FUTURE SMART FOOD

Rediscovering hidden treasures of neglected and underutilized species for Zero Hunger in Asia

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11 Nepal

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11.1 Introduction

11.1.1 About the country

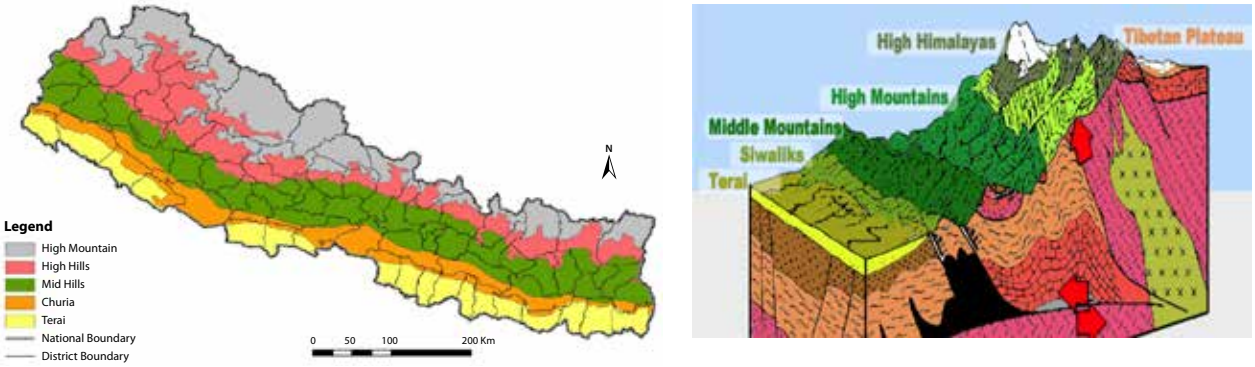
Nepal is situated from 26° 22′ N to 30° 27′ N and 80° 04′ E to 88° 12′ E and covers 141 181 sq km. The country is divided into five physiographic zones extending from east to west: High Himalaya, High Mountain (or High Hill), Middle Mountain (or Mid Hill), Siwalik and Lower Belt (*Tarai*) (Figure 11.1). The altitude ranges from 60 m above sea level in the *Tarai* plain to up 8 848 m at the peak of Mount Everest. The climate of Nepal is mainly characterized by altitude, topography and seasonal atmospheric circulations. As a result, climate types range from tropical to alpine in a south-north span of about 200 km.

The High Himalaya zone lies above 5 000 m in the northernmost part of the country and has a dry climate and winter snowfall. Above 5 500 m, the Himalayas are covered with perpetual snow with no tree vegetation. This area includes some dry inner-Himalayan valleys and treeless plateaus (such as the Dolpa, Manang and Mustang districts). The High Mountain zone is characterized by high steep slopes and deep gorges comprising subalpine and alpine climates and the associated vegetation types. The Middle Mountain region is physiographically the most diverse and has a subtropical to temperate monsoon climate. The Siwalik zone mainly comprises steep hills of unstable geomorphology. This region also provides ecosystem services, for example, prevention of soil erosion, the recharging of groundwater, and contributes to preventing natural disasters such as flash floods. The *Tarai* comprises a narrow belt of flat and fertile land in the southernmost region of the country with an elevation below 500 m. Soil types found in Nepal range from alluvial and fine-to-medium textured in the *Tarai*, sedimentary rocks with a sandy texture in the Siwalik, medium-to-light textured with a predominance of coarse-grained sand and gravel in the mid-hill to shallow, and stony and glacial in the High Mountain zone (MoFSC, 2002).

11.1.2 Agro-ecological zones

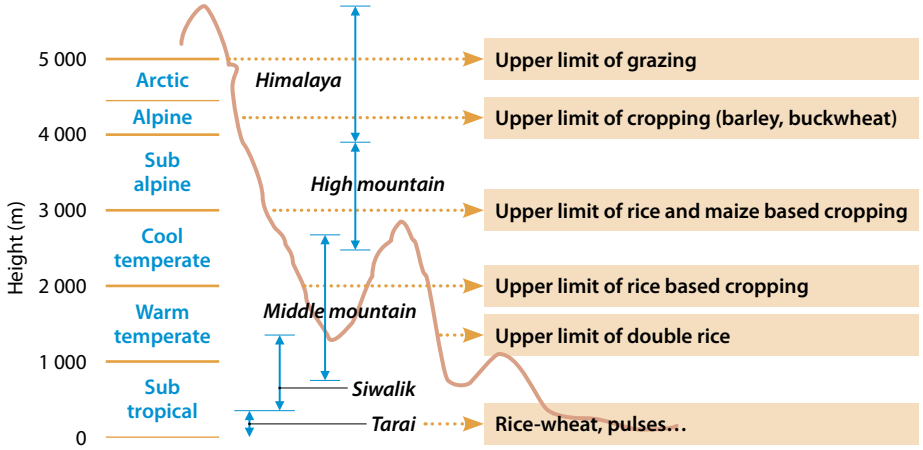
Nepal has a high degree of agro-ecological diversity, particularly in the hills and mountains owing to variations in topography, slope, aspect and altitude that allow for a range of biological environments, climatic regimes and varied ecosystems. Agricultural land and forests occupy about 30 percent and 39 percent, respectively, of the total geographical area of the country (Uddin *et al.*, 2015). Three major agro-ecological belts: High Hill, Mid Hill and *Tarai* occupy 43 percent, 45 percent and 12 percent of the agricultural area, respectively (Uddin *et al.*, 2015). There are four seasons in Nepal: pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and winter (December-February). The average annual rainfall is about 1 600 mm, but total rainfall differs in each eco-climatic zone. The north-central part near the Tibetan plateau records the lowest levels of rainfall of above 250 mm, while the southern slopes of the Annapurna range in central Nepal record the highest

FIGURE 11.1 Physiographic zones and topographical cross-section of Nepal



Source: WWF 2005

FIGURE 11.2 The diversity of agroecological zones and farming systems in Nepal



Source: Joshi (2017b)

TABLE 11.1 Crops grown in different agroecological zones of Nepal

Ecological region	Climate	Altitude (m)	Annual rainfall (mm)	Crops/livestock
High Himalaya	Arctic	Over 5 000	Snow	No tree vegetation, dry inner-Himalayan valleys
High Hill	Sub alpine and cold climate	2 000-5 000	150-200	*Agro-pastoral:* Almond, apple, apricot, barley, buckwheat, pear, plum, potato, radish waltnut; sheep and yaks
Mid Hill	Cool temperate and sub tropical	1 000-2 000	275-2 300	*Agro-pastoral:* Sheep and yaks, potato, buckwheat, barley, apple, walnut, almond, pear, plum, apricot, radish *Gentle slopes and mountain valleys:* Apple, cardamom, citrus, ginger, potato, tea and vegetables *Steep highland/hillslope forests:* Maize, millet, mustard, pear, plum, potato, wheat; buffalo, cattle and goats *Fertile terrace, river basin, valleys and flat plains:* Banana, cauliflower, cucumber, coriander, eggplant, garlic, guava, ladies finger, mango, onion, papaya, persimmon and rice
Siwalik	Tropical	500-1 000	1 100-3 000	*Fertile river basin, valleys and flat plains:* Banana, coriander, eggplant, garlic, grape, guava, jackfruit, ladies finger, lentils, litchi, mango, mustard, onion, papaya, pineapple, potato, rice, tomato, wheat; buffalo, cattle and goat
Lower belt		Over 500		

Source: MoFSC 2002, 2014, Gauchan and Yokohama 1999, Upadhyay and Joshi 2003.

with around 5 000 mm. About 80 percent of precipitation falls in the summer monsoon during June-September (NARC and AFACI, 2016). Temperatures vary with topography in a south-north direction, decreasing from south to north (Figure 11.2). In *Tarai* regions the average maximum and minimum temperatures range from 7-23°C in winter to as high as 40°C in summer. In the Middle Mountain region, average temperatures range from 12-16°C (MoFSC, 2002). In general, for every 100 m rise in altitude, the mean annual temperature drops by 0.5°C.

A huge range of food crops can be grown in Nepal due to its varied agro-ecological zones (Table 11.1). The elevation and soil moisture availability determine the crop species and intensity of cropping systems (Figure 11.2). In the southern plain, adjacent to India, with its tropical climate, two to three crops are grown per year depending upon irrigation facilities. The cropping intensity decreases with increasing altitude.

11.1.3 Status of Nepal's food basket: the composition of crops, including staples

Agriculture, including forestry and fishery, is the principal economic activity in Nepal, employing about 66 percent of the population and providing 32.7 percent of the gross domestic product (GDP) and 60 percent of export earnings (ABPSD, 2015). The total cultivated area of agricultural land is 3 091 000 ha while the uncultivated area is 1 030 000 ha. According to the 2011 population census, there are 542 702 households with a total population of 26 494 504 and a population growth rate of 1.35 percent per annum. Agriculture is basically subsistence, where crops, livestock and forests are the three major components of the complex farming system (Khadka, 1987). Cereal crops, including rice, maize and wheat are the main crops, followed by lentils and potato (Table 11.2). In the lowlands, rice is the major staple crop followed by wheat, while maize is the most important food crop in the Mid Hill area (Sharma, 2001). In the High Hill area, potato is the main food crop followed by maize, buckwheat (Joshi, 2008) and barley. Rice is the major source of energy for most Nepali people. The altitude of crop cultivation ranges from 60 m (Kechana Kalan, Jhapa) to 4 700 m (Khumbu, Solukhumbu) (Joshi, 2017a). Production and productivity of the five selected FSF crop species are currently very low (Figure 11.3).

11.1.4 Crop diversity and major cropping patterns

Nepal's diverse agro-ecology suits a range of genetic diversity and farming systems including crops (Joshi and Gauchan 2017), cropping patterns and animal husbandry. Nepal has 790 plant species, including forage species, with food value, of which 577 are cultivated (Joshi, 2017a; MoFSC, 2002). The estimated number of crop landraces is 30 000. Diversity and food insecurity zones are indicated in Figure 11.4. Three broad groups of agricultural plant genetic resources (APGRs) are agronomic crops, horticultural crops and forage species with 64 145 and 275 known species, respectively (Figure 11.5) (Joshi *et al.*, 2017a).

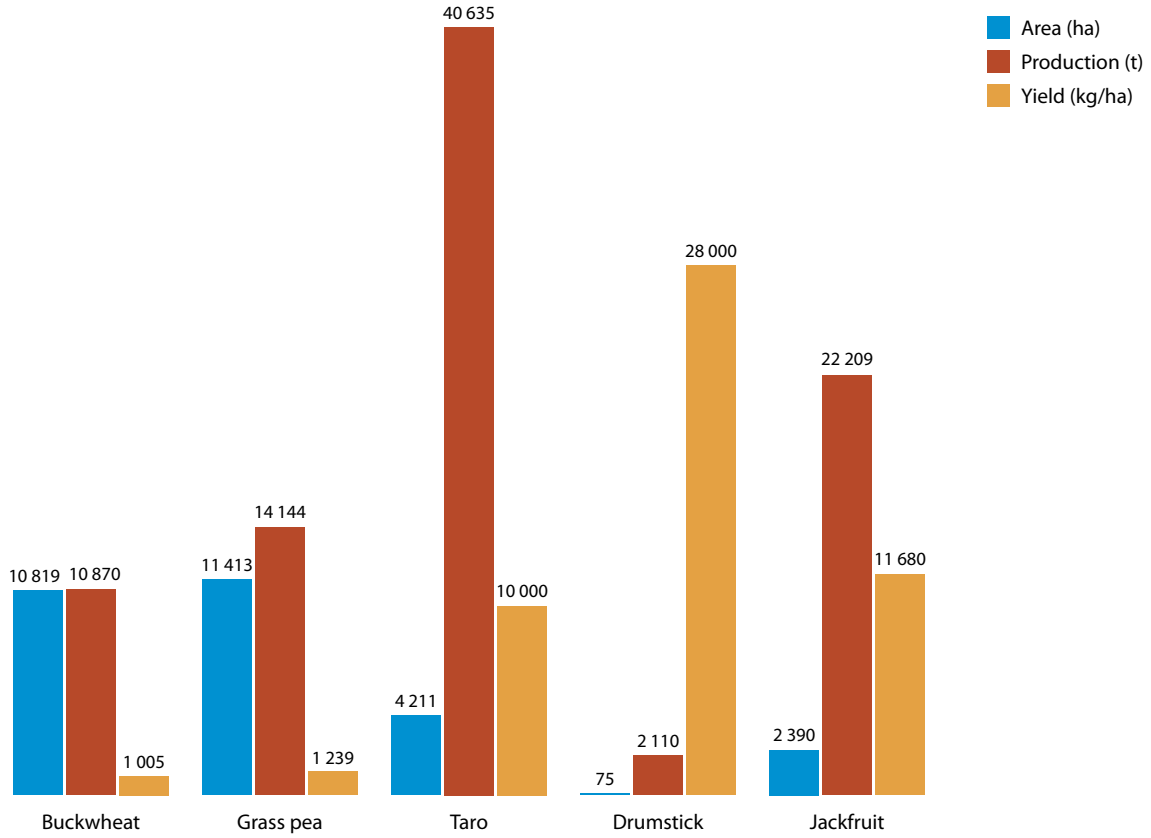
Farming systems in Nepal are based predominantly on cereal crop production to secure and sustain food security. Crops such as buckwheat, citrus, eggplant, foxtail millet, mango, rice, rice bean and underutilized food crops have a high genetic diversity that has been maintained through traditional farming systems and wild relatives in proximity (Joshi *et al.*, 2016b). Several fruit and vegetable species, with varieties including avocado, coffee, grape, macadamia nut, olive and strawberry, have been introduced into Nepal (MoFSC, 2002). A range of crop species is grown in different agro-ecological zones depending on the agro-climate (altitude, slope, aspect, topography, etc.), local food habits, and socio-economic status (Table 11.3 and Table 11.4). Some crop diversity has been conserved through various methods (Joshi *et al.*, 2016a).

TABLE 11.2 Area and production of major crops in Nepal, 2015

Sl. No.	Crop	Area (ha)	Production (t)	Yield (kg/ha)
1	Rice	1 425 346	4 788 612	3 360
2	Maize	882 395	2 145 291	2 431
3	Millet	268 050	308 488	1 151
4	Wheat	762 373	1 975 625	2 591
5	Barley	28 053	37 354	1 332
6	Buckwheat	10 819	10 870	1 005
7	Oilseed	233 041	209 612	899
8	Potato	197 037	2 586 287	13 126
9	Lentil	204 475	227 492	1 113
10	Horse gram	6 188	5 678	918
11	Black gram	23 147	19 439	840
12	Citrus (mandarin, sweet orange, lime, and lemon)	24 236	216 125	8 918
13	Vegetables	266 937	3 580 085	31 412

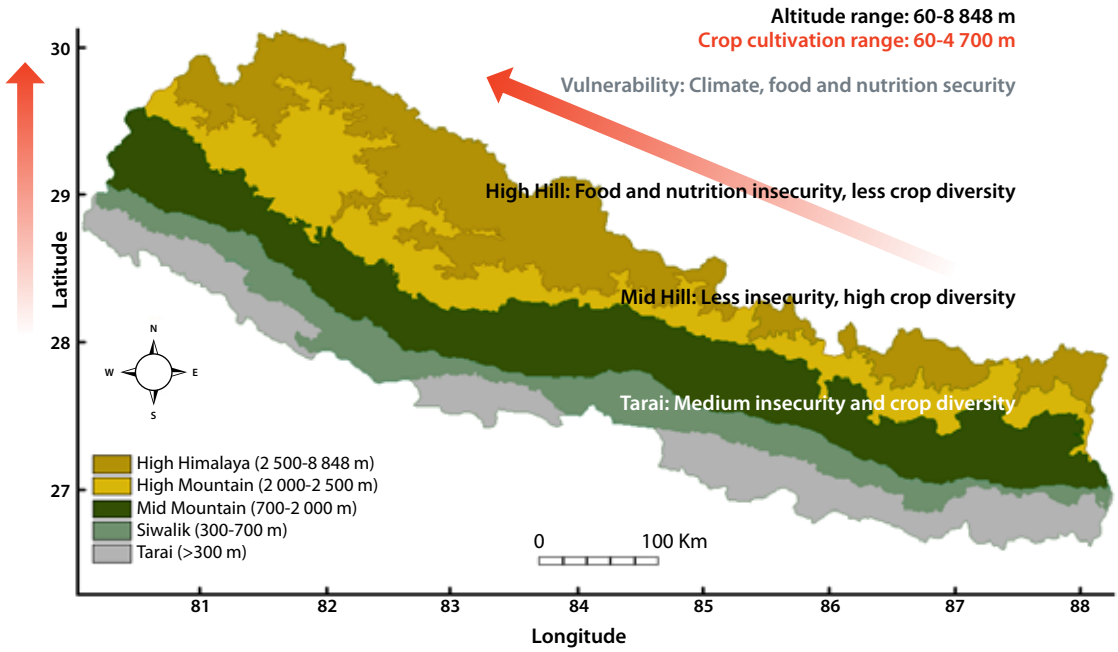
Source: ABPSD (2015).

FIGURE 11.3 Area, production and productivity of the five major FSF crops grown in Nepal



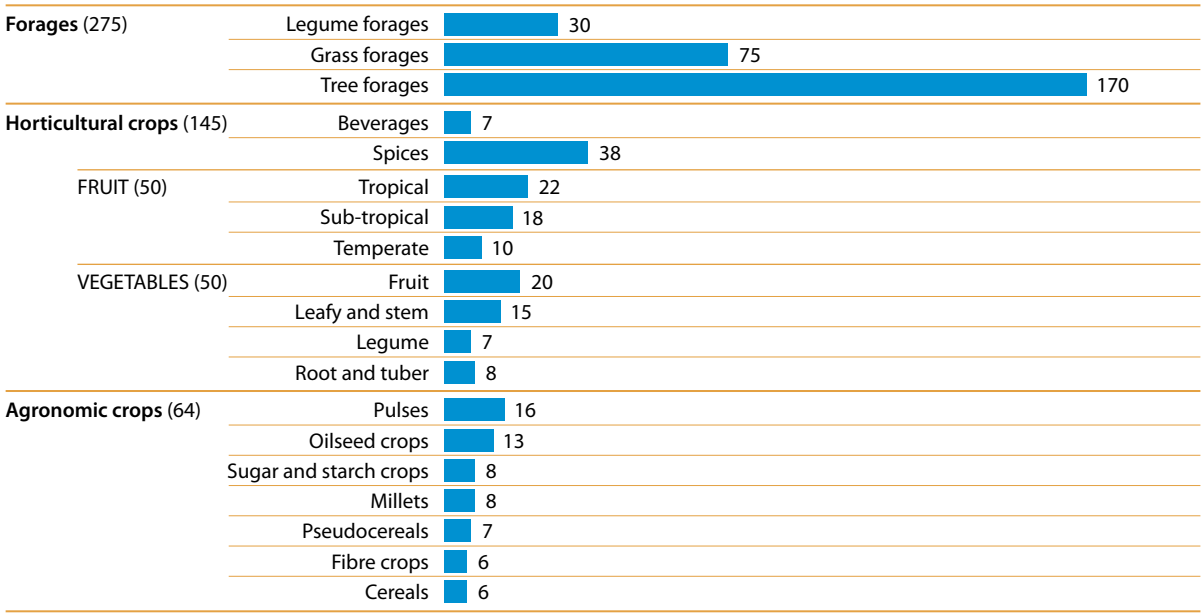
Source: MoAD 2015.

FIGURE 11.4 Location of diversity-rich areas, and food and nutrition insecurity areas, Nepal



Source: World Food Programme

FIGURE 11.5 The number of available species in various crop groups in Nepal (excluding ornamental plant species)



Source: Adapted from Joshi (2017a).

TABLE 11.3 Crop diversity in selected ecological regions of Nepal

Ecological region	Climate	Crop diversity
Siwalik* and *Tarai	Hot, humid and dry	*Brassica* species, chickpea, eggplant, jackfruit, jute, kodo millet, lentil, mango, niger, okra, perilla, pigeon pea, rice, sesame, wild relatives of rice
Eastern and Central Himalaya	Cool and humid	Barley, black gram, *brassica* species, buckwheat, citrus fruit, field peas, finger millet, foxtail millet, maize, niger, perilla, pigeon pea, rice, sesame, soybean, wild relatives of buckwheat
Western and Far-Western Himalaya	Cool and dry	Amaranths, black gram, *brassica* species, buckwheat, chenopods, cold tolerant rice, field peas, maize, naked barley, niger, perilla, proso millet, radish, rice bean, sesame, soybean, walnut, wheat, wild apple, wild pear

Source: MoFSC (2002); Upadhyay and Joshi (2003).

11.2 Situation and gap analysis

11.2.1 Hunger and malnutrition

Nepal ranks 157th out of 187 countries on UNDP's Human Development Index, with 25 percent of its population living below the poverty line (Chaparro *et al.*, 2014). Slow economic growth and human development, political instability, high susceptibility to climate change, vulnerability to earthquakes, and weak governance are some of the challenges facing Nepal.

Food access and availability, healthcare, and socio-economic and political issues are the major issues that influence malnutrition in vulnerable women and children. The distribution of malnutrition varies geographically by ecological zone, and rural and urban residences. The Nepal Demographic and Health Survey (2011) reported that the prevalence of stunting and severe stunting in children less than five years old was 41 percent and 16 percent, respectively (Tiwari *et al.*, 2014). Higher rates of stunting occur in rural children (42 percent) than urban children (27 percent). The High Hill has higher rates of stunting (53 percent), wasting (11 percent) and underweight (36 percent) than the *Tarai* (37 percent stunting, 11 percent wasting and 29 percent underweight) and the Mid Hill (42 percent stunting, 11 percent wasting and 27 percent underweight) (Joshi, 2012). Micronutrient deficiencies are widespread, with almost half of pregnant women and children under five years old, and 35 percent of women of reproductive age being anaemic. The poorest households and prolonged breastfeeding (over 12 months) showed an increased risk of stunting and severe stunting among Nepalese children (Tiwari *et al.*, 2014). The prevalence of anaemia is high in the *Tarai* (50 percent), followed by 41 percent in the Hills and 48 percent in the mountains. Anaemia is also common

TABLE 11.4 Major cropping patterns in each ecological region of Nepal

Ecological region	Land type	Cropping patterns	
Tarai	Irrigated lowland	Rice–Wheat–Maize Rice–Wheat–Mung bean Rice–Potato–Vegetables Rice–Potato–Maize Rice–Potato–Potato Rice–Potato–Jute Rice–Peas–Rice	Rice–Mustard/Peas–Vegetables Rice–Rice–Wheat Rice–Rice–Maize Rice–Rice/Legumes Rice–Vegetables–Maize–Mustard–Fallow Rice–Berseem
	Rainfed	Rice–Wheat–Fallow Rice–Mustard/Peas–Fallow Rice/Lentil–Fallow Rice–Lentil+Chickpea+Linseed Rice–Sugarcane–Sugarcane (ratoon) Rice+Pigeon pea (on bunds)–Mustard or Lentil	Rice/Lathyrus+Lentil or Linseed Maize–Buckwheat–Fallow Maize+Soybean–Mustard–Fallow Maize/Finger millet–Wheat Maize+Upland rice (Ghaiya)–Wheat Maize–Wheat–Fallow Rice–Wheat+Pea
	Upland	Maize–Mustard–Fallow Maize–Lentil or Chickpea Maize–Lentil+Mustard Maize+Pigeon pea–Fallow Maize/Pigeon pea–Fallow Pigeon pea+Sesame–Fallow	Pigeonpea+Sorghum (fodder)–Fallow *Siwalik* and *Tar* (plain area in river basin zone) areas: Upland rice+Maize Sandy soils: Pigeon pea+Groundnut Light sandy soils: Groundnut–Fallow
Mid Hill	Irrigated lowland	Rice–Wheat–Maize Rice–Potato–Maize Rice–Wheat–Vegetables Rice–Lentil–Vegetables Rice–Vegetables–Rice	Rice–Wheat Rice–Barley Rice–Potato Rice–Vegetable crop Maize–Wheat Maize–Vegetable–Fallow
	Upland	Maize+Millet–Black gram–Fallow Maize–Millet–Vegetables Maize/Finger millet–Fallow Maize+Legumes–Potato–Fallow Maize+Upland rice–Vegetables–Fallow Maize–Black gram+Niger Upland rice–Legumes–Fallow Upland rice–Black gram Maize+Ginger–Fallow Maize+Soybean–Mustard/Fallow Maize–Wheat	Maize+Upland rice–Wheat or Lentil or Fallow Maize+Soybean–Mustard Potato–Fallow Maize+Potato–Winter crops Maize/Potato–Fallow Maize/Pea or Maize–Pea Maize+Ricebean (terrace risers) Maize–Ricebean Maize/Soybean (river basins)
	River basin	Rice–Wheat–Mung bean (irrigated) Maize/Soybean–Fallow Upland rice–Black gram	Maize/Black gram–Fallow Maize+Ghaiya–Fallow Maize–Black gram+Niger (rainfed)

Defintions of table symbols: – = followed by, / = relay, + = intercropping or mix cropping.

Source: Sharma 2001, MoFSC 2002.

among children aged 6–59 months (MoHP, 2015) (Table 11.5). In rural areas, the prevalence of night blindness is 5 percent, while it is 1 percent in urban areas. The Nepal Iodine Deficiency Disorders Status Survey (2005) indicated an overall iodine insufficiency among rural children and an excess iodine intake among urban children.

Ecological region	Land type	Cropping patterns	
High Hill	Irrigated	Rice–Naked barley, Rice–Wheat, Potato–Buckwheat or Mustard or Vegetables	Bean–Barley Maize–Vegetables–Fallow Potato–Potato–Fallow Bean–Buckwheat
	Rainfed	Potato–Fallow Naked barley–Fallow Maize–Wheat Maize–Wheat+Finger millet Maize–Naked barley–Finger millet	Niger–Potato–Fallow Maize–Fallow–Fallow Wheat–Fallow

Defintions of table symbols: – = followed by, / = relay, + = intercropping or mix cropping.

Source: Sharma 2001, MoFSC 2002.

TABLE 11.5 Status of malnutrition in Nepal and the world in 2014

Indicator		Prevalence (%)			Health effects
		Nepal	World	Nepal rank in world	
Stunting (height for age)		37.4	23.8*	109	Weakened immune system, high risk of death
Wasting (weight for height)		11.3	7.5*	111	
Overweight (under five years)		2.1	6.1	17	
Anaemia in women of reproductive age		36.1	29	146	
Exclusive breastfeeding rate		56.9	39	25	
Adult overweight		18.0**	39	6	Risk of chronic illness (diabetes)
Adult obesity		3.3	13	7	
Adult diabetes		–	9	–	
Micronutrient deficiencies	Vitamin A: 6-59 months	5.5	–	–	Night blindness, serum retinol
	Women				
	Iron	36.1	–	–	Anaemia, worm infestations, malaria, genetic blood disorders
Women of reproductive age with chronic energy deficiency (measured as low BMI)		18.0	–	–	Stillbirth, underweight childbirth

* Children under five years, ** Overweight and obesity.

Source: FAO, IFAD and WFP 2015, IFPRI 2016, Rudert 2014, MoHP 2015.

There is a positive association between household food consumption score and a lower prevalence of stunting, underweight and wasting. Maternal education for low socio-economic status intervention is needed to reduce preventable deaths caused by malnutrition in Nepal. Undernutrition in Nepal is estimated to cost the country USD 190 million annually (World Bank, 2011).

The government of Nepal is focused on solving the issue of undernutrition in children and women of reproductive age through its Agriculture Development Strategy (ADS) 2015–2035. The nutritional status indicators and targets set by the ADS can be seen in Table 11.6.

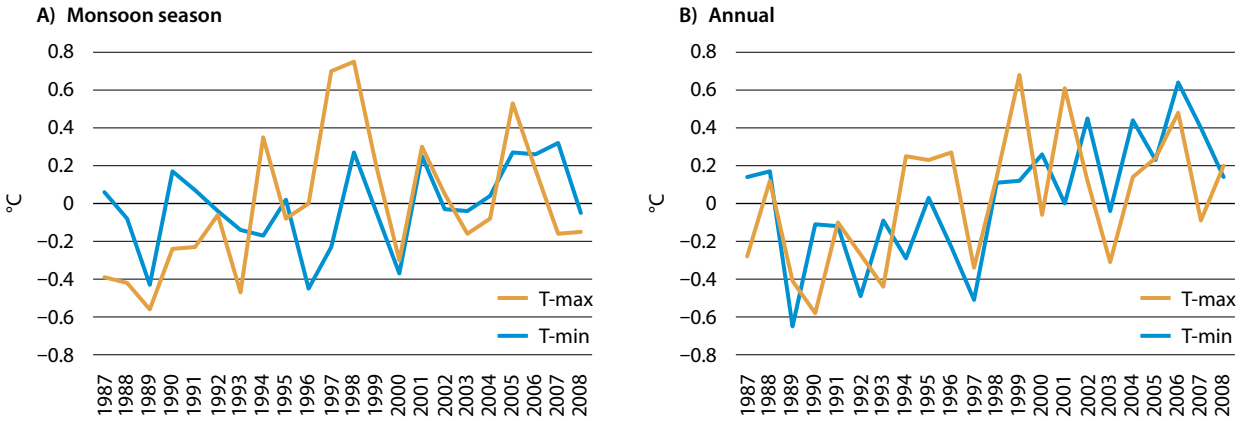
11.2.2 Climate-change constraints

Nepal is ranked the fourth-most vulnerable country of 170 in the world when it comes to vulnerability to the impacts of climate change over the next 30 years. Nepal's geo-climatic conditions (23 percent of the total area is above the permanent snowline and 3.6 percent of the total area covered by glaciers), poverty, food

TABLE 11.6 Indicators and targets of food and nutrition security in the Agriculture Development Strategy 2015-2035 for Nepal

Indicator	Current situation (2010)	Target		
		Short term (5 years)	Medium term (10 years)	Long term (20 years)
Food poverty	24.0%	16%	11%	5%
Stunting (children under 5)	41.5%	29%	20%	8%
Underweight (children under 5)	31.1%	20%	13%	5%
Wasting (children under 5)	13.7%	5%	2%	1%
Women of reproductive age with chronic energy deficiency (measured as low BMI)	18.0%	15%	13%	5%

FIGURE 11.6 Maximum and minimum temperatures from 1987-2008 in Nepal



Source: MoSTE 2009.

insecurity, natural-resource-based livelihoods and economy (agriculture and tourism based), and political conflicts make it vulnerable to the many affects of climate change (Dahal, 2014; MoAD DNA). The impact of climate change in Nepal is evident in the increased melting of glaciers, warmer days and nights, erratic monsoons (drought and flood), increased numbers of rainy days with more than 100 mm per day, and extreme foggy and cold periods in the *Tarai* (NARC and AFACI, 2016).

The predominantly rain-fed agriculture in Nepal is highly vulnerable to changes in climatic variables. Weather data from 1975 to 2009 shows that temperatures have increased by around1.5 °C (Figure 11.6), mostly during the dry season (December to March), and particularly in the Himalaya region (Krishnamurthy *et al.*, 2013). The Global Climate Model Projection indicated a 0.5 °C to 2 °C increase in temperature by 2030 with frequent heat waves and less frost, and a wide range of precipitation changes, especially during the monsoon from a decrease of 14 percent to an increase of 40 percent by the 2030s, and from a decrease of 52 percent to an increase of 135 percent by the 2090s (NCVST, 2009). Annual average temperatures are expected to increase by around 0.06 °C (NCVST, 2009). A crop simulation model predicted that rice yields would increase with elevated CO_2 and a 4 °C rise in temperature in the *Tarai*, but wheat and maize yields would decline (NARC and AFACI, 2016). A recent study showed that increases in maximum temperature during the ripening phase (30.8 °C base average maximum temperature from 1999 to 2008) would increase rice yields up to a critical threshold of 29.9 °C, beyond which rice yields will decline (Karn, 2014). Climate change also changes pest insect and disease dynamics; for example, the prevalence of disease in chayote and insect pest in drumstick has increased. Farmers are reluctant to cultivate drumstick near their homesteads due to the increased prevalence of hairy caterpillars that can infest homes and buildings.

11.2.3 Market and economic constraints

Around half of the population in Nepal lives in rural mountain areas with fragile topography, where agricultural productivity is very low. In recent years, these areas have been temporarily abandoned primarily due to labour scarcity caused by the migration of young people

seeking off-farm and foreign employment. Subsistence farming is a major concern for household food security and nutrition.

The FAO food deprivation data (2005-2007) for Nepal showed that 4.5 million people are undernourished (FAO, 2011). Cereal crops are the staple food and contribute a major share in area and production. About 21 percent (3.2 million ha) of the total land area of Nepal is used for cultivation, with the major crops being rice (46 percent), maize (29 percent), wheat (25 percent), followed by pulses (10.5 percent), millet (8.7 percent), oilseeds (7.5 percent), potato (6.4 percent), sugarcane (2.2 percent), jute (0.3 percent), barley (0.9 percent), vegetables (8.6 percent) and fruits (3.6 percent) (ABPSD, 2015). The major constraints for markets are low-volume production in scattered areas, lack of processing facilities, and lack of knowledge about processing, product diversification, nutritive value of FSF commodities to consumers, and production in localized areas.

11.2.4 Cultural relevance and local availability

Most of the FSF selected for cultivation in Nepal are considered socio-culturally inferior, including millet, grass pea, and colocasia, despite being nutritionally rich commodities. Most FSF are consumed by poor people and the lower castes (e.g. dalit, *kami*, *damai*). Many FSF are localized and maintained by individual castes. At the local level, there is much diversity in FSF, but they are not grown widely by many households. Among the agricultural species, crops such as amaranth, buckwheat, citrus fruits, eggplant, foxtail millet, horse gram, mango, proso millet, rice, rice bean, soybean, sweet potato, taro and yam; and tropical fruit species, such as black plum, jackfruit, jujube and litchi, have high genetic diversity relative to other food crops (MoFSC, 2014).

11.3 Scoping and prioritization of Future Smart Food

11.3.1 Scoping of availability of FSF

A team of scientists from the Nepal Agricultural Research Council (NARC) discussed the status of crops and farming in Nepal along with criteria to define neglected and underutilized crop species (NUS) and FSF in early 2017 in Kathmandu. NUS are crop species that have no released or registered varieties. FSF are NUS that have high potential for food and nutritional security, and are considered highly adaptable. Of the 484 cultivated indigenous crop species in Nepal, the team identified more than 200 NUS with 50 considered as potential FSF crop species, most of which are listed in Table 11.7.

11.3.2 Prioritization analysis

Agricultural scientists from NARC reviewed relevant documents for prioritizing the FSF crop species of Nepal. There were five focus group sessions and seven email discussions to generate information on the prioritization of FSF. After listing the FSF crops, the team generated information on each crop based on the steps listed below:

Step 1: Nutrition

- Buckwheat, rich in rutin
- Grass pea, rich in protein
- Chiuri, for flavour, essential oils, vitamins, sulfur
- Moringa, a very nutritious vegetable
- Taro, rich in vitamin A
- Jackfruit, rich in energy and minerals

Step 2: Production and ecology (climate change)

- Buckwheat, short-duration crop grown in low rainfall areas on marginal land
- Grass pea, hardy crop requiring little care, irrigation and management, can be grown on degraded land
- Chiuri, drought tolerant and easily grown on marginal land
- Moringa, grown in the *Tarai* as a rain-fed crop
- Taro, adapted to a wide range of areas
- Jackfruit, high yield in lower belt of Nepal

Step 3: Economic potential

- Buckwheat, potential export commodity
- Grass pea, has market potential if low in the neurotoxin ODAP (β-N-oxalyl-L-αβ diamino propionic-acid)
- Chiuri, high demand for oil and fresh seed. The seeds are also used for making soaps, and beekeepers pay chiuri tree owners to allow their bees to graze their trees
- Moringa, popular vegetable with medicinal value
- Taro, multipurpose vegetable with high market value
- Jackfruit, high market value

TABLE 11.7 List of potential future smart food crop species in Nepal identified in group discussions

Sl. No.	English name	Local/Nepali name	Scientific name	Accession	Priority
Cereals/pseudo-cereals					
1	Tartary buckwheat	*Tite Phaper*	*Fagopyrum tataricum (L.) Gaertn.*	400	1
2	Sorghum	*Junelo*	*Sorghum bicolor (L.) Moench*	100	
3	Prince's feather	*Latte dana*	*Amaranthus hypochondriacus L.*	70	
4	Foxtail millet	*Kaguno*	*Setaria italica (L.) P.Beauv.*	50	2
5	Proso millet	*Chino*	*Panicum miliaceum L.*	50	3
6	Foxtail amaranth	*Jhule Latte*	*Amaranthus caudatus L.*	40	4
7	Blood/ Red amaranth	*Rato Latte*	*Amaranthus cruentus L.*	30	
8	Pearl millet	*Bajra*	*Pennisetum glaucum (L.) R.Br.*	0	
Root and tubers					
1	Taro	*Pindalu*	*Colocasia esculenta (L.) Schott*	30	1
2	Greater yam, White yam	*Tarul, GharTarul*	*Dioscorea alata L.*	5	3
3	Elephant foot yam	*OI*	*Amorphophallus paeoniifolius (Dennst.) Nicolson*	0	4
4	Deltoid yam	*Vhyakur*	*Dioscorea nepalensis (Jacquem. ex Prain and Burkill) Sweet ex Bernardi*	2	2
5	Topioca, cassava	*SimalTarul*	*Manihot esculenta Crantz*	0	
Pulses					
1	Rice bean	*Mashyang/ Jhilinge/Siltung*	*Vigna umbellata (Thunb.) Ohwi and H.Ohashi*	80	3
2	Horse gram	*Gahat*	*Macrotyloma uniflorum (Lam.) Verdc.*	30	4
3	Grass pea	*Khesari*	*Lathyrus sativus L.*	50	1
4	Small pea, Field pea	*Sano Kerau*	*Pisum sativum L. var. arvense L.*	30	4
5	Faba bean	*Bakulla*	*Vicia faba L.*	20	2
6	Swordbean	*Tarbare simi*	*Canavalia gladiata (Jacq.) DC.*	1	
7	Velvet bean, Horse eye bean	*Kause Simi*	*Mucuna pruriens (L.) DC.*	2	
8	Cluster bean	*Juppe simi*	*Cyamopsis tetragonoloba (L.) Taub.,*		
Fruit vegetables					
1	Chayote	*Iskush*	*Sechium edule (Jacq.) Sw.*	15	2
2	Balsam apple	*Barella*	*Momordica balsamina L.*	20	
3	Drumstick	*Sahinjan/Sital Chini*	*Moringa oleifera Lam.*	0	1
4	Ash gourd, Wax gourd	*Kubhindo*	*Benincasa hispida (Thunb.) Cogn.*	10	
5	Chathel gourd	*Chattel, Chuche Karela*	*Momordica cochinchinensis (Lour.) Spreng.*	0	

Sl. No.	English name	Local/Nepali name	Scientific name	Accession	Priority
Leafy vegetables					
1	Fenugreek	*Methi*	*Trigonella foenum-graecum L.*	10	1
2	Dill	*Soup*	*Anethum graveolens L.*	4	
3	Lamb's quarter	*Bethe*	*Chenopodium album L.*	2	3
4	Water cress	*SimSaag*	*Nasturtium officinale R.Br.*	0	
5	Green pigweed, Green amaranth	*Lunde*	*Amaranthus gracilis Desf.*	2	2
6	Sweet belladonna, Indian poke	*Jaringo*	*Phytolacca acinosa Roxb.*	2	4
Fruits					
1	Walnut	*Okhar*	*Juglans regia L.*	0	
2	Jackfruit	*RukhKatahar*	*Artocarpus heterophyllus Lam.*	0	2
3	Wood apple, Bael tree, Bengal quince	*Bel*	*Aegle marmelos (L.) Correa*	1	3
4	Nepalese hog plum	*Lapsi*	*Choerospondias axillaris (Roxb.) B.L.Burtt and A.W.Hill*	1	
5	Lemon	*Nibuwa*	*Citrus limon (L.) Osbeck*	0	
6	Pummelo, Shaddock	*Bhogate*	*Citrus grandis (L.) Osbeck*	2	
7	Indian gooseberry, Embelicmyrobolan	*Amala*	*Emblica officinalis Gaertn.*	1	2
8	Custard apple	*Saripha, Sitaphal*	*Annona squamosa L.*	0	4
9	Rough lemon	*Jyamir*	*Citrus junos Siebold ex Tanaka*	0	
10	Tamarind, Indian date	*Imli*	*Tamarindus indica L.*	0	
11	Java plum, Surinam cherry, Black plum	*Jamun*	*Syzygium cumini (L.) Skeels*	0	
Oilseeds					
1	Linseed	*Aalash*	*Linum usitatissimum L.*	5	1
2	Nepali butter tree	*Chiuri, Mahuwaa*	*Bassia latifolia Roxb.*	0	2
3	Himalayan cherry	*Dhatelo*	*Prinsepia utilis Royle*	0	3
Spices					
1	Perilla	*Silam*	*Perilla frutescens (L.) Britton*	20	1
2	Nepal pepper, Prickly ash, Toothache tree	*Timur*	*Zanthoxylum armatum DC.*	1	2
3	Caraway, Ajowan, Ammi	*Jowano*	*Trachyspermum ammi (L.) Sprague*	0	4
4	Black cumin	*Himali Jira, Kalo Jira*	*Bunium persicum (Boiss.) B. Fedtsch.*	0	3

Step 4: Social and cultural potential

- Buckwheat is considered a healthy food among urban population
- Grass pea soup is a delicacy, and the tender shoots of grass pea are also eaten
- Chiuri (butter tree), considered a private resource and multipurpose tree in the Chepang community and is given as gift to daughters when they get married
- Moringa, is a highly popular vegetable
- Taro is a culturally valued commodity
- Jackfruit has cultural uses when combined with with other items, e.g. milk, ghee

11.3.3 Details on the prioritized FSF

Prioritized FSF 1
Tartary buckwheat (*Fagopyrum tataricum* (L.) *Gaertn.*)

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General characterization

- **Origin and distribution**: Tartary buckwheat self pollinates and is predominant in the High Hills.
- **Life form and ecology**: Annual and adapted to mountain ecosystems. It is a short-duration crop grown on marginal land.
- **Uses and used parts**: Grain can be consumed after grinding as pancakes or porridge, tender leaves and tips are eaten as leafy vegetables. The grain itself can be cooked like rice *(Bhate Phaper)*.
- **Yield**: 983 kg per ha.
- **Ingredients and health benefits**: Tartary buckwheat grain contains 13.3 pecent protein, 1.3 percent minerals, 3.4 percent fat, 71.5 percent carbohydrates and is a good source of rutin (which reduces cholesterol in the blood) and dietary fibre. It is seen as a healthy food by urban dwellers.
- **Problems**: It is difficult to process with low yields and small grains. It is also susceptible to waterlogging and frost, damping off, powdery mildew and rust.

Prioritized FSF 2
Grass pea (*Vicia sativa* L.)

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General characterization

- **Origin and distribution**: Grown in rice-based cropping systems in the Indo Gangetic plains in the 1970s, grass pea was the number one pulse in terms of area and production in Nepal. However, the sown area declined drastically due to a huge decline in consumption following a health scare.
- **Life form and ecology**: This annual plant is grown in sub-tropical areas, mainly in the *Tarai*. Often grown as a relay crop in rice, it is drought and waterlogging tolerant relative to other pulses.
- **Uses and used parts**: Young leaves are consumed as green vegetables, also rolled and dried for off-season use. The fodder is used as a valuable livestock feed. Grain is used in vegetable soup. It is cheaper than other grain legumes and mostly consumed by the rural poor.
- **Yield**: Fresh biomass yields 5–6 tonnes per ha, grain yields 1.2 tonnes per ha.
- **Ingredients and health benefits**: Rich in protein.
- **Problems**: The grass pea is low yielding and can contain oxalyldiaminopropionic acid (ODAP) in levels from 0.6 percent to 0.8 percent in local grass pea. Regular intake of grain is believed to cause the neurological disorder lathyrism. A ban has been inposed since 1991/1992 on marketing grass pea. This led to a huge reduction in sown area (after being the number one pulse in terms of area and production in the 1970s).

Prioritized FSF 3
Taro (*Colocasia esculenta* (L.) *Schott*)

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General characterization

- **Origin and distribution**: Taro is grown in the Mid Hill and Tarai districts and distributed widely across the country.
- **Life form and ecology**: An annual plant, cultivated on 4 040 ha, sown April–May as a rain-fed crop in the *Tarai* and Mid Hill regions and harvested Nov–Jan. A common cropping pattern is taro–maize–legume vegetable, while intercropping with maize, ginger or turmeric and other summer crops.
- **Uses and used parts**: The corms, petioles (*gaaba*) and leaves (*karkalo*) are edible after cooking. The tubers are used as a root vegetable, steamed, fried or cooked with black gram in the preparation of some soups. It is never eaten raw because it causes an itchy, stinging, and very irritating sensation to the throat. Leaves are also dried and stored. Tubers are also consumed during festivals.
- **Yield**: 10 tonnes per ha.
- **Ingredients and health benefits**: Corms are rich in carbohydrates, and the leaves have high levels of calcium and vitamin A.
- **Problems**: Crops can be attacked by white grub, are subject to wilting and have a poor cooking quality.

Prioritized FSF 4
Drumstick (*Moringa oleifera Lam.*)

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General characterization

- **Origin and distribution**: Drumstick is a fast-growing drought-resistant tree, widely cultivated in tropical and subtropical areas.
- **Life form and ecology**: In seasonally cool regions, flowering occurs once a year between April and June. With more constant seasonal temperatures and rainfall, flowering can occur twice or even year-round.
- **Uses and used parts**: Young seeds, pods and leaves are used as vegetables or as low-cost feed for animals. The seeds have a cooling effect when eaten.
- **Yield**: 40 tonnes per ha of green pods.
- **Ingredients and health benefits**: Used for water purification, hand washing and herbal medicine. It is a nutritious vegetable and rich in vitamin A.
- **Problems**: It can be a difficult plant to propagate in Nepal and attracts hairy caterpillars. Being tall, it is difficult to harvest and produces low yields. It is also relativity expensive to produce.

Prioritized FSF 5
Jackfruit (*Artocarpus heterophyllus Lam.*)

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General characterization

- **Origin and distribution**: Grown in tropical to subtropical regions.
- **Life form and ecology**: Flowering from February-March, available in markets from April-May as tender fruits and from July-August as ripe fruits.
- **Uses and used parts**: The unripe fruit is used as a vegetable and is popular in urban areas. Ripe fruit is eaten fresh. Mature seeds are used as as vegetables, roasted and boiled. The jacktree's wood is used to make *theki*, the pots in which ghee is churned.
- **Yield**: 11.6 tonnes per ha and so has high yield potential.
- **Ingredients and health benefits**: Useful for treating dysentery and diarrhoea. The fruit is nutritious, rich in calcium, carbohydrates, potassium, protein and vitamins A, B and C.
- **Problems**: The amount of fruit that can be consumed in proportion to the weight is low. In addition, jackfruit is difficult to process and propagate and trees do not bear fruit for several years. Jackfruit also tends to attract borers, pink disease, leaf spot, collar rot and rust.

Prioritized FSF 6
Nepal butter tree (*Bassia latifolia Roxb.*)

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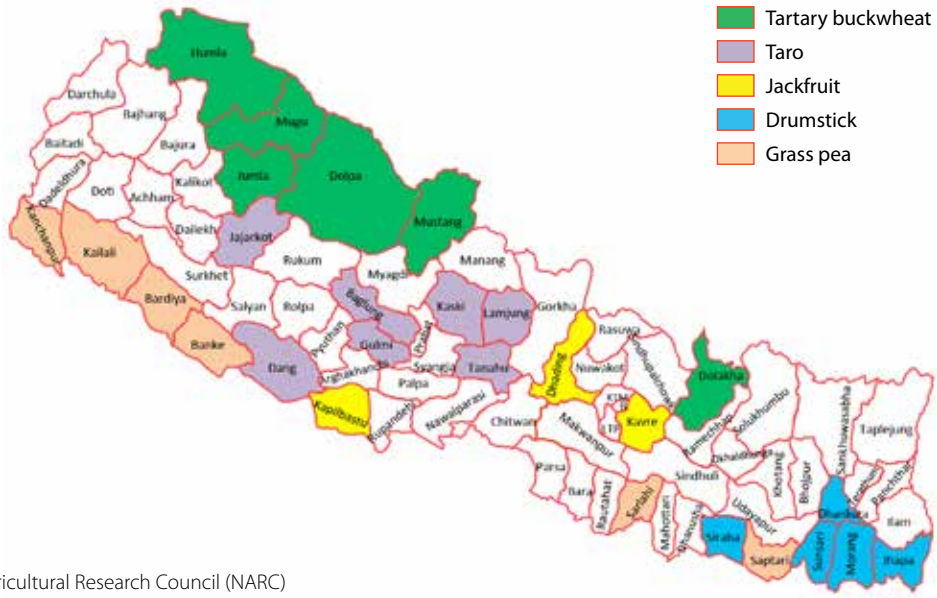
General characterization

- **Origin and distribution**: Grown in sub-Himalayan regions at elevations from 400-1 400 m. The butter tree or *chiuri* is a popular crop among hill tribes such as the Chepang community.
- **Life form and ecology**: The tree produces flowers from November-January and fruits are available from April-June. The tree offers good protection from soil erosion.
- **Uses and used parts**: It is estimated that 35-40 percent of oil can be extracted from fully ripe, dried seeds. Products are used in confectionery, pharmaceuticals, vegetable ghee production, candle manufacturing and soap making. It is also used as an additive in animal ghee. Ghee is the main source of edible oil used to cook vegetables and roti in Nepal. Chiuri juice is also consumed to quench thirst. The cake produced after processing is used as fertilizer on paddy fields for its pesticide properties.
- **Yield**: 100-800 kg per ha (around 1-14 kg per tree).
- **Ingredients and health benefit**: Seed oils are used in head massages and can be highly effective in the relief of rheumatism.
- **Problems**: Processing requires a substantial amount of fuelwood which contributes to deforestation. Oil extraction rates are low when using a traditional oil expeller *(Chepuwa)*, with only 38 percent recovery. The taste may seem unfamiliar and so off-putting to potential consumers.

FIGURE 11.7 Potential sites for field surveys on FSF crops, Nepal



Source: Nepal Agricultural Research Council (NARC)

TABLE 11.8 Collaborators from NARC for research and development of FSF

Sl. No.	Crop	Lead organization	Collaborators
1	Tartary buckwheat	HCRP, Dolakha	ARS Jumla, ARS Dailekh, RARS Lumle, FRD Khumaltar, Genebank Khumaltar, SARPoD Khumaltar (6)
2	Grass pea	GLRP, Banke	RARS Parwanipur, NORP Nawalpur, FRD Khumaltar, Genebank Khumaltar, RARS Doti, SARPoD Khumaltar (6)
3	Taro	HRD, Khumaltar	FRD Khumal, Genebank Khumal, SARPoD Khumal, HRS Malepatan, GRP Kapurkot, CRP Gulmi, RARS Nepalgunj (7)
4	Drumstick	HRD, Khumaltar	RARS Tarahara, ARS Belachapi, FRD Khumal, Genebank Khumal, SARPoD Khumal, ARS Pakharibas (6)
5	Jackfruit	HRD, Khumaltar	FRD Khumal, Genebank Khumal, SARPoD Khumal, RARS Tarahara, RARS Nepalgunj (5)

11.3.4 Sites for surveys and collaborators

Of the six potential FSF, the team of scientists considered five for further research and development. These five crops: buckwheat, drumstick, grass pea, jackfruit and taro are available across Nepal. Based on the diversity and economic value in particular locations of these crops, potential sites for field surveys were identified (Figure 11.7). NARC is the leading body for agricultural research in Nepal, with 61 branch offices across the country. The potential collaborators for each FSF crop species are listed in Table 11.8.

11.4 Conclusion and recommendations

Nepal is rich in agro-biodiversity as a result of extreme variation in altitude, ecology, farming systems and sociocultural values. Most of the population relies on three main crops for their food supply: rice, wheat, and maize. However, minor millets are an integral part of subsistence farming in the Mid Hills and High Hills, and contribute to food and nutritional security to some extent.

Many NUS crops have medicinal, religious and industrial significance for various tribal groups, and have a high potential for export value. Climate change will impact considerably the hill ecosystem of Nepal. Research and development are needed in the conservation, evaluation and utilization of NUS crops, which are more nutritious, climate resilient and better adapted to marginalized areas. Recommendations for better utilization of NUS and FSF for nutrition and food security in Nepal include the following:

- There needs to be **status and gap analysis** to document the information available on the dependency of households on certain crops, and the contribution that NUS and FSF make towards both household and national food and nutrition security, income generation, health security and the role of NUS and FSF in subsistence farming.
- To further advance NUS and FSF, a **baseline survey** should be carried out focusing on food, nutrition, health and climate change, and assessing crop status and diversity across the country. This needs to explore medicinal, religious, industrial and nutritional values along with different food recipes using NUS to expand cultivation areas, increase consumer numbers, and encourage researchers and policymakers to consider NUS and FSF as priority crops. As many NUS and FSF crops are adapted to different farming systems, cultures and climates, more value-added opportunities are needed to make them popular in different parts of the country.
- To protect these plants and ensure that they benefit future generations, **conservation, pre-breeding, exchange and utilization of NUS and FSF plants and seeds** should be initiated across Nepal. Processing techniques should be advanced, and recipes need to be diversified. Currently there is only limited information on the nutrient composition of NUS and FSF, which needs to be analysed and linked to respective health benefits.
- NUS and FSF crop species are more climate resilient than many current species and they could be vital in future sustainable production. More research is needed to identify climate-resilient varieties and varieties more tolerant to abiotic and biotic stresses. Priority should be given to **genetic and husbandry improvement** of NUS and FSF.
- To make NUS and FSF an export commodity, **strong market links should be established and programmes implemented**. Some NUS and FSF have geo-linked traits that can be marketed as geographical indicators (Joshi *et al.,* 2017b).

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