil. When the monsoon starts in the month of May, there is generally little requirement for irrigation, but it is still needed occasionally. Weeding usually starts at 10-12 days after sowing and continues whenever necessary. Harvesting starts from April or May and continues up to October with a harvesting cycle of 20-25 days. In each cycle, an average of 740 kg coriander leaves can be harvested from 0.1 ha of land. Leaves are usually collected between 7 and 9 times from each plot. The leafy spiny coriander plants are uprooted, washed and bundled to sell in the market. After each harvest, Urea is applied as fertilizer at a rate of120 kg/ha to stimulate the growth of the remaining plants. Insecticides and fungicides are also sprayed whenever necessary.


Fig. 2—Different stages of spiny coriander cultivation; a. shade house and land preparation, b. leveling, c. fertilization, d. seed broadcasting, e. mulching, f. mulch removed after germination, and weeding, g. irrigation, and h. growing spiny coriander, i. harvested coriander, and j. drying of matured coriander

## Pest and disease infestation

In this study a total of 68 % of those interviewed reported symptoms which they described as leaf dying, rot or a combination of the two whereas 32% reported no disease. Based on their descriptions and those of local suppliers and advisory services this appear to be caused by the fungal pathogens; *Pythium, Rhizoctonia, Phytophthora* and *Fusarium*. These

Table 2—Spiny coriander production cycle in the study areas

| Activity | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Land preparation and construction of shade house | + | + | | | | | | | | | | |
| Seed broadcasting | + | + | | | | | | | | | | |
| Weeding | | + | + | + | + | + | + | + | + | | | |
| Fertilization | + | + | + | + | + | + | + | + | | | | |
| Irrigation | | + | + | + | + | | | | | | | |
| Harvesting | | | | + | + | + | + | + | + | + | | |

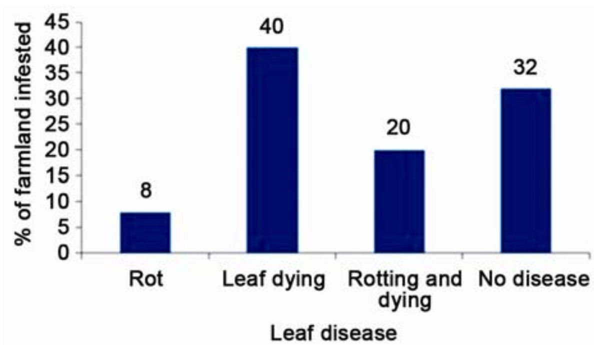


Fig. 3—Disease infestations in spiny coriander cultivation

fungal pathogens cause leaf damage and root rot in the early stages which can cause young seedlings to die (Fig. 3). Locals indicated that diseases occur if the farm is not watered regularly at optimum level. Rotting may also occur due to cold and/or excessively wet soil conditions. Local people also stated that fungal infections also occur at the mature stage if there is excessive use of urea (N) fertilizer. Farmers usually communicate with the local agriculture officer (block Supervisor), shops supplying agrochemicals and sometimes with representatives of agro-chemical companies for suggestions. Normal treatments involve the application of broad spectrum anti-fungal agents such as Bavistin (50% WP carbendazim) or Amistar Top (containing Azoxystrobin and Difenoconazole) applied as a foliar spray. According to the farmers and local agricultural extension officers the disease resistance capacity of coriander is naturally higher than other crops (eggplant, tomato, bean, etc.) grown in the study area which face frequent infestation by insects and fungi.

**Yield and market potential**

Leafy plants and seeds are the two marketable products of spiny coriander. The leaves are used for garnishing, marinating, flavoring and seasoning food whereas seeds are used for sowing in the next season. Farmers reported that leafy plants are the major product sold in the market (Fig. 4). Production costs

Fig. 4—Spiny coriander leaf bundles (price BDT 10 each) for sale in the local market

(i.e., land preparation, seed collection, preparation of temporary structures, fertilizer application, irrigation, etc.) and benefits per unit land varied with farm sizes (Table 3). The average production cost incurred in cultivating an area of one hectare of spiny coriander varied from Bangladesh Taka (BDT)1354959 to 1400262 (US$ 17000 to 18000). When cost of cultivation and benefits from sale of products are examined it appears that costs per hectare in units of different plot sizes are broadly comparable. However, larger farms enjoy better returns per unit land (hectare). The variation in spiny coriander leaf production, net benefit per hectare and net benefits per household differs significantly at $p< 0.05$ with the changes in farm size. The reasons for the improved cost to benefit ratio for cultivators of larger plots are not obvious. One possible explanation is that producers with larger plots achieve some economies of scale or marketing advantage as a result of having larger quantities for sale. It may also be related to the attributes of individual farmers, with those who cultivate larger plots being more capable in commercializing their cultivation. The production, cost and benefits received from spiny coriander cultivation in the study areas are also similar to what

Table 3—Spiny coriander yield, production cost and benefit from unit land cultivation

| Farm size (hectare) | Production per hectare (kg) | Cost per hectare (BDT)=B | Benefit per hectare (BDT)=A | Net benefit per hectare (BDT)=A-B | Net benefit per household (BDT) |
|---|---|---|---|---|---|
| Small (0.004 – 0.081) | 54931 ± 910 | 1354959 ± 41389 | 5113702 ± 82527 | 3758743 ± 100616 | 227543 ± 21161 |
| Medium (0.082-0.161) | 61957 ± 2317 | 1386567 ± 52955 | 5576100 ± 20856 | 4189533 ± 229639 | 574269 ± 46641 |
| Large (0.162-0.242) | 62868 ± 473 | 1400262 ± 41184 | 5658087 ± 42625 | 4257825 ± 83809 | 1033850 ± 20350 |
| Mean (0.12 ± 0.01) | 59219 ± 1426 | 1375019 ± 31677 | 5397699 ± 40821 | 4022680 ± 131154 | 472345 ± 53935 |

Table 4—Pearson correlation between land area, production, cost and benefit per unit land of spiny coriander cultivation farm

| Categories | Farm size | Production per unit land | Benefit per unit land | Cost per unit land | Net benefit per unit land |
|---|---|---|---|---|---|
| Farm size | 1 | 0.492* | 0.408* | 0.161 | 0.337 |
| Production per unit land | 0.492* | 1 | 0.992** | -0.176 | 0.956** |
| Benefit per unit land | 0.408* | 0.992** | 1 | -0.209 | 0.972** |
| Cost per unit land | 0.161 | -0.176 | -0.209 | 1 | -0.434* |
| Net benefit per unit land | 0.337 | 0.956** | 0.972** | -0.434* | 1 |

*correlation is significant at 0.05 level, **correlation is significant correlation at 0.01 level.

Singh *et al*. (2014) reported from a study in India[16]. Mazumder *et al*. (2010) reported a comparable yield of 54.94 t/ha using gibberellic acid (GA3) (500 ppm) and kinetin (50 ppm) as growth regulator with 40 kg seed/ha[21]. In another study, Mozumder *et al*. (2012) reported a yield of 16.23 t/ha when seeds were broadcasted at 15×15 cm spacing[22]. Farmers broadcasted seeds densely using 49kg seed/ha and hence the average yield in the study areas was higher than the yield reported by Mozumder *et al.* (2012). This suggests that broadcasting at high seed density generates a higher leaf yield. Coefficients of Pearson correlation (Table 4) revealed that farm size is significantly and positively associated with production per unit land (Pearson's $\rho = 0.492$, $n = 25$, $p \leq 0.05$) and benefit per unit land (Pearson's $\rho = 0.408$, $n = 25$, $p \leq 0.05$). It indicates that, average production received and benefits obtained from per unit land increase significantly with increase in farm size. This may be due to more effective commercialization of the whole cultivation system by larger farm holders. Farm size has poor positive correlation with cost of cultivation per unit land (Pearson's $\rho = 0.161$, $n = 25$, $p \leq 0.05$) and net benefit per unit land (Pearson's $\rho = 0.337$, $n = 25$, $p \leq 0.05$) but this is not significant at $p \leq 0.05$.

## Marketing

Spiny coriander has great market demand over the region because of its culinary use, nutritional value and medicinal ingredients[23]. Field observations revealed that wholesalers and businessmen visit farmers to buy harvested spiny coriander. In the retail market, its price is about BDT 5 per bundle of 2-3 plants or BDT 80-120 per bundle of 1 kg of plants depending on size and market condition. Generally, the farmers receive higher returns from spiny coriander when compared to other crops. This suggests that there is strong market demand for the crop. This echoes similar observations that have been reported from India[16]. Besides sales of raw leaves studies suggest that the spiny coriander also has huge potential as the source of an essential oil for which there is significant demand in the cosmetic, perfumery and pharmaceutical industries[16]. Essential oil extracted from aerial parts of spiny coriander contains higher percentage of (E)-2-Dodecenal (58.1%), dodecanal (10.7%), 2,3,6-trimethylbenzaldehyde (7.4%) and (E)-2-tridecenal (6.7%) which together form about 82.9% of the leaf oil[24,] . Currently access to foreign export markets for indigenous communities in the CHT is limited to raw fruits, vegetables and certain spices[25]. There may be opportunities to generate more revenue by exporting spiny coriander to the foreign markets in both raw and processed form as essential oil (coriander oil[26]) extracted from spiny coriander leaf.

## Changing climate, local livelihoods and role of spiny coriander

Indigenous communities are more vulnerable to climate change as compare to other section of the community because their livelihoods are more dependent on the natural environment and they are the first ones to experience, identify and adapt any climate related change[27]. During the FDG and subsequent interviews participants identified some changes in the climate pattern in the studied areas of the CHT. The noted changes include a reduction in and more irregular rainfall, increased temperature, shortening of the winter season, excessive cold in winter, sudden and frequent fluctuations in temperature in the winter and rainy season, and increased dust in the atmosphere. A majority of farmers (88%) stated that rainfall is reduced and 68% farmers mentioned increases in temperature during the summer season. Some farmers (58%) pointed to a related reduction in crop production. This is consistent with the findings of Nath *et al*. (2015) which examined the effects of climatic conditions on crops selection and cultivation in Wagga union of CHT[8]. Half of the farmers said that the drying up of streams in both winter and summer seasons has resulted in significant shortages of water for irrigation. These changing climatic patterns thus impose higher production costs as well as greater crop damage, and insect infestation. These changes have had a perceived negative impact on the capacity of local indigenous people to secure the same quality of livelihood that they previously achieved through shifting cultivation.

It was reported that spiny coriander grows well in moist-warm weather under shady condition but it is also tolerant of heat and drought conditions[28]. This crop is found to grow well in the high plain lands with sufficient irrigation and on the hill slopes of CHT without any irrigation. This suggests that the promotion and improvement of spiny coriander cultivation techniques in the study areas has the potential to provide a substantial monetary return while also building the resilience of local farming systems to climate change and other environmental changes shocks.

## Conclusion

The findings of this research provides a baseline of information concerning cultivation techniques, market potential and climate resilience of spiny coriander with special reference to its cultivation by ethnic communities in the CHT of Bangladesh. In response to changing economic and environmental conditions farmers in both of the studied communities have made significant changes in the use of the crop. While still underutilized in farmers in both communities have been successful in bringing the crop into commercial cultivation. The study thus sheds light on the capacity of small holders to engage in self driven development strategies employing a traditionally cultivated crop in the face of changing agro-ecological and socio-economic conditions. While this is an exploratory study it does at the least suggest that further research and the engagement of policy makers concerning the future development and expansion of this herb is merited and has the potential to enhance the financial and environmental wellbeing of marginal farmers in the CHT.

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