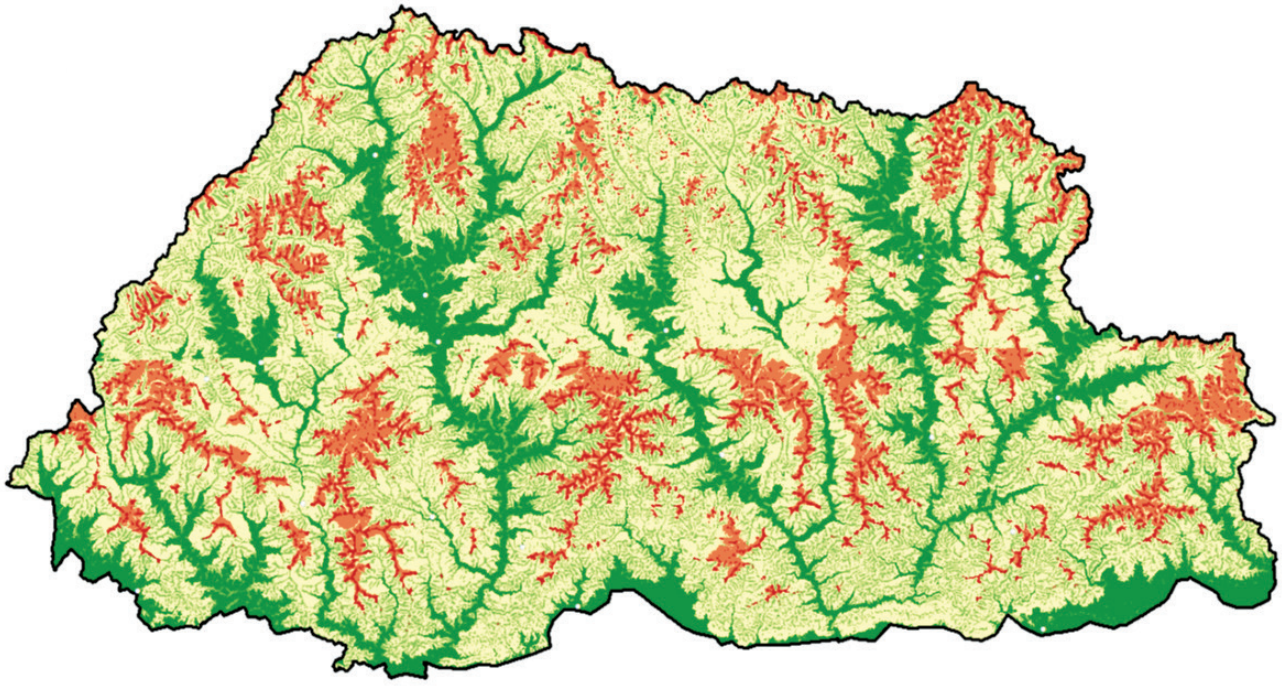
POLICY BRIEF

SOIL FERTILITY MANAGEMENT IN BHUTAN – IMPROVING CROP PRODUCTION LEVELS AND ENHANCING NATIONAL FOOD SELF-SUFFICIENCY

12 AUGUST 2021



EU Technical Assistance Complementary Support Project (EU-TACS) - Bhutan

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POLICY MESSAGE

Improved soil fertility planning can help ensure the increased stability of crop yields and lead to higher aggregate production of key crops, would enhance food security, and should aid the planning food import substitution requirements for each crop.

KEY CONCERNS AFFECTING SOIL FERTILITY MANAGEMENT IN BHUTAN

Soil Fertility Management is affected by a number of issues, with the main concerns that were identified through literature review and from surveyed farming households, that range from:

- **Low natural fertility** levels of most soils. This is linked to the frequent inability of farmers to maintain **high organic matter** content of the sandy and gravelly soils that dominate agricultural land throughout Bhutan;
- **"Nutrient mining"** by farmers who pay limited attention to soil fertility replenishment. These farmers continuously growing the same or similar crops and are infrequently applying methods for maintaining soil fertility, such as fallow-years, or crop rotations;
- The inability of farmers to **afford or to access chemical fertilizers**, linked with weak understanding of application rates, leading to the common practice of the **imbalanced use of chemical fertilizers**;
- Topsoil is lost to **soil erosion**, exposing infertile subsoils. Rural development extension programmes have had mixed success, and many **soil erosion control measures are of limited effectiveness**.
- There has been very limited out-scaling of **nitrogen-fixing plants** within cropping systems, despite their major benefits. Farmers' knowledge concerning **bringing green manuring techniques** within their crop rotations is limited. Farmers advise that they lack access to **seed sources** of important nitrogen-fixing crops;
- Many farmers are unwilling to diversify to adopt crop types and cropping patterns (such as reduced planting density) that can tolerate lower soil fertility levels;
- Limited knowledge on how to produce **organic fertilizer with high nutrient content** (such as composts; **combined foliar & insect repellent** based upon fermented livestock urine (as widely scaled-out in Nepal where it is widely-known as Jholmal); farmyard manure, vermi-culture);
- Lack of a **Fertilizer and Soil Fertility Management Policy**. As a result, the available technological options for ensuring adequate crop nutrition are not being promoted and adopted at the scale and speed needed.

SOURCE: *Soil Fertility Management Study, EU-TACS project FOR NSSC and PPD at MoAF, 2021*

Low soil fertility and problems in managing soil fertility lead to decreasing crop yields which feeds into national crop self-sufficiency ratios. 35% of farming households consider that there is a decline in soil fertility in irrigated lands and 40% consider a decline in dry land cropping areas. The main reason for declining crop yields as state by farmers in numerous surveys is soil fertility, followed by damage from wild animals, lack of access to organic and chemical fertilizers, pests and diseases, and water shortages.

Despite numerous efforts, Bhutan has been unable to achieve self-sufficiency in key staple commodities such as rice, maize and beans. For other crops, there are high self-sufficiency levels such as for potatoes, mandarin, apple, and cabbage. Rice self-sufficiency targets were maintained at 60% for many years; this has been reduced to 43% in 2021 after it was realized that the current self-sufficiency rate was 37% and is not stable year-on-year. In 2019 rice imports were 19% of total food imports. Rice is affected by low crop water shortages for irrigation primarily caused by spring lines drying up due to climate change.

During the COVID-19 pandemic, almost half of the population claims to have decreased their consumption of food in some way (either rice, fruit, vegetables or meat) due to non-availability and food price inflation, which were partly caused by lockdowns in India and problems with importing cereals and other foodstuffs.

Maximizing crop yields and production from kitchen gardens, homestead plots and farmers' fields needs to be a priority whilst at the same time extending crop production into fallow land lying idle and into unused shrubland and forest outside forest and protected area status and where slopes are appropriate for agriculture.

DRIVERS OF CHANGE FOR SOIL FERTILITY MANAGEMENT

NATIONAL MASS SOIL ANALYSIS

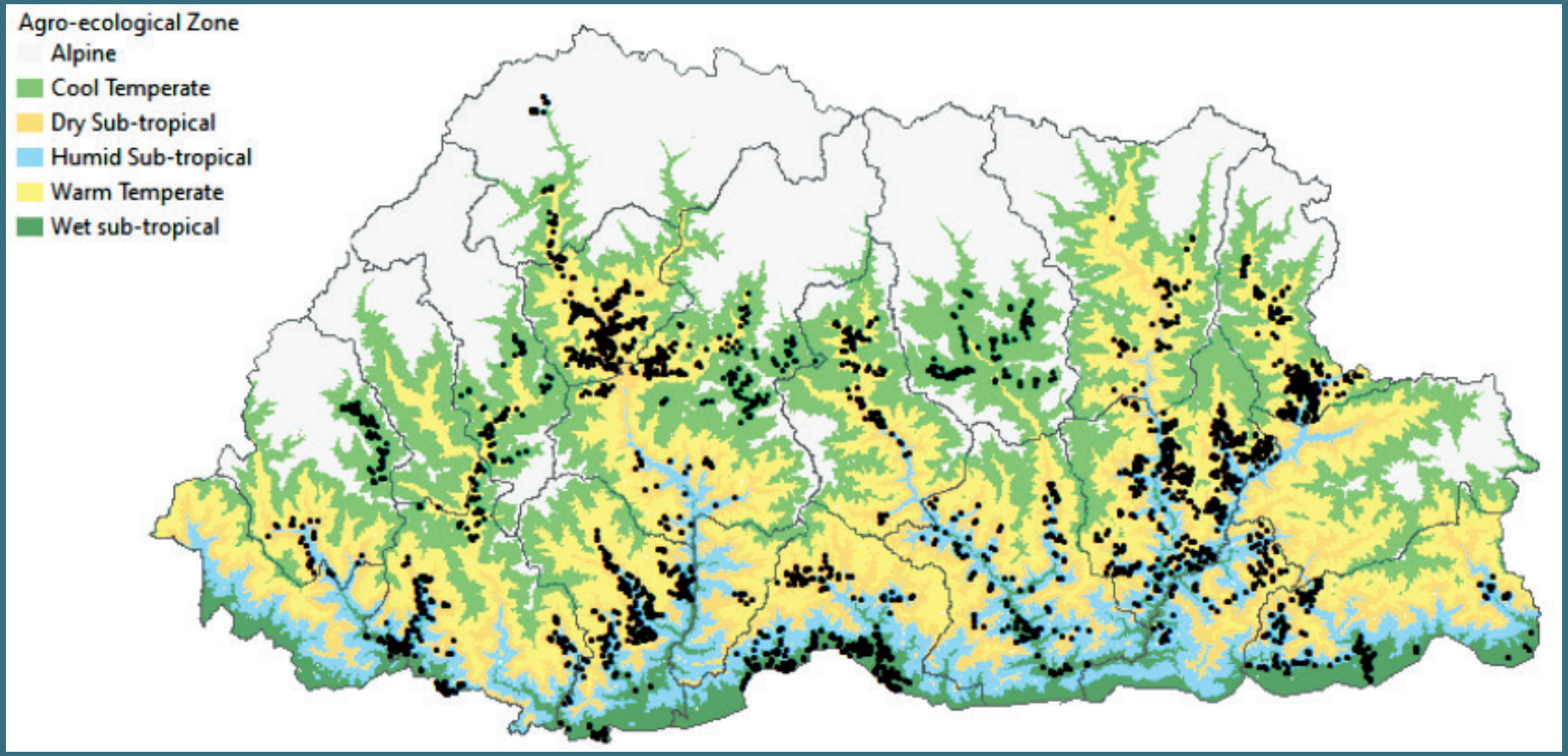
As part of the soil fertility management process, it is important that soil fertility levels should be regularly assessed by the NSSC. This will involve identifying Gewogs where crop yields are declining on what was formerly productive farm land, and where it is suspected that the reason for declining yields is due to soil fertility. The main problems affecting soil fertility are listed in Table 1 and farming households need to explain the reasons for declines in crop yields on their own fields as part of the mass soil analysis programme on a site-to-site basis.

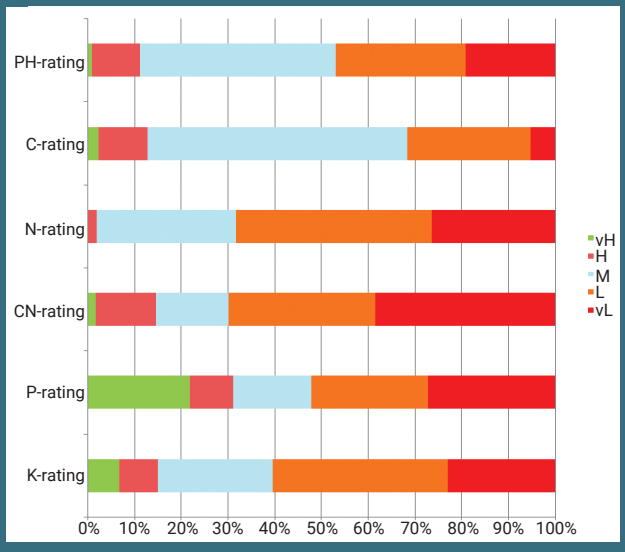
Knowledge of soil fertility levels in different soil types in Bhutan's varied agroecological zones is important for agricultural planning of small and medium scale farms, and for building the capacities of community members and local governments on what crops to plant and how to manage them.

Mass Soil Analysis Strategy

1. Ensure that the sampling size reaches 10,000 with an even distribution throughout the country to be achieved within the 13th FYP
2. Identify Gewogs with high levels of declining crop yields due to soil fertility issues and start the sampling programme in these Gewogs
3. Make a detailed sampling survey of topsoil in land parcels for all key crops in target Chiwogs ensuring sites are referenced by GPS, crop type, fertilizer regime, altitude. aspect, and the plot history is described
4. Analyze all samples for key soil fertility parameters
5. Where there are suspected micronutrient deficiencies, analyze for micronutrient levels
6. Plot all the sample sites using a GIS
7. Prepare separate national soil fertility maps for pH, C, N, C-N ratio, phosphorous, potassium, sand content and texture
8. If possible, prepare soil fertility maps of micro-nutrients.

Current Status of Mass Soil Analysis Dataset (2010)





The distribution of soil analyses carried out by the National Soil Laboratory at the NSSC is shown in map at left from 2759 soil samples taken in 2010. This is considered to be the baseline for soil fertility levels in **Bhutan**.

There is a general understanding of the main levels of major soil fertility parameters in Bhutan. 50% of pH levels are low or very low. 65% of carbon levels are moderate to very high. 65% of nitrogen levels are low or very low. 50% of phosphorous levels are low or very low. 60% of potassium levels are low or very low. No micro-nutrients were included in the previous mass soil analyses and CEC, Ca, Mg, K, Na, Fe, Al, Mn and others.

Soil textures are mainly sandy or loamy and have low water holding capacities unless there is a high organic matter in the soil surface. Since soils in Bhutan are derived from regolith and colluvium there are significant amounts of coarse pebbles and stones in the soil profiles.

(Source: Soil Fertility Management Study, EU-TACS project on behalf of NSSC and PPD at MoAF, 2021)

NATIONAL SOIL CORRELATION MAPPING

Although soil mapping has taken place in Bhutan since the early 1990's, there are no national soil maps available that allow correlation of soils throughout the country to assist with land management. Data on geology, soil types and their properties are of universal value. In the context of the Himalayas in Bhutan, soil depth and soil fertility are of primary importance to agriculture. Soil texture, soil structure, and sand or gravel content of soils dictate the levels of hydraulic conductivity and infiltration capacity that guide irrigation regimes and water use efficiency. Knowledge of soil fertility levels in different soil types is important for agriculture and hence crop production, food security, and food import substitution levels.

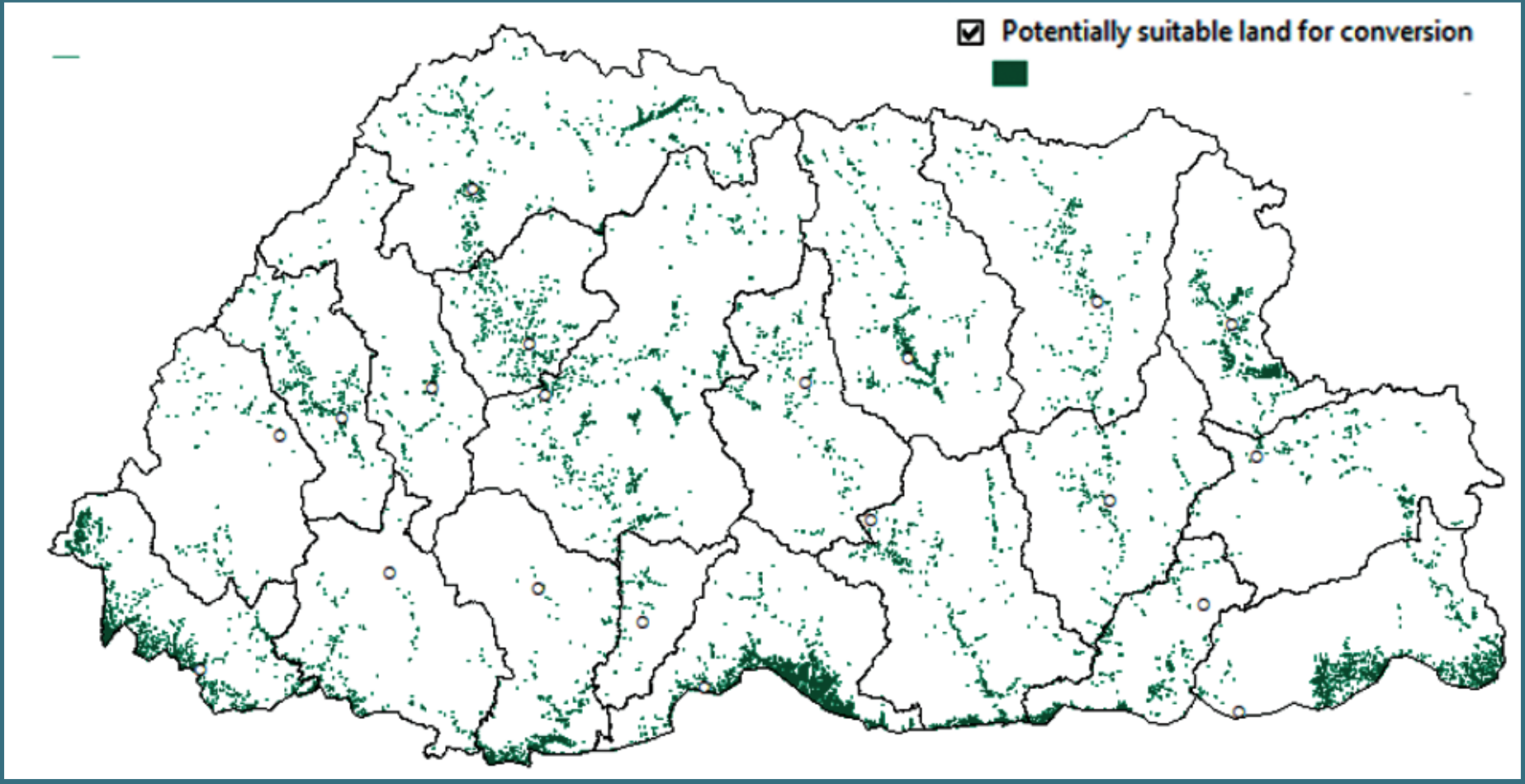
In the context of the Himalayas in Bhutan, soil depth and soil fertility are of primary importance to agriculture.

Soils are the starting point for soil erosion studies and sediment loss and delivery into rivers and lakes that affect the hydropower industry. It is important that a national soil mapping programme is started with the aim to prepare four regional soil maps, using Soil Groups or Sub-groups as the level of taxonomic detail, at a scale of either 1:125,000 or 1:250,000.

DETAILED SOIL SURVEYS AND LAND SUITABILITY FOR EXTENSIFICATION OF AGRICULTURE

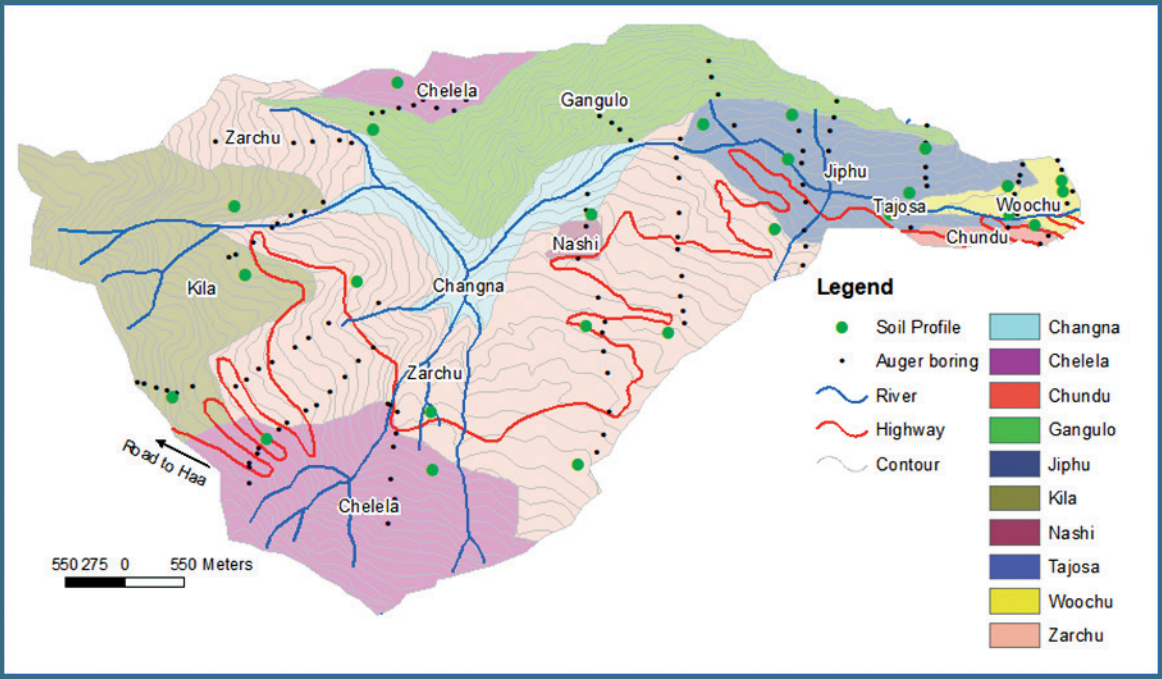
Large areas of land owned by farmers are currently lying unused in the form of short-term and long-term fallow (estimated at 27,000ha). In addition to this land, there are areas of shrubland and forest that not owned by farmers that remain idle and are unused with slopes suitable for various agricultural cropping patterns (estimated at 21,000ha). There is a potential to convert these areas to agricultural use, but the type of cropping patterns that would be suitable depend on the soil types and land capability. Some areas may be suited to arable, fruit or nut orchards, agroforestry, or social forestry. Identifying this unused land is difficult using remote sensing techniques due to the poor resolution of satellite imagery, planimetric distortion in mountainous terrain, small size of areas to be mapped and the high costs involved. It is considered easier to assess these areas locally using soil mapping and land capability/suitability techniques by either teams of NSSC surveyors and agricultural extension agents or the private sector using guidelines provided by the NSSC. At the same time as identifying soil types and fertility levels, there will be a need to report in the land suitability assessment reports on water availability, altitude, slope, access to road networks, human-wildlife conflict issues to allow for accurate potentials for agricultural extensification in each target Chiwog.

Potential land for agricultural extensification.



Land suitable for agricultural extensification is indicated in the map above. This land includes shrubland and forest that falls outside existing fallow land, designated forest land status, or protected status. There is estimated to be about 21,000 hectares in total with most being in the southern region of Bhutan in alluvial fan areas (parts of which are at risk from flash flooding). The remaining area is scattered throughout Bhutan and is adjacent to nearby agricultural settlements.

Detailed soil surveys for assessing land capability for potential extensification



Detailed soil surveys with land capability assessment are required in Gewogs where there is a significant potential for extensification of agriculture. Mapping will be carried out to Soil Series or Soil Type level and at a scale of 1:10,000 or 1:25,000 depending on the complexity and variability of soils in each area to be surveyed. The maps will guide decisions on how to make use of the currently idle shrubland and forest. Land use may be for single crops, cropping patterns (multiple crops) or different types of entrepreneurial agroforestry depending on the and capability.

FERTILIZER POLICY PAPER

Fertilizer consumption in Bhutan has increased from around 10 kg per hectare of arable land in 1974 to about 36 kg per hectare in 2018. However, there has been a decline in recent years and imports tend to fluctuate markedly. Use of chemical fertilizers such as Urea, Ammonium nitrate, and Sulphate of potash) in Bhutan is much lower than the international average. The use of chemical fertilizers does not square well with the policy of becoming 100% organic in the future, and besides organic manures often provide lower crop yields against the use of chemical fertilizers.

Most farmers use farm yard manure (FYM) as the main fertilizer on rice and other cereal crops with between 5-7 ton/ha being applied on rice. The use of chemical fertilizers is still limited with the most popular being Urea (nitrogen) – only a few Dzongkhags are using chemical fertilizers, namely, Punakha, Wangdi, Paro and Trongsa. Although there are extension guidelines on the amount of chemical fertilizer to use, most farmers are using below the recommended rates for nitrogen, and other nutrients are not applied resulting in “nutrient mining”. Imbalanced applications are a concern for overall soil fertility management.

Other soil fertility management techniques such as green manuring, use of poultry manure and nitrogen fixing plants have been tested. Green manuring has been piloted and demonstrated in Bhutan in almost all Dzongkhags, but the adoption rate is almost zero or at best very limited. There are issues of seed supply, lack of water at critical growth stages, and free grazing animals destroying crops. Poultry manure is becoming more popular due to the large number of poultry farms in the country; however there are issues over application rates.

Bulk production of bio-fertilizers is needed from using organic waste collected by municipal authorities, however Bhutan still lacks the technologies to make this work. On farm vermi-culture is also possible in the warmer agro-climatic zones.

It is important that a national study on soil fertility management is carried out. This should lead to a white paper on a "Soil Fertilizer Policy for Bhutan" and a "Research and Extension Strategy for Soil Fertility Management for all Agro-Ecological Zones in Bhutan". A clear decision has to be taken on the future policy direction for Bhutan between "100% organic" and "food self-sufficiency".

POLICY IMPLICATIONS AND INSTITUTIONAL REFORMS

STRUCTURAL CHANGE

In order to implement the soil fertility management policy, strategy, and action plan, major structural change at MoAF may not be needed. However, different agencies will be involved and a multi-agency task force will need to be set up for implementing the soil fertility management process going forwards:

- Implementation of *National Mass Soil Analysis Project* in all Gewogs, a *National Soil Correlation Mapping Project* for the four regions, and a *Land Suitability and Soil Survey for Agricultural Extensification Project* for gewogs with high potential within the NSSC at MoAF.

- Implementation of a *Soil Fertility Management Research Project* in all agro-ecological zones with a focus on on-farm research through researcher-managed trials and farmer-managed tests and managed by the Agriculture Research and Extension Division (ARED) and each Agricultural Research and Development Centre (ARDC) at MoAF.

- Implementation of a *Bio Fertilizer and Organic Fertilizer Project* throughout Bhutan to promote *bio-fertilizers* using microbial inoculants and *organic fertilizers* using animal manure, pelleted chicken manure, plant waste, green manure, vermi-composting, and bulk compost from municipal and human waste collection. Bio-fertilizers and organic fertilizers will be sold through farm shops and will aim to provide an alternative to imported chemical fertilizers possibly under the management of the Food Corporation of Bhutan at MoAF.

- Development of a *National Fertilizer Policy* to take account of conflicting demands for chemical, bio, and organic fertilizers amongst researchers, extension agents and farmers, and to assess import substitution potentials, to be spearheaded and coordinated by the Policy and Planning Division at MoAF.

Since there are likely to be several stakeholders involved, the most effective implementing structure would be through establishment of a *"2040 Soil Fertility Management Task Force"* at MoAF to spearhead the programme.

VISIONS, MANDATES AND ROLES	Visions, mandates, roles will need to be developed for the *Soil Fertility Management Task Force* up to 2040.
Processes, procedures and guidelines will need to be developed in relation to implementation of the various projects outlined above. These can be developed with support from funding agencies involved through internal capacity, local experts, or international exerts where needed.	**PROCESSES, PROCEDURES AND GUIDELINES**
HUMAN RESOURCES AND TRAINING	In order to carry out implementation of the various projects, there will be a need to increase the number of key staff with a wide range of disciplines at both central and local levels. A human resources gap analysis will be required together with a training needs assessment and a training plan. The *Soil Fertility Management Task Force* will also need capacity strengthening.

POLICIES, STRATEGIES AND PROGRAMMING

A strategy will need to be developed to provide direction for achieving the various soil fertility management result areas. This will include expanding the area of agricultural land through an agricultural extensification programme that includes soil surveys and land suitability assessments to ensure that the correct land is used (see also the Policy Brief on Fallow Land Conversion for parallel strategies concerning intensification of existing agricultural land).

The strategy options for Agricultural Extensification could be:

- To convert 25% of shrubland and forest land on suitable slopes (outside private farm ownership or protected status) to intensive agricultural cropping patterns that contribute directly to food security targets for rice and maize (5,000 hectares by 2040)
- To convert 30% of shrubland and forest land on suitable slopes (outside private farm ownership or protected status) to high-intensity entrepreneurial agroforestry systems that contribute to local livelihood enhancement and diversification of cropping patterns (6,000 hectares by 2040)
- To convert 45% of shrubland and forest land on suitable slopes (outside private farm ownership or protected status) to low-intensity agroforestry systems through enrichment planting and other natural forest/shrub management techniques (9,000 hectares by 2040)

The strategy options for Agricultural Intensification could be:

- Soil testing for major and micro nutrients in all Gewogs (10,000 farm plots by 2040)
- National Soil Correlation Maps at 1:125,000 or 1:250,000 scale (4 regional maps by 2040)
- Land Suitability and Soil Survey Maps at 1:10,000 or 1:20,000 scale covering Chiwogs with high potential for agricultural extensification (20,000-30,000 hectares mapped by 2040)
- All Gewogs have sites for either researcher-managed trials or farmer-managed tests aimed at improving soil fertility management to act as demonstration sites by 2040
- Industrial scale bio-fertilizer and organic fertilizer units established (at least four factories established by 2040 (one in each region)
- All farm shops selling Bhutan branded and packaged bio-fertilizer and organic fertilizer of various types by 2040

MONITORING AND EVALUATION

Monitoring and evaluation of the soil fertility management programme should be linked to indicators in the five-year plans under MoAF. The emphasis in previous five-year plans had been on defining: links to National Key Result Areas (NKRA), links to Agency Key Result Areas (AKRA), Programme Outcomes, Programme Outputs, Programme Key Performance Indicators (KPI) and Programme Activities. These will need to be developed for all soil fertility management result areas that are defined in the next three five-year plans (13th 14th and 15th). M&E Annual Plans will be prepared by the implementing agencies with support of PPD staff. Monitoring of implementation of agricultural extensification may need the use of drones with cameras to map conversion rates and the types of cropping system being developed to provide accurate evidence-based statistics (this to be promoted by NSSC).

COORDINATION, COLLABORATION AND LINKAGES

Coordination, collaboration and linkages will need to be developed by the Policy and Planning Division (PPD) to support the *Soil Fertility Management Task Force* at MoAF.

Policy Briefs

Policy Briefs provide highlights on development issues in the renewable natural resources sector in Bhutan. The Policy Briefs provide information on topics such as governance, livelihoods, natural resources and sustainability in an accessible way for decision makers and donors.

Many of the Policy Briefs are based on evidence-based statistics available at the Ministry of Agriculture and Forests together with Research Studies carried out by the Policy and Planning Division at MoAF, and are often a synthesis of study reports prepared by international experts on behalf of donor agencies assisting the MoAF in Bhutan.

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