IDENTIFYING STRESS TOLERANT CROPS IN NORTH EAST INDIA

nesfas

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INTRODUCTION

This Study is linked to the IFAD-EU-CCAFS Grant of linking agrobiodiversity to value chain, climate adaptation and nutrition for empowering the poor to manage risk. The Indigenous Partnership for Agrobiodiversity and Food Sovereignty (TIP) and NESFAS decided for North East India they would work with community members to define stress-tolerant crops and assess their conservation status, erosion threats and degree of use. We decided that not to look at the nutritional value of the identified crops because of lack of capacity within NESFAS. However, issues arising out of the Study including the nutritional values of some species will be undertaken by NESFAS as a separate exercise in 2018 and 2019. TIP sent Dr. Francisco Rosado May to help the NESFAS staff to work out the survey approach which was conducted among 262 households residing in eleven villages which are spread over four districts, viz. West Khasi Hills, West Jaintia Hills, Ri Bhoi and East Khasi Hills. These areas are a part of the larger Khasi-Jaintia region (eastern part of Meghalaya) and the four districts represent the four sub-groups within the Khasi-Jaintia community. The groups chosen for this study are the Pnar-Khasi, Khynriam-Khasi, Bhoi-Khasi and Lyngngam-Khasi and can be identified on the basis of their geographical distribution. The Bhoi-Khasi are found in the warm northern lowlands (Ri Bhoi); Khyriam-Khasi reside in an area stretching from the edges of the southern slopes to the pine forest covered central plateau (East Khasi Hills); Pnar-Khasi occupy the low undulating hills to the east (West Jaintia Hills); and Lyngngam-Khasi are found to stay among the thickly forested areas to the west (West Khasi Hills). Apart from these Khasi sub-groups the study also included members of other indigenous groups like the Karbi in Sohliya village (Ri Bhoi) and the Garo in Porksai village (West Khasi Hills). Both these villages are situated in a multi-ethnic zone, which has led to the creation of a way of life, which reflects the influence of different ethnicities. After many focused discussions, the 282 farmers selected for the study made many suggestions, which have led to the main findings of the study. These findings can be divided into four categories: indigenous communities' perceptions and experience of climate change, character of the indigenous food production system, identification of stress tolerant crops and stakeholder's role in their conservation.

According to the farmers, the local climate has become highly variable with extreme events becoming more common. But at the same time, they have a robust traditional weather forecasting system, which is derived from observing the behavior of the flora and fauna

around them. The farmers identified three such weather forecasting systems during the exchanges. With the help of these prediction techniques they have been making decisions regarding crop management since antiquity and in an accelerating climate change scenario these systems are slated to become more relevant.

The farmers explained that the local food production system is based on complementarity of different cultivation methods, diversity of flora and fauna both within and outside the plots, and emphasis on sustainability. They adopt these different systems viz., *jhum* (shifting cultivation), *bun* (terrace farming), *kper* (kitchen and forest gardens) and *pynthor* (wet paddy cultivation), in varying combinations to ensure food security. Duration of cultivation, state of agro-biodiversity in the plot, differences in land preparation and female participation were reported as being the criteria along which these systems are differentiated. At the same, linkages between these different systems were also brought out during these interactions.

When asked to identify stress tolerant varieties, the farmers named 39 such crops (including their multiple varieties as well) belonging to different categories, viz., grain crops (3), fruit crops (6), tuber and root crops (9), shrub crops (1), sugar crops (1), spice crops (2) and vegetable crops (17) revealing a conscious desire on the part of the farmers to balance their cropping system to meet different dietary needs. Among these individual crops there are some, which are clearly showing signs of falling out of favour (e.g., banana, cabbage, turmeric and millet, etc) and some that are demonstrating a rise in their preference (e.g., jackfruit, sugarcane, tomato, etc). At the same time, during the Four Cell Analyses the farmers revealed that the varieties within the individual crops had varying importance, i.e., some are deemed important while others are getting demoted.

Of the 39 crops identified to be stress tolerant, the farmers reported that around 35% are highly resilient to multiple stress conditions with only 10% of the crops being very weak, i.e., unable to cope with multiple stress conditions. In terms of strategy for climate change adaptation (associated with increase in stress conditions) four categories of crops were thus identified, viz., crops that need encouragement (e.g., jackfruit, millet, bitter gourd, etc.) or guard against any decline in their importance (e.g., yam, maize, cucumber, etc.) because of their resilience to multiple stress conditions; crops whose growing importance (e.g., tomato, broom etc.) is be checked; and finally crops whose decline in favorability (e.g., cabbage, cauliflower) is to be allowed.

During the discussions, the local farmers also emphasized the important role that female farmers play in the conservation of the stress tolerant varieties (those identified by the study), especially those that are of indigenous origin (larger geographical region of South and South East Asia). The female farmers perform the role of seed-keeper in the community and have been delegated with decision making power (plot selection, crops to be grown, etc.) by the local institutions (like *seng kynthei*, *seng longkmie*, *seng samla* working with the village *durbar*). These local institutions in turn are been derived from the indigenous system of governance, especially grassroots. Finally, storytelling sessions among the local farmers brought out the fact that local community perceive agriculture (as a source of food security, livelihood, identity, communal ethics, morality) and tradition (preservation of traditional methods of cultivation and crops) to be very important for their well-being.

This study began on the 26th July with the commencement of the household survey. Dr. Lavinia Mawlong helped in the study design, which included selection of villages, sample selection criteria, and data gathering format. In this regard, we would like to thank Protasius Puwein (West Khasi Hills cluster), Bibiana Ranee (East Khasi Hills cluster), Realsing Muskor (Jaintia Hills cluster) and Redian Syiem (Ri Bhoi cluster) who helped in creating goodwill among the local community for sharing their time and knowledge. During the fieldwork stage, Pius Ranee (senior associate) and Merrysha Nongrum (junior associate) worked tirelessly to ensure that the whole exercise progressed smoothly. They supervised the data collection process and kept a constant line of communication with the local community to verify discrepancies. Dr. Cal Rangad reviewed the whole operation and provided crucial inputs that helped the study plug any gaps. But the biggest thank and gratitude is expressed towards the community members in the selected villages who helped make this study possible. They not only provided the information but also kindness and warmth, which made the whole, exercise a pleasant one. In the future, NESFAS in collaboration with REC (Rural Electrification Corporation) is looking to look more closely into the indigenous farming system with TIP, Biodiversity International NUS Programme, ICAR (North Eastern Hills Region) and the Botanical Survey of India (North East India). It is hoped that this study will act as a prelude to that.

Photographs from the field

Picture 1: Ms. Merrysha Nongrum (Junior Associate) conducting participatory discussions with the local community

Picture 2: Field investigators with a Custodian Farmer

Picture 3: Field investigator interviewing a local farmer

Picture 4: Seed-keeper in the local community

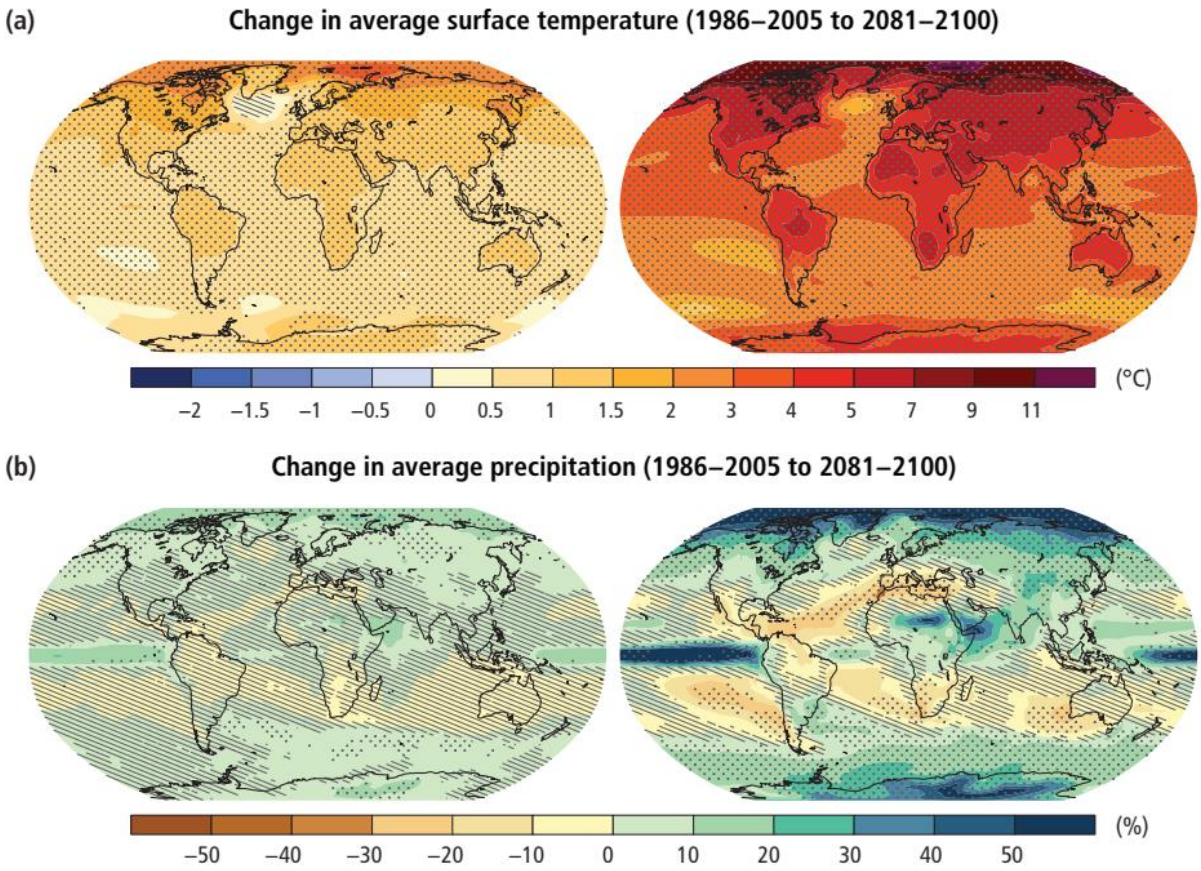
Picture 5: Crops that are being stored for planting in the future

Picture 6: One of the farmers who took part in the stud

1. General Background

Eighty percent of the population of Meghalaya is found to be residing in the rural areas (Census of India, 2011) and its indigenous food and agricultural systems are very much part of the ecosystem and local cultural fabric giving its communities a strength and resilience which are potentially very important for achieving the United Nations 2030 Sustainable Development Goals (SDGs) of food and nutrition security. The indigenous communities found in the state, viz., Khasi-Jaintia, and Garo are one of the major indigenous groups in the country. The Khasi-Jaintia themselves are one of the oldest groups of the sub-continent with imprint of their culture in this region going back more than 2000 years ago (Prokop, 2013). The food and agricultural systems they have developed is a product of their interaction with the landscape which itself is of very old antecedent.

Meghalaya is a part of the Deccan plateau which made up the ancient Gondwana shield. It is separated from its counterpart by the Rajmahal gap, which was created by the erosive work of rivers coming from the Himalayas. Although both the regions share a similar geologic history, heavy rainfall in the eastern side has led to Meghalaya having a much rugged topography and denser vegetation cover (Taher and Ahmed, 2001). This provides opportunity for a great deal of flora and fauna to thrive in the state which is in fact a part of the Eastern Himalayas Biodiversity Hotspot. The differences in elevation and topography have led to a diversity of climatic zones which has allowed a variety of agro climatic zones to exist in the State (Government of Meghalaya, 2008). Such diversity also allows a variety of crops to be grown in Meghalaya. These can vary from food crops like paddy, millet, the various wild and cultivated edible vegetables, horticultural products like citrus fruits, pineapple etc. and non food items such broom grass to name a few within the wide biodiversity found in Meghalaya. The agricultural system in Meghalaya is, in fact, a mixed type with both jhum (shifting cultivation) and settled agriculture found to exist together (Dikshit and Dikshit, 2014). Both practiced in conjunction play a very important role in ensuring food security to the cultivators and providing cash income for meeting various needs. Global climate change however threatens to disrupt the form and functioning of these modes of existence.



Source: IPPC, Fifth Assessment Report (2014)

Figure 1: Predicted changes in global average surface temperature (a) and average precipitation rates (b) (1986-2005 to 2081-2100)

The "Fifth Assessment Report - Impacts, Adaptation and Vulnerability" Intergovernmental Panel on Climate Change (IPCC) published in 2014 devoted a chapter on 'Food Security and Food Production System' and presented various scenarios (see Figure1). It looked at the regional impacts of changing climatic regime on the yield of various crops and livestock population. How these changes then affect food prices and food security is discussed along with adaptation mechanisms while giving examples of both successful as well as unsuccessful attempts (IPCC, 2014). Keeping this in mind, this brief reports looked into the local food production system and attempts to assess if the components, i.e., crops grown and associated species, can withstand the changes in local climatic regime. Overriding aim is to be able to identify certain crops & non-crops but important for food and nutrition that can be the bedrock for any adaptation mechanism that would be under consideration in the future.

2. The Purpose of the Study and its Approach

This particular study is confined to the eastern part of Meghalaya, i.e., Khasi-Jaintia Hills. This is the higher section of the Meghalaya plateau with the average elevation ranging from 900 m to 1066 m. This zone has the highest point in the state, Shillong peak which stands at a height of 1961 m. The mountain range in which this peak is located, the Shillong range, acts as the main water-divide with streams emerging from it descending to the Sylhet plains in the South and the Brahmaputra valley in the North (Taher and Ahmed, 2001). For the study, 11 villages from five separate districts representing four different cultural milieus, those of the Khynriam-Khasi, Lyngngam-Khasi, Bhoi-Khasi and the Pnar-Khasi, were selected. From these villages, 262 households were again chosen for the household survey for identifying the various stress tolerant crops grown in these areas. The size of the sample from the respective villages was determined on the basis of the size of the household population in those villages. A higher number of respondents were selected from larger villages like Sohliya and Langshongthinag (>150 households) while smaller villages like Nongtraw (< 50 households) had only few respondents.

More than 75% of the population in Meghalaya is made up on two indigenous groups, i.e., Khasi-Jaintia and the Garo. The present study has concentrated itself on the former who are located in the eastern section of the State. Within the Khasi-Jaintia again, there are sub-groups which can be identified on the basis of their geographical distribution. The Bhoi-Khasi are found in the warm northern lowlands; Khyriam-Khasi reside in an area stretching from the edges of the southern slopes to the pine forest covered central plateau; Pnar-Khasi occupy the low undulating hills to the east; and Lyngngam-Khasi are found to stay among the thickly forested areas to the west. The farmers covered in this study come from these different physiographic regions and the different indigenous groups described to be residing in them (see table 1). Apart from the Khasi sub-groups mentioned above the study was also able to include members of other indigenous groups like the Karbi in Sohliya (Ri Bhoi) and the Garo in Porksai (West Khasi Hills). Both these villages are situated in a multi-ethnic zone which has led to the creation of a way of life which reflects the influence of different ethnicities. This variety of participants has allowed the construction of a composite picture regarding the indigenous food production systems which nevertheless incorporates the diversity found in the region.

Table 1: Village selected for field study along with their ethnic and demographic characteristics

Date Of Survey	Villages	District	Ethnic Groups	Number Of Farmers	Percentage Of Female Farmers
17th August 2017	Nongriangka	West Khasi Hills	Lyngngam-Khasi	19	73.3
18th August 2017	Langshongthiang	West Khasi Hills		41	34.1
18th August 2017	Porksai	West Khasi Hills		15	31.6
31st August 2017	Moosakhia	West Jaintia Hills	Pnar-Khasi	51	68.6
1st September 2017	Samanong	West Jaintia Hills		30	56.7
10th August 2017	Liarsluit	Ribhoi	Bhoi-Khasi	29	29.6
11th August 2017	Sohliya	Ribhoi		27	75.9
25th August 2017	Khweng	Ribhoi		18	88.9
3rd August 2017	Nongtraw	East Khasi	Khynriam-Khasi	9	91.7
3rd August 2017	Dewlieh	East Khasi		12	66.7
8th August 2017	Pyrda Village	East Khasi		11	81.8

The study began with Focus Group Discussion (FGD) with the farmers deriving from the different groups residing in those diverse physiographic regions. Four Cell Analysis (FCA) techniques were used to identify the crops grown in their villages and its importance in terms of the local food system. From these 37 FGDs Custodian Farmers were identified on the basis of the breadth of knowledge that they displayed during the discussions. A follow up field visit was undertaken to the plots of the chosen Custodian farmers to confirm the information generated during the FGDs. After confirmation, key informant interviews were conducted with the custodian farmers to understand their role in conserving the agro-biodiversity in their respective areas. The focus was also on the adaptive practice they followed, information on any seed banks that are available in their area and the local marketing networks. It is important to mention that all the custodian farmers are female which highlights the importance of women in safeguarding of traditional food-production systems. After the personal interview, 11 villages were selected for household survey to assess the importance of the various crops found in the area in terms of their stress tolerance. The format for the household field survey was the outcome of the FGDs and the key informant interview of the Custodian Farmers.

For gathering household data on the stress tolerant crops found in the area, field visits were undertaken in two stages, viz., a pilot field survey and then the final field survey. A pilot survey was first done in Laitsohpliah (East Khasi Hills district) on the 26th July 2017 to help in understanding the various kinds of data that could be generated from the field for the purpose of the study. After the survey the findings were discussed and a more comprehensive schedule was designed for field visit to the selected villages. This schedule consisted of not only information on the specific crops that could withstand various kinds of stresses but also their place within the local farming system itself, i.e., production pattern and mode of consumption. This was done to help in determining the resilience of not just the crops but the whole system itself making a holistic analysis possible. The field visits started in August, 2017 and continued till the early part of September.

Except three villages, viz., Langshongthiang, Porksai and Liarsluit the majority of the farmers (>2/3rd) who took part in the household survey were females (see table 1). In some cases, a male farmer was assisted by his female counterpart during the interview, especially when it comes to identifying varieties of a particular crop. There could be three reasons for the pre-eminent position of female farmers when it comes to knowledge about the crops in the villages. Firstly, because of their cooking duties they are more observant of the manner and type of food items that are used in preparing the dishes; secondly, apart from helping in the field they also have the responsibility collect the wild edibles from the forest; and thirdly they are crucial for seed storage in their areas. This gives them an edge on their male counterpart in terms of knowledge about the crops and their various characteristics. A preponderance of female farmers during the household survey was therefore an advantage for the study.

Even after coming back from the field, contacts were regularly maintained with the farmers back in the villages in case of discrepancies or confusions. This was important in authenticating the data and impairing greater confidence into the outcomes that would be generated in the process of analyzing them. The data collected were entered in Excel datasheet and analysis was done using the tools available in Microsoft Excel. Finally, the results were then systematized and analyzed for identifying critical crops that can withstand stresses emerging out of a global climate change scenario.

3. Food Production System

The villages selected for the study represent different ecological zones with its own geo-environment setting. Village like Nongtraw, Dewlieh and Pyrda (East Khasi Hills) are located to the south of the Shillong range and have highly undulating topography flanked by deep gorges. Suitable lands for cultivation in such locations are very limited. On the other hand, villages, like Khweng, Liarsluit and Sohliya (Ri Bhoi) are found to the north of the Shillong range and have much gentler topography with small valleys nestled between low hills. A product of both erosion and deposition these landscapes are very conducive for growing a variety of crops. Nongriangka, Langsongthiang, Liarsluit and Porksai (West Khasi Hills) located to the west of the Shillong plateau, and Moosakhia and Samanong (Jaintia Hills) to its east offer different opportunities. The latter has been greatly transformed by settled agriculture and can be described as a landscape being dotted by terraces engraved on low hills with wet paddy cultivation taking place on the valleys carved by rivers flowing through the area. In complete contrast, Langshongthiang, Nongriangka and Porksai have low hills covered by thick forest with relatively smaller streams traversing their area. This diversity of settings has an effect on the system of cultivation the farmers adopt in their respective villages as well.

There are four types of cultivation systems that are followed by the farmers in the area, viz., *kper* (homestead gardening), *bun* (terrace farming) cultivation, *jhum* (shifting cultivation) and *pynthor* (settled valley cultivation). The simplest way to differentiated between these different systems is by determining whether there is any movement of the plots where crops are grown. As the name suggests, *jhum/*shifting cultivation involves the movement of plots from one location to another. An area is selected and cleared of all vegetation during the months of December and January. The fallen materials are then left to dry for around 2-3 months after which they are burned. The ash acts as fertilizer which gets settled into the soil with the onset of the pre-monsoon showers. After which the land is made ready and the seeds are planted. The crops are harvested at the end of the season and are grown for a few more seasons until the land becomes exhausted of all nutrients. When this happens, the farmer allows the land to remain fallow for a period of time until it can recuperate its fertility. In the meantime, the farmer selects another plot of land and the whole process is repeated. This movement of plots is absent in the case of *kper, bun* and *pynthor*.

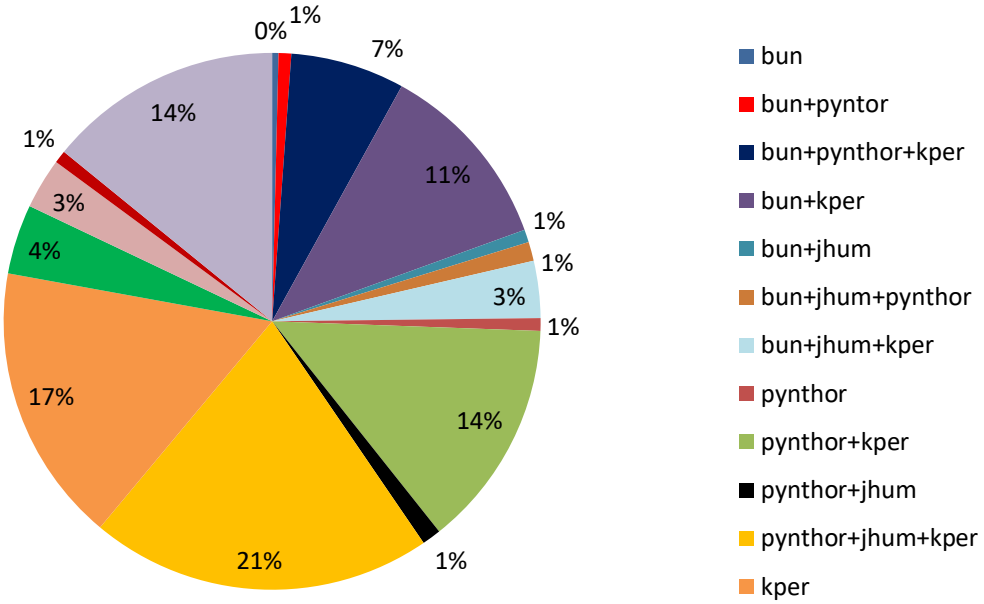


Figure 2: Farming system followed by the farmers

Bun is a settled form of cultivation in which terraces are constructed on hill slopes running across the slopes. Raised mounds are then created which are known as *bun* on which crops are grown. The space between two *buns* is leveled using cut and hill method. The vertical interval between the terraces is not usually more than one meter. Such measures help to prevent soil erosion and retaining maximum rainwater within the slopes and safely disposing off the excess runoff from the slopes to the foothills (Jeeva et al. 2006). Before cultivation starts, the *buns* are covered with plant residues which are left to dry for 2-3 months. Just like in the case of *jhum* these are then burned just before the onset of the rains so that they can act fertilize the soil. Seeds are then planted and crops harvested when they are ready. This process is repeated year-after-year in the same plot. For many farmers in the area bun cultivation is also important for the fact that it helps in preventing soil erosion which is very much associated with *jhum* cultivation. So in an area with scarce land and extensive soil erosion (southern part of Meghalaya) *buns* are a good substitute and a more ecologically friendly technique especially in the context of reducing length of the fallow period in the *jhum* cycle.

Table 2: The proportion of famers following particular combination of the farming systems identified in the selected villages

Farming system	East Khasi (% of farmers)			Bhoi (% of farmers)			West Khasi (% of farmers)			Jaintia (% of farmers)	
	Dewlieh	Nongtraw	Pyrda	Khweng	Lirasluit	Sohliya	Langshongthiang	Nongriangka	Porksai	Moosakhia	Samanong
Bun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.96	0.00
Bun+Pynthor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
Bun+Pynthor+ Kper	0.00	0.00	0.00	44.44	6.90	3.70	0.00	0.00	0.00	1.96	20.00
Bun+Kper	8.33	0.00	90.91	11.11	3.45	18.52	0.00	15.79	0.00	9.80	10.00
Bun+Jhum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
Bun+Jhum+ Pynthor	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	0.00	1.96	3.33
Bun+Jhum+ Kper	0.00	0.00	9.09	11.11	3.45	0.00	7.32	0.00	0.00	0.00	6.67
Pynthor	0.00	0.00	0.00	0.00	3.45	0.00	0.00	0.00	0.00	0.00	3.33
Pynthor+Kper	0.00	0.00	0.00	0.00	13.79	14.81	4.88	10.53	6.67	37.25	13.33
Pynthor+Jhum	0.00	0.00	0.00	0.00	3.45	0.00	0.00	10.53	0.00	0.00	0.00
Pynthor+Jhum+ Kper	16.67	0.00	0.00	5.56	24.14	29.63	34.15	26.32	46.67	7.84	20.00
Kper	41.67	100.00	0.00	5.56	27.59	7.41	7.32	15.79	6.67	21.57	3.33
Kper+Bun+ Pynthor+Jhum	0.00	0.00	0.00	0.00	13.79	11.11	0.00	15.79	0.00	0.00	3.33
Jhum	0.00	0.00	0.00	5.56	0.00	0.00	12.20	5.26	6.67	0.00	0.00
Jhum+Pynthor+ Kper	0.00	0.00	0.00	0.00	0.00	0.00	4.88	0.00	0.00	0.00	0.00
Jhum+ Kper	33.33	100.00	0.00	11.11	0.00	14.81	29.27	0.00	33.33	17.65	3.33

Kper is very similar to *bun* cultivation with the only difference being scale and proximity. *Bun* is being practiced as a substitute for *jhum* and therefore the plots are found to be away from the farmers' residence. The *kper* however is located around the premises of the farmer's house. These are small gardens in which crops are grown for mostly household consumption. They are much smaller in size than the *jhum* or *bun* plots. Unless the farmer relocate the plot remains in the same location. Many of the fruit trees are found to be grown in these plots. However apart from the *kpers* found around the residence of a farmer there is another type of *kper* which is found inside the forest. These are gardens that the farmer tends to for collection of wild edibles. Harvesting is mostly done during the period when crops grown in the fields are not yet ready to be harvested. This takes place mainly during May to July but wild edible are collected throughout the year. Therefore the plants collected not only supplement the diet of the farmers but can also be the only source during periods of distress. The existence of these gardens is very much connected with the *jhum* cycle. As the farmer moves from one plot to another leaving the initial ones to remain fallow for rejuvenation, wild edibles starting appearing in those abandoned plots. These plants are then collected by the farmers for consumption. These *kpers* can thus be considered as an extension of the *jhum* system and their health and vitality is much dependent on the length of the fallow period and continuation of the practice.

Pynthor is also a form of settled cultivation and it actually translates to flat land, which are mostly elongated valleys created by the erosive work of river followed by deposition of sediments brought from the catchments around the area. Unlike the alluvial plains found in the Brahampatura valley, these stretches of flat lands are very small. Still, these are one of the most fertile lands available and farmers practice wet paddy cultivation in them. Some choose to keep the land fallow during the dry season and wait till the onset of monsoon to start planting. Others plants vegetables in the interregnum. Unlike the *jhum* plots (most of which are in community, i.e., village durbar, owned areas) *pynthor* are the private property of the farmer. Those who do not have their own plot rent it from others.

Another way of differentiating between the different systems is in terms of crop diversity. *Jhum*, *kper* and *bun* encourage a great deal of crop diversity in their plots. In the Porksai-Nongriangka area (West Khasi Hills) seeds of various crops like beans, chillies, yam, pumpkin, mustard, cucumber, etc., are planted in the *jhum* plots during the month of March with the onset of the

pre-monsoon showers. When the seeds of these crops have started germinating, hill paddy is then planted during the month of April. Then in the same plot, sweet potato and radish are planted in the month of July. The different crops are harvested at different times of year ensuring that food availability throughout the year (see appendix 5). For example, yam and its different varieties are available till February, very close to the next planting season. *Bun* follows the same system while *kper* (i.e., the homestead gardens) have a little less diversity. Crops like seasame, paddy and chillies are not grown in *kper*. *Pynthor* are at the extreme end of this scale with mono-culture being the dominant form. Here only paddy is only cultivated during the Kharif season with the land being left fallow for the remaining period. This though means that for fulfilling all the dietary requirements farmers cannot depend entirely on *pynthor*.

In terms of land preparation as well there is a great deal of variation between these farming systems. Here again *jhum* and *pynthor* are at opposite ends. The farmers in the Nongtraw-Dewlieh-Pyrda are practice zero tillage in their *jhum* fields. This is a very important technique to minimize soil erosion in these areas characterized by steep topography and very high rainfall. In order to further conserve soil cover in such a fragile environment, potatoes are planted as cover crops before the main planting season begins in March. The other crops that follow are also by using less intrusive techniques like “dibbling” in which the farmers dig a small hole with a long knife or pointed stick and sow seeds with a minimum tillage. For planting tubers, hoeing method is adopted. This practice is replicated in regards to land preparation in *bun* and *kper* as well. In comparison to such minimal impact strategies, preparation of *pynthors* for paddy cultivation requires a greater degree of involvement and impact. Farmers in Moosakhia-Samanong and Sohliya-Khweng-Liarsluit area, use draught animals to plow the land in preparation for the planting of paddy. Some farmers even use power tillers for the purpose. In order to maintain the fertility of the *pynthors* farmers in Moosakhia-Samanong also apply a lot of organic manure especially those derived from cow, pig and goat. Of these, cow dung is the most important with cowsheds being built close to the *pynthors* for ease of transporting the manure to the fields. In Sohliya-Khweng-Liarsluit farmers however choose to keep the land fallow after paddy has been harvested to allow it the time to recuperate for next year cycle. This method however seems to have come under stress, especially in Sohliya and Liarsluit where some farmers have reported of using fertilizers in their plots to maintain fertility. Pesticides are also used for crop protection. In *kper* and *bun* lesser intensification is observed. In these plots farmers would collect the biomass,

allow it to decompose for a couple of months, chop it into smaller pieces after the period, then mix it with manure (derived from cow, pig, chicken) and finally apply it to the field. Here no synthetic fertilizers are used. In *jhum* no such preparation is required as the plot is burned before the first round of planting begins with the ash fertilizing the soil. In the Nongtraw-Dewlieh-Pyrda area, fertility of the soil is further maintained by planting cover crops like potato, and performing an activity called *ka-ot-kdait* – which means cutting down a particular grass called *kdait* and using it for mulching. The weeds also are useful for the purpose with those collected during June and July being turned into manure and applied to crops like sweet potato in the month of September. Farmers also collect the leaves of tree known as *diengphyllut* (*Albizziachinensis*) to provide nutrients to the soil. And as for crop protection, rather than pesticides, the biodiversity in these farming systems, viz., *jhum*, *bun* and *kper* perform the role of pest control. Insects like the praying mantis known as *niangryntoh* are very important in this regard. These farming systems can therefore be also differentiated according to the intensity of the application of inputs with farmers choosing more less intrusive techniques in *jhum* while *pynthor* at the other end requiring a great deal of alteration to the landscape and the biodiversity.

There is still another way in contrasting the different systems found in the area. In terms of gender equity *pynthor* are again at a disadvantage when compared to other systems especially *bun* and *kper*. *Pynthor* are highly technology intensive requiring if not machinery but draught animals to prepare the field for planting of seeds. For this reason, women are normally kept out of such operations. On the other hand, *bun* and *kper* are easier to cultivate and women in many cases have stated that they do not need the help of men for preparing and taking care of these fields. As already mentioned collection of wild edibles from *kper*s in the forest is mostly undertaken by women. This creates a distinction between a pynthor which is a male-centric system against a more female-participatory *bun* or *kper* based system.

In general, the farmers mostly used a two field system. In practice, though, they may employ various combinations which may vary from a single system, purely *jhum*, *kper*, *bun* or *pynthor* to a combination of all types (see figure 2). But as explained in the beginning the villages selected are located in different geo-environmental settings. Those diverse conditions will likewise provide dissimilar opportunities as well as distinct constraints. As such the kinds of systems the

farmers adopt in different villages would also vary accordingly. And indeed this is what is found (see table 2).

The villages of Dewlieh, Nongtraw and Pyrda (East Khasi Hills) hardly have any *pynthor* and they mostly grow crops in their *kper* and either *bun* (Pyrda) or *jhum* (Dewlieh) (see figure 3). Being located in an area characterized by highly rugged topography with deep gorges surrounding the whole area, flat land is highly scarce. Farmers are therefore compelled to clear the slopes (which can accelerate soil erosion) and plant their crops on them. In this regard, Pyrda have changed their farming system from a previously *jhum*-based system to *bun* cultivation. Nongtraw, on the other hand, have taken a completely different trajectory altogether. They are greatly dependent on crops grown in both the *jhum* and their *kpers*. This is not so with the farmers from the other districts.

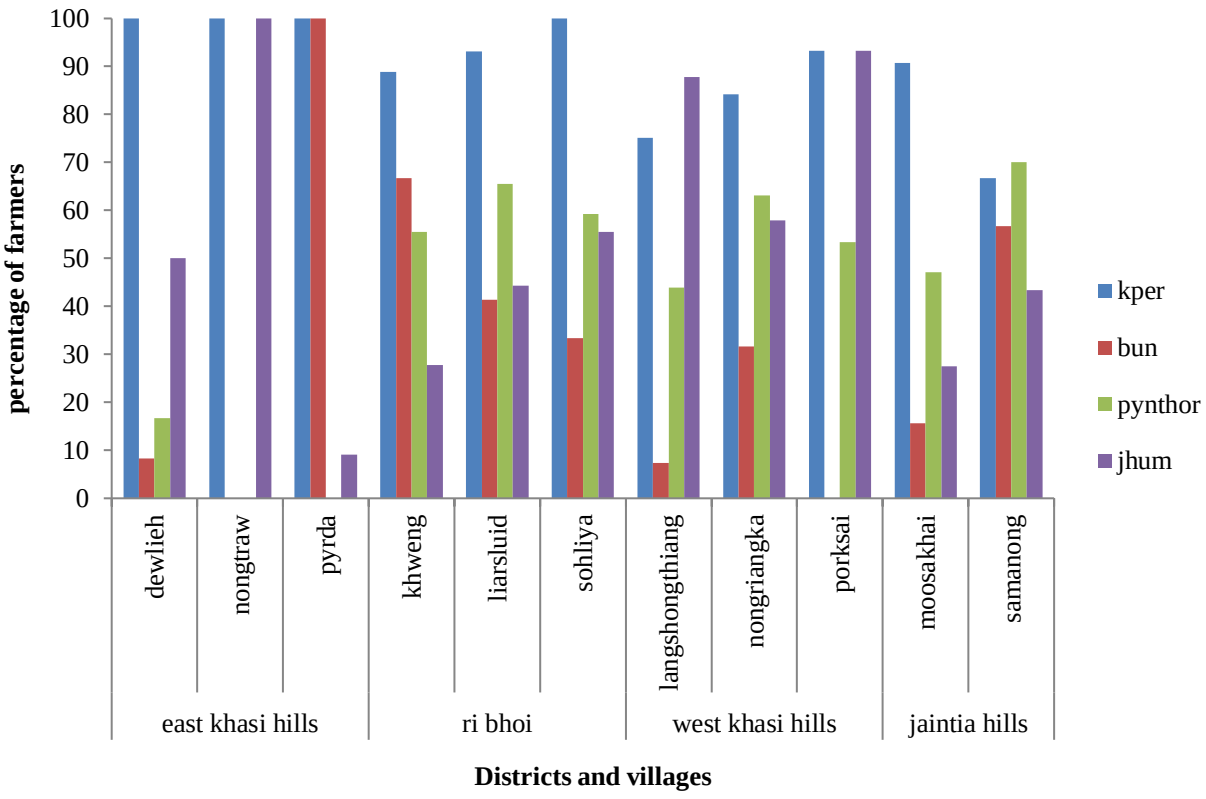


Figure 3: Farming systems adopted by the farmers in the different villages

Farmers from Ri Bhoi (Sohliya, Liarsluit and Khweng) and Jaintia Hills (Moosakhia and Samanong) follow the *kper-pynthor* based system (see figure 3). The villages in these two

districts have plenty of flat land available. The low lying hills in these districts have elongated valleys between them which is utilized by the farmers to grow various crops, mostly, paddy. The slopes above these valleys are then used for either *bun* or *jhum* cultivation. The villages in these two districts are in fact well-endowed in terms availability of agricultural land. The villages in West Khasi Hills (Langshongthiang, Nongriangka and Porksai) also have plenty of land. But these are under thick natural vegetation. So although *pynthor* is available, *jhum* is a more common strategy (see figure 3). Langhonthiang have informed that they are able to keep the land fallow for more than 10 years after a period under *jhum*. The lack of this option might have forced Pyrda to change to a *bun*-based system, while for the farmers of this district, except in Nongriangka, *bun* is almost absent from their farming system.

However it would be a mistake to consider these different farming techniques, *bun, jhum, kper* and *pynthor* as being separate and having no connection to each other. They can be understood in many ways. One approach is to arrange them in a continuum which begins with *jhum* and ends with *pynthor*. The constant movement of plots which is associated with *jhum* is moderated by the presence of *kper* who are a stable feature of the household's food production strategy. These *kpers*, whether around the premise of the farmers' house or in the forest, are the immobile plots to which the farmers constantly return to irrespective of the mobility of the *jhum* plots. With time as the jhum cycle starts getting shorter *bun* cultivation techniques get incorporated into the food production system. These are first practiced in the abandoned *jhum* plots that in time become permanent. At the other end of the spectrum are *pynthor*. These are permanent fields which begin in the valleys and slowly move up in the form of terraces cut across the slope. While this linear trend can be observed the current reality is of a system in which all the different farming systems are incorporated to ensure food sufficiency for everyone in the village (see figure 3). Productions in *jhum*, *bun* and *pynthor* have to be supplemented by items grown or collected from the *kpers*. These again would not exist without the *jhum* plots that had been abandoned by the farmers as they search for new locations for cultivation. *Buns* are but an evolution of the *jhum* plots that in many cases still exists in conjunction with the former to supplement production. While *Pynthor* makes the cultivation of wet paddy (staple diet of the local population) possible, for acquiring vegetables and wild edibles either *jhum* or *bun* and *kper* have to be practiced alongside. To summarize, it can be stated that the unity of all these different farming systems form the overall local food production system which has emerged by taking into consideration not just the

constraints and opportunities provided by the geo-environmental setting but local food security requirements as well (see figure 4).

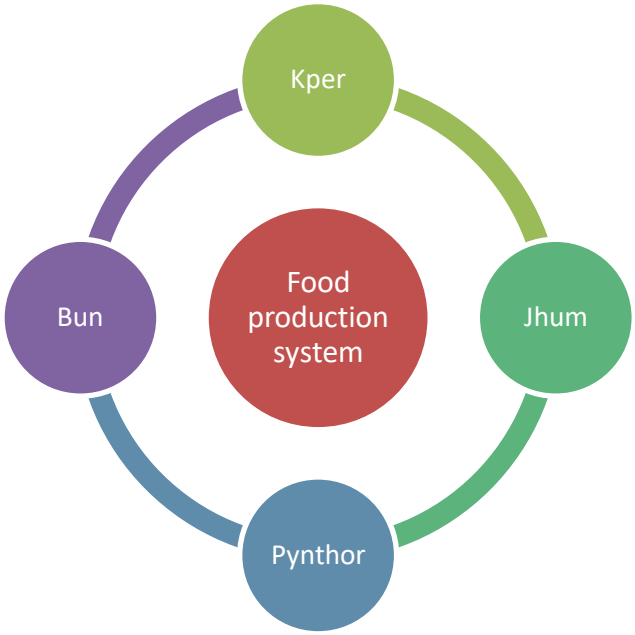


Figure 4: The components of the food production system in the study area

Whatever combination the farmers adopt there are two common features that are discernible. First of all, all of them have *kper* as an important part of their agricultural strategy. This reiterates the importance of women to the food production system and reveals the awareness among the farmers about the need to ensure household food security. Some of the crops grown in these *kper* are sold in the market but a good part of it is actually consumed by the farmer's themselves. This helps the farmers insulate themselves from the vagaries of the market. The market, nevertheless, is important which brings to the second commonality. The second similarity between the different farmers in all the villages is that all of them produce crops for sale in the local markets. For the farmers from East Khasi Hills the important markets are Sohra, Laitryngew and Shillong; for those from Jaintia Hills it is Ummulong, Jarain and Jowai; Shillong and Bhoirymbong are the main markets for farmers from Ri Bhoi; and for West Khasi Hills farmers the take their produce to Riangdo, Shallang and Umdang. These local markets however are not just sites of exclusive economic transaction. Their form and operation is very influenced by the local society and polity.

Markets in the Khasi-Jaintia cultural region generally follows an eight-day cycle following the traditional eight day calendar of the Khasis. Farmers follow this calendar to make decisions regarding the sale of their produce. In the past, with the *Syiems* or the traditional chieftains not being allowed to impose any taxation on the common people, duties on the products that are sold in the markets was the only source of income for the tribal chiefdoms that dotted this region (Gurdon, 1914). This system has continued to the present times with the District Councils established in the wake of the adoption of the Sixth Schedule collecting their share from these local markets. The importance of these local markets within the cultural fabric of the region has been alluded even in the folktales wherein animals were also believed to have held their own weekly markets (Rafy, 1920). For the indigenous people, these markets are also spaces of reverence. For followers of the Khasi-Jaintia traditional religion (indigenous faith), Ïewduh (an important market in Shillong for the farmers from throughout the entire Khasi-Jaintia region) is not merely a business centre but a holy ground where the *Hima* Mylliem (erstwhile Khasi princely State) has been offering an annual sacrifice to the Shillong deity (name of the City is derived from him) since the genesis of the market (Mawrie, 2017). These local markets (where the produce of the local farmers are sold) are not just economic institutions impressed on the landscape but important socio-cultural spaces reflecting the local culture. The food production system in the area cannot be understood in isolation from the geo-environmental setting and the socio-cultural configuration of the Khasi-Jaintia polity. All of them come together to create a whole which is the articulation of the indigenous way of life.

4. Indigenous Communities' Perceptions and Experience of Climate Change

Climate change is often studied by analyzing the time series data of the different climatic factors, most common of them being rainfall, precipitation. Such kinds of data are collected via meteorological observatories that have been set-up in different corners of the Earth. Such stations were first set-up in India during the 18th Century by the East India Company. Among these the one in Cherrapunjee has been collecting weather data for more than a century. Other stations have been established in different parts of the State but they are still few and far between. In fact, many areas still do not have any observatories and therefore there is difficulty in understanding any changes that may have occurred in the local weather conditions. The weather data that is available for the state and the districts cannot be

generalized for all the smaller areas. Taking cognizance of this difficulty the study decided to instead focus on the perception of the local farmers on any changes that may have taken place in the local weather system. Almost 60% of those selected were female and had attained an average age of 40 years. Having been engaged in agriculture since a very young age, they are highly sensitive to the changes in the seasonal rhythm. So any changes in the local weather system will be recorded by them as an unusual year or the years that market the start of unusual weather patterns. And indeed this was found to be case.

Table 3: The period since changes in local climatic pattern started becoming evident according to the farmers in the villages

Serial number	Village	Commencement of abnormal weather pattern	Average age of respondents
1	Dewlieh	Since mid-1990's	42.08
2	Nongtraw	Since early 2000's	46.44
3	Moosakhai	Since late 1990's	39.59
4	Samanong	Since early 2000's	35.43
5	Porksai	Since mid-1990's	40.87
6	Langshongthiang	Since mid-1990's	40.68
7	Liarsluit	Since early 2000's	36.10
8	Pyrda	Since early 1990's	46.00
9	Khweng	Since mid-1990's	44.39
10	Nongraingka	Since mid-1990's	38.16
11	Sohliya	Since early 1990's	34.22

People in Dewlieh, Porksai, Langshongthiang, Khweng and Nongriangka reported that the weather starting becoming highly variable after the mid-1990; for those in Moosakhia it was the later part of the 1990's while those in Pyrda and Sohliya it was during the early 1990's. The remaining villages, i.e., Nongtraw, Samanong, Liarsluit, started to experience a change from the past weather pattern from the early 2000's. Notwithstanding these differences in recollection, it is reasonable to suggest that the changes in the local climate system started emerging from the later part of the 20th century which has become more intensified in the present century. This is corroborated by the memory shared by the people of certain years which had highly abnormal weather conditions. Farmers in Moosakhia talked about the extreme weather conditions they experienced in 2002 and 2009. During these years, their area experienced severe storms which were accompanied by hail and very heavy rainfall. The subsequent years, 2012 and 2014 in contrast were marked by severe droughts. A couple of years later, farmers in Langshongthiang

complained of very heavy rainfall which damaged their crops. In the Porksai-Nongriangka area severe frosts in 2008 and 2018 were responsible for massive crop losses in the area. Apart from extreme events becoming a regular feature of the local weather system, certain long term trends are also apparent. For example, according to the farmers in Moosakhia and Pyndengmulieh (neighbouring village of Porksai) winters are getting warmer in their areas. The recollection of extreme events and observation of rising temperature fits very well with the predications of an accelerating climate change scenario.

These long terms trends have a great bearing on the short term weather conditions on which farmers make their decision regarding planting and harvesting of crops. In this context the farmers in the area have developed a form of indigenous weather forecasting system taking notice of the behavior of plants/animals and signs noticeable around their environment. Some of the most prominent ones are found in the Nongtraw area where the local farmers have developed three such warning systems. The first system is the observation of a certain phenomenon called *mangkariang*. These are yellow coloured spots which appear on the rocks along the river bank. By noticing the height of these spots farmers can make prediction of the rainfall pattern. If the marks are higher, it is an indication of impending very heavy rainfall which would lead to extensive damage to crops. This is a warning for the farmers to begin the harvest early. If the marks are lower, less rainfall is expected which the farmers take as a sign to allow the crops to remain in the field for a longer period. The other warning system is the inspection of the foliage of the bamboo groves. If the leaves in these groves start falling, it is a sign to start planting potato in the plots. This takes place during the month of February. This timing is very important because it is only after the potatoes are planted that other crops like millet, pumpkin, cucumber, etc., can follow. The last system in place to predict short term weather is observing the movement of worms known as *wieh rong*. When the first thunderstorms strike the area during the month of April (pre-monsoon season) these worms start their ascend upslope. This is taken as an indication of incoming very heavy rainfall in the area. In such a scenario, planting of seeds of crops like yam, tapioca are to be commenced as soon as possible. The worms move downward during August-September (end of the monsoon season) when the last thunderstorms hit the area. In this case, rainfall is expected to begin receding from the area. Here again, certain details are important. Worms that are found in the windward side (south facing slope) are the first ones to migrate down with those in the leeward side (north facing slope) to last to do so. If these worms

are found to be stuck somewhere halfway along the slope, it is a sign of rainfall continuing for the time being. And only when all the worms have reached the foothills then the weather will start drying up. The local farmers may not be responsible for global climate change which is affecting their local weather system but they already have an indigenous weather prediction system which allows them to adapt their farming practices in accordance to the changes.

Other studies done in these areas have also confirmed the trend of changing climate pattern in the area. In a study conducted by the Platform for Agro-biodiversity Research (PAR) (2016) have been found that irregular and erratic to have cause negative impact on the crop yield in the Lyngngam areas, i.e., West Khasi Hills. On the one hand, while intense floods are causing damage to the paddy in the *pynthors*, on the other hand, water shortage during dry months is becoming more pronounced. What all this suggests is that the process of climate change (as being experienced by the farmers) in the area is intensifying. This puts great pressure on them since such changes can have a very devastating impact on local agriculture. Many farmers have complained of pests of becoming an increasing problem in many of the areas. Whether this is also associated with the changing weather system is difficult to determine. But the impact on the farming community is unambiguous. During such abnormal years as mentioned above, crops like ginger got spoilt in great quantities resulting in massive financial loss to the people (ginger is one of the most important cash crops of the State). This makes adaptation to a changing climate scenario very essential.

There are two ways in which adaptation to climate change can take place, viz., short term and the long term. Short term adaptation requires being aware of the kind of climatic changes that it may entail and the adaptation to the farming practices that it would involve. On this aspect, there is already a well developed indigenous system of weather forecasting which enables the farmers to predict and adapt their farming practices to the changes in short term weather conditions. For long term adaptation, the types of crops the farmers choose to grow become very critical in the process. If the crops can tolerate a high degree and variety of stress, such crops have a very high chance of survival. Continued dependence on crops that cannot do so can threaten the local economy which is greatly dependent on returns generated from agriculture. Therefore, it is very important to find out (a) the crops that can tolerate a variety of stress and (b) the degree of stress

they can tolerate. The remaining report will be focused on finding the answers to these two questions.

5. Assessing Stress Tolerance at Species, and Variety Levels

When people in the different villages were asked to name all the crops that they consider to be highly tolerant to the various kinds of stress, they name more than 100 such crops. However, on closer examination it was found that Most of the time, these are just varieties rather than a common single crop. For example, *phan lieh, phan saw, phan pyllun, phan teret,* and *phan syntiew* are part of the potato family (*Solanum tuberosum*). Even then the number of such instances is very few. Of the more than 100 crops identified few were again found to be mentioned very sparsely. It is very difficult to include such crops because of their very little mention. Therefore, if particular a crop is mentioned by less than ten farmers (just over 1%) it was not included in this list. When all these discrepancies were removed, 39 crops were selected which had been identified by the farmers in the area to be tolerant to the various kind of stresses, viz., heat, rain, cold, frost, drought, storm and flood.

Still the crops that have been omitted for present consideration can be of great value in case of a follow up study wherein their importance to the cropping system and their nutritive value is to be investigated (something which this study has been unable to do so because of lack of expertise). Therefore their full details have been provided in appendix 1. And even though they have not been used for preparing the final list of stress tolerant crops identified by the farmers, they still provided great insights into the variation among the varieties regarding stress tolerance. They have been included as part of the discussion below but will need further investigation in the future.

The crops that have been selected have been classified according to use/agronomic scheme. In this manner six groups were identified, viz., vegetable crops, tuber and root crops, grain crops, sugar crops, shrub crops and spice crops (excluding those that belong to the second group). Since fruits have also been identified by the farmers to be important stress tolerant species they have been included as fruit crops in the list. Of the 39 crops that were identified by the farmers as being stress tolerant the maximum number of those are vegetable crops (e.g., mustard, bean, pea, cabbage) followed by tuberous/root (e.g., yam, tapioca, sweet potato) and fruit (e.g., pineapple,

papaya, jackfruit) crops. Grain, spice, shrub and sugar crops have less than five varieties in the list. In short, more than 1/3rd of the varieties that were identified to be stress tolerant are vegetable crops.

Table 4: Stress tolerant crops identified by the farmers in the study area

Type of crop	Crops	Scientific name	Percentage Of Farmers
Grain crops (3)	Maize	Zea mays	45.42
	Millet	Eleusinacoracana	16.41
	Paddy	Oryza sativa	47.71
Fruit crops (6)	Soh Phlang	Flemingia procumbens	3.82
	Pineapple	Ananas comosus	20.23
	Papaya	Carica papaya	7.25
	Mango	Mangifera indica	4.58
	Jackfruit	Artocarpus heterophyllus	6.11
	Banana	Chenichampa spp	18.32
Sugar crops (1)	Sugarcane	Saccharum officinarum	4.96
Shrub crops (1)	Broom	Thysanolaena maxima	29.77
Spice crops (2)	Sesame	Anisomelesindica	6.11
	Chilies	Capsicum annuum	30.53
Tuber and root crops (9)	Yam	Dioscorea alata	67.18
	Tapioca	Manihotesculenta	22.90
	Sweet Potato	Ipomoea batatas	40.84
	Radish	Raphanus raphanistrum subsp. sativus	16.41
	Potato	Varieties of Solanumtuberosum	40.84
	Ginger	Zingiberofficinale	27.86
	Edible Tuber (arrow root)	Maranthaarundinacea	12.98
	Turmeric	Curcuma longa	9.54
	Carrot	Daucus carota subsp. sativus	13.74
Vegetable crops (17)	French bean	Phaseolus vulgaris	15.27
	Bamboo Shoot (Bamboo)	Bambusa vulgaris	5.34
	Cucumber	Cucumis sativus	48.09
	Cauliflower	Brassica oleracea var. botrytis	10.31
	Buri	Phaseolus vulgaris spp	6.49
	Bean	Phaseolus vulgaris	21.76
	Tomato	Solanum lycopersicum	8.40
	Squash	Cucurbita	21.37
	Pea	Pisum sativum	22.14
	Mustard	Brassica juncea	48.74
	Ladies Finger's	Abelmoschus esculentus	3.82
	Gourd	Lagenaria siceraria	5.34
	Garlic	Allium sativum	12.98
	Cabbage	Brassica oleracea var. capitata	14.89
	Brinjal	Solanum melongena	17.56
	Bitter Gourd	Momordica charantia	5.73
	Pumpkin	Cucurbita pepo L.	56.11

However, it is a tuberous/root crop Yam, which has been identified as the most widespread stress tolerant crop (more than 2/3rd of the farmers) with the least common being lady finger (less than 5% of the farmers), a vegetable crop. This still does not give an accurate picture regarding the

choice of stress tolerant crops among the farmers in the area. Because of the varying sizes of the villages that have been selected for the study (ranging from >150 households in Sohliya to <50 households in Nongtraw) it is very difficult to generalize just in terms of absolute numbers. For example, certain crops like squash have been mentioned by less than 25% of the farmers as their choice for being stress tolerant. However, the particular crop is grown in nine out of the 11 villages making it a very important crop. The inverse could be true. Therefore, in order to truly ascertain the importance of a particular stress tolerant crop, it is important to consider its pervasiveness not just throughout the study area but within the individual villages as well. To achieve this, a framework has been designed (see table 5) which can identify crops that are have found universal acceptance in the region for being stress tolerant varieties. At the same time, crops that are considered to be stress tolerant but are restricted in terms of their geographical scope are also recognized. Such an exercise is important to understand the perception of the farmers in terms of the choice of crops that they want to grow in their plots. This gives an insight into why certain crops are preferred than others, notwithstanding their capacity to withstand various types of stresses.

Table 5: Framework for determining the importance of stress tolerant crops among the farmers in the various villages

Category	Degree Of Importance	Crop cultivation	
		Village	Households
I	High Importance	>50%	>50%
II	Important	>25%	>25%
III	Minor Importance	≤25%	≤25%

If a crop is grown by more than 50% of the villages (i.e., 6 villages) by more than 50% of the farmers in all those villages it is considered to be a very important crop. However, those crops that are grown by less than 3 villages with less than a quarter of their farming community considering them as stress tolerant are recognized as being of minor importance. This, though, does not mean that these crops are not important. The fact that they were identified by the local farmers is evidence of their significance as stress tolerant varieties. The inclusion of crops in this category (minor importance) is only due to their restricted geographical distribution. As already discussed in the beginning, the selected villages are situated within differing geo-environmental settings. This could very well be the reason for the concentration of these crops in a few areas

only. However, when judged regarding their ability to withstand stress some have very high tolerance capacity. For example, edible tubers (as will be seen in the later section) have been found to be one of the most stress resilient crops in the different villages. So when discussing the crops that have been identified to be of minor importance it only means that they have a limited spread, and nothing more. And lastly, the final category is made up of those crops which are widespread in the area but have not achieved universal acceptance as being important stress tolerant varieties. Crops in this particular category in time can move up or go down depending on their intrinsic ability to withstand the various stresses (for ensuring food security) and/or economic viability (for attaining financial security).

Of the 39 crops that have been identified as being stress tolerant, only three crops, viz., pumpkin, maize and yam have been found to be considered as being very important by the farmers in the different villages. These three individual crops consist of their respective varieties as well. These include the three varieties of maize viz., *hadem balieh, hadem manir* and *hadem basaw*, five varieties of yam, viz., *riew thahmah, riew bahjah, riew saw, riew iong*, and *riew bam im*, and three varieties of pumpkin, viz., *pathaw*, pathaw *lieh* and *pathaw saw* grown in the Porksai-Nongraingka-Langshongthiang area (for detail on other villages see appendix 5). All of these varieties have been reported by the farmers to be of indigenous origin. This is a testament to the resilience of the indigenous system of knowledge transfer which has made the continuation of these local varieties possible. In this regard the role of female farmers is very important. All the Custodian Farmers who were identified after rounds of FGDs were female. They not only demonstrated tremendous knowledge about the local food production system but also displayed the earnest desire to pass that knowledge to the future generations, like their parents and grandparents did with them. As such, it is appropriate to speculate that these varieties will continue to exist in the future as well.

Furthermore, it is interesting to note that the three crops identified to be very important stress tolerant crops by the farmers represent three different types of crops, a vegetable, a grain, and a tuberous/root specie showing a conscious desire on the part of the farmers to balance their cropping system to meet different dietary needs. The same can be said of those crops that are considered to be important stress tolerant types by the farmers. Of the 11 species that are considered to be important around 1/3rd are tuberous species with one grain (rice), one shrub

(broom) and one spice variety. What this reveals is that the farmers in the different villages have developed a system of cultivation in which different stress tolerant varieties are given equal importance. Still, among all the crops the importance of tuberous/root crops are most prominent, viz., yam, ginger, potato, sweet potato and tapioca. These include their varieties as well. For example, two ginger varieties, viz., *sying bah* and *sying makhir* in the Nongtraw-Dewlieh-Pyrda area and an additional variety viz., *sying heh* in the Porksai-Nongraingka-Langshongthiang area are grown as important stress tolerant crops in the study area. More than 60% of these tuberous species identified to be stress tolerant crops are found to be either important or very important. It is highly likely that during times of severe environmental stress when production of other crops is severely curtailed these tuberous species provide the bulk of the dietary needs of the population.

The remaining crops however do not fit neatly within the framework. Except buri and lady finger, the other crops have characteristics which derive from either the first (very important) or the second category (important). This diversity of combinations provides some important insights. More than half of the crops in the last category (i.e., minor importance), are those that are grown by more than half of the villages in the area but within those villages less than 25% of the farmers deem to be important. Among them are important crops like banana (fruit), cabbage (vegetable), turmeric (tuberous/root) and millet (grain). The widespread nature of the crop implies that these were important crops in the past for the people in the various villages. However at the moment their importance is declining. This include the two varieties of millet grown in the Nongtraw-Dewlieh-Pyrda area, viz., *krai lon* and *krai jasheh*, and the three varieties of millet found in the Porksai-Nongraingka-Langshongthiang area, viz., *krai ieng*, *krai heh*, *krait thit* (within it *iong*, *stem* and *tmain* varieties). This can be because of many reasons.

One of the important reasons could be that these crops may not be economically viable to grow any more. Millet is a good example of that. It is a coarse cereal whose cultivation has been greatly affected by the availability of cheap cereals like rice, especially from outside the region. Millet is in fact being replaced by other crops that promise higher economic returns. The inclusion of banana in this category could be similar reasons. In this case, instead of a different variety, it could be the availability of the same crop but at cheaper rates making extensive local cultivation unnecessary. But this explanation cannot be attributed to crops like turmeric which

are important cash crops for the farmers. Unless a more remunerative variety is introduced the farmers would not give up their cultivation. Also turmeric is a very important part of local dish and traditional rituals. In the indigenous tradition when a child is born, fermented rice is mixed with water and placed in a gourd along with some powdered turmeric which is kept ready in a plantain leaf and five pieces of *kha piah* or dried fish (Gurdon, 1914). Therefore, the reason for their being considered not important anymore could be because of their increasing vulnerability to changes in the natural environment. Turmeric in fact is highly susceptible to various kinds of stresses (see table 7). This is more so during the present time when extremes are becoming a common feature of global as well as local climate regime. And even if the crops in this category were resilient in the past, they are no more capable in adapting with the contemporary pace of global climate change. Banana falls somewhere in between. Either one or both the factors in some combination might explain the placement other crops in this group. However at the same time, there are some practical reasons for which these crops might losing their popularity among farmers, For example, Four Cell Analysis done in Dewlieh found that only few households were presently engaged in cultivation of the two varieties mentioned above, i.e., *krai lon* and *krai jasheh*. These varieties required weeding to be done thrice a year and even after harvesting grinding them is a very laborious and physically taxing activity. Taste could also be an important factor. For example, although paddy has been found to be an identified by the farmers to be an important stress tolerant crop, some of its varieties are being abandoned by the farmers. *Daloi lieh* (a variety of paddy) is grown by only a few households in Samanong and Moosakhia (Jaintia Hills) for the reason that it is not very tasty compared to the other varieties. Taste has been an issue with millet as well. So every individual crop in this category might have some very specific reasons for its loss of acceptance among farmers. These can range from simple economic considerations to practical matters of the effort required to grown it and the satisfaction it provides during consumption. Notwithstanding the diversity of the reasons there is a real possibility that unless interventions are made some of these crops (at least their varieties) may go extinct like it has happened in the case of *krai war* and *krai bhoi* in Moosakhia (Jaintia Hills).

The other varieties are those crops that are commonly grown as a stress tolerant crop but whose importance is steadily growing. Jackfruit (fruit), sugarcane (grass) and tomato (vegetable) are the important varieties in this category. These are crops that are an important part of the local diet and are sold in the local markets for income generation as well.

Table 6: Importance of the identified stress tolerant crops in the villages

Degree Of Importance	Crops	Number Of Villages	Percentage Of Farmers
High Importance	Yam	11	68.15
	Pumpkin	11	55.85
	Maize	11	54.01
Important	Mustard	11	49.94
	Cucumber	11	46.97
	Potato	10	45.88
	Sweet Potato	11	44.60
	Paddy	9	40.37
	Chilies	10	34.49
	Pea	7	31.96
	Ginger	10	30.80
	Broom	10	30.44
	Tapioca	9	28.61
	Squash	9	25.63
	Pineapple	9	26.17
Minor Importance	Soh Phlang [a]	2	39.72
	Millet [b]	10	24.39
	Brinjal [b]	8	23.51
	Radish [b]	9	22.59
	Cabbage [b]	6	22.23
	Bean [b]	10	22.19
	Banana [b]	10	21.66
	Edible Tuber [b]	8	20.60
	Buri	3	19.56
	Tomato [c]	5	19.41
	Papaya [c]	4	19.04
	Sesame [b]	6	19.01
	French Bean [b]	8	18.41
	Carrot [b]	9	17.55
	Garlic [b]	6	17.26
	Mango [c]	4	15.58
	Cauliflower [b]	8	15.33
	Gourd [c]	4	12.36
	Ladies Finger's	2	12.00
	Turmeric [b]	9	11.68
	Jackfruit [c]	5	10.17
	Sugarcane [c]	5	8.88
	Bamboo Shoot [b]	6	8.63
	Bitter Gourd [b]	8	8.26

NB: a - These are crops that are grown in less than 25% of the villages but within those villages more than 25% of the farmers identify it as a stress tolerant crop.

b - These are crops that are grown by more than 50% of the villages but within those villages less than 25% of the farmers identify it as a stress tolerant crop.

c - These are crops that are grown by more than 25% (but less than 50%) of the villages but within those villages less than 25% of the farmers identify it as a stress tolerant crop

From among them, Jackfruit is a native to the sub-continent and is a very important part of the local cuisine. It can be eaten raw or cooked with other ingredients to prepare various dishes. The renewed importance of jackfruit could therefore, be attributed to its importance to local food security, which is aided by the crop's high resilience to various kinds of stresses (see table 7). This could point to potential rekindling of interest in other similar crops that might be useful in terms of food security rather than based on purely economic viability. Sugarcane, on the other hand, has greater intrinsic value for cash rather than consumption. Tomato is an introduced variety brought by the Spanish to Europe (and elsewhere) from the Mexico during the 16th century. But since it has become an important part of the local food system and is also sold in the markets in and around the villages. Some find their way to bigger markets like Jowai (Jaintia Hills), Bhoirymbong (Ri Bhoi) and Shillong (Khasi Hills). In time, it is very much possible that crops from this group may replace the crops that are found in the former, i.e., grown by more than half the villages but less than 25% of the farmers in those villages. This of course can change if these crops themselves are not able to adapt to the emerging stresses in the future. Like discussed above, it may very well be that some crops that are declining due to constraints on income generation may make a comeback. In this regard it is worthwhile to point out that while jackfruit and sugarcane have been reported to be of indigenous variety, the tomatoes grown in Dewlieh (East Khasi Hills), Liarsluit and Sohliya (Ri Bhoi) are of the hybrid variety. This is important for the fact that these are the only villages that have been found to be using chemicals in their fields. In case of crops that have a very important cash component like tomato fails because of the unavailability of fertilizers (supply bottlenecks) or reducing fertility of the plots requiring constant reinvestment (beyond the capacity of the farmer), crops, especially of indigenous variety, that may not need so much input and are more important for local food security may see a revival in their importance. The future of crops in this group is very much wide open.

Finally there are those crops that are considered as important for being stress tolerant in less than 3 villages but within those areas, they are considered to be very crucial. Only one crop is found to be in this group, Sohphlang (a fruit). It is found to be identified as an important stress tolerant crop in Liarsluit (Ri Bhoi district) and Moosakhia (Jaintia Hills district). While Liarsluit is located in the Umsing block of Ri Bhoi adjoining Assam has an elevation of 600-900 m, Moosakhia is situated along the Indo-Bangla border having an average elevation of 150-300 m.

The occurrence of Sohphlang in such diverse natural setting indicates that it is highly adaptable to different ecological conditions. Also, Sohphlang is a fruit which is grown throughout the Khasi-Jaintia region. So if only two villages have mentioned it as being an important stress tolerant crop, it could mean that the particular variety found in these areas (esp. Mooshakhia where more than 3/4th of the farmers identify it as being stress tolerant) is very vital. With rapid changes in global climate scenario imminent the particular variety could be an important addition to the adaptation strategies of the farmers in the region.

Thus it is seen that the framework designed to assess the importance of the various crops identified by the farmers to be stress tolerant has been very helpful in many ways. It has not only given a clearer picture of the significance of those crops for the farmers in the particular villages but the discrepancies gave an insight into the possible trends for the future as well. This though tells nothing about the strength of the particular crops in withstanding the various kinds of stress. For that, a detailed analysis of the capacity of individual crops to withstand the diverse stresses, single as well as multiple, is essential.

6. Degree of Stress Tolerance

Changes in climatic factors do not take place in isolation. When one factor experiences a change there are corresponding changes in the other factors as well. An increase in general temperature can enhance the potential evapotranspiraton of an area leading to contradicting outcomes. On the one hand, it leads to an increased water loss from the particular area but at the same it can augment the amount of water vapour that the air in the specific location can hold. This later can translate to increased rainfall. Therefore for a particular crop variety to be considered strong in terms of stress tolerance it has to possess the ability to withstand multiple stress conditions. For the present study, seven stress indicators were chosen, viz., heat, rain, cold, drought, frost, storm and flood.

Among the various crops identified to be stress tolerant 14 were reported by more than half of the farmers to have the capacity to withstand at least two types of stress conditions. The important crops in this group are mango, (fruit), sweet potato (tuber/root), broom (shrub), paddy (grain) and pumpkin (vegetable). Here again it is evident that there is balance regarding the choice of crops grown since almost all the types are represented. It only confirms that the

farmers in the villages have developed a system where the different dietary requirements can be fulfilled. At the same time, these crops are spread out throughout the year as well. For example, while rice and pumpkin are grown during the *kharif* season (June to October), papaya and sweet potato are *rabi* season (October to April) crops. Bitter gourd, another important crop, planted during the pre-monsoon period and harvested around the beginning of the monsoon season is a *zaid* crop. The distribution of the crops across varieties and growing seasons is indicative of the multiple cropping systems that the farmers practice. Instead of concentrating on a single crop, numerous crops are grown together and harvested at different periods of the year. This has numerous positive implications. The biggest advantage of multiple cropping is that the diversity of food sources is assured since failure of a single crop has limited capacity to affect the nutritional requirement of the community. There is greater nutritional richness as well. Food security is assured since the crops grown are supplemented by gathering of wild edibles like *jarain, jamyrdoh, ja ngew, jail, japarnai, poshor, jajew, jatira,* etc. from the village forests. In terms of ecology it is a better system because it encourages a greater biodiversity in the area.

Among the different varieties, tuber/root species and fruits are found to be most important stress tolerant crops. Almost half of the tuber species, viz., sweet potato, tapioca, yam and edible tuber identified by the farmers as being stress tolerant are in this category, i.e., very strong resilience to multiple stresses. From among these the case of edible tuber is a little disconcerting. It has high stress tolerance and, similar to tapioca and sweet potato, 1/3rd of the farmers claim that it can withstand three of more stress. However, it is found that it is losing its importance as a stress tolerance crop (see table 6). This indicates a decline in its consumption as well as cultivation. In its place more commercially viable crops are being preferred by the farmers. It would be a big loss if its cultivation is abandoned altogether. The crops that may replace may not have its resilience and that could be a problem in a highly uncertain global climate system. The other remaining tubers, viz., potato, radish, ginger, carrot and turmeric are also well placed with more than quarter of the farmers reporting that they can handle more than two stress conditions. But of these the situation regarding potato and turmeric is highly contrasting. While the former is situated at the higher end of the list (closer to very strong category) the latter is lying at the lower end of the scale (closer to weak category) (see table 7).

Table 7: Degree of stress tolerance among the identified crops in the villages

Degree Of Stress Tolerance	Crops	More Than 2 Stress	More Than 3 Stress
Very strong	Mango	83.33	50.00
	Pineapple	72.88	44.07
	Sweet potato	66.36	38.32
	Bamboo shoot	57.14	14.29
	Pumpkin	55.10	15.65
	Tapioca	55.00	33.34
	Broom	53.85	35.89
	Paddy	53.60	10.40
	Yam	53.41	17.04
	Bitter gourd	53.33	6.67
	Edible tuber	52.94	35.29
	Papaya	52.63	15.79
	Maize	51.26	11.76
	Jackfruit	50.00	31.25
Strong	Millet	41.86	18.61
	Cucumber	40.48	5.56
	Brinjal	39.13	15.21
	Bean	38.60	10.52
	Potato	38.32	12.14
	Garlic	38.24	14.71
	Radish	37.21	11.63
	Mustard	37.01	12.60
	Ginger	36.99	9.59
	Banana	35.42	20.83
	Chilies	35.00	20.00
	Pea	34.48	10.34
	Carrot	33.33	16.67
	Sesame	31.25	0.00
	Sugarcane	30.77	7.69
	Ladies finger's	30.00	10.00
	French bean	30.00	5.00
	Soh phlang	30.00	10.00
	Squash	28.57	8.93
	Cabbage	28.21	7.69
	Turmeric	28.00	0.00
Weak	Buri	23.53	5.88
	Cauliflower	22.22	7.41
	Tomato	18.18	9.09
	Gourd	0.00	0.00

Potato, on the other hand, was first introduced by David Scott in 1830. Along with its commercial importance, in time it has also become one of the staple diets in the local food landscape. Potato is grown throughout the various villages and majority of the farmers accept it to be an important stress tolerant crop. Its premier position could further strengthen in days to come when climate extremes become more frequent. As such it will have an important role to play in the strategy adopted by the farmers to combat uncertain weather conditions. But there is a need to consider the varying capacity of the different varieties. From among those identified by

the farmers to be stress tolerant, *phan saw* and *phan syntiew* are the strongest able to withstand four different type of stresses, viz., heat, rain, cold, drought. *Phan jata* however was found to be the weakest having the capacity to tolerate any one stress, i.e., heat. This could be very important in the case of turmeric as well and should be looked in the future.

Four varieties of fruits, viz., mango, pineapple, papaya and jackfruit, have been identified by the farmers to have the ability to endure multiple stress conditions. These fruits are either widely considered to be important stress tolerant crops or have shown indications of experiencing a rise in their importance in the near future (see table 6). Among these the role of pineapple will be very significant. Almost 60% of the farmers have identified pineapple as being able to withstand more than two types of stress conditions with more than 1/3rd stating it can tolerate 5 or more stress conditions. It is an important cash crop for especially the farmers in the Ri Bhoi district. With accelerating changes in the local climatic conditions it could be one of the best suited crops to deal with the stresses that accompany it. With more than half of the farmers informing they can tolerate more than three types of stresses, jackfruit and mango are also slated to become more important in the coming days. Jackfruit as already mentioned above is very important part of the food system and thus will have very positive ramifications on local food security as well. The growing importance of mango is particularly pleasant considering the fact that it is believed to have its origin in Meghalaya itself (Singh et al. 2016).

But maybe the most important crop in this category is broom, the lone representative from the shrub family. It is grown extensively throughout the Khasi-Jaintia region as a cash crop. Its significance as an important source of income is attested by the fact that broom has been singularly responsible for transforming thatch houses to RCC ones in the Ri Bhoi region (a sign of increasing economic security). According to more than half of the farmers who identified it, broom can withstand multiple stresses, from excess rainfall to drought conditions. There is though the problem that it requires mono-culture and in times depletes the fertility of the soil considerably. Streams have been reported to get dried up in areas where broom cultivation takes place. Another corollary negative impact of broom cultivation is its impact on the local biodiversity with special references to pollinator species that are found in the area. A study conducted by Robert Leo for Biodiversity International (2016) found about 16 species of *hymenopteran* pollinators (bees, solitary and social), and seven species of *dipteran* pollinators

(hover flies and bee flies) in the Moosakhia-Samanong and Nongtraw-Dewlieh-Pyrda areas. These insects were found to visit tree species like *dieng-kasari*, *soh-khyllam*, *pyrshit*, *soh shang*, *lakhar*, etc. But with broom requiring that the entire area is to be cleared of any tree cover (affecting these insects as well) the entire biodiversity in these areas is under serious threat. At the same time, some farmers in the area are also found to practice log hive beekeeping which provides source of nutrition for their families. There is thus an ecological cost and the threat of food insecurity which is associated with broom cultivation along with the financial benefits that it brings. This makes the choice of broom as part of the strategy to encourage the adaptation of stress tolerant crops highly problematic. Broom also raises some very important questions regarding considering only stress tolerance as the criterion for determining the suitability of a crop for being included as part of the climate change adaptation strategy. It may be one of the strongest crops in terms of stress tolerance but in the long run it brings more harm than good.

All the cereal crops viz., paddy, maize and millet, are in good positions with around half of more of the farmers having confidence in their ability to withstand multiple stresses. Of the two crops, paddy and millet are very significant because they are thought to have their origins around this region (South and South-East Asia). As a result, they have been an important part of the staple diet of the people. For this reason, these crops have been commemorated in folk mythology (Jaintia tale of how rice came to be cultivated) and traditional festivals (recently revived millet festival in Syndai village in Jaintia Hills) underlying their importance to not just the local agro-ecology but the cultural ecology as well. But while paddy is still going strong, millet has been suffering due to emergence of substitutes. Both, however, will be very important for the any adaptation strategy and thus there is a need to make efforts for reviving the previous position of millet as an important part of the local food basket. Maize is an introduced variety having its origin from Mexico and transplanted by the Spanish to Europe and elsewhere around the 16th century. It has become an important source of food not just for human but for animals as well. Apart from crop cultivation, the farmers in the selected villages also keep various kinds of livestock. Maize is an important ingredient in their feed. Livestock keeping is a very important part of the agricultural strategy of the local farmers, poultry, piggery the most important although in recent times goat, especially in the Lyngngam areas (PAR, 2016) are becoming more important as well. These animals are an important source of protein for the farmers and their families. It is therefore not a surprise that farmers consider it to be one of the most important

stress tolerant crops in their villages (see table 6). This preeminence position will only become stronger in more time. Here again it is important to consider the differences in stress tolerance capacity within an individual crop, i.e., different degree resilience among different varieties. As mentioned above, *daloi lieh* (a variety of paddy) is grown by only a few households in Samanong and Moosakhia (Jaintia Hills) for the reason that it is not very tasty compared to the other varieties. But according to the Four Cell Analysis done in these villages, along with *kba rymbai* (from Mooskhia) and *kba jwat* (from Samanong) they are one of the most stress resilient varieties in the area. From among the vegetables, only pumpkin and bitter gourd are considered to be highly resilient to multiple stress conditions. While it is heartening to see pumpkin continuing to be a very important crop (see table 6) among the farmers in the different villages, the declining status of bitter gourd is alarming. It is further depressing considering the fact that gourd has its origin in the Indian sub-continent (of which Meghalaya is a part) and must have had an important position in the cropping system of the past. The remaining vegetables (excepting buri, cauliflower, tomato and gourd to be discussed later) have been reported to have varying degrees of resistance to multiple stress conditions. Squash and cabbage are very close to the bottom, i.e., less capacity to endure multiple stress conditions. Cabbage is losing its importance as an important stress tolerant crop (see table 6) but squash continues to have a good following among the farmers in spite of its weakness. This could be because of its widespread use in the local food system.

And finally, at the other extreme of the scale are crops that have been overwhelmingly (more than 3/4th) reported by the farmers as being least resilient to multiple stresses. These are crops like buri (variety of bean), cauliflower, tomato and gourd (all vegetables) that can endure only a single stress. In this context, it is a bit alarming to notice the rise in interest among the farmers in especially tomato (an introduced variety from South America during the early 16th Century) and gourd (see table 7). These are being grown in almost half of the villages and are important as cash crops in the local markets. An increase in their area under cultivation could spell difficulties for the farmers in the future when extreme events become more frequent. Not only it will affect local food security but because of its strong linkage to the market it will have negative effects on the financial capacity of the farmer as well. As for the remaining crops, they are either in the process of losing their importance (cauliflower) or are already unimportant (buri) as stress tolerant crops (see table 6). Their weak capacity to withstand multiple stresses could have been

the cause for it and as such they are an indication of what await crops like tomato and gourd in the upcoming days.

7. Future prospects

The most important question that remains after determining the importance of particular stress tolerant crops to the farmers and their capacity to endure multiple stress conditions is to decide on the strategy. What are the crops that need encouragement and special attention? What are the crops that could pose a threat in the future? And what are the crops whose current status has to be maintained if not strengthened further? The answers to these questions have already been alluded in the previous sections. What remains is a more systematic exposition of the concrete measures for climate change adaptation that needs to be undertaken with respect to individual crops. These specific measures are displayed in the table below.

Table 8: Specific measures suggested for adaption to climate change

	Measures			
	Need Encouragement	**Maintain Current Status**	**Guard Against**	**Neglect**
Crops	Jackfruit	Yam	Tomato	Cabbage
	Papaya	Pumpkin	Gourd	Cauliflower
	Edible Tuber	Maize	Broom	Turmeric
	Millet	Mustard	Squash	Buri
	Bamboo Shoot	Cucumber		
	Bitter Gourd	Potato		
	Brinjal	Sweet Potato		
	Bean	Paddy		
	Radish	Chilies		
	Banana	Pea		
	Sesame	Ginger		
	French Bean	Tapioca		
	Garlic	Pineapple		
	Carrot			
	Mango			
	Soh Phlang			
	Ladies Finger's			
	Sugarcane			

NB: This table has been constructed by compiling information from table 5 and table 6

The highest numbers of crops are those that need a great deal of encouragement. These are crops that are currently not considered to be an important stress tolerant variety by the farmers in the villages. Most of the crops in this category are becoming less important for the farmers, the most important examples being millet, edible tuber, bitter gourd, banana, etc. there are many reasons

for it, e.g., lack of financial returns from their cultivation, availability of cheaper substitutes from the market, taste, physically taxing in growing and take care of the crops especially in times of labour shortage (especially in Lyngngam areas), are some of the reasons for their declining popularity. There are many ways in which this can be rectified. One of the ways is to expand the market for the crops from this category. Value addition is an important strategy in this regard. This will have the corollary effect of promoting local agro-based units of varying sizes which will have a positive impact on local employment. This is crucial due to the fact that apart from farming, many of the farmers have reported of being engaged in casual labour during the off-season to supplement household income. With many households identifying poverty as being one of their biggest concerns it has the potential to alleviate some of those difficulties as well. The other approach would be to help farmers understand the tremendous benefits in terms of food security for giving more importance to these crops. Most of the crops have been a part of the local food system with crops like millet having been a part of the socio-cultural landscape as well. As such they can be encourage to look at these crops in terms of enrichment of local food basket, security of nutrition in case of rise in the prices of conventional crops, and tremendous opportunity cost gains. Important outcomes of all this will be strengthening of local food security and weakening of economic vulnerability. The rise in importance of jack fruit, papaya, garlic and mango, in this context, is therefore very encouraging. However they would still need tremendous support if they are to play an important role in future climate change adaptation strategy.

The second category of crops is of those varieties that are already an important part of the current agricultural system practiced by the farmers in the different villages. Among the different varieties in this group, tuberous species like yam, potato, sweet potato, ginger, tapioca are very important. Of these potato and ginger are important not just for the purpose of local consumption but are important commodities for domestic as well as larger markets, inside and outside the state of Meghalaya. This makes these two crops an important component of the local programs for promoting economic development as well. The same can be said of pineapple whose cultivation is very essential for the wellbeing of the local agri-business. Any decline in their importance (subsequently affecting production) can have adverse effects on the local economy. On the other hand, the importance of paddy and maize is more for local food security concerns rather than income earnings. Paddy is one of the most important staple food items for the local population while maize is important for the livestock's which are an integral part of the local agriculture.

The animals are not only an important source of protein but they also provide manure for the fields and their sale in the village markets generates hard cash which can be very critical in times of financial constraints. The other remaining crops are essential for a combination of both the reasons provided above. If strengthening is not possible in the near future, care has to be taken that they are at least not devalued by the farmers in the area, especially not in favour of the crops in the third category.

In the third category are those crops that are increasing in their importance among local farmers or are already an important part of their cultivation system. These are tomato, gourd, squash and broom. The first three crops have exhibited a trend of increasing their evaluation in the opinion of local farmers as important stress tolerant crops. However, a look at their capacity to withstand multiple stress conditions demonstrates that they are ill-equipped to do so. In such a situation, if they continue the trend and become a very important part of the local farming system, future extreme events could result in devastating results. Large scale crop failures will be followed by worsening of the farmer's economic capacity while will translate to increased local food insecurity ultimately leading to destitute and misery. There is a need to monitor the performance of these crops and any sign of imminent debacle must be dealt with swiftly. Promotion of alternatives is one way to tackle the rising significance of these crops. This strategy, however, will face its greatest obstacle in respect to broom. It is already a very important crop with very strong linkages with the local economy. At the same time, it has also been reported to be very resilient to many kinds of stress conditions. But the most important dampener is its negative effects on the ecology and local food security which will increase the vulnerability of the farmers in a highly strained environment compounded by increasing land scarcity. Farmers in Nongtraw (Khasi Hills) and Liarsluit (Ri Bhoi) are already reporting land shortage as a big problem in their agricultural operations. There are two options in this scenario: encourage a crop which can match the current profitability of broom, and expand the market for those that already exist but are suffering from various bottlenecks. Though both are difficult but for long term sustainability a strategy which incorporates either one, both or some combination has to be found.

The last category are those crops that are already facing a decline in their importance as stress tolerant crops and have been found to indeed be very weak in adapting to multiple stress conditions. One could actively discourage their cultivation but it would be easier to let them slip

into a quite demise on their own. This approach can be adopted in the case of cabbage, cauliflower and buri but becomes complicated when applied to turmeric. In spite of being a crop of high demand, the decline in the importance of turmeric as a stress tolerant variety is indicative of the fact that it is already facing severe stresses. At the same time, the revenue generated from its cultivation is very important for the local economy, especially in Jaintia Hills. Turmeric is also an integral part of the local indigenous tradition as well as food system. In the larger region of South and East Asia, it has always been a very crucial ingredient in their traditional medicinal practices. As such, the significance of turmeric cannot be restricted to only one aspect of the local community. Therefore, a completely different strategy is necessitated because of such dilemmas. Research and development of stress tolerant varieties could be a way out for this crop. Ecological concerns however will have to be addressed if this strategy is to succeed. Otherwise, regrettable however, allowing a natural decline and gradual promotion of a stress tolerant crop is the only solution to this predicament.

8. Stakeholders' Role in Conservation

Any course of action chosen for designing a climate change resilient food production system that has conservation of these stress tolerant varieties as one of their main component will have to work very closely with the stakeholders on the ground, female farmers being one of the most significant among them. Because of their superior knowledge about the local food production system and its various components, systems of farming and types of crops (and their varieties), female farmers and especially the Custodian Farmers identified (all female) will have a very important role to play in any adaptation program. These female farmers not only possess tremendous knowledge about the local food production system but also display an earnest desire to pass that knowledge to the future generations, like their parents and grandparents did with them. The absence of community seed banks, as such, is a temporary disadvantage that can be rectified with the leadership of these Custodian Farmers with the support of the youth. At the moment the seeds of the various stress tolerant crops are being stored by these farmers using a variety of method depending on the type of crops involved.

Seeds of crops like cucumber, pumpkin, brinjal, mustard, bitter gourd, garlic, cabbage, beans are wrapped in a piece of cloth and hung over the fireplace in a overhanging platform known as *ka*

tyngier. The hearth is crucial in terms of seed storage since the fire and the smoke keeps the seeds dry and free of any insects. That the role of women in this activity is fundamental is demonstrated by the terms used to refer to these spaces, *ka tympan* (the spot from which some of the seeds are hung from the ceiling) and *ka lyngwiar dpei* i.e., the hearth (*ka* is used as a prefix for a feminine noun in the Khasi-Jaintia lexicon). Paddy though is stored inside the house in a separate room. For tuberous/root crops though other methods of storage are used. The tubers of crops like potato, sweet potato, yam, etc., are buried in hole dug around the *bun* plots. The hole is then covered with biomass (plant debris) which is then finally covered with soil. When the planting season arrives, the farmer goes to these spots and dig up the tubers for replanting in the fields. As already discussed in the beginning *bun* cultivation has a much more female-participatory character unlike the *pynthor* system. The importance of female farmers is thus further vindicated. In the Lyngngam area it is a little different with some households reporting that instead of burying the tuber they are stored in a separate shed known as *ka rynsan* (another female reference). It was therefore not a surprise that female farmers demonstrated a more superior knowledge regarding the different varieties that are grown in the villages and in the process proved more eligible to be considered as Custodian Farmers.

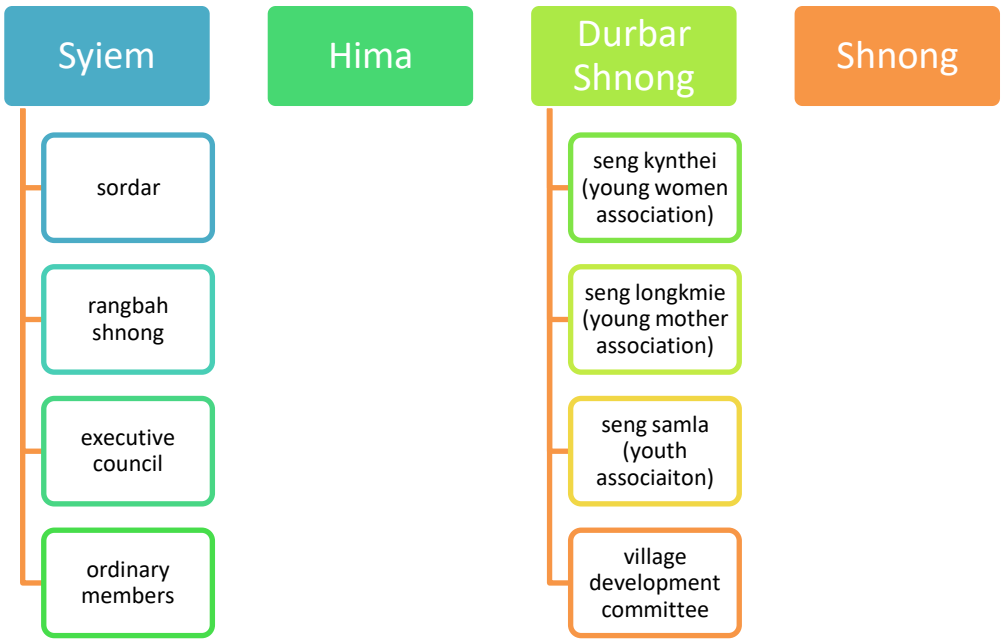


Figure 5: Structure of the traditional governance system (Hima – tribal chieftainship) and the community based organizations in the village durbar (Shnong - village)

The other stakeholders that have to be brought into confidence in any proposed program are the traditional institutions that exist in these areas. These indigenous institutions have survived the upheavals of colonialism into the modern age. In the context of the nature and form of the food production system the existence of community bodies like *seng kynthei*, and *seng longkmie* (associations of women in the village) along with *seng samla* (youth association in the village) in all these villages plays a very important role. These bodies work alongside the village *durbar* (indigenous system of grassroots' governance) in ensuring that community harmony is maintained and appropriate decisions are made for the future betterment of the village. Except the additional activities that have been incorporated with changing times, the form and structure of the village administration has continued since its pre-colonial antecedent (see figure 5). The Custodian Farmers identified are members of the executive council as well as the other community based organizations in their respective villages. As such they have great influence in the decision making process. This influence also extends to the domain of the home which is very important regarding any decisions made regarding the local food production system.

In Nongtraw there are two types of land category, private holdings (*ri kynti*) and community plots (*ri shnong*). While food production decision in ri kynti is very much left to the preferences of the land owner, use of community land is very much regulated by the community. In this category no monoculture is allowed. Farmers can only grow those crops that are required for household consumption. The strict control of the land use stems from two facts. First, community land is distributed to the farmers in the village who desire to undertake any farming on them. In this the community is guided by egalitarian principles. Land is divided equally among the needy farmers and demand for extra land which breaks the principle of equality is not entertained. To ensure that everyone in the village has access to the community land, a very nominal fee of a maximum of ₹ 1000 to a minimum of ₹ 200 is charged for four years. After the period the land reverts back to the community. Second, the size of land to be distributed again depends on the capacity of the farmer and the size of the corresponding family. Crops grown in these lands are primarily meant for household consumption rather than for the market. All these decisions at the households level is again made by the female head. Being the one responsible for caring and protecting the seeds they are in the best position to understand the needs and capacity of the household and the crops that are to be planted. Unlike men whose main aim is for earning cash, and hence the preference for cash cropping, female are guided more by the need to ensure

household food security. Therefore crops like broom which bring a lot of financial returns but has negative effects on the local biodiversity and local food security is not permitted. The kind of farming system practiced in these plots is *jhum* and *bun* which as has been already discussed above are environmentally sustainable and gender friendly. For those that wish to grow crops for the market (esp. broom which has led to shortage of land in the village), they can do so in their own fields (*ri kynti*) or rent others' land. The *kper* has a very important function in this respect. In the *kper* (of the homestead variety and not the ones in the forest from where edibles vegetables are collected by the female farmers), the farmers usually grow horticultural products destined for the market. These kpers though are limited in size, found only around the premises of the farmer's house. Thus, the institutional mechanism in the village ensures a framework within which food security, environmental sustainability, social justice and gender equity are achieved.

There are however two very critical disadvantages being faced by the farmers in this village (similar to all other villages selected in the study). The most important is in terms of market access. Nongtraw, especially is a village which is located along the slopes and can only be reached after descending scores of stone steps. This makes it very difficult for the local farmers to carry their produce in the market which are located at the top and at great distance. At the same time, it increases the cost of production by adding additional transportation charges thus making their produce comparatively higher priced than the cheaper substitutes coming from outside the region. For example, though North East India produces more than half of the country's ginger with Ri Bhoi being an important area low rates for the farmers due to transport bottlenecks are a major problem. The other difficulty is regarding the lack of processing tools for value addition of crops such as millet which is facing a decline. In the past, they had a grinding stone which involved a lot of drudgery. This was one of the reasons cited by the farmers in the Four Cell Analysis done in this village for the decline in popularity of millet. Taking note of such practical difficulties, NESFAS had donated a millet grinding machine to the village. This has gone a long way in reducing the drudgery. It has also encouraged the youth in the area to take initiatives for not only protecting their agro-diversity but promoting it as a sustainable alternative for the future as well. Therefore, with the help of the youth in the area the Custodian Farmers will be highly instrumental in conservation of the traditional food production system which

includes the method of cultivation and the conservation of the crops (and their varieties) which are planted.

The thing that gives a lot of hope in this regard is the way how people perceive the nature of their well-being. Rather than correlation material advances with their well-being the Khasi-Jaintia give preference to community harmony as being more important. They use the word *Ibha I Mit* to describe well-being and happiness which implies peace and harmony between family and community members. In this the importance of agriculture and the need to preserve traditional values have a very important for the local indigenous community. Story telling sessions to capture community's perception of well-being captured this very well among all the villages that have been included in this study. More than half the participants in these sessions were women farmers. Many of the stories recorded during these sessions had agriculture as a very important theme with stories from Moosakhia-Samanong area titled "I am a farmer" and "I am proud to be a farmer". Agriculture was identified to be very important for the community's well-being in many ways, viz., source of food security, livelihood, identity, communal ethics, morality etc. In their desire to achieve well-being through agriculture, the local indigenous farmers especially from Moosakhia-Samanong consider tradition as the most sacrosanct medium which included passing down of indigenous techniques of cultivation and conservation of traditional seeds as an important activity. At the same time, the worry that modern forms of agriculture involving fertilizers and pesticides are creating a threat to their sense of well-being was also stated by the local farmers' esp. in Nongtraw-Dewlieh-Pyrda area. Thus, it is harmonious amalgamation of agriculture and tradition that creates the feeling of well-being among these indigenous communities. With the crucial role of Custodian Farmers (female) supported by the time-tested indigenous institutions, any adaptation program which has conservation of the local food producing system with preservation of traditional seeds as an important component will be a grand success.

9. Conclusion

North East in general and Meghalaya in particular are lying at the edge of two major regions of plant and animal domestication, South and South-Eastern Asia. The southern slopes of Meghalaya have in fact been thought to have been the first region where oranges were grown

(Gurdon, 1914). These were then taken to Europe by the Arab traders and spread throughout the continent, especially the Mediterranean region. But at the same time they have also received a lot of crops (mainly vegetables) from the other parts of the world via the European colonization process. It has created a situation wherein both traditional as well as modern crops exist side by side. This, though, has meant that some of the local varieties are getting threatened. At the same time, modern agriculture which is based on mono-cropping, specialization and consolidation are not the answer for the future (Mawlong, 2017). There is a need for a balanced approach where both sets of crops, traditional as well as modern, especially crops and their varieties identified as being stress tolerant are incorporated in a way that the agricultural system in the region can withstand the vagaries of global climate change. Some of the signs of stress are already visible in the weather pattern which local farmers have also noticed. Selection of appropriate crops which will continue to provide gains but do not compromise with local food security and ecological balance is urgently required. While doing this it is also very important to identify stakeholders and understand not just the production side but the social management side as well to build a resilient system (ibid. 2017). During this study, the farmers from the different villages selected for the study have identified 39 crops as being stress tolerant with an average of 28 crops per village. Similar measures however as explained above cannot be prescribed for all the crops. Customization of tactics rather than one-fit-all approach is required. The role of female Custodian Farmers, traditional institutions and indigenous perception of well-being will play a very important role. All this will be very crucial for preventing global climate change from causing havoc to their lives and their food production system. Stress tolerant crops are going to be an important part of that strategy. What could also have been an important addition to this study was the nutritional aspect of the various crops that have been described. The important of the various crops to the local food system has been mentioned, but is clearly not enough. A lot more work can be done on this aspect since it has a great bearing on the sustainability of the local food security and food production system. That is something for the future.

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Appendix 1: Crops which have not been included in the preparation of the final list of stress tolerant crops and their stress tolerant capacity

Species	Varieties	Type/Scientific Name	Stress Tolerance Functions						
			Heat	Rain	Cold	Drought	Frost	Storm	Floods
Potato[a]	Phan Jyrmi	Solanumtuberosum Spp	x	x		x			
	Phan Pyllun	Solanumtuberosum Spp	x	x		x			
	Phan Saw	Solanumtuberosum Spp	x	x	x	x			
	Phan Syntiew	Solanumtuberosum Spp	x	x	x	x			
	Phan Lieh	Solanumtuberosum Spp	x		x				
	Phan Teret	Solanumtuberosum Spp			x				
	Phan Jyoti	Solanumtuberosum Spp			x				
	Phan Jata	Solanumtuberosum Spp	x						
Beans	Ri Khyndew	Vignaumbellata Spp		x					
	Ri Majai	Vignaumbellata Spp		x					
	Rymbai Ja	Vignaumbellata Spp	x	x					
	Ri Dieng	Vignaumbellata Spp		x					
	Ri Tari	Vignaumbellata Spp		x					
	Tohja Rymbai	Vignaumbellata Spp	x	x					
	Phyrnob	Vignaumbellata Spp	x						
Paddy[b]	Sticky Rice	Oryza Sativa Var. Glutinosa	x	x					
Peach[c]		Prunus Persica			x	x			
Bean[f]	Phyrnob		x						
Black Berry[c]		Prunus Nepalensis	x			x	x		
Bay Leaf[d]		Laurus Nobilis		x					
Maize[b]	Sohru Lieh	Zea Mays	x		x				
	Soh Riew	Coix Lacryma-Jobi	x	x	x	x		x	
Spinach[f]		Spinacia Oleracea	x	x	x		x	x	
Pumpkin[f]	Pathaw	Cucurbita Pepo L.	x						
Jaut[f]		Allium Schoenifolium	x						
Soh Thangkalor[c]				x					
Song Hati[f]						x			
Fermented Bean[f]			x	x	x				
Spring Onion[f]		Allium Fistulosum			x				
Pepper[f]		Piper Nigrum	x	x					
Soh Them[f]				x					
Lettuce[f]		Lactuca Sativa			x	x	x		

Litchi[c]		Litchi Chinensis				x			
Sohlah Thiang[f]					x				
Jatalo[f]					x				
Diengbah[f]							x		
Soh Shang[c]		Eleagnus Latifolia	x			x			
Jaing[f]		Brassica Juncea	x	x	x				
Jajew[f]		Bergonia Roxurghii			x				
Soh Bah[c]					x		x		
Wang[f]		Colacasia Sp	x						
Jamyrdoh[f]		Houttuynia Cordata	x	x	x				
Jatira[f]		Corydals Sibiricus	x	x	x				
Yam[a]	Taro Root	Solanumtuberosum Spp	x	x	x	x			
Orange[c]		Citrus Reticulata			x		x	x	
Soh Bol[c]					x				
Turnip[a]		Brassica Rapa Subsp. Rapa	x	x				x	
Pumpkin[f]	Pathaw Iong	Cucurbita Pepo L		x					
Soh Priam[c]		Species Of Psidium Guajava L		x					
Soh Thri[c]		Calamus Erectus Roxb.	x						
Soh Kulei[c]						x			
Coriander[f]		Coriandrum Sativum	x	x	x	x	x	x	
Guava[c]		Psidium Guajava						x	
Lemon[c]		Citrus Medica		x	x	x		x	
Onion[f]		Allium Cepa			x	x	x		
Lupong[f]					x				
Mint[f]		Mentha	x	x	x				
Soh Phoh[c]		Pyrus	x	x	x				
Tree Tomato[c]		Solanum Betaceum	x		x	x			
Soh Prew[f]		Lagenaria Siceraria	x	x					
Beet Root[a]		Beta Vulgaris		x	x				
Jali[f]								x	
Soya Bean[f]		Phaseolus Vulgaris Spp					x		

NB: a – tuber/root crops; b – grain crops; c – fruit crops; d – tree crop; e – vegetables; f – vegetables

Appendix 2: Stress tolerant crops identified by the farmers and the types of stress

Crops	Type Of Stress A Crop Can Tolerate (% Of Households)						
	Heat	**Rain**	**Cold**	**Drought**	**Frost**	**Storm**	**Flood**
Yam	77.84	56.25	12.50	13.07	4.55	11.36	1.70
Radish	30.23	2.33	48.84	9.30	18.60	2.33	2.33
Mustard	19.69	9.45	77.95	7.87	29.13	1.57	0.79
Banana	45.83	41.67	20.83	39.58	8.33	6.25	0.00
Broom	43.59	38.46	39.74	42.31	20.51	23.08	11.54
Sweet Potato	58.88	70.09	28.97	32.71	14.02	29.91	9.35
Carrot	41.67	36.11	50.00	5.56	11.11	2.78	0.00
Potato	53.27	50.47	27.10	11.21	2.80	5.61	0.00
Squash	42.86	57.14	28.57	1.79	1.79	7.14)*	1.79
Pumpkin	58.50	48.30	14.97	3.40	1.36	13.61	1.36
Bean	73.68	40.35	21.05	12.28	3.51	5.26	1.75
Paddy	72.00	61.60	11.20	8.80	2.40	3.20	4.80
Brinjal	71.74	32.61	23.91	15.22	2.17	2.17	4.35
Papaya	0.00	15.79	42.11	52.63	26.32	5.26	21.05
Jackfruit	43.75	31.25	56.25	37.50	25.00	18.75	6.25
Cabbage	33.33	12.82	64.10	7.69	7.69	7.69	0.00
Bamboo Shoot	7.14	14.29	14.29	64.29	14.29	35.71	14.29
Ginger	57.53	23.29	24.66	12.33	0.00	10.96	0.00
Chilies	51.25	46.25	35.00	12.50	7.50	3.75	0.00
Bitter Gourd	66.67	66.67	20.00	6.67	0.00	0.00	0.00
Pea	37.93	22.41	50.00	12.07	18.97	3.45	0.00
Cucumber	59.52	66.67	10.32	2.38	1.59	6.35	0.00
Tapioca	41.67	53.33	23.33	30.00	6.67	23.33	6.67
Millet	76.64	51.16	11.63	16.28	2.33	2.33	6.98
Cauliflower	14.81	7.41	85.19	11.11	14.81	0.00	0.00
Garlic	61.76	26.47	29.41	5.88	20.59	2.94	2.94
Edible Tuber	44.12	44.12	20.59	38.24	23.53	29.41	26.47
Maize	75.63	63.03	15.13	2.52	1.68	7.56	1.68
Sugarcane	53.85	23.08	30.77	0.00	23.08	0.00	0.00
Pineapple	67.80	52.54	42.37	38.98	33.90	20.34	3.39

Mango	66.67	50.00	50.00	33.33	58.33	8.33	8.33
Sesame	62.50	56.25	12.50	0.00	0.00	0.00	0.00
Turmeric	72.00	32.00	0.00	8.00	4.00	12.00	0.00
Tomato	9.09	13.64	81.82	18.18	4.55	4.55	0.00
Ladies Finger	80.00	40.00	10.00	0.00	10.00	0.00	0.00
Gourd	21.43	50.00	14.29	7.14	0.00	7.14	0.00
Buri	82.35	41.18	5.88	5.88	0.00	5.88	5.88
Press Bean	67.50	17.50	30.00	7.50	7.50	5.00	7.50
Sohphlang	10.00	70.00	0.00	10.00	0.00	30.00	0.00

NB: The percentage has been calculated from the number of farmers who have identified the particular crop of being stress tolerant and not the total number of number of farmers who have taken part in the study

Appendix 3: Stress tolerant crops identified by the farmers and the different degrees of stress

Crops	Degree of stress tolerance (% of households)		
	≤ two stress	> two and <five	≥five
Yam (176)	82.95	15.34	1.70
Radish (43)	88.37	11.63	0.00
Mustard (127)	87.40	12.60	0.00
Banana (48)	79.17	18.75	2.08
Broom (78)	64.10	21.79	14.10
Sweet potato (107)	61.68	22.43	15.89
Carrot (36)	83.33	16.67	0.00
Potato (107)	87.85	11.21	0.93
Squash (56)	91.07	7.14	1.79
Pumpkin (147)	84.35	14.29	1.36
Bean (57)	89.47	8.77	1.75
Paddy (125)	89.60	9.60	0.80
Brinjal (46)	84.78	13.04	2.17
Papaya (19)	84.21	15.79	0.00
Jackfruit (16)	68.75	12.50	18.75
Cabbage (39)	92.31	7.69	0.00
Bamboo shoot (14)	85.71	14.29	0.00
Ginger (73)	90.41	9.59	0.00
Chilies (80)	80.00	18.75	1.25
Bitter gourd (15)	93.33	6.67	0.00
Pea (58)	89.66	8.62	1.72
Cucumber (126)	94.44	5.56	0.00
Tapioca (60)	66.67	26.67	6.67
Millet (43)	81.40	16.28	2.33
Cauliflower (27)	92.59	7.41	0.00
Garlic (34)	85.29	14.71	0.00
Edible tuber (34)	64.71	8.82	26.47
Maize (119)	88.24	10.08	1.68
Sugarcane (13)	92.31	7.69	0.00
Pineapple (53)	55.93	27.12	16.95
Mango (12)	50.00	25.00	25.00
Sesame (16)	100.00	0.00	0.00
Turmeric (25)	100.00	0.00	0.00
Tomato (22)	90.91	9.09	0.00
Ladies finger (10)	90.00	10.00	0.00
Gourd (14)	100.00	0.00	0.00
Buri (17)	94.12	5.88	0.00
Press bean (40)	95.00	2.50	2.50
Sohphlang (10)	90.00	10.00	0.00

NB: The percentage has been calculated from the number of farmers (given within the brackets) who have identified the particular crop of being stress tolerant and not the total number of number of farmers who have taken part in the study.

Appendix 4: crops identified as being stress tolerant by the farmers in the different villages selected in the study

Crops		Villages										
		Dewlieh	**Nongtraw**	**Moosakhia**	**Samanong**	**Porksai**	**Langsohthiang**	**Liarsluid**	**Pyrda**	**Khweng**	**Nongriangka**	**Sohliya**
Yam	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	83.33	66.67	70.59	43.33	53.33	60.96	82.76	72.73	66.67	78.95	70.37
Pumpkin	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	16.67	33.33	33.33	40.00	53.33	56.10	72.00	45.45	88.89	93.74	81.48
Mustard	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	66.67	22.22	40.38	73.33	13.33	26.83	68.97	90.91	72.22	26.32	48.15
Cucumber	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	75.00	44.44	35.29	56.67	33.33	53.66	55.17	18.18	27.78	57.89	59.26
Paddy	Status	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	(%)	8.33	0.00	45.10	53.33	73.33	68.29	48.28	0.00	44.44	47.37	55.56
Maize	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	75.00	66.67	15.69	10.00	60.00	51.22	51.72	81.82	61.11	57.89	62.96
Sweet	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Potato	(%)	33.33	88.89	45.10	46.67	6.67	26.83	37.93	72.73	83.33	15.79	33.33
Potato	Status	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	91.67	22.22	49.10	50.00	0.00	24.39	41.38	81.82	11.11	31.58	55.56
Chilies	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	(%)	50.00	22.22	15.69	3.33	20.00	24.39	44.83	0.00	16.67	73.68	74.10
Broom	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	(%)	66.67	11.11	13.73	23.33	33.33	26.83	31.03	0.00	11.11	47.37	70.37
Ginger	Status	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	8.33	22.22	11.76	0.00	40.00	14.63	65.52	9.10	44.44	10.53	81.48
Tapioca	Status	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
	(%)	8.33	33.33	11.76	0.00	26.67	41.46	27.59	0.00	77.78	15.79	14.81
Beans	Status	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	0.00	11.11	25.49	6.67	26.67	12.20	51.72	27.22	22.22	5.26	33.33
Squash	Status	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	50.00	0.00	19.61	10.00	0.00	7.32	41.38	9.10	27.78	21.05	44.44
Pineapple	Status	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	0.00	0.00	5.88	6.67	40.00	48.78	3.45	9.10	38.89	63.16	3.70

Banana	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	(%)	58.33	22.22	3.92	3.33	6.67	46.34	10.34	0.00	33.33	21.05	11.11
Brinjal	Status	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	0.00	0.00	5.88	0.00	26.67	34.15	13.79	18.18	5.56	57.90	25.93
Radish	Status	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	0.00	0.00	29.41	20.00	13.33	7.32	13.79	90.10	16.67	5.26	7.41
Millet	Status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
	(%)	33.33	88.89	7.84	36.67	26.67	9.76	6.90	9.10	0.00	21.05	3.70
Phrenbean	Status	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes
	(%)	8.33	0.00	13.76	23.33	0.00	4.88	37.04	0.00	16.67	21.05	22.22
Cabbage	Status	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
	(%)	0.00	0.00	27.45	30.00	0.00	0.00	20.69	18.18	22.22	0.00	14.81
Pea	Status	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No
	(%)	8.33	11.11	47.06	30.00	0.00	0.00	41.38	63.64	22.22	0.00	0.00
Carrot	Status	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	8.33	0.00	11.76	16.67	0.00	2.44	27.59	45.46	16.67	10.53	18.52
Garlic	Status	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No
	(%)	0.00	0.00	45.10	10.00	0.00	0.00	10.34	27.27	5.56	5.26	0.00
Edible	Status	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Tuber	(%)	66.67	0.00	11.76	3.33	13.33	7.32	0.00	0.00	11.11	10.53	40.74
Cauliflower	Status	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
	(%)	33.33	0.00	13.73	6.67	13.33	0.00	20.69	18.18	5.56	0.00	11.11
Turmeric	Status	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	(%)	8.33	0.00	7.84	0.00	13.33	2.44	31.03	9.10	16.67	5.26	11.11
Tomato	Status	Yes	No	No	No	No	No	Yes	Yes	Yes	No	Yes
	(%)	16.67	0.00	0.00	0.00	0.00	0.00	37.93	9.10	11.11	0.00	22.22
Motor	Status	No	No	Yes	Yes	No	No	Yes	No	No	No	No
	(%)	0.00	0.00	9.80	30.00	0.00	0.00	20.69	0.00	0.00	0.00	0.00
Papaya	Status	Yes	No	No	No	No	Yes	Yes	No	Yes	No	No
	(%)	8.33	0.00	0.00	0.00	0.00	7.69	37.93	0.00	22.22	0.00	0.00
Buri	Status	No	No	No	No	No	Yes	Yes	No	No	No	Yes
	(%)	0.00	0.00	0.00	0.00	0.00	4.88	24.18	0.00	0.00	0.00	29.63
Jackfruit	Status	No	No	Yes	No	Yes	Yes	Yes	No	No	Yes	No
	(%)	0.00	0.00	1.96	0.00	13.33	26.83	3.45	0.00	0.00	5.26	0.00
Sesame	Status	No	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	No

	(%)	0.00	55.56	3.92	0.00	13.33	0.00	3.45	27.27	0.00	10.53	0.00
Bitter	Status	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Gourd	(%)	8.33	0.00	1.96	0.00	0.00	4.88	6.90	9.10	11.11	5.26	18.52
Bamboo	Status	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Shoot	(%)	0.00	0.00	9.80	3.33	0.00	2.44	3.45	0.00	22.22	10.53	0.00
Gourd	Status	No	No	Yes	No	No	No	Yes	No	Yes	No	Yes
	(%)	0.00	0.00	1.97	0.00	0.00	0.00	34.48	0.00	5.56	0.00	7.41
Sugarcane	Status	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No
	(%)	0.00	0.00	1.97	0.00	0.00	17.07	3.45	0.00	16.67	5.26	0.00
Mango	Status	No	No	No	No	Yes	Yes	Yes	No	No	Yes	No
	(%)	0.00	0.00	0.00	0.00	13.33	12.20	3.45	0.00	0.00	33.33	0.00
Ladies	Status	No	No	No	No	No	No	Yes	No	No	No	Yes
Finger	(%)	0.00	0.00	0.00	0.00	0.00	0.00	13.79	0.00	0.00	0.00	22.22
Sohphlang	Status	No	No	No	Yes	No	No	No	Yes	No	No	No
	(%)	0.00	0.00	0.00	6.67	0.00	0.00	0.00	72.77	0.00	0.00	0.00

NB: The percentage has been calculated from the number of farmers (given within the brackets) who have identified the particular crop of being stress tolerant in the particular village;

Yes indicates the mention of the particular crop in the specified village while No indicates the absence of mention of the crop in the specified village.

Appendix 5: Different crops grown in the villages and their varieties

Area	Name Of The Crop	Varieties	Months	Plot
Porksai-Nongrianka-Langshongthiang	Paddy	Kba Bhoi Kba Bha Kba Badem Rit Kba Saw Kba Lieh Kba Iong Kba Ninagwa Kba Bit Kba Baiju Kba Iewbih	April-November	Jhum
	Maize	Hadem Balieh Hadem Manir Hadem Basaw	March-July	Jhum+kper
	Cucumber	Sohkhia Sohkhia Rit	March-August	Jhum+kper
	Brinjal	Soh Baigon Soh Baigon Thang	March-January	Jhum+kper
		a) Pyllun i. Pyllun Rit ii. Pyllun Heh		
	Mustard	Tyrso Lieh Tyrso Iong	March-November	Jhum+kper
	Pumpkin	Pathaw Lieh a) Jrong b) Lyngkot Pathaw a) Pyllun b) Jrong Pathaw Saw a) Pyllun b) Jrong	March-December	Jhum+kper
	Beans	Khariak Tonalieh Rymbai Ja	March-August	Jhum+kper
	Chillies	Sohmynken Rit Sohmynken Heh	March-November	Jhum
	Tapioca	Snep Saw Snep Lieh	April-August	Jhum+kper
	Sweet Potato	Balieh Basaw	July-November	Jhum+Kper
	Sesame	Nei Lieh Nei Iong	April-November	Jhum
	Ginger	Snging makher Snging heh	April-December	Jhum+Kper
		a) Stem b) Iong c) balieh		
	Yam	Riew Thahmah	March-February	Jhum+Kper

	Riew Bahjah		
	Riew Saw		
	Riew Iong		
	Riew Bam		
Millet	Rai Rieng	March-July	Jhum
	Rai Heh		
	Rai Thit		
	a) Iong		
	b) Stem		
	c) Tmain		
Banana	Kait Khar	February to after two year	Jhum+Kper
	Kait Iong		
	Kait Koma		
	Kait Puh		
	Kait Saheb		
Edible tuber	Phan Bah	April-November	Jhum+Kper
	Phan Tyndaw		
	Basaw		
	Phan Longtang		
	Phan Prah		
	Phah Thahdikhi		
	Phan nirsaw		
Squash	Biskot	April-September	Jhum+Kper
Pineapple	Sohtrun	Sown anytime, but harvest a) February b) August	Jhum+Kper
Radish	Muli	July to October	Jhum+Kper
Mango	Soh pieng	July to after 6 years	Kper
Soh Shang	Soh shang	July to after 6 years	Kper
Soh Iong	Soh iong	July to after 6 years	Kper
Gauva	Soh priam	July to after 6 years	Kper
Soh Sir	Soh sir	July to after 6 years	Kper
Soh Bah	Soh bah	July to after 6 years	Kper
Soh Proi	Soh proi	July to after 3 years	Kper
Tamarind	Soh kyntoi	July to after 6 years	Kper
Jaiur	Jaiur	Throughout the year	Kper in forest
Tyrkhang	Tyrkhang	Throughout the year	Kper in forest
Jamyrdoh	Jamyrdoh	Throughout the year	Kper in forest
Jakaij	Jakaij	Throughout the year	Kper in forest
Jubuij	Jubuij	Throughout the year	Kper in forest
Jariang Rap	Jariang Rap	Throughout the year	Kper in forest
Khar Kha	Khar Kha	Throughout the year	Kper in forest
Japuh	Japuh	Throughout the year	Kper in forest
Jalang Jir	Jalang Jir	Throughout the year	Kper in forest
Tiewserbih	Tiewserbih	Throughout the year	Kper in forest
Jarain	Jarain	Throughout the year	Kper in forest
Jatira	Jatira	Throughout the year	Kper in forest
Jathang	Jathang	Throughout the year	Kper in forest
Pai Khlaw	Pai Khlaw	Throughout the year	Kper in forest
Pai Lok	Pai Lok	Throughout the year	Kper in forest
Pai Diengiong	Pai Diengiong	Throughout the year	Kper in forest

	Wangshirew	Wangshirew	Throughout the year	Kper in forest
Moosakhia-Samanong	Paddy	kba Mulong	May-January	Pynthor
		Kba Rymbai		Pynthor
		Kba Daloi Lieh		Pynthor
		Kba Laispah	May-April	Pynthor
		Kba Jwat		Pynthor
		Kba Daloi Saw		Pynthor
	Turnip	Soh Lakum	May-January	Kper
	Bean	Toh Shroi	April-August	Kper
		Toh Manipur	April-August	Kper
		Toh Tari	April-March	Kper
		Toh Ja Saw		Jhum+Kper
		Toh Ja Lieh		Jhum+Kper
	Soh Thliem	Soh Thliem	July-November	Kper
	Red pumpkin	Pathaw Saw	April-March	Bun+Kper+Jhum
	Sohlah Stem	Sohlah Stem	April-March	Bun+Kper+Jhum
	Millet	Krai	April-February	Jhum
	Soh Lyngngi	Soh Lyngngi	March	Kper
	Ginger	Sying	April-March	Bun+Kper+Jhum
	Blackberry	Sohiong	June after 10 years	Kper
	Brinjal	Soh Kthang	April-March	Kper
	Tree tomoto	Soh Baigongtieng	April-March	Kper
	Soh Lah Sying	Soh Lah Sying	Dec	Bun+Kper+Jhum
	Garlic	Rasun	April-March	Kper
	Radish	Muli	April-March	Kper
	Yam	Shriew Saw	April-March	Bun+Kper+Jhum
	Pea	Motor Rasnap	May-August	Kper
	Maize	Riew Hadem	April-August	Kper,Bun
	Sohtew	Sohtew	March	Kper
	Saphai	Saphai	April-May	Kper
	Turmeric	Shynraia longa	April-March	Kper
	Mint	dhania	April-March	Kper
	Spring onion	Jyllang	April-March	Kper
	Cauliflower	Phulkubi	Nov-March	Kper
	Fern	Tyrkhang	June-September	Kper in the forest
	Tangduma	Tangduma	May-October	Kper in the forest
	Shiahkrot	Shiahkrot	Throughout the year	Kper in the forest
	Jarem	Jarem	Throughout the year	Kper in the forest
	Jarain	Jarain	May-October	Kper in the forest
	Jali	Jali	May-October	Kper in the forest
	Jalyniar	Jalyniar	May-December	Kper in the forest
	Jakhria	Jakhria	May-October	Kper in the forest
	Jajew	Jajew	Throughout the year	Kper in the forest
	Batpyllon	Centella	Throughout the year	Kper in the forest
	Sohpong	Sohpong	Sep-December	Kper in the forest
	Wild banana	Musa acuminata	Throughout the year	Kper in the forest
	Sohma	Sohma	Sep-December	Kper in the forest
	Sour frigid	Sohphie	April-June	Kper in the forest
	Sohmalien	Syzygium	Sep-December	Kper in the forest
Sohliya-Khweng-Liarsluid	Paddy	Khaw Laispah	May-April	Pynthor
		Kba Mawtawar	May-April	Pynthor
		Kba Mynri/Kba heh	May-April	Pynthor
		Kba Manipur Skuin	May-April	Pynthor
		Pnah Ther	May-April	Pynthor
		Kba Lakang	May-April	Pynthor

			Kba Eit-hati	May-April	Pynthor
			Pnah Iong	May-April	Pynthor
			Pnah Latara	May-April	Pynthor
	Yam		Shriew	April-March	Jhum+Kper
	Pumpkin		Pathaw	April-March	Jhum+Kper
	Tapioca		Phandieng	April-August	Jhum
	Ginger		Sying	April-March	Jhum
	Turmeric		Shyrmit	April-March	Jhum
	Lungsiej		Lungsiej	Throughtout the year	Kper in the forest
	Jamahek		Jamahek	Throughtout the year	Kper in the forest
	Jajew		Jajew	Throughtout the year	Kper in the forest
	Sohlyndung		Sohlyndung	Throughtout the year	Kper in the forest
	Jatira		Jatira	Throughtout the year	Kper In the Forest
Nongtraw-	Jobs Tears		Sohriew	April-November	Jhum
Pyrda-Diewlieh	Maize		Riew Hadem	April-September	Jhum
	Bean		Rymbaija	April-November	Jhum
	Jaing		Jaing	April- August	Jhum
	White Sesame		Nei	April-December	Jhum
	Arrowroot		Alarut	April-February	Jhum
	Brinjal		Soh Baingon	April-November	Jhum
	Sohpodok		Sohpodok	April-December	Jhum
	Blackberry		Sohiong	September after 10 years	Kper
	Sohshang		Sohshang	February after 10 years	Kper
	Banana	a)	Kait Khar	June after 2 years	Kper
		b)	Kaitmon		
	Guava		Sohpri	June after 6 years	Kper
	Mulberry		Sohlyngdkhur	June after 5 years	Kper
	Sohmad		Sohmad	June after 3 years	Kper
	Fern		Tyrkhang	June-September	Kper in the forest
	Tangduma		Tangduma	May-October	Kper in the forest
	Sohshiat		Sohshiat	Throughout the year	Kper in the forest
	Shiahkrot		Shiahkrot	Throughout the year	Kper in the forest
	Nub		Nub	June-November	Kper in the forest
	Jarem		Jarem	Throughout the year	Kper in the forest
	Jarain		Jarain	May-October	Kper in the forest
	Jali		Jali	May-October	Kper in the forest
	Jamiang		Jamiang	May-October	Kper in the forest
	Jalyngkhan		Jalyngkhan	May-October	Kper in the forest
	Jalyniar		Jalyniar	May-December	Kper in the forest
	Jakhria		Jakhria	May-October	Kper in the forest
	Jajew		Jajew	Throughout the year	Kper in the forest
	Jabuit		Jabuit	Throughout the year	Kper in the forest
	Batpyllon		Centella	Throughout the year	Kper in the forest
	Sohliang		Sohliang	September-December	Kper in the forest
	Sohpdok		Sohpdok	August-December	Kper in the forest
	Sohthri		Sohthri	November-January	Kper in the forest
	Sohpong		Sohpong	September-December	Kper in the forest
	Sohkhyrwiat		Sohkhyrwiat	June-September	Kper in the forest
	Siahsohtah		Siahsohtah	June-October	Kper in the forest
	Sohben		Sohben	September-January	Kper in the forest
	Jaiur		Jaiur	June-October	Kper in the forest
	Khawiang		Khawiang	October-December	Kper in the forest
	Sohma		Sohma	October-December	Kper in the forest
	Potato		Phan Jata	March-October	Jhum

		Phan Lynseng	March-October	Jhum
		Phan Synreh	March-October	Jhum
		Phan Saw	March-October	Jhum
		Phan Syntiew	March-October	Jhum
		Phan Jyoiti	March-October	Jhum
		Phan Imslem	March-October	Jhum
		Phan Sawhoin	March-October	Jhum
	Yam	Shriew Saw	April-February	Jhum
		Shriew Snem	April-February	Jhum
		Shriew Phan	April-February	Jhum
		Shriew Khnap	April-February	Jhum
		Shriew Lieh	April-February	Jhum
		Shriew Lynkait	April-February	Jhum
		Shirew Pangong	April-February	Jhum
	Tapioca	Phandieng Lieh	April-February	Jhum
		Phandieng Saw	April-February	Jhum
	Millet	Krai Lon	April-November	Jhum
		Krai Jasheh	April-November	Jhum
	Cucumber	Sohkhia stem	April-August	Jhum
		Sokhialong	April-August	Jhum
	Wild potato	Sohlal	April-February	Jhum
	Mustard	Tyrso	April-August	Jhum