Rapid Appraisal on Farming Systems for Nutrition of Farmers by Using GIS through UAV Data

Abstract

The conventional farming systems of Meghalaya largely aim at food security with a major focus on productivity, profitability, sustainability and stability. Nutrition security therefore has to be addressed by both availability and accessibility of nutrient-rich foods at the household level, which is central to Farming System for Nutrition (FSN). The present scientific inquiry with research objectives of to conduct rapid appraisal on food and nutritional security of farmers by using GIS through UAV data has been performed in the three adopted villages of the research project—DHaBReT at Bhoirymbong C&RD block, Ri-bhoi, Meghalaya. A Descriptive research design and Mixed-method sampling procedure were followed in the study. Fifty four (54) respondents have been identified from three villages, namely (i) Thadnongiaw, (ii) Kdonghulu, and (iii) Liarkhla from Bhoirymbong C&RDB of Ri-bhoi district of Meghalaya. Performance of Rapid Rural Appraisal (RRA) using UAV data could ascertained that about 38% and 73% of arable land had aspect toward North-West (very low sunshine) and situated in a steep location, wherein administration of improved scientific agriculture was a challenge. Therefore, the study recommends that agricultural research institutions and department of agriculture, state government *etc.* should take prime initiatives in order to incept FSN to farmers of Bhoirymbong, Ri-bhoi, Meghalaya.

Keywords: *Nutritional Security, Food Security, Meghalaya, UAV*

Introduction

The problem of food and nutritional insecurity can be concomitant with the backwardness in agricultural development. In the world, malnutrition statuses as one of the principal public health problems, exclusively among children and women folks. In India, malnutrition levels are unswervingly linked to inadequate food intake and a deficiency of a balanced diet among the rural inhabitants. The scenario has spawned tremendous anxiety, particularly among low-income individuals consuming predominantly carbohydrate-based staples that are highly deficient in micronutrients (Rajendran *et al.*, 2017). The National Family Health Survey (NFHS-4) of India, 2015–16, revealed that 41.00% of children under the age of 5 years are stunted, and 38.00% percent are underweight while 59.00% are anaemic. Furthermore, approximately 54.00% of women between the ages of 15 to 49 years are anaemic (IIPS, 2017). But over millennia, it's been accepted that the diversity of food crops has declined considerably, with a propensity towards cereal based rice and wheat farming methods and declining production of a wide varieties of millets and pulses.

The North-Eastern Hill Region (NEHR) of India has a unique diversity of agro-climatic zones combined with fertile and well-drained soil, making it suitable for growing a wide variety of fruits, vegetables, cereals and spices. Traditional farming systems of the north-eastern hill states of India principally focussed at food security with a prime focus on productivity, profitability, and sustainability. During the 2016-17 fiscal year, Meghalaya produced 41.82 thousand MT, 12.68 thousand MT, and 21.12 thousand MT of food grains, pulses, and oilseeds, respectively (GoM, 2017b). The food and nutrition security analysis reported that the North Eastern states of India have a gap or deficit in calorie intake per person (Nongbri*et al.*, 2021). However, enhancing food production and/or income doesn't mean to guarantee a balanced diet for rural households. As a consequence, addressing

household availability and accessibility of nutrient-rich foods through Farming System for Nutrition (FSN) approach has been proved to be more effective to address these issues. It connotes the malnutrition-reduction strategy endorsed by the M. S. Swaminathan Research Foundation in India (MSSRF). It has been proposed that a design for the farming system should include feasible agricultural interventions to address the nutritional deficiencies of the household and community. The FSN approach integrating horticulture, backyard farming and animal husbandry to sustainably improve household nutrition availability while extenuating risk and sustaining natural resources.

Therefore, it is felt necessary to introduce the FSN that the approach primarily calls for promoting location-specific farming systems. For instance, the approach on scaling-out of bio-fortification agriculture systems, especially on nutritional dense cereals and pulse crops by augmenting the production, productivity of crops and animal husbandry at the farm level, while promoting nutrient-dense fruits and vegetables in kitchen or nutritional gardens, alongside integration of livestock and small-scale fisheries with nutrition training, can definitely increase income as well as dietary diversity at household level. The approach poses possibility of farmers to increase the core competencies on adopting FSN.

At the center of the smart agriculture expansion, unmanned aerial vehicles (UAV) have been extensively applied(Ju and Son, 2018). UAV applications have contributed to the expansion of many areas of agriculture, including insecticide and fertilizer prospecting and spraying, seed planting, weed recognition, fertility assessment, mapping and crop forecasting (Mogili and Deepak. 2018; Ravi, 2023)

In this juncture, as the School of Social Sciences, College of Post Graduate Studies in Agricultural Sciences (Central Agricultural University, Imphal) at Umiam, Ri-bhoi, Meghalaya is implementing the research project — "Integration and Application of UAV for Crop Health Assessment and Monitoring with IIDS in Providing Evidence-Based Agro-Advisory Services to Farmers of North-East India (DHaBReT)", funded by the Digital India Corporation, Ministry of Electronics and Information Technology, Govt. of India since the year 2020; the researcher identifies the convenience of conducting a scientific inquiry. In which the inherent mandate of the research project is to imply Geographic Information System (GIS) technologies by using Unmanned Aerial Vehicle (UAV) for near real-time analysis on crop stresses assessment, forecast on crops losses owing to vagaries of weather, linking to market *etc*. to augment food security of farmers.

Methodology

Descriptive research design was adopted in the study to obtain pertinent and precised information with respect to the identified variables of the study. The study was conducted at Bhoirymbong C&RD block of Ri-bhoi district, Meghalaya State. Keeping into consideration, the criteria of power analysis for determination of sample size of the study as: (1) t-test, (2) Two tail, (3) Effect size = 0.5, (4) α error probability = 0.05, and (5) Power (1 - β) = 0.95, the sample size was determined to 54. The scientific inquiry administered mixed-method sampling method, wherein both 'Purposive Sampling' and 'Probability Proportional to Size Sampling (PPSS)' methods were implied upon.

Results and discussion

Output of rapid appraisal on food and nutritional farming systems for nutritionof farmers by using GIS through UAV data.

Rapid appraisal was conducted in the present inquiry on examining the Farming System for Nutrition (FSN) to assess the status of food and nutritional security of the respondents through qualitative and quantitative data. Quantitative data was collected using the pre-tested interview schedule, whereas the qualitative data was gathered through Focus Group Discussion (FGD) with key informants and farmwomen respondents. The study endured the steps of rapid appraisal as specified in Figure 1. In the outset, site selection was performed by the researcher with the two representatives from each village using image of Google Earth Pro as depicted in Figure 2. Orientation on the process of rapid appraisal was performed to them. The study used Hexacopter rotor DJI Matrice 600 pro with 42 Mega Pixel RGB optical sensor and dual multi-spectral sensors (MicaSenseRedEdge-MX and MicaSenseRedEdge-MX Blue), with PIX4Dmapper pro and PIX4Dfields data processor to acquire and process UAV data in generating topographic profiles and cadastral maps of the study sites as depicted in Figure 3 and Figure 4. The morphological parameters of the study sites has been depicted in Table 2. Laterally, rapid rural appraisal of the farming systems of the respondents had been performed. Subsequently, FSN maps of the three villages, namely (i) Thadnongiaw Village, (ii) Kdonghulu Village and (iii) Liarkhla village had been generated from the key informants and respondents of the study, as specified in Figure 5, 6 and 7, respectively.

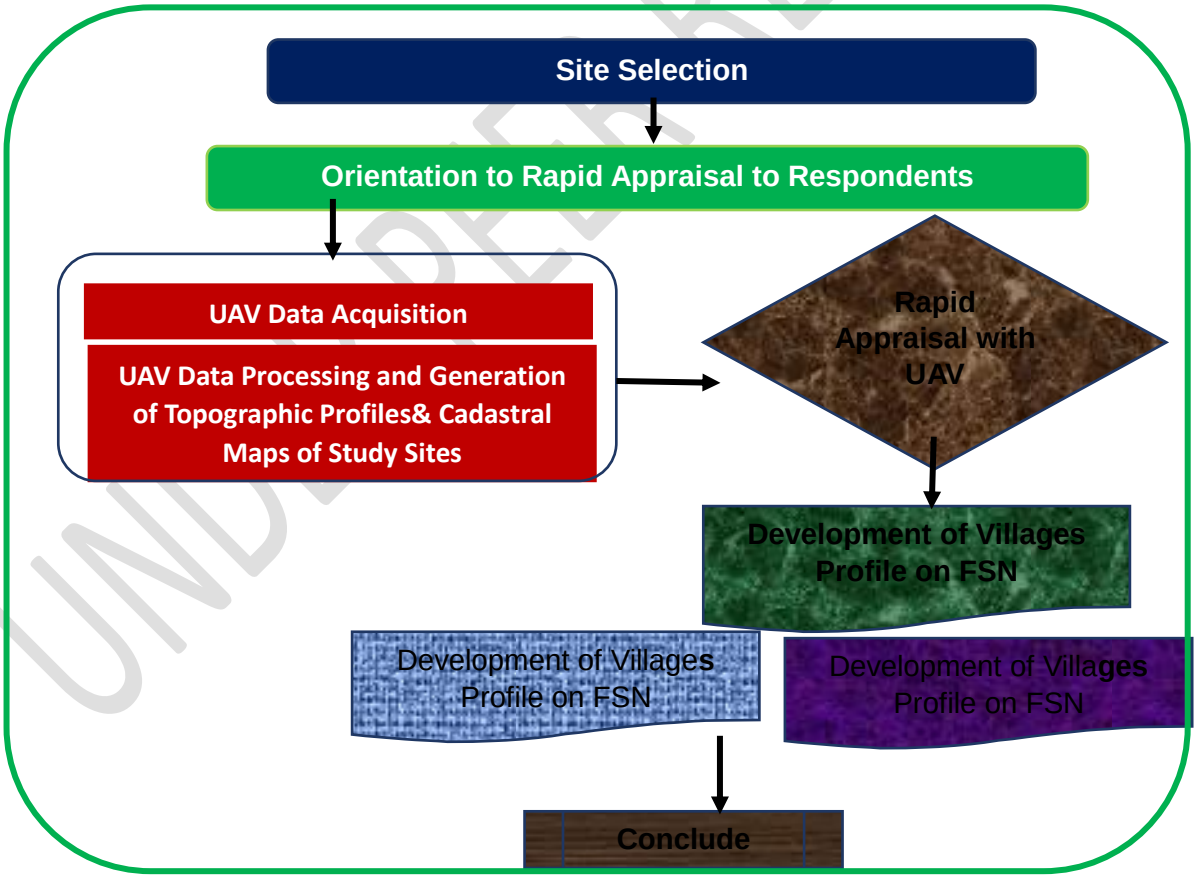


Figure 1: Schematic diagram on procedure of rapid appraisal on Farming System for Nutrition undertaken in the study.

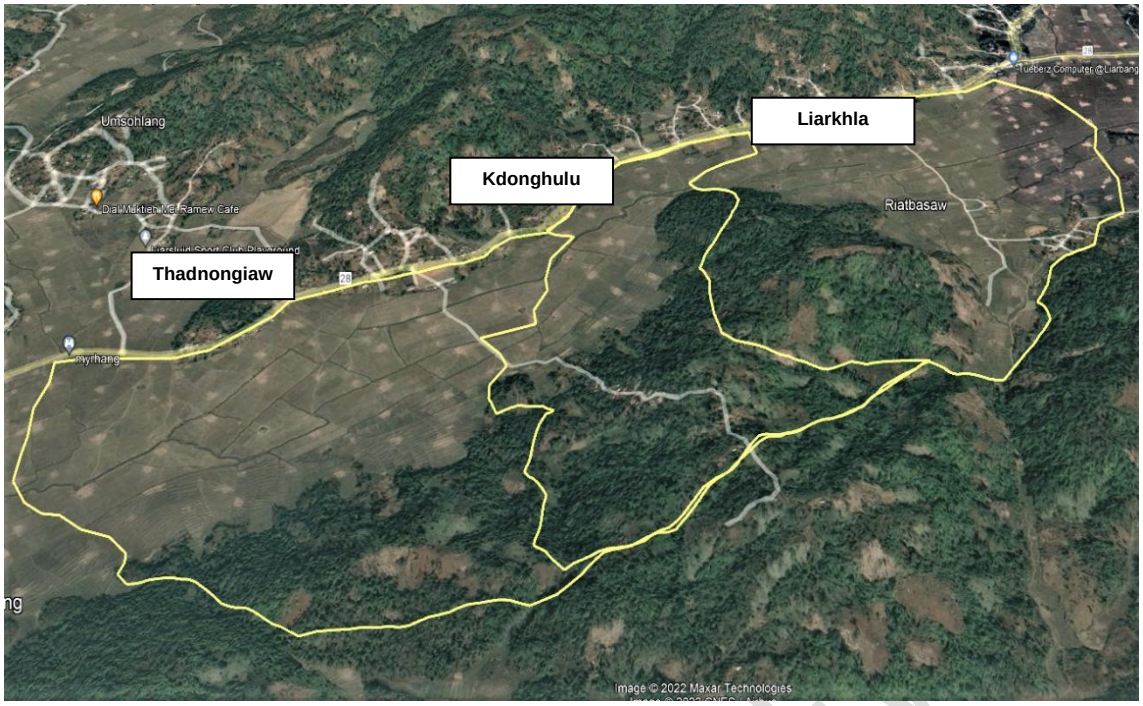
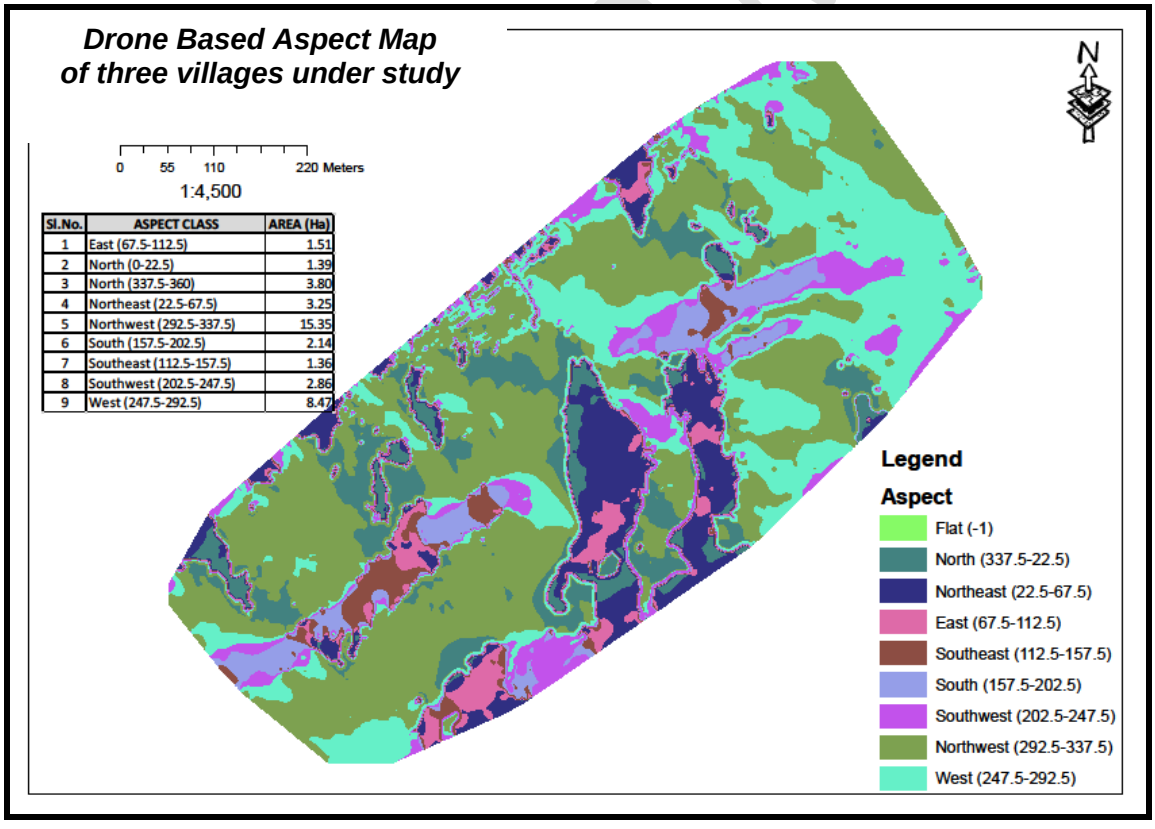


Figure 2: Google Earth Pro derived map of three villages under the study.



Sl.No.	ASPECT CLASS	AREA (Ha)
1	East (67.5-112.5)	1.51
2	North (0-22.5)	1.39
3	North (337.5-360)	3.80
4	Northeast (22.5-67.5)	3.25
5	Northwest (292.5-337.5)	15.35
6	South (157.5-202.5)	2.14
7	Southeast (112.5-157.5)	1.36
8	Southwest (202.5-247.5)	2.86
9	West (247.5-292.5)	8.47

Figure 3: UAV based aspect map of three villages under the study.

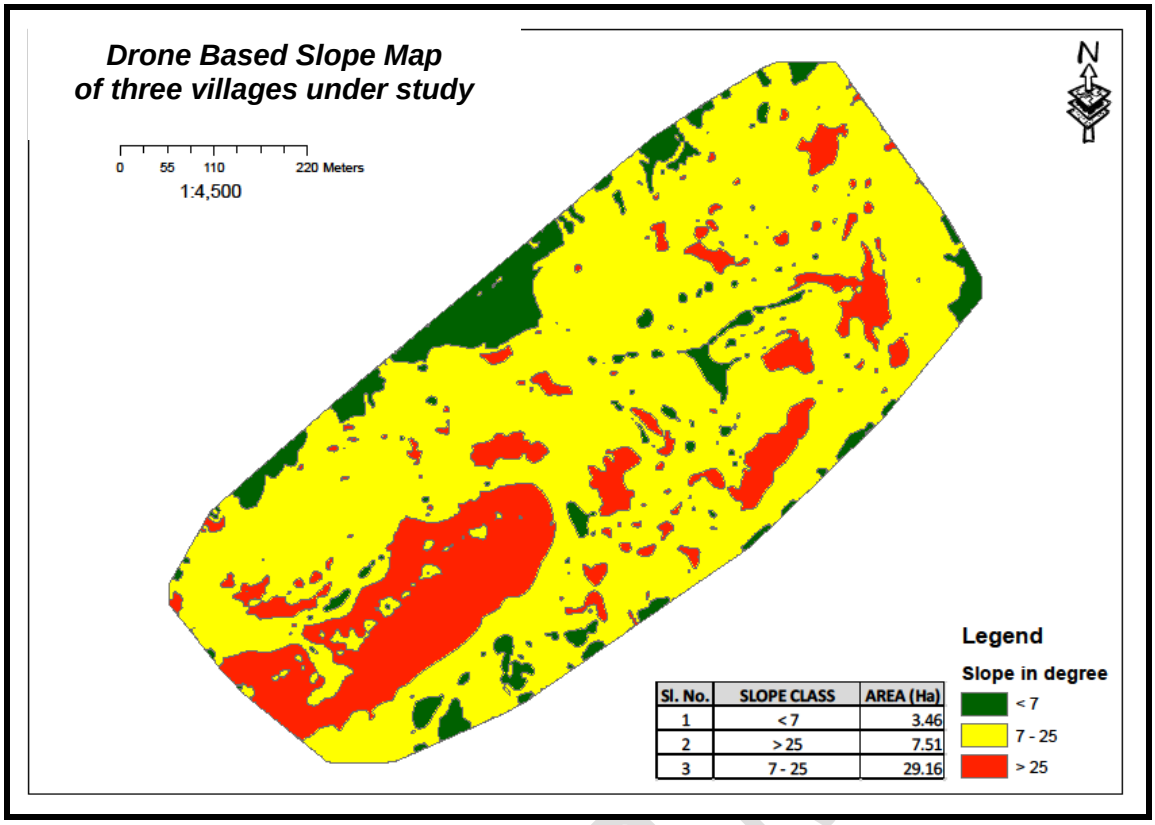


Figure 4: UAV based slope map of three villages under the study.

Table 1: Morphological parameters of the study area

S.No.	Morphological Parameters	Classification Criteria	Area (Ha)
1.	Area	-	40.13
2.	Aspect	North (N)	5.19
		South (S)	2.14
		East (E)	1.51
		West (W)	8.47
		NE	3.25
		NW	15.35
		SE	**1.36**
		SW	**2.86**
3.	Slope	**< 7**	**3.46**
		7 – 25	**7.51**
		25	29.16

Figure 5: FSN map of Thadnongiaw Village as developed by respondents.

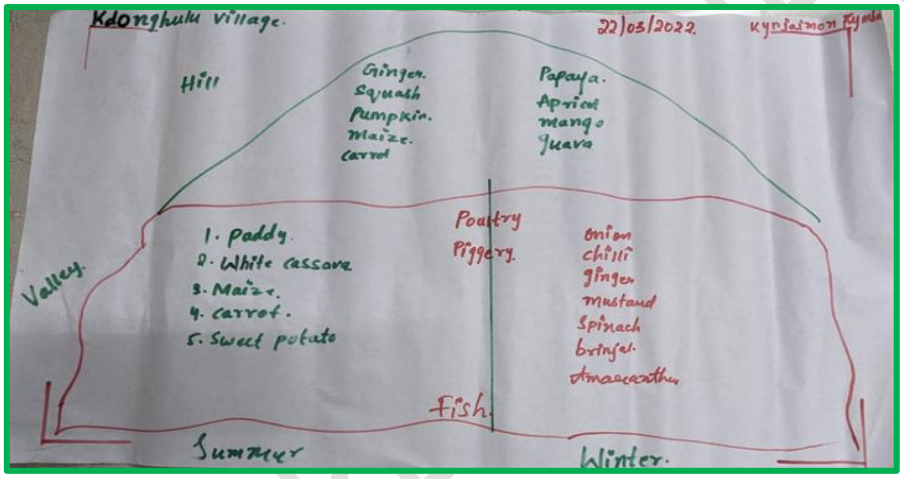


Figure 6: FSN map of Kdonghulu Village as developed by respondents.

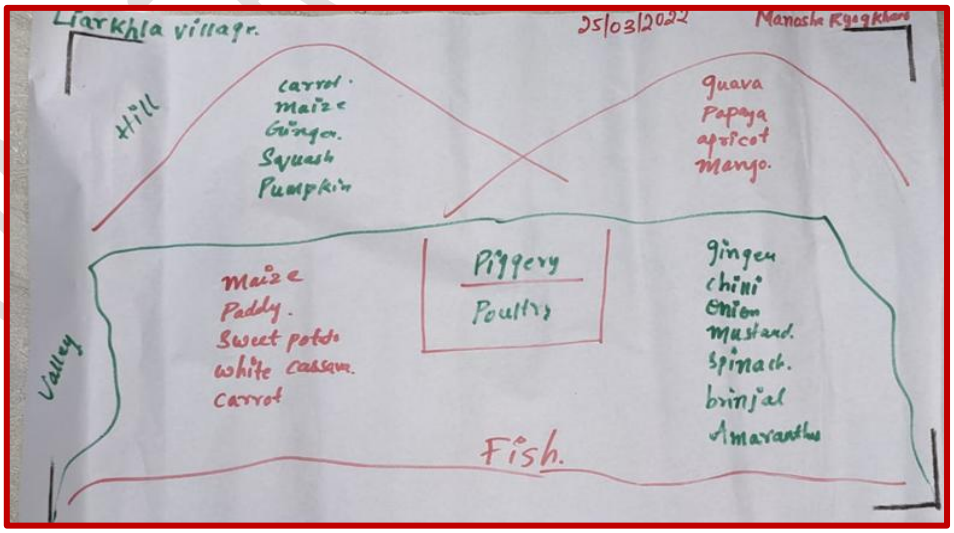


Figure 7: FSN map of Liarkhla Village as developed by respondents.

Inferencing the Figure 3 and Table 1, it could be reported that the study area with 40.13 Ha is located in between 25º42´51″ to 25º45´01″ North and 92º3´18″ to 92º3´18″ to 92º5´17″ East. Further, it could be delved that the locale of the study had an aspect of North, South, East, West, North East, North West, South East and South West with respective areas of 5.19 Ha, 2.14 Ha, 1.51 Ha, 8.47 Ha, 3.25 Ha, 15.35 Ha, 1.36 Ha and 2.86 Ha. The findings limelighted that very few areas of 4.22 Ha, that is about 11% of the arable land was encompassed under South East and South West direction which is considered productive owing to more sunshine hours. Conjecturing, Figure 4 and Table.1, it could be reported that 3.46 Ha, 7.51 Ha and 29.16 Ha had slope of $< 7^{0}$, $7 – 25^{0}$ and $> 25^{0}$. The study ascertained that about 38% and 73% of arable land had aspect toward North-West (*very low sunshine*) and situated in a steep location, wherein administration of improved scientific agriculture was a challenge.

Referring to Figure5 and as specified in Table.2, it could be reported that the hill FSN of Thadnongiaw village was composed of both uplands and lowlands. The study could revealed that FSN has been reported to be practiced in both uplands and lowlands in summer as well as winter seasons. The main summer vegetables that were grown in upland were: (i) Ginger *(Zingiber officinalis),* (ii) Pumpkin *(Cucurbita moschata),* (iii) Carrot (*Daucus carota*), & (iv) Squash (*Sechium edule*). Maize (*Zea mays*) was the prime cereal crop of upland. The important upland summer fruits were (i) Mango (Mangifera indica), (ii) Guava (Pisidium guajava), (iii) Apricot (Prunus armeniaca), (iv) Papaya (Carica papaya), and (v) Pomelo (Citrus maxima). The respondents had depicted and reported that no major vegetables were grown in the upland FSN during the winter, however, the fruits such as (i) Pear (*Pyrus communis*), (ii) Plum *(Prunus domestica), and* (iii) Apricot *(Prunus armeniaca)* were grown. The important winter vegetables grown in the lowland were - (i) Mustard *(Brassica nigra),* (ii) Spinach *(Spinacia oleracea),* (iii) Amaranthus *(Amaranthus viridis),* (iv) Chili *(Capsicum frutescens),* (v) Potato *(Solanum tuberosum), and* (vi) Onion *(Allium cepa).* Homestead Poultry, Piggery and Fishery were the three allied common endeavour being practiced by the respondents in both Summer and Winter seasons.

Table 2: Cultivated vegetables, cereals & fruits and animal husbandry & fishery practices thatare undergone in uplands and lowlands of three villages in two main seasons of a year.

Type of Land	**Crops**	**Animal Husbandry (Along with Fishery)**	**Season**
THADNONGIAW VILLAGE			
Upland		Piggery Poultry Fishery	**Summer**
	VEGETABLES & CEREALS		
	Ginger *(Zingiber officinalis)*		
	Maize *(Zea mays)*		
	Pumpkin *(Cucurbita moschata)*		
	Carrot *(Daucus carota)*		
	Squash (*Sechium edule*)		
	FRUITS		
	Mango (Mangifera indica)		
	Guava *(Pisidium guajava)*		
	Apricot *(Prunus armeniaca)*		

	Papaya *(Carica papaya)*		
	Pomelo *(Citrus maxima)*		
Lowland			
	VEGETABLES & CEREALS		
	Paddy *(Oryza sativa)*		
	Maize *(Zea mays)*		
	Carrot *(Daucus carota)*		
	Sweet Potato *(Ipomoea batatas)*		
	White Cassava *(Manihot esculenta)*		
	FRUITS		
	Pomelo *(Citrus maxima)*		
Upland			
	FRUITS		**Winter**
	Pear (*Pyrus communis*)		
	Plum *(Prunus domestica)*		
	Apricot *(Prunus armeniaca)*		
Lowland			
	VEGETABLES		
	Mustard *(Brassica nigra)*		
	Spinach *(Spinacia oleracea)*		
	Amaranthus *(Amaranthus viridis)*		
	Chili *(Capsicum frutescens)*		
	Potato *(Solanum tuberosum)*		
	Onion *(Allium cepa)*		
KDONGHULU VILLAGE			
Upland		Piggery Poultry Fishery	**Summer** **SUMMER**
	VEGETABLES & CEREALS		
	Ginger (*Zingiber officinalis)*		
	Squash (*Sechium edule*)		
	Pumpkin*(Cucurbita moschata)*		
	Carrot *(Daucus Carota)*		
	Maize*(Zea mays)*		
	FRUITS		
	Pomelo *(Citrus maxima)*		
	Papaya *(Carica papaya)*		
	Mango *(Mangifera indica)*		
	Guava *(Pisidium guajava)*		
	Apricot *(Prunus armeniaca)*		
Lowland			
	VEGETABLES & CEREALS		
	(i) Sweet Potato *(Ipomoea batatas)*		
	(ii) White Cassava *(Manihot esculenta)*		
	(iii) Paddy *(Oryza sativa)*		
	(iv) Maize *(Zea mays)*		
	(v) Carrot (*Daucus Carota)*		
	FRUITS		
	(i) Pomelo *(Citrus maxima)*		
Upland			**Winter**

	FRUITS		
	(i) Pear (*Pyrus communis*)		
	(ii) Plum *(Prunus domestica)*		
	(iii) Apricot *(Prunus armeniaca)*		
Lowland			
	VEGETABLES & CEREALS		
	(i) Mustard *(Brassica nigra)*		
	(ii) Spinach (*Spinacia oleracea)*		
	(iii) Amaranthus *(Amaranthus viridis)*		
	(iv) Chili *(Capsicum frutescens)*		
	(v) Potato *(Solanum tuberosum)*		
	(vi) Onion *(Allium cepa)*		
LIARKHLA VILLAGE			
Upland		Piggery Poultry Fishery	
	VEGETABLES & CEREALS		**Summer**
	(i) Ginger (Zingiber Officinalis)		
	(ii) Maize *(Zea mays)*		
	(iii) Pumpkin *(Cucurbita moschata)*		
	(iv) Carrot (Daucus Carota)		
	(v) Squash (*Sechium edule*)		
	FRUITS		
	(i) Mango (Mangifera indica)		
	(ii) Guava *(Pisidium guajava)*		
	(iii) Apricot *(Prunus armeniaca)*		
	(iv) Papaya *(Carica papaya)*		
	(v) Pomelo *(Citrus maxima)*		
Lowland			
	VEGETABLES & CEREALS		
	(i) Paddy *(Oryza sativa)*		
	(ii) Maize *(Zea mays)*		
	(iii) Carrot (Daucus Carota)		
	(iv) Sweet Potato *(Ipomoea batatas)*		
	(v) White Cassava *(Manihot esculenta)*		
	FRUITS		
	(i) Pomelo *(Citrus maxima)*		
Upland			
	FRUITS		**Winter**
	(i) Pear (*Pyrus communis*)		
	(ii) Plum *(Prunus domestica)*		
	(iii) Apricot *(Prunus armeniaca)*		
Lowland			
	VEGETABLES & CEREALS		
	(i) Mustard *(Brassica nigra)*		
	(ii) Spinach *Spinacia oleracea)*		
	(iii) Amaranthus *(Amaranthus viridis)*		
	(iv) Chili *(Capsicum frutescens)*		
	(v) Potato *(Solanum tuberosum)*		
	(vi) Onion *(Allium cepa)*		

Delving into the FSN map of Kdonghulu village as illustrated in Figure 6 and Table 2, it could be described that (i) Ginger *(Zingiber officinalis),* (ii) Squash (Sechium edule), (iii) Pumpkin *(Cucurbita moschata),* &(iv) Carrot (*Daucus carota*) were the main upland summer vegetables and (i) Maize *(Zea mays)* was the main upland summer cereal crop. (i) Pomelo *(Citrus maxima),* (ii) Papaya *(Carica papaya),* (iii) Mango *(Mangifera indica),* (iv) Guava *(Pisidium guajava),* and (v) Apricot *(Prunus armeniaca)* had been reported to the prime summer upland fruit crops. However, the following vegetables, viz., (i) Sweet Potato *(Ipomoea batatas),* (ii) White Cassava *(Manihot esculenta), and* (iii)Carrot (*Daucus Carota)* were reported to be the major lowland summer vegetables.(i) Paddy *(Oryza sativa) and* (ii)Maize *(Zea mays)* were described to the cereals of choice during summer at lowland in the village. Pomelo (*Citrus maxima*) was the only paramount summer lowland fruit crop. During the winter season, the village cultivated maximum on the following fruits crops in upland, *viz.*, (i) Pear (*Pyrus communis*), (ii) Plum *(Prunus domestica)* and (iii) Apricot *(Prunus armeniaca).* The primary vegetables crops grown in the lowland during the winter included: (i) Mustard *(Brassica nigra),* (ii) Spinach *(Spinacia oleracea),* (iii) Amaranthus *(Amaranthus viridis),* (iv) Chili *(Capsicum frutescens),* (v) Potato *(Solanum tuberosum) and* (vi) Onion *(Allium cepa).* Homestead Poultry, Piggery and Fishery were the three allied common ventures being practiced by the respondents in both Summer and Winter seasons.

Investigating the FSN map of Liarkhla village, as portrayed in Figure 7 and Table 2, it could be revealed that the main summer vegetable crops grown in the upland were: (i) Ginger *(Zingiber officinalis),* (ii) Pumpkin *(Cucurbita moschata),* (iii) Carrot (*Daucus carota*), and (iv) Squash (*Sechium edule*). Maize (*Zea mays*) was the prime cereal upland crop in the village. (i) Mango *(Mangifera indica*), (ii) Guava *(Pisidium guajava*), (iii) Apricot *(Prunus armeniaca),* (iv) Papaya *(Carica papaya),* and (v) Pomelo *(Citrus maxima)* were the important summer fruit crops grown on the upland. (i) Paddy (*Oryza sativa) and* (ii)Maize *(Zea mays)* were the main lowland cereal crops. Carrot *(Daucus carota),* Sweet Potato *(Ipomoea batatas)* and White Cassava *(Manihot esculenta)* were the predominant summer vegetables grown in the lowland. Pomelo (*Citrus maxima*) was the sole summer fruit crop grown in lowland.

During the winter season, the village cultivated the following fruits in the upland, *viz.*, (i) Pear (*Pyrus communis*), (ii) Plum *(Prunus domestica)* and (iii) Apricot *(Prunus armeniaca).* Vegetables, namely (i) Mustard *(Brassica nigra),* (ii) Spinach *(Spinacia oleracea),* (iii) Amaranthus *(Amaranthus viridis),* (iv) Chili *(Capsicum frutescens),* (v) Potato *(Solanum tuberosum) and* (vi) Onion *(Allium cepa)* were the major crops cultivated in lowland. Three common subsidiary vocations assisting nutritional security that had been practiced by the respondents in both seasons were Poultry, Piggery and Fishery.

The EU & FAO in 2013, when studying the Dietary Diversity and nutritional security of household/individual, had contemplated the following categories of food namely, (i) Cereals, (ii) Roots and tubers, (iii) Vitamin A rich vegetables and tubers, (iv) Dark green leafy vegetables, (v) Other vegetables, (vi) Vitamin A rich fruits, (vii) Other fruits, (viii) Meat, poultry and eggs, (ix) Fish and Seafood, (x) Legume, Nuts and Seeds, (xi) Milk and milk products, (xii) Oil and fats, (xiii) Sweets, (xiv) Spices, Condiments & Beverages (Guidelines for measuring household and individual dietary diversity.EU and FAO, 2013). Referring to the same guideline, the study conceived that FSN was considered apposite if the farming system could furnish the daily requirement of an individual or a household.

However, the study could divulged that the FSN in all the three villages did not suffice the obligation of being food and nutritionally secured.

Conclusion

The study area, spanning 40.13 hectares between specific coordinates, showcased diverse aspects—North, South, East, West, North East, North West, South East, and South West—ranging from 1.36 to 15.35 hectares. Notably, only about 11% of arable land lay in productive directions like South East and South West, receiving more sunlight. Slopes varied, with $< 7^0$, $7–25^0$, and $> 25^0$ areas measuring 3.46, 7.51, and 29.16 hectares respectively. However, a substantial portion faced North-West, lacking sunlight and posing challenges for agriculture. In villages like Thadnongiaw, Kdonghulu, and Liarkhla, uplands cultivated summer vegetables and fruits while winter crops thrived in lowlands. Despite diverse cultivation, these farming systems fell short of ensuring food and nutritional security, highlighting challenges in these communities.Therefore, the study recommends that agricultural research institutions and department of agriculture, state government *etc.* should take prime initiatives in order to incept FSN to farmers of Bhoirymbong, Ri-bhoi, Meghalaya.

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