Agricultural Technology Center Pvt. Ltd.
Kupondole-01, Lalitpur

Report on Survey of Soil Quality and Management

Submitted to:
Madan Bhandari Science and Technology University
Sainbu, Lalitpur

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Table of Contents

List of Figures

List of Tables

Acronyms

FAO	Food and Agriculture Organization
ATC	Agricultural Technology Center Pvt. Ltd.
BS	Bikram Sambat
℃	Celsius
DAP	Diammonium Phosphate
IPM	Integrated pest management
IPNM	Integrated plant nutrient management
Km	kilometer
MBUST	Madan Bhandari University of Science and Technology
MOP	Muriate of Potash
NASA	National Aeronautics and Space Administration
NTFPs	Non-forest Timber Products
SDGs	Sustainable Development Goals
SOCLAS	Latin American Society for Agroecology
SSM	Sustainable Soil Management
SWSR	World's Soil Resources Study
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations. Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

1.1 Background

Soil is a very important natural resource. Having commodities and services that are crucial to ecosystems and human existence, soil is a necessary non-renewable natural resource. Directly or indirectly, all the activities we do in this earth are linked to soil. As a core component of land resources, agricultural development and ecological sustainability, it is the basis for food, feed, fuel and fiber production including many other critical ecosystem services. It is therefore a highly valuable natural resource, yet, is often overlooked[1]. Approximately 95% of the world's food is generated in soil, which also has the greatest terrestrial carbon store on earth.

Rapidly rising population demands more and more land for shelter, food production and other requirements. Food production can be increased either by crop intensification or by extensification. For both the cases, land quality assessment and sustainable planning is necessary. Besides production of cereals, fruits, vegetables, and other commercial crops, land is also required for pasture, fodder trees, forages, forest, and non-forest timber products (NTFPs). However, the land and soil requirements for each of these categories vary greatly. However, new information from the Status of the World’s Soil Resources Study (SWSR) and other research indicate that around 33% of the world's soils are moderately or substantially degraded, as a result of unsustainable management methods. A global loss of 75 billion tons of soil from arable land is thought to cost roughly $400 billion annually to the agriculture industry[2]. Additionally, this loss drastically lowers the soil's capacity to store and cycle nutrients, water, and carbon.

Sustainable Soil Management (SSM) is a useful tool for coping with climate change and a strategy to protect important ecosystem functions and biodiversity. Because soils give tremendous benefit, SSM guarantees a high return on investment by sustaining ecosystem services that provide benefits to the society as well as expanding these services. The widespread use of SSM tool results in many socioeconomic benefits, particularly for large-scale agricultural producers and smallholder farmers who rely only on their land resources for their means of subsistence. SSM strongly contributes to collective efforts towards the climate change adaptation and mitigation, combating desertification and promoting biodiversity, and therefore has specific relevance to the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD) and United Nations Convention on Biological Diversity (UNCBD). SSM supports a number of Sustainable Development Goals (SDGs)[3]:

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[1] FAO. (2015). *FAO Annual Summary Report 2015-Guyana*.
[2] FAO. (2017). *Voluntary Guidelines for Sustainable Soil Management*.
[3] FAO-ITPS. (2020). *Protocol for the assessment of Sustainable Soil Management*.

- Sustainable productivity (SDG 2: Ensures sustainable food production systems and implement resilient agricultural practices that increase productivity and production, and that progressively improve land and soil quality).
- Soil water availability (SDG 6: Freshwater withdrawal as a proportion of available freshwater resources).
- Soil pollution (SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable)
- Sustainable use of agricultural inputs (SDG 12: Achieve the management of chemicals and all wastes, and significantly reduce their release to air, water and soil).
- Soil carbon capture (SDG 13: Take urgent action to combat climate change and its impacts).
- Soil degradation (SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss).

1.2 About the Assignment

In order to help Nepal fulfill its citizens' ambitions for a successful Nepal and contented Nepalis, the Madan Bhandari University of Science and Technology (MBUST) was established in accordance with the Madan Bhandari University of Science and Technology Act 2079 by the government of Nepal. The institution has chosen a plan to match its academic and research initiatives with sectors of the economy that have a great potential to contribute to the nation's economic growth and prosperity. In order to do this, the institution built a farm in Chitlang and had already carried out plant disease survey in order to manage plant disease of Chitlang and the surrounding area properly and with fewer chemical applications. Then, MBUST had planned out a soil assessment in addition to improving soil quality for the purpose of organic farming.

Within given scope of service, this assignment was handed over to the Agricultural Technology Center (ATC) Pvt. Ltd. by MBUST through direct procurement method as set in Public Procurement Act 2007 and Public Procurement Regulation 2007. Agricultural Technology Center (ATC) is an agriculture specialist company that has provided lab services, project consultancy services, training and a variety of technical solutions since its establishment in 1993. We work with farmers, agricultural investors; government agencies, I/NGOs and UN agencies to ensure that up-to-date and context-appropriate agricultural knowledge can be implemented effectively at field level where it matters the most. ATC has a professional team of experts with several years of experience in different areas of expertise, serving clients with high-quality technical and research solutions.

For the survey and study following team from ATC was involved:

Table 1: Team composition for survey and soil sampling from ATC

S.N	***Position***	***Name of the personnel***	***Qualification***
1	Team Leader (Soil Expert)	Santosh Shrestha	MSc. Soil Science
2	Field Technician	Monika Thapa	BSc Agriculture
3	Field Technician	Alina Poudel	BSc Agriculture

1.3 Objective

Following were the objectives of our study:

1. To collect the soil samples from all the arable areas of Chitlang and adjoining areas
2. Conduct a survey of the farmers regarding the current soil management practices and problems
3. To analyze the collected soil sample in laboratory and recommend soil management strategies for the upliftment of soil health and productivity of the area

2. METHODOLOGY

2.1 Sampling and survey area

The study area was mainly focused on Chitlang along with the nearby adjoining areas of Madan Bhandari University of Sciences and Technology (MBUST). As planned, there were four study areas i.e. Chitlang where University is located, Goat Development Farm, Taukhel and Bajrabarahi. Soil sampling and survey was conducted in these areas on 14th-15th October 2022. Soil sampling was randomly taken from the areas following all the guidelines of soil sampling (See Annex 12)

As depicted in the Figure 1 each green triangle represents the sampling and survey points (see Annex 7 for point location).

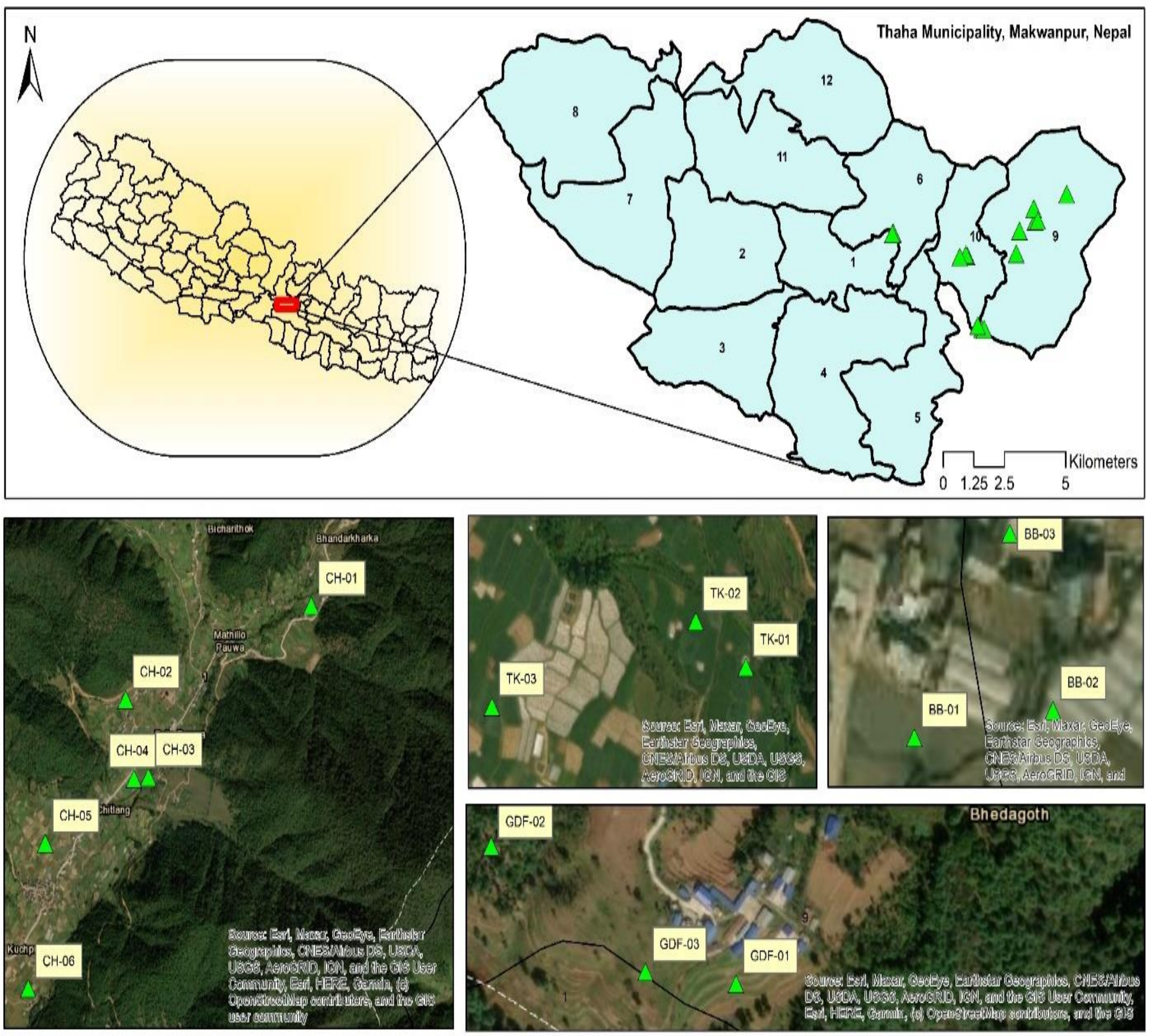

Figure 1: Areas of soil sampling and survey for the study

2.2 Soil sampling sites

A total 15 soil samples were collected from the visit within 2 field days. Out of 15 samples 6 samples were from Chitlang, 3 from Goat Development Farm, 3 from Taukhel and remaining 3 from Bajrabarahi area. Sampling was done with help of soil auger and soil was withdrawn from 0-30cm depth as recommendation was targeted for vegetable cultivation. Samples were taken randomly from 7-8 sub sampling points and were composited to make one main sample in each point. Samples were then packed and sent to the laboratory for further testing.

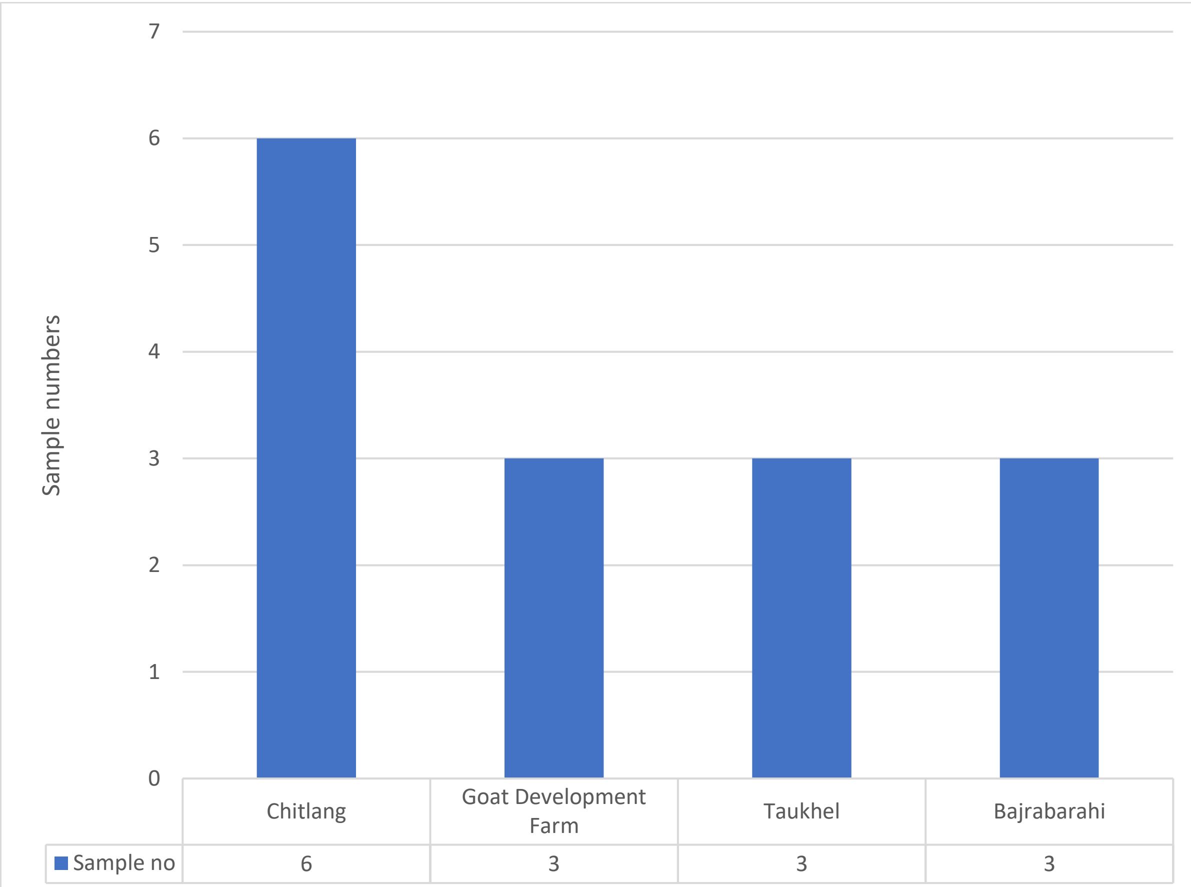

Figure 2: Location wise soil sample number distribution in Thaha municipality

2.3 Laboratory Testing

Soil samples were sent to Agricultural Technology Center Pvt. Ltd (soil laboratory) at Kupondole-01, Lalitpur for testing of different soil parameters. Tested parameters are listed in the Table 1. Besides routine analysis, about 4 samples (1 from each representative unit) were also further analyzed for micronutrients. Details of analysis and methods are described in Table 2.

Table 2: Tested parameters of the soil samples

S.N	***Tested Parameters***	***Methods***	***Sample Numbers***
1.	Total Nitrogen	*Kjeldahl Digestion Distillation Method*	15
2.	Available Phosphorus	*Modified Olsen's Bicarbonate Method*	15
3.	Available Potassium	*Ammonium Acetate (Flame Photometric Method)*	15
4.	Soil pH	*Potentiometric (1:2.5) Method*	15
5.	Buffer pH	*SMP Buffer method*	15
6.	Soil organic matter	*Walkley and Black Method*	15
7.	Soil Texture	*Hydrometer Method*	15
8.	Available Iron	*DTPA Extraction and AAS Method*	4
9.	Available Zinc	*DTPA Extraction and AAS Method*	4
10.	Available Boron	*Hot Water Extraction and Azomethine-H Method*	4

2.4 Field visit and survey

Field visit for assessing the soil nutrient status and recommending site specific soil management strategies were carried out by a team of professionals having past experience in the similar field. Following criteria were observed during field visit (See Annex 1 for the questionnaire):

- Farm details (area, cropping calendar, complaints, etc.)
- Soil status and its management practices (soil testing, acidity, erosion, slope, aspect, fertilizer usage, irrigation, management practices, problems identified and complaints, etc.)
- Crop health status (crop variety, disease and pest, management and cultivation practices, manure management, etc.)
- Field management status (manuring details, irrigation details, farm integration, residue management, sanitation, input and outputs, etc.)
- Modified SOCLAS soil health assessment (soil health indicators) (see Annex 2)

3. FINDINGS AND RECOMMENDATION

3.1 Site Description

Thaha municipality is located in the northern part of Makwanpur district in Bagmati province, with 191.2 km² of area[4]. Sampling site has elevation ranging from 1610masl (Taukhel) to 1825masl (Chitlang) with a slope less than 35°. It borders Kathmandu valley to the northwest and lies midway from the federal capital Kathmandu and the provincial capital Hetauda. It is one of the local units out of 10 in Makwanpur district, formed by merging the existing Thaha municipality, Bajrabarahi VDC, Chitlang VDC and Aagra VDC. The municipality is further divided into 12 wards, out of which three (Ward no.6 - Bajrabarahi, Ward no.9 – Chitlang, Goat Development Farm and Ward no.10-Taukhel) was under our area of study[5].

Thaha municipality is easily accessible by motorable roads from neighboring areas via the Naubise-Hetauda road of Tribhuvan highway, that passes around 22 km of the municipality or via Pharping-Kulekhani road ways (57 kms). With the opening of the Ganeshman Singh Marg from Thankot via Chandragiri, Chitlang is now just 13 kms away from the capital[6]. However, many rural settlements of the area lack the road network. Shikharkot, Thana Bazaar, Bagekhola, Okhar Bazaar, Phant Bazaar and Khalte Bazaar are the major market places within the municipality. Whereas, Kathmandu, Birgunj, Hetauda, Narayanghat, Pokhara, Butwal, Bharatpur are the major market centers for agricultural products.

The municipality is best known for its variation in topography, geographical features and majorly the climatic conditions, and biodiversity. Most of the households in this municipality were involved in agriculture, followed by tourism, trade and business and foreign employment. Before 2050 B.S, agriculture was solely based on cereal crop production but now the Thaha municipality specializes in vegetable production. Every year the production worth 1 billion is transported not only to the major cities of the country but also to the neighboring country India[5]. Ward no 6, Bajrabarahi is known for its off-season vegetable production. Radish, Capsicum (bell pepper), chilli, cauliflower, cabbage etc. are the major productions of this area. Ward no 9, Chitlang also outstands in vegetable production and it is also being developed as a tourist (local as well as international) destination in the recent years.

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[4] https://thahamun.gov.np/ne/content/नगर-प्रोफाइल

[5] GGGI (2018). *Thaha Municipality, Nepal: Situation Analysis for Green Municipal Development.* Seoul: Global Green Growth Institute.

[6] https://nepalnews.com/s/nation/popular-tourist-destination-chitlang-now-only-15km-away-from-thankot

3.2 Climatic conditions

Last ten-year (2012-2021) climatology data was extracted from the Power data access source provided by National Aeronautics and Space Administration (NASA). The data shows that the area experience huge rainfall of maximum 377mm from the month of Baishakh to Asoj (May-September). This maintains average relative humidity to 36-88% (Figure 4). Average temperature was recorded to be 13-28 ℃ but may reach maximum to 40.5℃ in summer (June) and least to 2.5℃ in winter (December) (Figure 3). During the winter days, the place experiences chilling frost (Figure 5) which is considered detrimental for plants in winter.

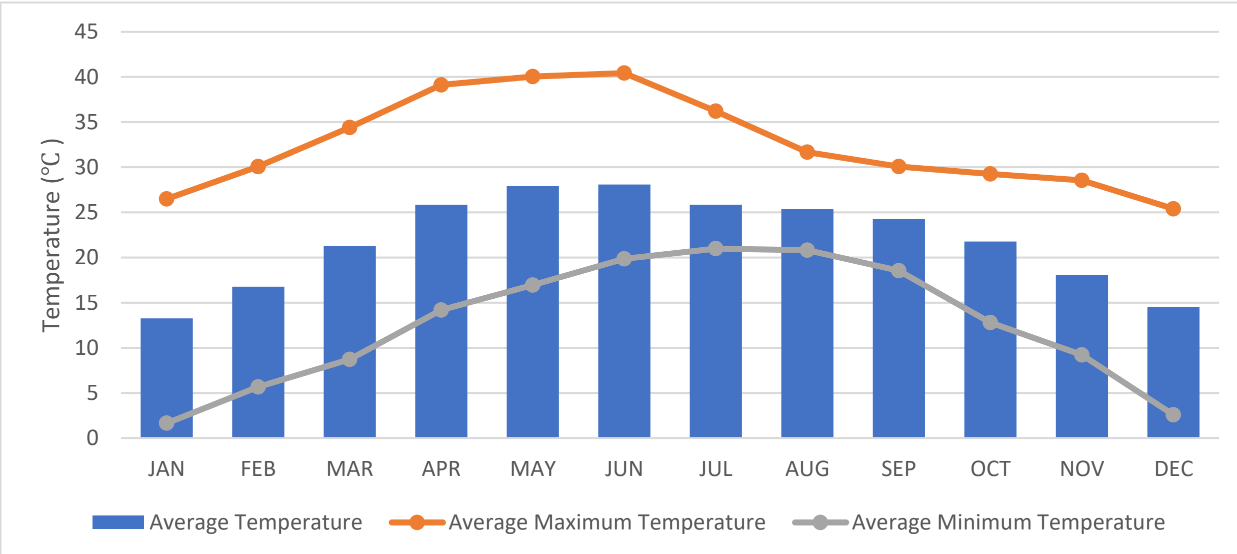


Figure 3: Annual Temperature status of Thaha municipality, Makawanpur

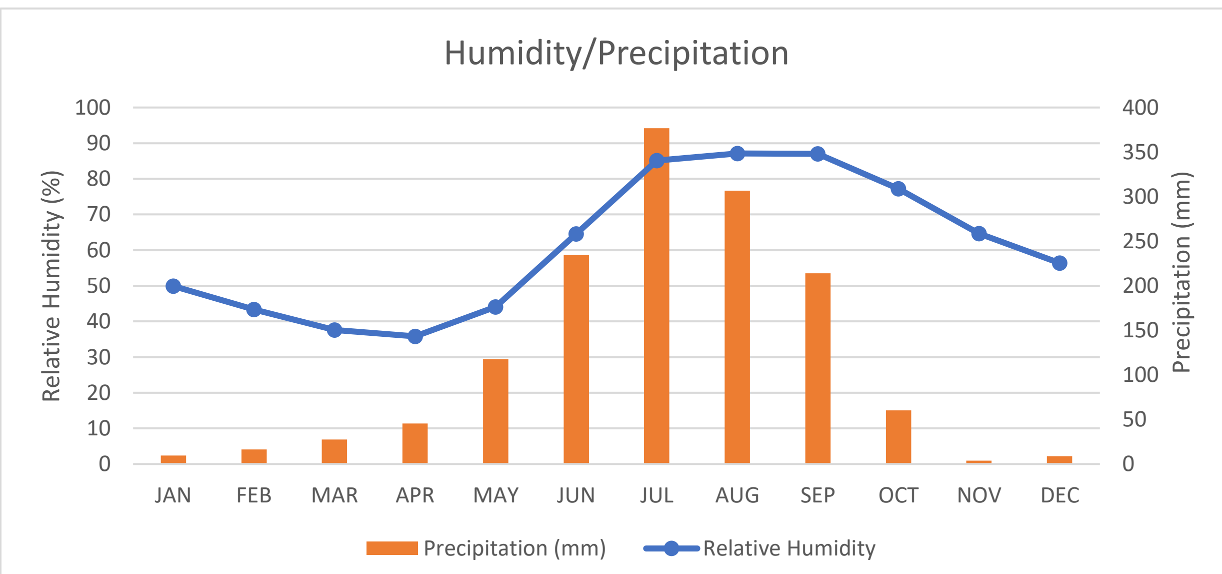


Figure 4: Average monthly precipitation and relative humidity status of Thaha municipality, Makawanpur

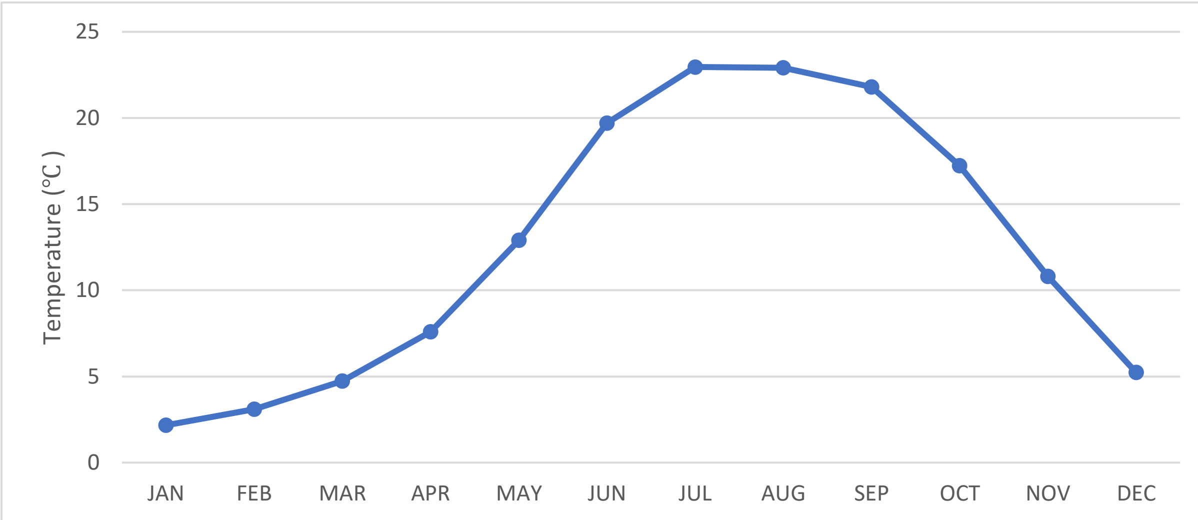


Figure 5: Average monthly frost/dew point status of Thaha Municipality, Makawanpur

3.3 Sampling and Survey Details

Collected soil samples are of two categories: Open farming and Tunnel house farming. Tunnel house farming represents the area covered with plastic tunnel either hi-tech or simple one with continuous and intensive cropping pattern while open farming belongs to area with no any structure like plastic tunnel (Figure 6); openly cultivated area. About 53% samples belongs to tunnel type and remaining to the open farming systems.

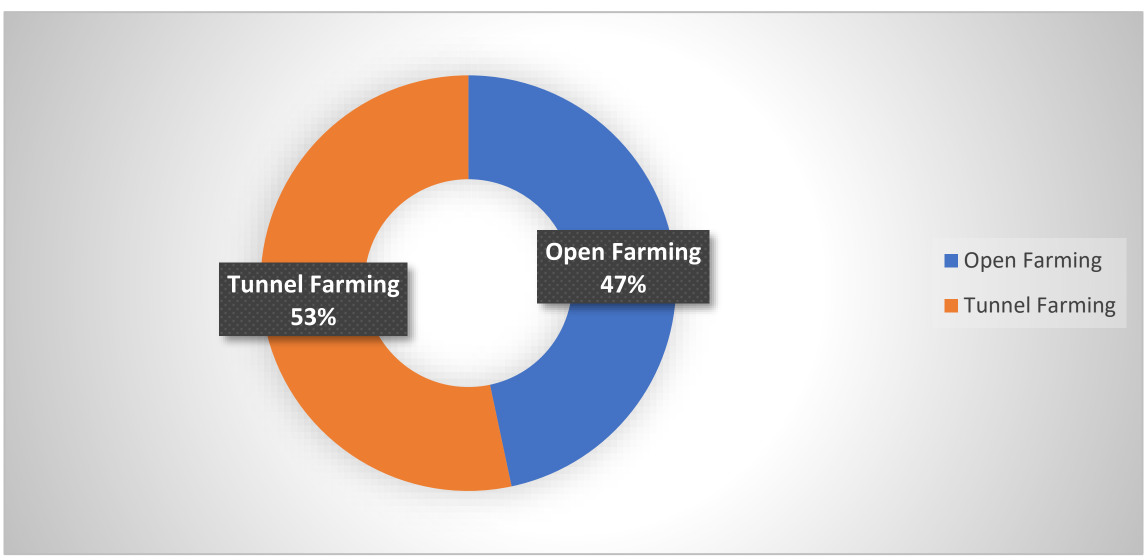


Figure 6: Farm types in the study area

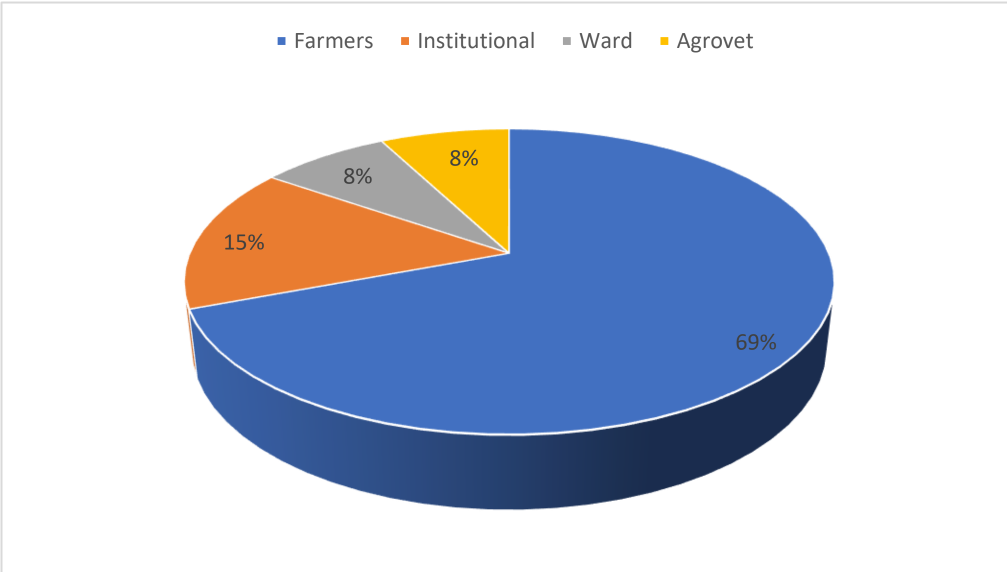


Figure 7: Composition of survey respondents

Along with the soil sampling, survey was carried from respective owner of the farms (see Annex 5). A total 15 surveys was done during the visit with well-designed set of questionnaires (see Annex 1) covering soil health, management, problems, and many other indicators. The composition of survey was such that it covered all the related information centers. About 69% respondents were farmers, 15% was institutional i.e., MBUST and Goat Development Farm, 8% was governmental ward office at Taukhel and 8% was ruling agrovet of the area (Figure 7). So, this makes total 8 surveys from Chitlang, 3 from Taukhel, 1 from Bajrabarahi and 3 from Goat Development Farm (Figure 8).

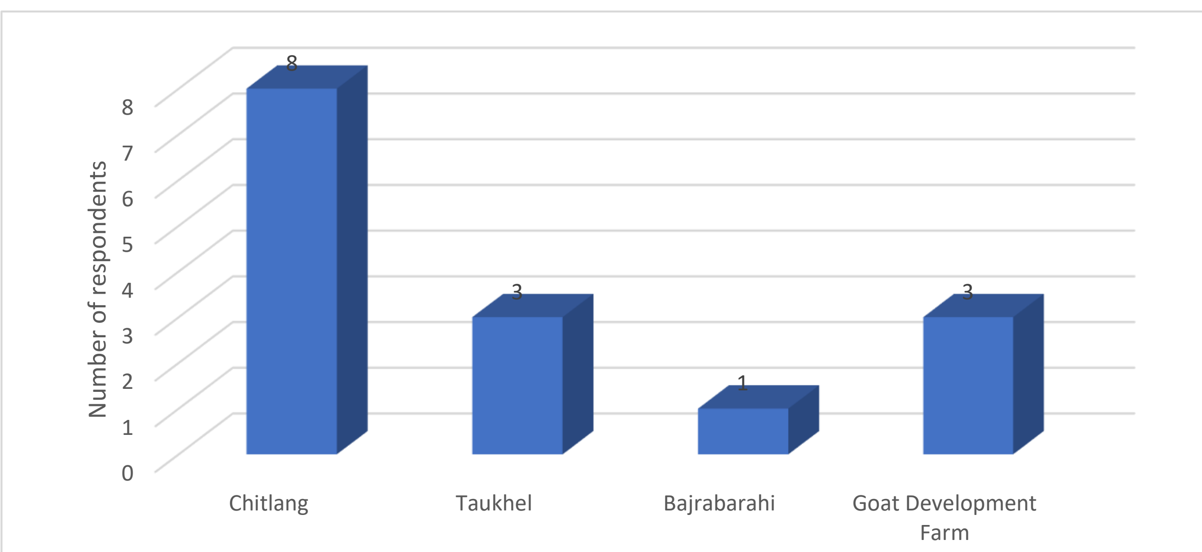


Figure 8: Number of respondents from different areas

3.3 Soil Nutrient Status

3.3.1 Soil nutrient status of Chitlang

As per the laboratory report Chitlang (Table 3) (see Annex 6 for detail report) area has good concentration of nutrient holding from medium to high range. Total nitrogen, available phosphorus, available potassium and organic matter are all in best concentration for cultivation. Phosphorus and potassium are all at higher range(see Annex 10 for the nutrient range) with exception of nitrogen. Soil textures are almost same for all the area which is loam. One spot was detected to be sandy loam. Such soils have lower nutrient holding capacity and availability. Micronutrient like boron and zinc is too low in the area with high concentration of iron.

Main constraints for the soil were found for soil pH. All the soil are under highly acidic range (<5.50). This causes severe loss in the yield and soil health. Soil biodiversity and nutrient availability are seriously injured due to acidic soil pH.

Agriculture lime is recommended to apply on the recommended dose with the recommended methods for recovery and sustained yield (See Annex 3). Sustainable soil management practices are to be followed for sustained production.

Table 3: Laboratory report of soil analysis of Chitlang

S.N.	***Sample Code***	***Sample Identification***	***N %***	***P_2O_5 kg/ha***	***K_2O kg/ha***	***O.M.%***	***Boron ppm***	***Iron (ppm)***	***Zinc (ppm)***
1	079/513	CH - 01	0.39	230.75	455.6	6.08	0.37	66.76	0.30
2	079/514	CH - 02	0.32	311.94	1313.2	4.81	-	-	-
3	079/515	CH - 03	0.39	278.82	576.2	5.32	-	-	-
4	079/516	CH - 04	0.32	425.18	576.2	5.19	-	-	-
5	079/517	CH - 05	0.19	631.36	656.6	4.37	-	-	-
6	079/518	CH - 06	0.19	210.45	321.6	3.48	-	-	-

S.N.	***Sample Code***	***Sample Identification***	***pH***	***Buffer pH***	***Sand %***	***Silt %***	***Clay %***	***Soil Texture***
1	079/513	CH - 01	4.94	5.39	58.1	30.82	11.08	SL
2	079/514	CH - 02	5.01	5.82	49.1	33.82	17.08	L
3	079/515	CH - 03	4.38	5.35	39.1	37.82	23.08	L
4	079/516	CH - 04	5.49	5.78	39.1	37.82	23.08	L
5	079/517	CH - 05	5.10	5.99	49.1	41.82	9.08	L
6	079/518	CH - 06	5.65	6.32	29.1	45.82	25.08	L

Note: SL=Sandy Loam, L=Loam

3.3.2 Soil nutrient status of Bajrabarahi

With the same constraint as in Chitlang (i.e., acidic soil pH) nutrient status ranges from low to highest (see Annex 10 for the nutrient range). Available phosphorus and potassium seem suitable while nitrogen content is lowest to medium range (Table 4). Organic matter is also at the medium range. Organic matter needs to be improved for sustained production. Soil texture is same as in Chitlang i.e. Loam which is good for vegetable cultivation. This area has a good level of micronutrient as well.

Agriculture lime is recommended to apply on given dose with given methods for recovery and sustained yield (See Annex 3). Sustainable soil management practices are to be followed for sustained production.

Table 4: Laboratory report of soil analysis of Bajrabarahi

S.N.	***Sample Code***	***Sample Identification***	***N %***	***P_2O_5 kg/ha***	***K_2O kg/ha***	***O.M.%***	***Boron ppm***	***Iron (ppm)***	***Zinc (ppm)***
7	079/519	BB - 01	0.19	629.22	348.4	3.48	-	-	-
8	079/520	BB - 02	0.06	805.49	201.0	3.23	1.87	147.49	6.50
9	079/521	BB - 03	0.26	995.65	455.6	4.05	-	-	-

S.N.	***Sample Code***	***Sample Identification***	***pH***	***Buffer pH***	***Sand %***	***Silt %***	***Clay %***	***Soil Texture***
7	079/519	BB - 01	5.71	6.47	43.1	43.82	13.08	L
8	079/520	BB - 02	5.46	6.20	41.1	49.82	9.08	L
9	079/521	BB - 03	4.56	5.65	43.1	41.82	15.08	L

Note: L=Loam

3.3.3 Soil nutrient status of Goat Development Farm

Similarly, Goat Development Farm has high range of phosphorus and potassium level (see Annex 10 for the nutrient range) with varying nitrogen level. It ranges from lowest to medium range (Table 5). Organic matter is at medium level which needs to be improved for sustained production. Soil is clay loam in agricultural plot and loam in both demo and pasture area. Pasture area is deficient in nitrogen. Soil is deficient in boron and zinc while iron is at quite good level.

Soil pH had played major constraints in this area too. Agriculture lime is recommended to apply on the provided dose with the recommended methods for recovery and sustained yield (See Annex 3). Sustainable soil management practices are to be followed for sustained production.

Table 5: Laboratory report of soil analysis of Goat Development Farm

S.N.	Sample Code	Sample Identification	N %	P_2O_5 kg/ha	K_2O kg/ha	O.M.%	Boron ppm	Iron (ppm)	Zinc (ppm)
10	079/522	GDF - 01	0.13	429.45	857.6	3.54	-	-	-
11	079/523	GDF - 02	0.13	148.49	549.4	3.23	0.12	14.42	0.30
12	079/524	GDF - 03	0.06	159.18	348.4	2.78	-	-	-

S.N.	Sample Code	Sample Identification	pH	Buffer pH	Sand %	Silt %	Clay %	Soil Texture
10	079/522	GDF - 01	5.75	6.08	37.1	31.82	31.08	CL
11	079/523	GDF - 02	5.29	6.47	43.1	31.82	25.08	L
12	079/524	GDF - 03	4.99	6.57	35.1	46.82	18.08	L

Note: L=Loam, CL= Clay Loam

3.3.4 Soil nutrient status of Taukhel

For Taukhel farm, nitrogen is at deficient level while phosphorus and potassium seems to be at good condition (see Annex 10 for the nutrient range). Soil texture is loam and clay loam which suits for the production. Organic matter though is at the medium ranges, which needs to be improved for sustained production. Similarly it has low level of zinc and boron while iron remains at maximum (Table 6).

Since the pH level is too acidic, agriculture lime is recommended to apply on the given dose with the given methods for recovery and sustained yield (See Annex 3). Sustainable soil management practices are to be followed for sustained production.

Table 6: Laboratory report of soil analysis of Taukhel

S.N.	Sample Code	Sample Identification	N %	P_2O_5 kg/ha	K_2O kg/ha	O.M.%	Boron ppm	Iron (ppm)	Zinc (ppm)
	079/525	TK - 01	0.06	445.48	214.4	3.86	0.12	165.96	1.70
14	079/526	TK - 02	0.19	759.56	643.2	3.73	-	-	-
15	079/527	TK - 03	0.06	628.16	254.6	3.92	-	-	-

S.N.	Sample Code	Sample Identification	pH	Buffer pH	Sand %	Silt %	Clay %	Soil Texture
13	079/525	TK - 01	5.63	6.69	37.1	45.82	17.08	L
14	079/526	TK - 02	5.10	6.69	37.1	47.82	15.08	L
15	079/527	TK - 03	5.36	6.56	41.1	27.82	31.08	CL

3.3.5 Soil nutrient status of MBUST tunnel area

MBUST analyzed soil sample of its arable area before (Table 7) and after (Table 8) a tunnel house construction for research purpose. As per the report recent soil sample has lost its fertility due to excavation for land levelling. Due to excavation nitrogen level has declined along with other nutrients like phosphorus, potassium and organic matter. Soil acidity seems unchanged which needs to be corrected for the sustained production. Agriculture lime is recommended to apply on the recommended dose with the recommended methods for recovery and sustained yield (See Annex 3). Sustainable soil management practices are to be followed for sustained production. Organic matter is at medium level which needs to be improved for sustained production.

A. Before tunnel construction

Table 7: Laboratory report of soil analysis of MBUST tunnel house area before excavation

S.N.	Sample Code	Sample Identification	pH	N %	P_2O_5 kg/ha	K_2O kg/ha	O.M.%	Sand %	Silt %	Clay %	Texture
1	078/932	Site-9	5.11	0.13	12.56	361.8	2.64	57.06	29.8	13.18	SL

Note: SL=Sandy Loam

B. After tunnel construction

Table 8: Laboratory report of soil analysis of MBUST tunnel area after excavation

S.N.	Sample Code	Sample Identification	pH	N %	P_2O_5 kg/ha	K_2O kg/ha	O.M.%	Sand %	Silt %	Clay %	Texture
1	079/332	GH (Control)	5.44	0.10	5.81	335	2.06	36.22	41.82	21.96	L
2	079/428	Field Sample	4.55	0.13	41.06	522.6	2.68	54.4	21.76	23.84	SCL

Note: L=Loam, SCL=Sandy Clay Loam

3.4 Soil Quality and Health Index

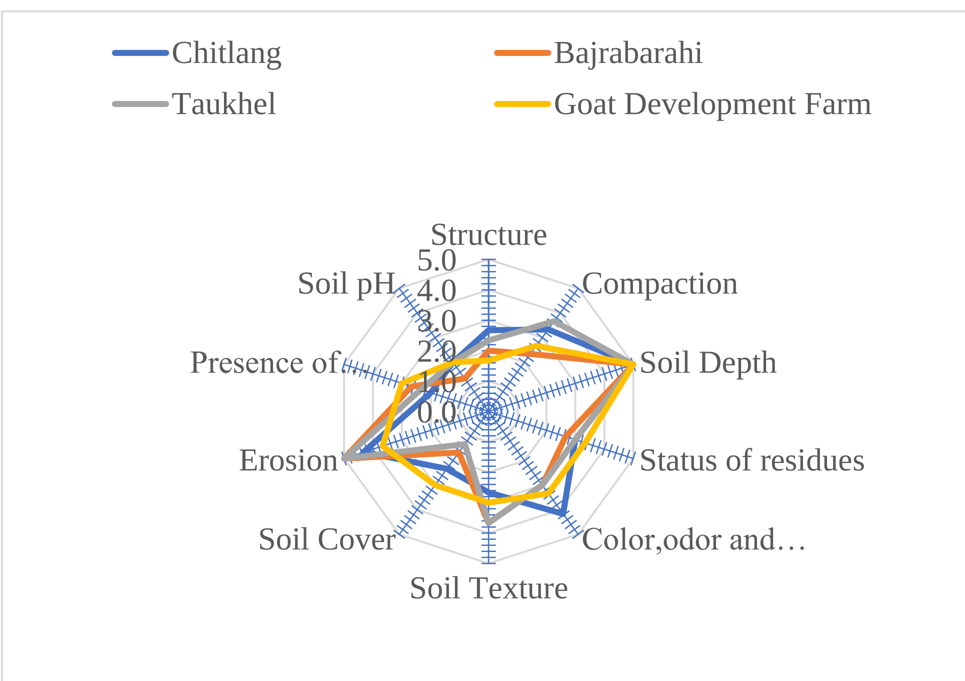
Soil Quality index (SQI) gives fertility level of soil based on the routine soil parameters like nitrogen, phosphorus, potassium, pH, organic matter and texture. It ranges from 0-1 with 1 being highly fertile soil. It helps to determine the exact soil fertility level with multiple analyzed parameters. SQI shows that Chitlang, Bajrabarahi and Goat Development Farm has Good to Best soil fertility level while Taukhel has Fair to Good fertility level (Table 9). SQI of the analyzed sample is minimum 0.58 at Taukhel while maximum 0.92 at Chitlang (see Annex 10 for the quality range). Higher SQI is due to higher phosphorus and potassium level which is due to standing crop and fertilization. Though the SQI index is better due to high available nutrient but here lower soil pH index cannot be neglected.

Soil health is a crucial factor in both agricultural productivity and environmental resilience because it includes stabilizing soil structure, preserving soil life and biodiversity, retaining and releasing plant nutrients, and maintaining water-holding capacity. The Latin American Society for Agroecology (SOCLAS) indicators were used to measure the soil health. The approach is based on the field observation and the laboratory measurements.

Soil health of almost all the areas is well acceptable but require good sustainable management practices to enhance soil organic content and nutrient holding (see Annex 9 for detail SQI and soil health points). Chitlang and Bajrabarahi had desirable range of soil health but minimal soil pH score (see Annex 10 for the quality range). Among collected soil sample all the samples have good level of soil structure, compaction and depth followed by lesser erosion symptoms (Figure 9). Organic residues found in the field was of varying stages with higher undecomposed types of residues. As indicated above, soil pH has pooled the soil health level to less acceptable zone due to high level of acidity. This has created less nutrient availability and less biodiversity in soil as presence of the invertebrates was minimal. Indicators like soil pH, soil cover, biodiversity, residues, organic matter are unsustainable which need immediate action for recovery.

Table 9: Location wise soil quality index and soil health status matrix

Location	***Soil Quality index***			***Soil Health***	
	Fair %	**Good %**	**Best %**	**Acceptable %**	**Desirable %**
Chitlang	0%	17%	83%	83%	17%
Bajrabarahi	0%	67%	33%	67%	33%
Goat Development Farm	0%	100%	0%	100%	0%
Taukhel	33%	67%	0%	100%	0%



Desirable

≥ 3.5

Acceptable

≥ 2.5 and <3.5

Unsustainable

<2.5

Figure 9: Location wise score of soil health indicators

3.5 Cultivated vegetable crops and cropping calendar

In the study area majority of the people were found to cultivate cruciferous crops like cauliflower, cabbage and radish; solanaceous crops like chilly, potato, tomato, capsicum (Figure 10). Besides we found legume crop like green beans as well. Maize was major cereal crop cropped during the fallow period.

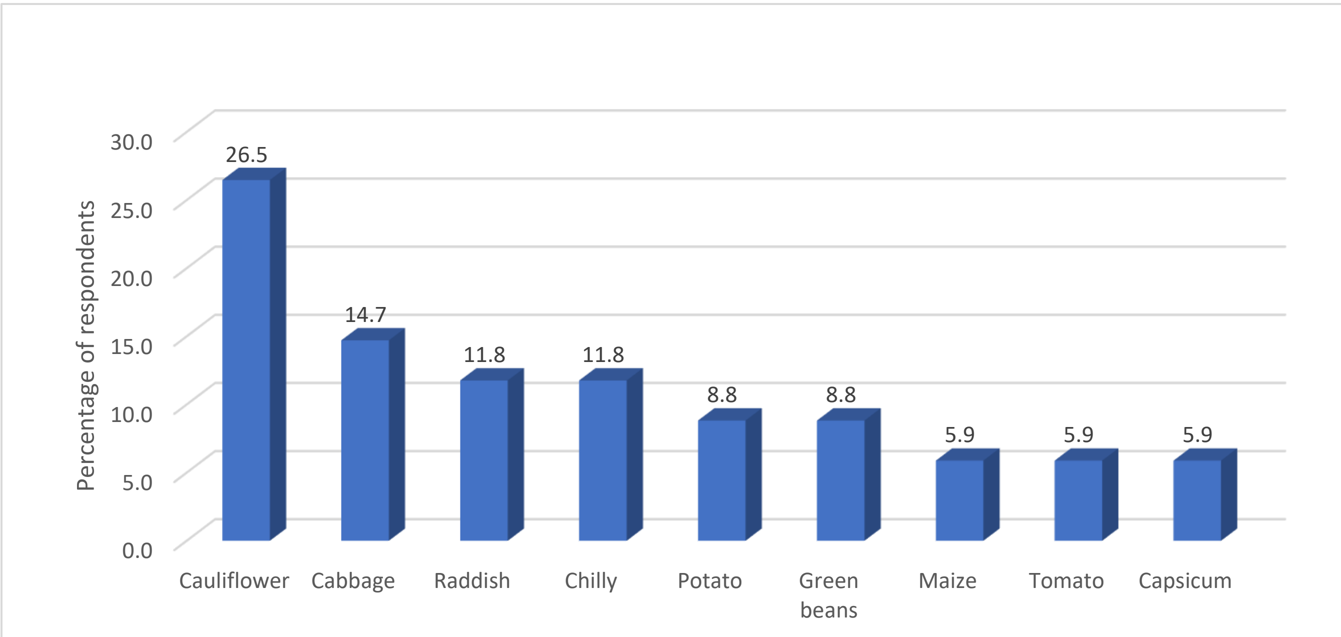


Figure 10: Cultivated vegetable crops in the study area

Mangsir-Magh remains fallow (Figure 11) due to chilling frost level in the area. Majority of the crops are planted after frost days and harvested before next frost days.

Crops	Baishakh	Jestha	Asadh	Shrawn	Bhadra	Asoj	Kartik	Mangsir	Poush	Magh	Falgun	Chaitra
Cauliflower												
Cabbage												
Raddish												
Chilly												
Potato												
Green beans												
Maize												
Tomato												
Capsicum												

Cropping cycle   Fallow

Figure 11: Annual cropping cycle of the area

3.6 Soil management practices

Majority of the farmers (67%) haven't tested their soil nutrient status yet (Figure 12). Few farmers/respondents had checked from Hetauda regional laboratory while the other has checked from cooperative initiatives. Among the tested area, soil pH was acidic with lower organic matter content as per the interview with the farmers. For this few have applied lime with no proper testing and management practices. Farmers are found to apply pine incorporated compost manure in the field which can be one of the major sources of soil acidity. Among non-tested area, presence of club root in cruciferous crops are indicating for soil acidity as well.

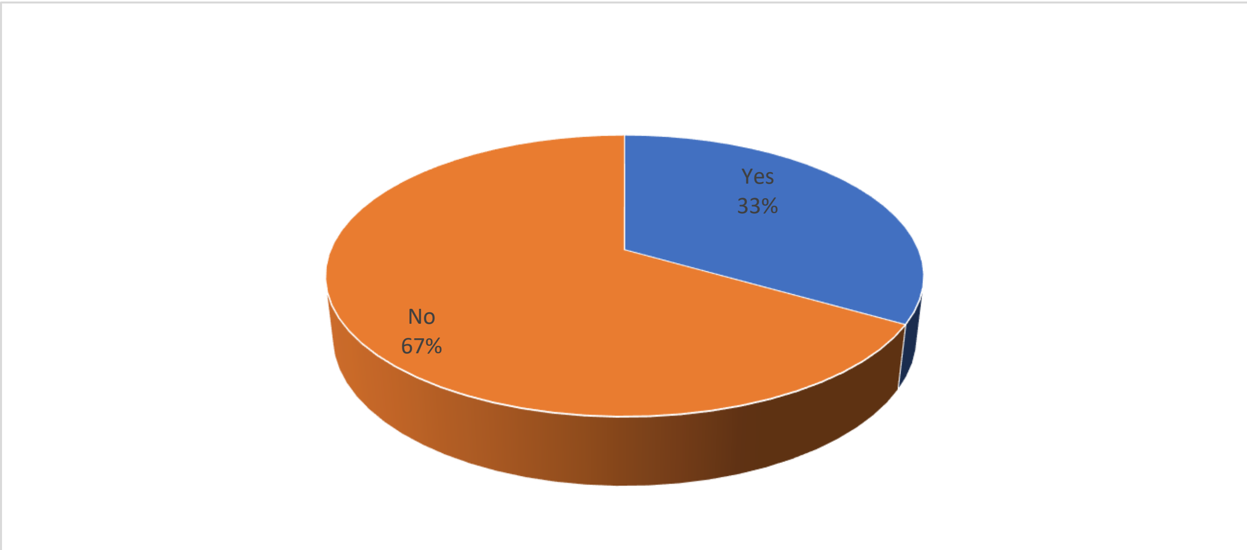


Figure 12: Status of soil testing of the area

Compost was incorporated with pine residues as it was easily available in the area. Goat manure, poultry manure and cattle manure decomposed via traditional system (Figure 14) was evident in the place. Manures are not applied with any additives and are piled in small heaps (Figure 13) in the field for application. Few farmers are using spent mushroom substrate for the organic manure purpose as well. Applied compost/manure are not well decomposed as many undecomposed resides can be visible in the study area.

Figure 13: Open application of FYM in field at Goat development farm

Urea, DAP, MOP and ammonium sulphate are available inorganic sources of fertilizer applied in the field. Normally fertilizer (NPK) ratio was found to range from 0.5-1:1.5-3: 1 in the area which was only limited to few crops like tomato, capsicum. Only DAP and MOP were prominent in the crops like cauliflower, potato, cabbage. This makes an unbalanced fertilizer usage in lower rate.

For the given crops normally, the recommended ratio is 1-1.5: 1.5-2:1. People have applied too less nitrogen in respect to the other fertilizer.

Figure 14: Open FYM heap near shed of the house in Chitlang

3.7 Vegetable/Grass cultivation problems

Mainly farmers were facing problems of four main category i.e., soil, pest, institutional and miscellaneous. As this survey was mainly focused on soil health and management, we identified the following major soil threats/problems which resulted in the reduced yield (Figure 16):

- Soil acidity
- Micronutrient deficiency (Figure 15)
- Unbalanced fertilizer use
- Biodiversity loss
- Lower organic matter, etc.

a **b** **c**

Figure 15: Nutrient deficiency symptoms observed during field visit in capsicum (a & b) and tomato (c)

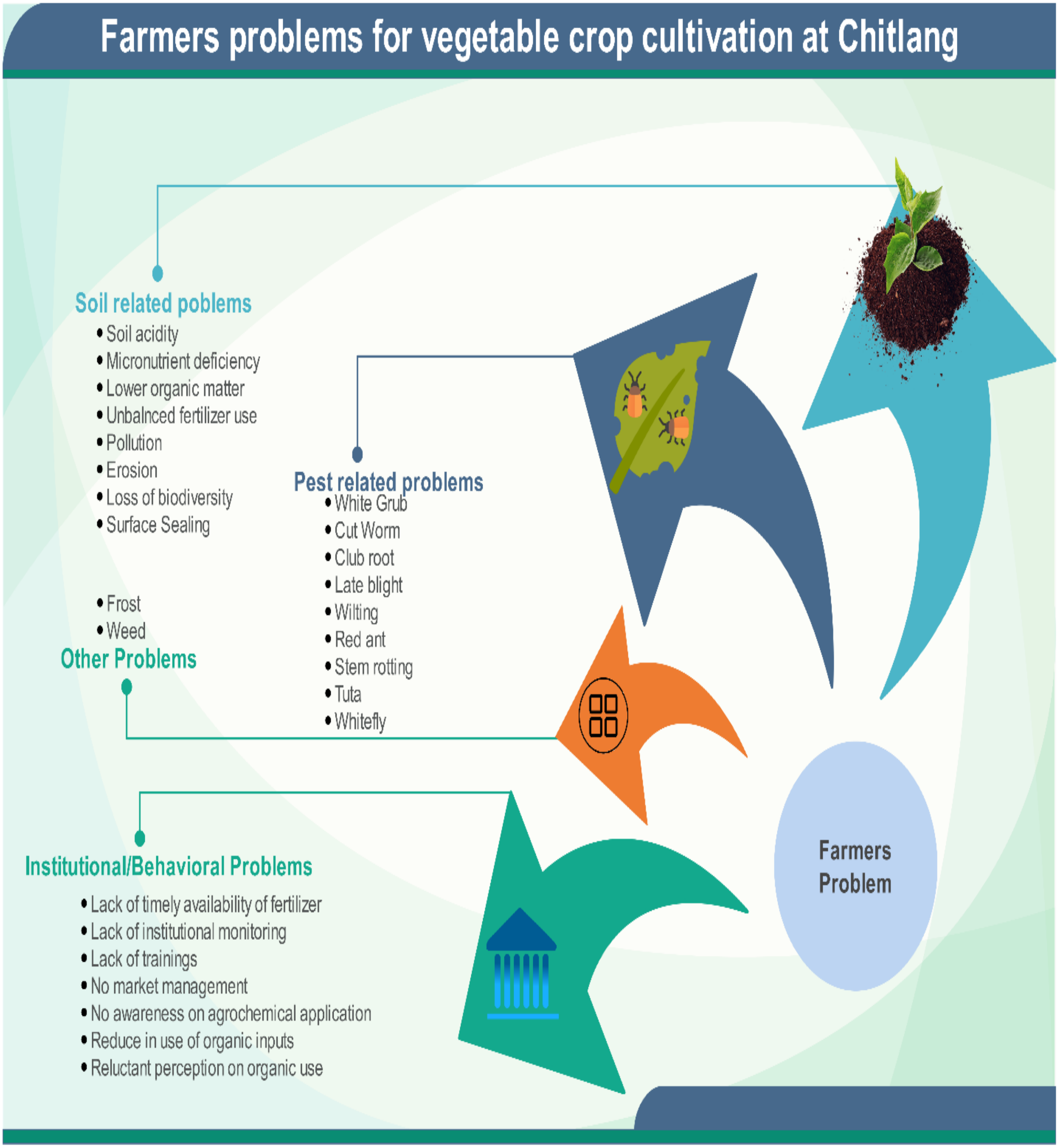


Figure 16: Farmers problems for vegetable production at Chitlang and adjoining areas

3.8 Identified soil threats, their drivers and challenges

Soil threats are those which affects soil health critically and if not managed in time can degrade soil health to non-recoverable. Mainly 8 soil threats were identified in the area. Their reasons and consequences are listed in the Figure 17.

Soil acidity is the major threats in the area which has caused nutrient loss and unavailability to plants. Increased infestation of club root is due to higher soil acidity level. More the use of pine incorporated compost more is the soil acidity.

Haphazard use of toxic pesticides and amendments without test or verification has caused soil pollution visible in the area. Use of undecomposed organic manure has resulted in increased pest infestation and lower organic matter in the soil. Inorganic fertilizer like Urea, DAP and MOP are not used in proper dose while the micronutrients are not used at all except in tomato production. Due to tourism, soil sealing is being more prone for arable area. Excessive pollution, low organic matter and acidity has caused decline in soil biodiversity as well, which is not good for sustainable soil health.

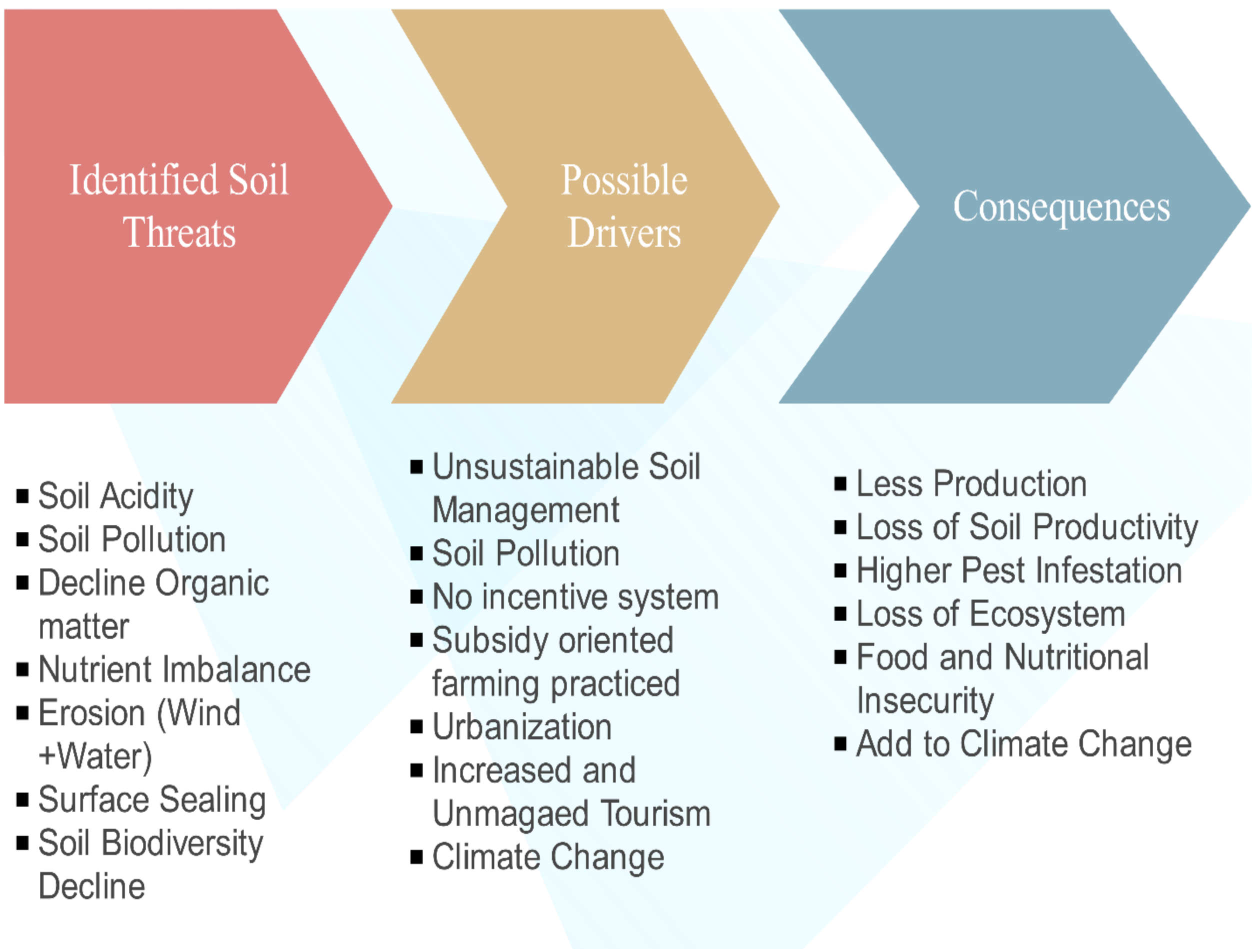


Figure 17: Identified soil threats, drivers and consequences in given study area

3.9 Achieving sustainable soil management

3.9.1 Understanding farmers behavior

Many of the respondents were found to be well trained on soil management, production system, pest management with the initiatives of cooperatives like Sana kisan cooperative. But the way they have perceived the knowledge about soil management is quite negative. They have been trained on techniques like improved composting, preparation of botanicals from local resources but following main issues were visible:

- Unknown about the soil threats, management
- Perceived sustainable soil management practices not to generate short term profit, time-consuming, tedious and are reluctant to adopt
- People are easily being brain washed with new, non-certified products by agrovets, cooperatives and other players of markets

3.9.2 Pillars of sustainable soil management

Sustainable soil management is the comprehensive system of soil management in which the physical, chemical and biological properties of soil are taken into account, while maintaining the biological diversity, increasing the fertility of the soil, increasing the productivity of agricultural products and hence, contributing to the food security. Sustainable soil management maintains or improves the supporting, provisioning, regulating, and cultural functions that soil provides without severely compromising either the soil functions that support those functions or biodiversity. It is a holistic approach where soil is managed along with landscape, crop and pest occurred during the cultivation of crops. The pillars of sustainable soil management are:

- Land management
- Soil management
- Crop management
- Pest management

3.10 Recommendation for sustainability

LAND MANAGEMENT

- Excavated land must be recharged with surface scrapped soil nearby (MBUST area)
- Agroforestry is the necessity of the area. This will not only provide fodder, also maintains soil fertility level and reduce the use of pine in the farm yard manure. Tree species like Ipil Ipil, Dudhilo, Bakaino, Bamboo, Kaulo, Phalat, Mulberry and grass species like Napier, QQ, vetch, setaria, oat can be cultivated.
- Restriction of land take or designing alternate building technique that maintains soil permeability.

PEST MANAGEMENT

- Clubroot, blight, Tuta, etc. are the major highlighted pest problems that can be addressed with the proven Integrated pest management ((IPM) methods
- Healthy seedlings/seeds must be identified before plantation
- Use of jholmal must be increased

SOIL MANAGEMENT

- Compost/FYM used must be prepared through the improved way such as pit or heap method with the use of effective micro-organism products containing consortium of *Trichoderma*, *Metarhizium*, etc. (see Annex 4).
- Fodder species as indicated above must be used in compost or FYM rather to use pine residues
- Integrated plant nutrient management (IPNM) is the need of the area to maintain soil health and productivity rather than moving to organic agriculture at first phase.
- Soil liming is required at urgent with tested and certified agricultural lime in recommended dose (Annex 3)
- Use of biochar and wood ash must be awarded and increased to combat soil acidity
- Balanced fertilization should be done in all crops with the standard dose of Urea, DAP, MOP.
- Micronutrient must be used for proper growth
- Use of micro-organism (bio fertilizer) like phosphate solubilizing bacteria, mycorrhiza, *Trichoderma*, *Metarhizium* is to be increased.

SUSTAINABLE SOIL

CROP MANAGEMENT

- Legume crops like (soyabean, pea,
  Faba beans, lentils, etc. can be incorporated at high density in each cropping pattern to improve the soil fertility rather than production
- Multiple cropping must be practiced to maintain soil cover and fertility
- 2-3 years crop rotation is a must in the same place.
- Proper crop management like weeding, sanitation must be adopted
- Known variety and known amendments which are certified only to be applied to the crops with advice from the technician
- Oat is the frost tolerant species that can be planted in winter days.
- Practice of crop reside incorporation

Other recommendations

Agroecological practices such as minimal mechanical soil disturbance, organic fertilization from the compost or animal manure, permanent soil covers (organic matter supply through the preservation of crop residues and cover crops), crop rotation for biocontrol and effective use of soil profile, rotational grazing management, and minimal soil compaction are just a few that can help improve soil health.

- Awareness camp on soil threats must be of prior importance to aware people about the degrading soil health status, drivers and consequences.
- All the stakeholders are to be included, empowered for soil threats, their effect and management.
- Annual soil testing motivation is required for farmers to check and monitor soil health after crop harvest.
- Output based intensive system can be formulated by acting organization, municipalities in such a way that soil health increment is motivated rather than higher production. Subsidy can be regulated in inputs based on the outputs they have gained from the soil fertility management by local bodies.
- There is a necessity of market-oriented training packages, soil management packages.
- Agro-tourism is to be built rather than the tourist spot. Intervention that preserves soil health and minimizes soil sealing is to be identified to flourish the tourism of the area.
- Local government bodies must be aware about the concern of soil health and act responsible to quarantine all the non-certified inputs being purchased and sold.
- As per SSM techniques phosphorus and potassium dose can be reduce to $1/4^{th}$ of recommended dose (see Annex 11), but for nitrogen it must be halved (1/2) if the test value is at medium range and applied whole (recommended) dose if the test value is at low range but if the value is at high range, it must be $1/4^{th}$.

Other recommendations to MBUST

- Demo farm or plot can be introduced by MBUST to aware and demonstrate people to manage soil fertility without compromising the productivity.
- Research on IPNM, SSM practices to uplift the site-specific soil quality is a must and should be done by the organization like MBUST rather directing the vision to organic agriculture in the first phase as people are not willing for this system at present.
- MBUST should take soil management as holistic system, thus must take individual expert consultation for implementation of agroforestry system, research design, soil management, crop pest management
- Research on determining the best agroforestry model, increasing efficiency of traditional farm yard manuring system, trial on calculating field-based conversion period for organic agriculture practices, preparation of botanicals from local

resources, use of biofertilizers to enhance soil productivity along with chemical fertilizers, etc.

- Farmers participation is must in planning, training, and implementation of any soil management strategies as leaded by MBUST or anu other organization. Participation must be self-motivated and interactive.

CONCLUSION

From the study we observed that the soil health status of all the places is at acceptable to desirable range with good to best soil quality index. Economically this site will cost less to convert it to the desirable range through sustainable soil management. It is the holistic system of managing land, soil, crop and pest simultaneously to get sustainable soil health. If above mentioned practices are included and applied, soil health can be converted to organic within the 3-5 years of conversion period. These are the most economically viable and ecologically suitable techniques to achieve sustainability. MBUST can use these techniques with the active involvement of people along with the encouragement plans to improve soil quality. We can reduce the inorganic fertilizer simultaneously with the increased organic inputs and develop an organic soil. This will help MBUST to allow academic activities along with research activities and support local economy.

Annex

Annex 1: Questionnaire used during survey

Name of the respondent:…………………………………………………………..	**Field Visit by**
Contact:…………………………………………………….	……………………..………………………………….
Address:……………………………………………………………………….	**Date and days of visit**
Location……………………...…….N…………………………………….E	……………………
Altitude………………………....	……………………

Farm Details

Farm Name:……………………………………………………..   Farm area:…………………………

Crop/Fruit Name	Area	Number	Cultivation Practices	Crop Growth Stage	Farmers Complaint

Soil and soil management aspect						
Soil moisture status						
Soil pH				Texture		
Irrigation status				Irrigation frequency		
Do you have your soil checked?	Nitrogen	Phosphorus	Potassium	Organic matter	Texture	Micronutrients
If yes….						
Slope			Aspect		Soil Depth	
Erosion status		Color		Variation Count		
Soil management by farmers						
Fertilizer/Compost/Lime/Other amendments details						
Soil problems identified						
Other Observation						

Crop health aspect						
Crop Name	**Variety**	**Problems Identified**	**Problem Density/Severity**	**Fertilizer supply**	**Irrigation supply**	**Inference**
Other Observation						

Field management aspect	
Fertilizer/Compost details	
Irrigation to crops	
Ecology of the farm	
Enterprise integration like livestock	
Field Sanitation status	
Inputs Source for fertilizer/compost	
Field/Crop History	
Other Information	

Annex 2: Modified SOCLAS soil heath assessment sheets

Indicators	Value	Characteristics	Obtained
Structure	1	Loose, powdery soil without visible aggregates	
	3	Few aggregates that break with little pressure	
	5	Well-formed aggregates – difficult to break	
Compaction	1	Compacted soil, flag bends readily	
	3	Thin compacted layer, some restrictions to a penetrating wire	
	5	No compaction, flag can penetrate all the way into the soil	
Soil depth	1	Exposed subsoil	
	3	Thin superficial soil	
	5	Superficial soil (> 10 cm)	
Status of residues	1	Slowly decomposing organic residues	
	3	Presence of last year’s decomposing residues	
	5	Residues in various stages of decomposition, most residues well-decomposed	
Color, odor, and organic matter	1	Pale, chemical odor, and no presence of humus	
	3	Light brown, odorless, and some presence of humus	
	5	Dark brown, fresh odor, and abundant humus	
Soil Texture	1	Sandy Textured Soil	
	3	Loam Textured Soil	
	5	Clay Textured Soil	
Soil cover	1	Bare soil	
	3	Less than 50% soil covered by residues or live cover	
	5	More than 50% soil covered by residues or live cover	
Erosion	1	Severe erosion, presence of small gullies	
	3	Evident, but low erosion signs	
	5	No visible signs of erosion	
Presence of invertebrates	1	No signs of invertebrate presence or activity	
	3	A few earthworms and arthropods present	
	5	Abundant presence of invertebrate organisms	
Soil pH	1	>9,<5	
	3	5.5-6, 8-8.5	
	5	Neutral (6.5-7.5)	

Annex 3: Lime recommendation chart for analyzed soil

S.N.	***Sample Code***	***Sample Identification***	***Soil pH***	***Buffer pH***	***Recommended lime dose (kg/rop)***
1.	079/513	CH – 01	4.94	5.39	950.95
2.	079/514	CH – 02	5.01	5.82	703.95
3.	079/515	CH – 03	4.38	5.35	1012.70
4.	079/516	CH – 04	5.49	5.78	703.95
5.	079/517	CH – 05	5.10	5.99	580.45
6.	079/518	CH – 06	5.65	6.32	395.2
7.	079/519	BB – 01	5.71	6.47	271.7
8.	079/520	BB – 02	5.46	6.20	456.95
9.	079/521	BB – 03	4.56	5.65	827.45
10.	079/522	GDF – 01	5.75	6.08	518.70
11.	079/523	GDF – 02	5.29	6.47	271.70
12.	079/524	GDF – 03	4.99	6.57	209.95
13.	079/525	TK – 01	5.63	6.69	148.2
14.	079/526	TK – 02	5.10	6.69	148.2
15.	079/527	TK – 03	5.36	6.56	209.95
16.	079/322	GH (control)	4.94	5.39	950.95
17.	079/428	Field Sample	5.01	5.82	703.95

Note: Applied lime must have neutralizing value greater than 80% and must be applied before plantation in two split doses. One month gap is required between split and enough irrigation is required for proper reaction of lime on soil.

Annex 4: Improved composting procedure

Collection of degradable waste (leaf litters, agricultural byproducts, other grasses) at a place along with cow dung

↓

Make a layer of such degradable waste (alternative layer of dry materials and cow dung/urine/compost)

↓

Repeat the task until the heap becomes 1 m height (the length could be as per the need, keep the breadth to 1 m)

↓

While layering application of liquid decomposer will fasten the decomposition rate and maintain the quality of compost (EM=1litres in 19 litres of water and spray the mixture thoroughly in the heap)

↓

Cover the heap with black plastic (avoid direct sun exposure and rain)- This will also increase the temperature inside the heap and fasten the decomposition rate

↓

Turn heap every one month (for 2 times)- Spray EM (1 litre+19 litre water) while turning heap

↓

The good quality compost will be ready to use in 2-2.5 months time

Annex 5: Respondent details

S.N	*Soil Sample Code*	*Respondent Name*	*Location*
1	CH-01	Shanti Lama Jimba	Chitlang
2	CH-02	Ashok Kumar Singh Thakuri	Chitlang
3	CH-03	Rudra Bahadhur Basnet	Chitlang
4	CH-04	Mohan Prasad Joshi	Chitlang
5	CH-05	Mukesh Karmacharya	Chitlang
6	CH-06	Purushottam Lamichhane	Chitlang
7		Shyam Lal Balami	Chitlang
8	GDF-01	BP Yadav	Chitlang
9	GDF-02	BP Yadav	Chitlang
10	GDF-03	BP Yadav	Chitlang
11	TK-01	Rita Gopali	Taukhel
12	TK-03	Purushhotam Gopali	Taukhel
13		Kamala Subedi	Taukhel
14	BB-01/BB-02/BB-03	Jit Kumar Karmacharya	Bajrabarahi
15	MBUST	Bhushan Shrestha	Chitlang

Annex 6: Compiled lab test report

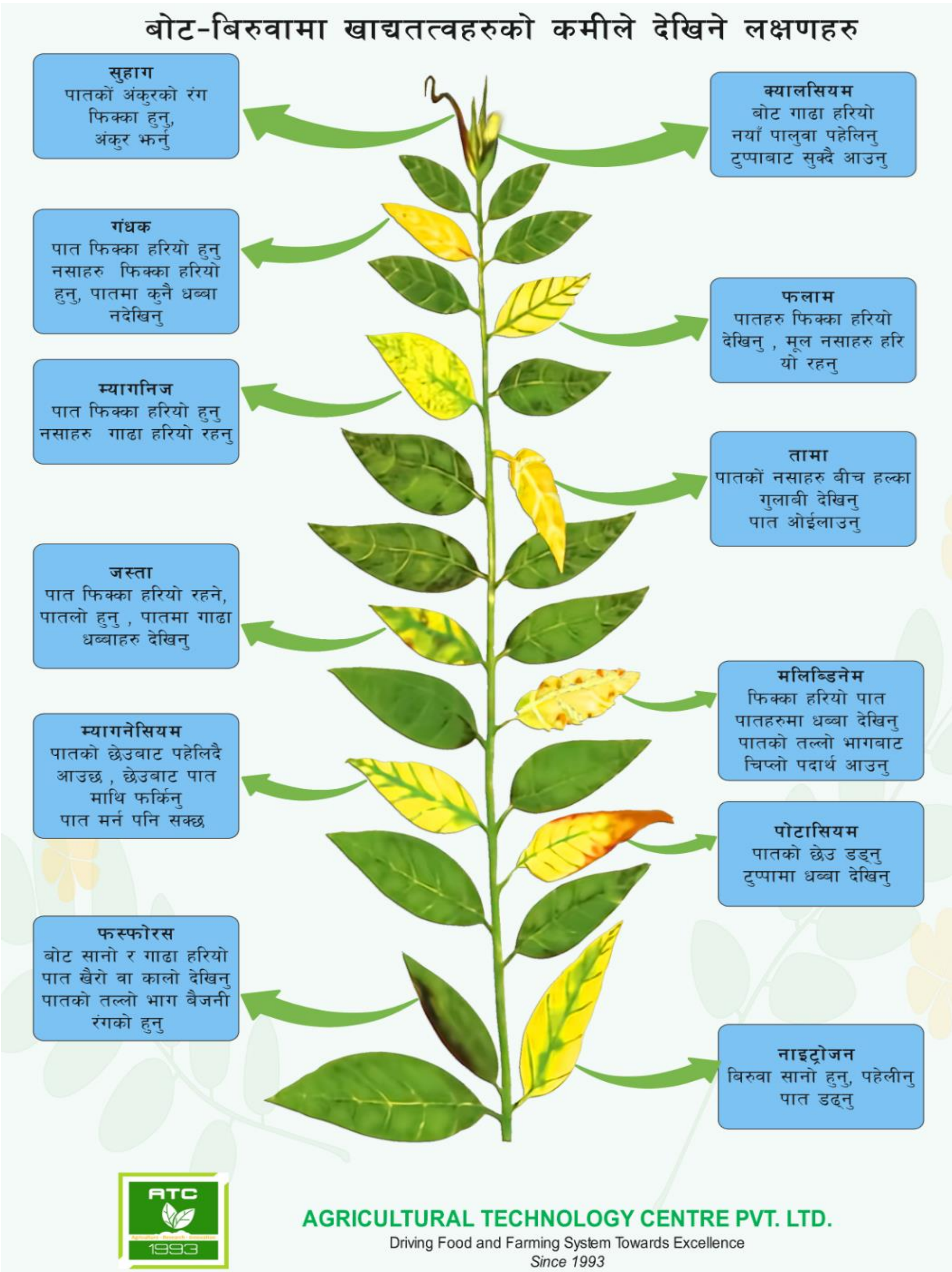
S.N.	Sample Code	Sample Identification	pH	Buffer pH	N %	P_2O_5 kg/ha	K_2O kg/ha	O.M.%
1	079/513	CH - 01	4.94	5.39	0.39	230.75	455.6	6.08
2	079/514	CH - 02	5.01	5.82	0.32	311.94	1313.2	4.81
3	079/515	CH - 03	4.38	5.35	0.39	278.82	576.2	5.32
4	079/516	CH - 04	5.49	5.78	0.32	425.18	576.2	5.19
5	079/517	CH - 05	5.10	5.99	0.19	631.36	656.6	4.37
6	079/518	CH - 06	5.65	6.32	0.19	210.45	321.6	3.48
7	079/519	BB - 01	5.71	6.47	0.19	629.22	348.4	3.48
8	079/520	BB - 02	5.46	6.20	0.06	805.49	201.0	3.23
9	079/521	BB - 03	4.56	5.65	0.26	995.65	455.6	4.05
10	079/522	GDF - 01	5.75	6.08	0.13	429.45	857.6	3.54
11	079/523	GDF - 02	5.29	6.47	0.13	148.49	549.4	3.23
12	079/524	GDF - 03	4.99	6.57	0.06	159.18	348.4	2.78
13	079/525	TK - 01	5.63	6.69	0.06	445.48	214.4	3.86
14	079/526	TK - 02	5.10	6.69	0.19	759.56	643.2	3.73
15	079/527	TK - 03	5.36	6.56	0.06	628.16	254.6	3.92

S.N.	Sample Code	Sample Identification	Sand %	Silt %	Clay %	Soil Texture	Boron (ppm)	Iron (ppm)	Zinc (ppm)
1	079/513	CH - 01	58.1	30.82	11.08	SL	0.37	66.76	0.30
2	079/514	CH - 02	49.1	33.82	17.08	L	-	-	-
3	079/515	CH - 03	39.1	37.82	23.08	L	-	-	-
4	079/516	CH - 04	39.1	37.82	23.08	L	-	-	-
5	079/517	CH - 05	49.1	41.82	9.08	L	-	-	-
6	079/518	CH - 06	29.1	45.82	25.08	L	-	-	-
7	079/519	BB - 01	43.1	43.82	13.08	L	-	-	-
8	079/520	BB - 02	41.1	49.82	9.08	L	1.87	147.49	6.50
9	079/521	BB - 03	43.1	41.82	15.08	L	-	-	-
10	079/522	GDF - 01	37.1	31.82	31.08	CL	-	-	-
11	079/523	GDF - 02	43.1	31.82	25.08	L	0.12	14.42	0.30
12	079/524	GDF - 03	35.1	46.82	18.08	L	-	-	-
13	079/525	TK - 01	37.1	45.82	17.08	L	0.12	165.96	1.70
14	079/526	TK - 02	37.1	47.82	15.08	L	-	-	-
15	079/527	TK - 03	41.1	27.82	31.08	CL	-	-	-

Annex 7: Geo points of the sample withdrawn locations

S.N.	***Sample Identification***	***Description***	***Latitude***	***Longitude***
1	CH - 01	Shanti Lama Jimba	27.66195	85.18639
2	CH - 02	Ashok Kumar Singh Thakuri	27.65781	85.17428
3	CH - 03	Rudra Bahadhur Basnet	27.6543	85.17572
4	CH - 04	Mohan Prasad Joshi	27.65424	85.17477
5	CH - 05	Mukesh Karmacharya	27.65137	85.16899
6	CH - 06	Purushottam Lamichhane	27.64482	85.16782
7	BB - 01	Jit Kumar Karmacharya (Capsicum Tunnel)	27.65045	85.12211
8	BB - 02	Jit Kumar Karmacharya (Tomato Tunnel)	27.6505	85.12255
9	BB - 03	Jit Kumar Karmacharya (Near House)	27.65089	85.12242
10	GDF - 01	Agriculture Area	27.62313	85.15594
11	GDF - 02	Pasture Area	27.62414	85.15364
12	GDF - 03	Demo Plot	27.62321	85.15509
13	TK - 01	Rita Gopali (Below Road)	27.64415	85.14973
14	TK - 02	Rita Gopali (Above Road)	27.6445	85.1492
15	TK - 03	Purushottam Gopali (Above Ward Office)	27.64388	85.14701

Annex 8: Visual symptoms of nutrient deficiency in plants



Annex 9: Point specific SQI and SH score

S.N.	Sample Code	Sample Identification	SQI	SQI Range	Soil health score	SH Remarks
1	079/513	CH - 01	0.90	Best	2.90	Acceptable
2	079/514	CH - 02	0.92	Best	3.20	Acceptable
3	079/515	CH - 03	0.90	Best	3.20	Acceptable
4	079/516	CH - 04	0.92	Best	3.10	Acceptable
5	079/517	CH - 05	0.86	Best	3.00	Acceptable
6	079/518	CH - 06	0.78	Good	3.50	Desirable
7	079/519	BB - 01	0.78	Good	2.80	Acceptable
8	079/520	BB - 02	0.72	Good	2.50	Acceptable
9	079/521	BB - 03	0.84	Best	3.50	Desirable
10	079/522	GDF - 01	0.70	Good	3.20	Acceptable
11	079/523	GDF - 02	0.78	Good	3.00	Acceptable
12	079/524	GDF - 03	0.64	Good	3.00	Acceptable
13	079/525	TK - 01	0.66	Good	3.40	Acceptable
14	079/526	TK - 02	0.78	Good	3.10	Acceptable
15	079/527	TK - 03	0.58	Poor	2.90	Acceptable

Annex 10: Range of nutrient, SQI and SHI

Parameters	Unit	Low	Medium	High
Total Nitrogen	%	<0.1	0.1-0.3	>0.3
Available Phosphorus	Kg/ha	<31	31-55	>55
Available Potassium	Kg/ha	<110	110-280	>280
Available Boron	ppm	<0.1	0.1-2	>2
Available Iron	ppm	<2.5	2.5-5	>5
Availabel Zinc	ppm	<0.2	0.2-2	>2
Soil Quality Index	-	<0.4	0.4-0.8	>0.8
Soil Health Index	-	<2.5	2.5-3.5	>3.5

Annex 11: Fertilizer recommendation chart

क्र.श	बाली	निम्न (के.जी/रोपनी)			मध्यम (के.जी/रोपनी)			उच्च (के.जी/रोपनी)		
		यूरीयाअ	डी.ए. पी	पोटास	यूरीयाअ	डी.ए. पी	पोटास	यूरीयाअ	डी.ए. पी	पोटास
1	धान सिचित	6.00	2.00	2.00	3.00	1.00	1.00	1.50	0.50	0.50
2	धान असिचित	3.00	1.00	1.00	1.50	0.50	0.50	0.75	0.25	0.25
3	मकै बर्षे	6.00	3.00	3.00	3.00	1.50	1.50	1.50	0.75	0.75
4	मकै हीउदे	5.00	2.50	2.00	2.50	1.25	1.00	1.25	0.63	0.50
5	गहु सिचित	2.50	2.50	1.00	1.25	1.25	0.50	0.63	0.63	0.25
6	गहु असिचित	1.50	1.00	1.00	0.75	0.50	0.50	0.38	0.25	0.25
7	कोदो उन्नत	7.50	3.00	2.00	3.75	1.50	1.00	1.88	0.75	0.50
8	ऊखु (मोरहन बाली)	10.00	3.00	2.00	5.00	1.50	1.00	2.50	0.75	0.50
9	उखु (खुटि बाली)	3.00	2.00	1.00	1.50	1.00	0.50	0.75	0.50	0.25
10	तोरी, रायो	3.00	1.50	1.50	1.50	0.75	0.75	0.75	0.38	0.38
11	जौ, उवा	1.50	1.50	1.00	0.75	0.75	0.50	0.38	0.38	0.25
12	फापर	2.50	1.50	2.50	1.25	0.75	1.25	0.63	0.38	0.63
13	अदुवा, अलैची	5.00	5.00	3.00	2.50	2.50	1.50	1.25	1.25	0.75
14	आलु	10.00	9.00	4.00	5.00	4.50	2.00	2.50	2.25	1.00
15	तरकारी बाली, सागपात जात	10.00	9.00	4.00	5.00	4.50	2.00	2.50	2.25	1.00
16	तरकारी बाली जरे जात	0.75	2.00	6.00	0.38	1.00	3.00	0.19	0.50	1.50

17	हरियो केराउ	7.00	2.00	5.00	3.50	1.00	2.50	1.75	0.50	1.25
18	काक्रो	12.00	9.00	3.00	6.00	4.50	1.50	3.00	2.25	0.75
19	जुकिनी	10.00	9.00	4.00	5.00	4.50	2.00	2.50	2.25	1.00
20	गोलभेडा (सृजना)	10.00	10.00	7.50	5.00	5.00	3.75	2.50	2.50	1.88
21	गोलभेडा (होचो, अन्य जात)	10.00	9.00	4.00	5.00	4.50	2.00	2.50	2.25	1.00
22	भन्टा	10.00	9.00	3.00	5.00	4.50	1.50	2.50	2.25	0.75
23	रामतोरिया	10.00	6.00	4.00	5.00	3.00	2.00	2.50	1.50	1.00
24	काउली (लोकल)	10.00	6.00	5.00	5.00	3.00	2.50	2.50	1.50	1.25
25	काउली (हाईब्रिड)	12.00	9.00	4.00	6.00	4.50	2.00	3.00	2.25	1.00
26	बन्दा	4.00	6.00	3.00	2.00	3.00	1.50	1.00	1.50	0.75
27	सिमि	10.00	6.00	3.00	5.00	3.00	1.50	2.50	1.50	0.75
28	तितेकरेला	4.00	6.00	2.00	2.00	3.00	1.00	1.00	1.50	0.50
29	तने बोडि	10.00	5.00	5.00	5.00	2.50	2.50	2.50	1.25	1.25
30	भेडे खुसानी	12.00	9.00	4.00	6.00	4.50	2.00	3.00	2.25	1.00
31	प्याज	12.00	9.00	4.00	6.00	4.50	2.00	3.00	2.25	1.00

Annex 12: Pictures taken during field visit

Field Survey with farmers of Chitlang

Soil sampling at Chitlang

Group picture taken at Goat Cheese Factory, Chitlang

Field Survey at agrovet of Chitlang

Soil Sampling at Goat development farm

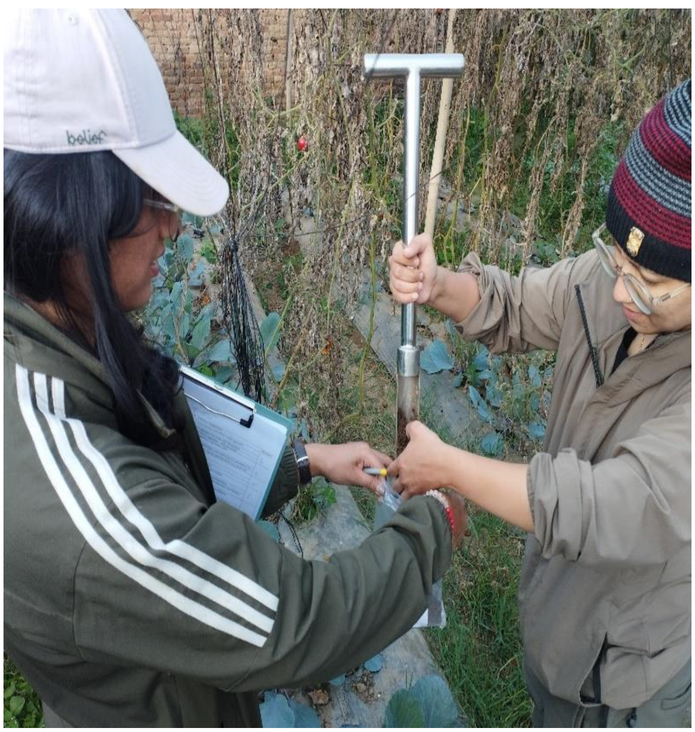
Vermicompost bed of MBUST

Field Survey at Goat development farm

Group picture after sampling at Bajrabarahi

Soil health assessment of Bajrabarahi

Soil sampling at arable area of Goat development farm



Soil sampling at Barjabarahi (tomato tunnel)

Nitrogen deficiency along with leaf spot in Capsicum