Agriculture in the Mountains of Northeastern Thailand: Current Situation and Prospects for Development

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The mountains in northeastern Thailand cover an area of about 25,000 km², which is about 15% of the region’s land surface. Although agriculture is the most important economic activity in the mountains, there has been little previous research on it. This study presents a general description of mountain agriculture in northeastern Thailand, which is shown to be quite different from the better-known agriculture in Thailand’s northern mountains. The northeastern mountains are diverse in environment, culture, and land use. Mountain agriculture is also diverse at the crop level. Field crops remain the main source of income, but in recent years, rubber has become increasingly important in some areas. Specialty crops (eg grapes, strawberries, exotic flowers, and temperate vegetables) generate high income and serve as a magnet for tourism, but they are grown in only small areas in a few favored locations. Poor-quality soil, seasonality and variability of rainfall, scarcity of surface water, broken terrain and steep slopes, insufficient supply of land, land tenure insecurity, limited possibilities for mechanization, high cost of transportation, and competition with foreign imports are the main constraints on development. However, promotion of specialty crops and agritourism offer some potential for mountain agricultural development in northeastern Thailand.

Keywords: Mountain environment; mountain development; agricultural intensification; agritourism; specialty crop.

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Introduction

The northeastern region of Thailand (14–19°N, 101–106°E), although mostly covered by undulating terrain, contains 4 major mountain ranges with an area of about 25,000 km² (about 15% of the region’s total land surface; Jarvis et al 2008). These mountains are home to almost 700,000 people (Department of Provincial Administration 2011). All major rivers in the region arise in the mountains, which are also important sources of raw materials, including timber and minerals. Although the mountains are recognized as constituting a distinctive agroecological zone within the region (Limpinuntana 2001), and although agriculture is the most important economic activity there, mountain agriculture has received little attention from researchers. This paper represents an initial attempt to fill this knowledge gap by describing the environmental and social characteristics of the mountains, identifying the main crops grown in different ranges, and examining factors influencing their spatial distribution. It then compares agriculture in the northeastern mountains with the better-known agriculture of the northern Thailand. Finally, it examines some constraints and opportunities for agricultural development in the northeastern mountains.

Methodology

In the Lao language spoken in most of northeastern Thailand, “mountain” (phu) refers to any landscape feature that is significantly higher than the surrounding relief. The distinction between mountains and “hills” (nern khao) is not clearly drawn, and all features of higher relief are likely to be called phu. The term “uplands,” which is often encountered in descriptions of northeastern agriculture, does not refer to hills or mountains but instead is applied to those areas in the undulating terrain of the Khorat Plateau that are too high for construction of paddy fields and are instead used to grow dryland cash crops, such as cassava and sugarcane (Limpinuntana 2001). For the purpose of this research, “mountains” were defined as any land surfaces that rise higher than 300 meters above mean sea level (mamsl). Although this is a relatively low elevation threshold compared to mountains elsewhere in the world, in northeastern Thailand it effectively delineates the base of each of the main mountain ranges. A map of mountain areas in...
northeastern Thailand was drawn using the digital elevation model (DEM) available through the Consortium for Spatial Information (Jarvis et al. 2008). The area covered by mountains was calculated using the Reclassify tool in ArcGIS version 10.1 (Esri) geographical information software.

The administrative boundaries of mountainous subdistricts (tambol; defined as those subdistricts that have more than 50% of their total surface area with an elevation higher than 300 mamsl) were then plotted with ArcGIS using the administrative map at the subdistrict level in the shapefile format made by the Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment.

Data on elevation and slope were obtained from the DEM. Geological, soil, and climatic data were obtained from provincial maps in the shapefile format (Department of Environmental Quality Promotion 2000; Office of Land Use Policy and Planning 2010). Data on climate, natural vegetation, and population were obtained from online government databases (Department of National Parks, Wildlife and Plant Conservation 2007; Department of Provincial Administration 2011; National Statistics Office 2013). These data were used to generate maps of topography, geology, soil, rainfall, and population density and to compile statistical tables. Information on distribution of crops was correlated with maps of environmental characteristics (topography, geology, soil, and rainfall) using ArcGIS.

Information about the areas devoted to agriculture and forests and the area under each crop was obtained from online government databases and local government offices (Office of Soil Resources Survey and Research 2008; District Office of Agriculture 2010). From December 2010 to May 2011, field trips were made to each of the mountain ranges to observe the pattern of land use and the occurrence of specific crops. Data on the production and marketing systems for each type of crop, including yields, methods of marketing, and prices received by the farmers, were collected in semistructured interviews with 30 farmers, 7 farmworkers, 8 businesspeople, and 6 local officials.

Physical, environmental, and social characteristics of the mountains in northeastern Thailand

The northeastern mountains are conventionally divided into 5 distinct ranges: Phetchabun, Dong Phayayen, Sankamphaeng, Phanom Dongrak, and Phu Phan (Jintasakun 1985; Kunirat 1987). The Dong Phayayen and the Phanom Dongrak ranges are not described in detail in this paper because only small areas of these ranges are used for agriculture. Because the northern and southern parts of the Phetchabun Range are physically and ecologically quite different, they are treated in this study as two separate ranges. Thus, this study is focused on 4 mountain ranges: the northern Phetchabun, southern Phetchabun, Sankamphaeng, and Phu Phan (Figure 1). The main physical and environmental characteristics of these ranges are summarized in Table 1.

Elevations range from 300 to 2500 mamsl. The highest level at which people live is about 900 mamsl, with higher areas mostly covered by conservation forest. Two thirds of the mountain land has a slope of less than 8%, which, according to the Food and Agriculture Organization's land suitability classification system, does not constrain agriculture (Huddleston et al. 2003).

The mountains are mostly composed of sandstone, shale, and granite, which produce infertile soils, but there are a few areas of limestone in the northern Phetchabun Range with more fertile soils. The soils in the mountains are diverse, belonging to more than 40 soil series, but about 40% of the area is classified as belonging to an undifferentiated “slope complex.” In general, the mountain soils are shallow, are infertile, and have a low water-holding capacity, so they are considered only suitable for forests (Land Development Department 2005).

The climate is tropical savannah, according to the Köppen climate classification (Mongkolsawat et al. 1994), with the rainy season occurring from May through September and a prolonged dry season during the remainder of the year. Average annual rainfall for each range for a 13-year period (2000–2012) is shown in Table 1. However, as is the case in most of the northeastern region, the amount of rainfall is highly irregular from year to year (Limpinuntana 2001). Thus, the Phu Phan Range is the wettest range, with an average annual rainfall of 1724 mm, but it had a minimum of 1301 mm in 2003 and a maximum of 2142 mm in 2008. Sankamphaeng is the driest range, with an average annual rainfall of 1143 mm; the maximum annual rainfall was 1470 mm in 2010, and the minimum was 767 mm in 2001 (National Statistics Office 2013). Average temperatures are also shown in Table 1. Although the mean minimum temperature in the northern Phetchabun Range is 9.3°C, temperatures as low as 0.1°C have been recorded occasionally at higher elevations (Northeast Meteorological Center [Lower Part] 2010b), and occurrences of hoarfrost are often reported in Thai newspapers. The minimum temperature in other ranges never goes below 0°C, although on rare occasions, the Phu Phan Range has recorded temperatures just above freezing.

The natural vegetation includes moist evergreen forest, dry evergreen forest, hill evergreen forest, dry dipterocarp forest, mixed deciduous forest, and coniferous forest (Department of National Parks, Wildlife and Plant Conservation 2007). Dry dipterocarp forest covers more than 50% of the total forest area of the
region, while about 35% of the area is covered by dry evergreen forest (Sutthisrisinn and Noochdumrong 1998). In 2008, forestland and cultivated land covered approximately equal shares (47.5% each) of the mountain area, while other land uses, such as residential areas and water bodies, accounted for about 5% (Office of Soil Resources Survey and Research 2008). The proportions of forest and protected areas (e.g., national parks and wildlife sanctuaries) are shown in Table 1.

Administratively, the study area comprises 94 subdistricts in 26 districts in the 7 provinces of Chaiyaphum (southern Phetchabun), Loei, Khon Kaen, Udon Thani and Nongbua Lamphu (northern Phetchabun), Nakhon Ratchasima (Sankamphaeng), and Sakon Nakhon (Phu Phan). There were 672,067 inhabitants in these subdistricts in 2011, with a mean population density of 58 people/km$^2$ (compared to 129 people/km$^2$ for the whole northeastern region; Department of Provincial Administration 2011). The highest population density is 161 people/km$^2$ in a subdistrict in the Sankamphaeng Range, and the lowest population density is 14 people/km$^2$ in a subdistrict in the northern Phetchabun Range. However, the average population density of all ranges is similar, ranging from 54 people/km$^2$ in the northern Phetchabun Range to 69 people/km$^2$ in the Sankamphaeng Range.

Speakers of the Lao Isan dialect of the Thai language family constitute the majority population in the mountains (Lewis et al. 2013). There are also several minority ethnic groups in different ranges, including the Tai Loei in the northern Phetchabun Range and the Kalaeng, Nyaw, and Phu Tai in the Phu Phan Range. The people in the southern Phetchabun Range are mainly Lao Isan, whereas those in the Sankamphaeng Range are
mostly Central Thai, along with a small group of Korat Thai (Premsrirat et al 2004). All of these ethnic groups belong to the T’ai language family, share many cultural patterns, and generally follow similar agricultural practices (Timsuksai 2014).

### Types of crops grown in the northeastern mountains

Three types of crops—field crops, tree crops, and specialty crops—are cultivated (Table 2). About 88% of the total agricultural area is occupied by field crops, which include maize, cassava, wet rice, hill rice, sugarcane, soybeans, and Job’s tears. Tree crops, including rubber, eucalyptus, teak, and local varieties of fruit trees (eg sweet tamarind, mango, custard apple, banana, orange, and litchie), account for about 11% of the area, while specialty crops, including exotic fruits (0.5%), vegetables (0.1%), and flowers (0.1%), cover less than 1%. Detailed information about the main crops grown in the mountains is presented in Table 3.

### Field crops

Field crops include maize, cassava, and sugarcane, which have been planted in mountains areas for more than 50 years. These crops are mostly planted as monocultures in large fields, but in a few areas maize and cassava are interplanted with fruit trees or rattan (Figure 2). The average maize yield for all ranges is about 5000 kg/ha compared to the regional average of 3625 kg/ha (Office of Agricultural Economics 2010). Farmers sell maize to middlemen, who come to the farms to purchase it, or to

### Table 1

| Biophysical features | Mountain ranges |
|----------------------|----------------|
|                      | Northern Phetchabun | Southern Phetchabun | Sankamphaeng | Phu Phan |
| Elevation\(^a\)\(^b\) (mamsl) | Maximum | 1795 | 1007 | 1322 | 570 |
|                      | Mean | 512 | 430 | 423 | 344 |
| Slope\(^c\) (% of total mountain range land) | <8% | 63 | 79 | 64 | 84 |
|                      | 8%–<16% | 35 | 20 | 34 | 16 |
|                      | ≥16% | 2 | 1 | 2 | 0 |
| Rainfall (13-year average)\(^d\) | Annual (mm) | 1321 | 1225 | 1143 | 1724 |
|                      | No. rainy d/y | 125 | 103 | 111 | 133 |
|                      | Daily maximum (mm) | 93 | 91 | 94 | 117 |
| Temperature (°C; 13-year average) | Mean maximum\(^b\) | 40.4 | 40.0 | 39.3 | 39.7 |
|                      | Mean minimum\(^b\) | 9.3 | 13.2 | 12.6 | 10.6 |
|                      | Daily maximum\(^c\) | 43.1 | 42.6 | 42.7 | 43.9 |
|                      | Daily minimum\(^d\) | 0.1 | 6.3 | 4.6 | 0.5 |
| Land cover (%) | Forest as share of total mountain land area\(^e\) | 49 | 44 | 47 | 51 |
|                      | Protected area as share of total forest land area\(^f\) | 55 | 35 | 58 | 82 |
|                      | Agriculture as share of total mountain land area\(^g\) | 49 | 51 | 43 | 40 |
|                      | Residential areas and water bodies\(^h\) | 2 | 5 | 10 | 9 |

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\(^a\)Jarvis et al 2008.
\(^b\)National Statistics Office 2013.
\(^c\)Northeast Meteorological Center (Lower Part) 2010a.
\(^d\)Northeast Meteorological Center (Lower Part) 2010b.
\(^e\)Office of Soil Resources Survey and Research 2008.
\(^f\)Office of Land Use Policy and Planning 2010.
### Table 2: Agricultural land use in each mountain range in the mountains in northeastern Thailand.

| Type of crops | Mountain ranges<sup>a</sup> | All mountain ranges<sup>b</sup> |
|---------------|-------------------------------|-------------------------------|
|               | Northern Phetchabun (%) | Southern Phetchabun (%) | Sankamphaeng (%) | Phu Phan (%) | All mountain ranges (%)<sup>b</sup> |
| **Field crops** | | | | | |
| Rice          | 16.0                        | 10.1                         | 4.6              | 15.6         | 12.4                                  |
| Maize         | 34.6                        | 7.8                          | 41.2             | —            | 31.2                                  |
| Sugarcane     | 8.5                         | 5.9                          | 11.6             | 2.0          | 8.7                                   |
| Cassava       | 9.7                         | 37.2                         | 24.9             | 43.6         | 18.3                                  |
| Soybean       | —                           | —                            | 0.5              | 0.5          | 0.1                                   |
| Job’s tears   | 0.1                         | —                            | —                | —            | 0.0                                   |
| Hill rice     | 0.1                         | —                            | —                | —            | 0.1                                   |
| Unclassified  | 18.7                        | 37.0                         | 0.6              | 34.4         | 17.7                                  |
| Total         | 87.6                        | 98.0                         | 83.5             | 96.1         | 88.5                                  |
| **Tree crops** | | | | | |
| Rubber        | 3.3                         | 0.7                          | ND<sup>b</sup>   | ND<sup>b</sup> | 2.1                                   |
| Eucalyptus    | 0.2                         | 1.3                          | 1.3              | 3.1          | 0.7                                   |
| Teak          | 0.9                         | ND<sup>b</sup>               | 0.3              | ND<sup>b</sup> | 0.6                                   |
| Orange        | 0.1                         | —                            | —                | —            | 0.1                                   |
| Lychee        | 0.1                         | —                            | —                | —            | 0.1                                   |
| Mango         | 0.3                         | ND<sup>b</sup>               | 6.9              | ND<sup>b</sup> | 1.8                                   |
| Custard apple | —                           | —                            | 5.8              | —            | 1.3                                   |
| Banana        | 2.0                         | —                            | —                | —            | 1.1                                   |
| Sweet tamarind| 4.2                         | ND<sup>b</sup>               | 0.7              | 0.2          | 2.7                                   |
| Longan        | 1.0                         | —                            | 0.1              | 0.4          | 0.6                                   |
| Total         | 12.1                        | 2.0                          | 15.1             | 3.7          | 11.0                                  |
| **Specialty crops** | | | | | |
| Edible rattan | —                           | —                            | —                | ND<sup>b</sup> | —                                     |
| Exotic fruits | 0.5                         | —                            | 0.9              | —            | 0.5                                   |
| Vegetables    | ND<sup>b</sup>              | —                            | 0.7              | —            | 0.1                                   |
| Flowers       | ND<sup>b</sup>              | —                            | 0.3              | —            | 0.1                                   |
| Mushrooms     | ND<sup>b</sup>              | —                            | ND<sup>b</sup>   | —            | —                                     |
| Total         | 0.5                         | —                            | 1.9              | 0.1          | 0.7                                   |

<sup>a</sup>%, percentage of total agricultural land area occupied by each crop.

<sup>b</sup>ND, no data; however, crop was observed in field surveys.

Source: Office of Soil Resources Survey and Research 2008.
| Crop                                | Location                        | Share of mountain agricultural land | Cropping system                                                                 | Marketing system                                                                 | Price paid to farmer<sup>a</sup> |
|-------------------------------------|---------------------------------|-------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------|
| Maize                               | All ranges                      | 31%                                 | Mostly monoculture                                                              | Sold to middlemen, who come to the farms to purchase it, or directly to warehouses located in the area | US$ 0.13–0.26/kg                |
| Cassava                             | All ranges                      | 18%                                 | Mostly monoculture                                                              | Sold directly to warehouses located in the area                                     | US$ 0.03–0.06/kg                |
| Sugarcane                           | All ranges                      | 9%                                  | Monoculture                                                                     | Sold directly to nearby sugar mills                                                | US$ 0.02–0.03/kg                |
| Rubber                              | All ranges                      | 2%                                  | Mostly monoculture but sometimes interplanted with crops such as cassava and rattan | Sold as uncured balls of dried latex to middlemen                                  | US$ 1.10–1.90/kg                |
| Fruit trees (eg oranges, lychees, mangoes, custard apples, bananas, sweet tamarinds, and longans) | All ranges                      | 8%                                  | Monoculture or interplanted with other kinds of fruit trees or maize, cassava, or rattan | Sold directly in the market or to middlemen, who come to the farms to purchase it | US$ 0.16–1.10/kg                |
| Edible rattan (Calamus sp.)         | Phu Phan Range                  | No data                             | Monoculture or interplanted with rubber, fruit trees, or cassava                  | Sold to middlemen from nearby provinces, who purchase the shoots directly from the farmers | US$ 0.06–0.13/shoot             |
| Grapes (table grapes and wine grapes)| Northern Phetchabun Range/ Sankamphaeng Range | 0.1%                                | Monoculture                                                                     | Wine grapes sold to middlemen; table grapes sold directly to tourists              | Wine grapes US$ 1.20–1.50/kg; table grapes US$ 5.80–6.50/kg |
| Exotic flowers and ornamental plants (eg marigolds, China pinks, roses, white Christmas flowers, hydrangeas, poinsettias, bromeliads, African violets, petunias, and phlox) | Northern Phetchabun Range/ Sankamphaeng Range | 0.1%                                | Grown in black plastic bags set on the ground in plots located along the road; some plots are open air, while others have plastic or shade cloth–covered shelters | • Sold as potted plants  
• Sold as cut flowers  
• Purchased as plants in the field by sellers from provinces such as Chiang Mai, Khon Kaen, and Bangkok  
• Delivered to consumers if they submit advance orders  
• Sold directly to tourists | US$ 0.10–3.20/pot               |
nearby agricultural warehouses for US$ 0.13–0.25/kg. The average cassava yield for all ranges is 19,500 kg/ha, compared to the regional average of 20,500 kg/ha (Office of Agricultural Economics 2010). Farmers sell cassava to agricultural warehouses for US$ 0.03–0.06/kg. The average yield of sugarcane in the mountains is 63,000 kg/ha, compared to a regional average of 69,000 kg/ha (Office of Agricultural Economics 2010). The price paid for sugarcane at local mills is about US$ 0.03/kg.

Tree crops
Tree crops include rubber, eucalyptus, teak, and local varieties of fruit trees, such as oranges, lychees, mangoes, custard apples, bananas, sweet tamarinds, and longans. Rubber is the most widespread plantation crop, although it was only introduced to the mountains about 20 years ago. It is planted both by local people and by experienced rubber farmers who have come to the northeastern region from the southern region (Tongkaemkaew 2013). Rubber mostly is grown as a monoculture, but while the trees are small many farmers interplant cassava or rattan with the rubber. Mature rubber plantations yield 1250–1600 kg of dry latex/ha, which the farmers sell to middlemen as uncured balls for US$ 1.13–1.90/kg. The main kinds of fruit trees grown in the mountains are sweet tamarind, mango, and custard apple. These trees are planted in monocultural plantations or are interplanted with other species of fruit trees or with maize, cassava, or rattan. Sweet tamarind yields 1250–1900 kg/ha, which sell for US$ 1.10/kg, and custard apple and mango yield 6300–9400 kg/ha, with a price of US$ 0.90/kg for custard apple and US$ 0.80/kg for mango.

Specialty crops
Specialty crops include edible rattan, grapes, exotic flowers and ornamental plants, temperate vegetables, and mushrooms.

**Edible rattan:** Edible rattan, which is grown only in the Phu Phan Range, was originally collected from wild plants in the forest but has been domesticated for the past 10 years. Recently, the area of rattan has sharply decreased because farmers prefer to grow rubber, which earns much higher profits. Rattan is planted as a monoculture or is interplanted with other crops, such as rubber, fruit trees, or cassava. Rattan yields about 19,000–20,000 shoots/ha, which are sold for US$ 0.06–0.10/shoot at the farm gate to middlemen from nearby provinces or to local vendors who have roadside stalls.

**Grapes:** Both table grapes and wine grapes are grown on both large and small vineyards in the northern Phetchabun Range, with table grapes grown on both large and small vineyards in the northern Phetchabun Range.
and Sankamphaeng ranges. Some vineyards are part of resorts, have their own wineries, and offer free tours for visitors. They also offer overnight accommodations for tourists and have spas, restaurants, and shops selling their products. Other large vineyards have no accommodations or restaurants but offer visitors free tours and wine tasting at the big shops where they sell their products. Table grapes are planted in small vineyards along the roadside. They often have small shops that sell fresh grapes, grape juice, and jelly directly to tourists. Table grapes yield 2500–6300 kg/ha and are sold for US$ 5.80–6.50/kg.

**Temperate vegetables:** Temperate vegetables (e.g., kale, several varieties of lettuce, spinach, broccoli, carrots, kohlrabi, leeks, spring onions, cucumbers, cauliflower, Chinese cabbage, Chinese radishes, green peppers, and Chinese kale) are mostly grown on small farms in the Sankamphaeng Range. These farms are often located next to homestay places or resorts to help attract tourists. Some resorts and homestays use the vegetables grown on these farms in preparing meals for their guests. Yields vary from 12,500–18,700 kg/ha. Vegetables are sold to vendors in local markets, restaurants, resorts, and homestays, as well as directly to tourists, for US$ 1.90–3.24/kg, depending on variety and season.

**Mushrooms:** Small mushroom farms are found in both the Sankamphaeng and the northern Phetchabun ranges. Mushrooms yield 12,500–15,500 kg/ha. They are sold to vendors who have stalls along the roadside, in the local market, or directly to tourists who visit the farms for US$ 1.60–1.90/kg for local mushrooms and US$ 5.80–7.10/kg for shiitake, black poplar, and eryngii mushrooms. Most
farms are small, but there is one large farm in the Sankamphaeng Range that raises mushrooms in air-conditioned buildings. Visitors are allowed to observe the production system on the farm. Besides producing fresh mushrooms, the farm processes mushrooms into sauce, paste, ice cream, sausages, and dried forms. This farm has a shop to sell its products directly to tourists. Customers can also order the products online.

Spatial distribution of crops and probable factors influencing their distributions

As Table 2 shows, the spatial distribution of crops differs among the different ranges, reflecting the influence of various factors, including soil quality, temperature, and transportation time and cost. Maize is mostly planted in the northern Phetchabun and Sankamphaeng ranges, which have more fertile soils, whereas cassava is largely planted in the poorer soils of the southern Phetchabun and Phu Phan ranges. Sugarcane is widely grown in all ranges except the Phu Phan Range, which has no sugar mills nearby. Rubber is widespread in the northern Phetchabun, southern Phetchabun, and Phu Phan ranges, with only a small area in the Sankamphaeng Range, because farmers there can earn high income from growing specialty crops, in combination with tourism. Local varieties of fruit trees are planted in all mountain ranges but primarily in the northern Phetchabun and Sankamphaeng ranges. Sweet tamarind is largely planted in the northern Phetchabun Range, whereas custard apple is widely planted in the Sankamphaeng Range. Specialty crops, such as exotic flowers and ornamental plants, temperate vegetables, grapes, strawberries, and shitake mushrooms, are found only in the northern Phetchabun and Sankamphaeng ranges, where they are often associated with tourism. Many factors favor growing specialty crops in the northern Phetchabun and Sankamphaeng ranges, including having optimum temperatures for these temperate species of plants. They are also endowed with beautiful scenery and pleasant climates that make them attractive destinations for tourists, have good-quality roads, and are easy to get to from Bangkok. Moreover, governmental agencies in both areas have attempted to promote agritourism to stimulate economic growth.

Comparison of mountain agriculture in the northeastern and northern regions of Thailand

When mountain agriculture in Thailand is mentioned, the image that is likely to spring to mind is of colorfully garbed hill tribe people planting opium or upland rice on swidden fields on the steep slopes of the high mountains that cover 80% of the northern region of the country. Numerous books, papers, and reports have been written describing the many types of shifting cultivation systems that were formerly practiced by different ethnic groups living in different altitudinal zones (e.g., Kunstadter and Chapman 1978; Forsyth 1995; Rerkasem 1995; Turkelboom et al. 1995). This image is largely outdated because, as a result of a multitude of agricultural development programs carried out by the Thai government, international aid agencies, and nongovernmental organizations (Dearden 1995; Jian 2001; Tungittiplakorn and Dearden 2002), northern mountain agriculture has been largely transformed into cash cropping on permanent fields (Van Keer et al. 1998; Trebuil et al. 2006). Hill tribe people still cultivate crops on the steep slopes but are now far more likely to plant cabbages than to plant poppies.

The mountains of northeastern Thailand are different from those in the north; consequently, development of mountain agriculture in the northeast needs to be understood in its own terms. The northeastern mountains cover only 15% of the area of the region and are relatively low and flat. The highest level at which people live is about 900 m asl, whereas in the northern mountains people live as high as about 1500 m asl. Most of the land in the northeastern mountains has a slope less than 8%, whereas most of the land in the northern mountains has a slope greater than 35%. Soils in the northeastern mountains are generally less fertile and temperatures are considerably warmer than in the north, which may explain why cultivation of cabbages for sale in lowland markets, which is now widely practiced by northern hill tribe farmers, occurs in the northeastern mountains in only one limited area in the northern Phetchabun Range. Ethnic diversity is limited, because the mountains are inhabited mostly by people who are culturally similar to the lowland Thai–Lao people. There is little or no swidden agriculture, and the crops grown in the permanent fields are mostly the same as the main crops planted in the surrounding lowlands. These include paddy rice, maize, cassava, sugarcane, and rubber. The main characteristic that distinguishes mountain agriculture from lowland agriculture in the northeast is the cultivation of high-value specialty crops, including temperate vegetables, exotic flowers, grapes, and strawberries, that cannot be grown in the lowlands. Although the area covered by such crops is still small, it is gradually expanding. This shift to specialized mountain agriculture primarily results from the efforts of private entrepreneurs because, in contrast to the north, few government programs are targeted at the development of mountain agriculture in the northeast.

Constraints on agricultural development in the northeastern mountains

Development of agriculture in the northeastern mountains is constrained by several factors, including poor-quality soils, seasonality and variability of rainfall, scarcity of surface water, steep slopes, land scarcity, land tenure insecurity, and competition from foreign imports.
Soils in the mountains are predominantly rocky, shallow, and infertile; have a low water-holding capacity; and have high erosion rates, which limit their suitability for agriculture (Vityakon et al. 2004). To maintain soil quality and productivity, farmers have to apply large amounts of chemical fertilizer, which increases production costs. Water is also frequently a limiting factor on mountain agriculture. The occurrence of a prolonged dry season and the irregular pattern of rainfall during the rainy season are major constraints on growing high-value crops such as exotic flowers and temperate vegetables, which require frequent watering (Figure 3). So, to produce these crops, farmers often have to invest in costly irrigation systems.

The broken terrain and steep slopes in the mountains inhibit mechanization and increase transportation costs. Use of farm machinery in agriculture is limited by the prevalence of sloping land. For example, farmers cultivating maize on steep slopes in the northern Phetchabun Range must use human labor for most production steps, including sowing using dibble sticks, applying fertilizer, and harvesting. Harvesting is difficult because the farmers have to carry heavy maize sacks on their backs on steep mountain trails. Usually, they hire neighbors to do this work for about US$ 7.00/day. Even in areas with good roads, the steep terrain greatly increases travel time and transportation costs to lowland markets for mountain crops.

The scarcity of suitable land also constrains development of mountain agriculture. Because almost half of the mountain area is covered by protected forests and national parks, the amount of land legally available for cultivation is limited, and many farmers have encroached on protected areas, which has resulted in serious conflicts with the government. In some areas in the Sankamphaeng Range, the government has physically evicted agritourism enterprises that have illegally encroached on national park land. Even in areas where agriculture is allowed, farmers in the mountains have difficulty obtaining legal title to their land. In contrast to the lowlands, where most farmers have secure land titles,
official documents have only been issued in 35% of mountain subdistricts. Consequently, farmers cannot borrow money using their land as collateral to make long-term investments in agriculture (Thapa and Rasul 2005).

Even though many high-value temperate crops can be grown successfully in the mountains of the northeast, the cost of the production of some of these crops is higher than in the temperate countries because of environmental limitations. Consequently, these crops were only profitable as long as the Thai government followed protectionist trade policies that favored high-cost local products. After adoption of World Trade Organization rules opened Thai markets to cheap foreign imports, growing of some crops, such as wine grapes, was no longer profitable. On one formerly prosperous vineyard in the northern Phetchabun Range, large areas of vineyards have been abandoned.

Although many of these constraints on mountain agriculture, eg poor soils, seasonal rainfall, and steep terrain, are essentially fixed, some factors are subject to human modification. For example, changes in government policies allowing farmers to develop agritourism in buffer areas of national parks and providing them with more secure land titles could create a more favorable environment for mountain agriculture.

Potential opportunities for mountain agricultural development

The mountains have a distinct climatic advantage for the production of high-value temperate vegetables and fruits, which cannot be produced in the lowlands. Some areas in the northern Phetchabun and the Sankamphaeng ranges can produce high-value crops, including strawberries, table grapes, macadamia nuts, exotic flowers and ornamental plants, temperate vegetables, and mushrooms, that are highly desired by lowland consumers. Although the area devoted to such crops is quite small, considerable expansion is possible; roughly one third of the agricultural land that is planted with low-value field and tree crops in these two ranges has conditions suitable for growing higher-value specialty crops.

The mountains also have beautiful scenery; many famous tourist spots, such as Khao Yai, Phu Kradueng, and Phu Ruea national parks; and a favorable climate that makes them an attractive destination for tourists. For example, the Wang Nam Kiew district in the Sankamphaeng Range and the Phu Ruea district in the northern Phetchabun Range attract many tourists who like to buy locally grown agricultural products, which benefits farmers by reducing their cost of shipping crops to lowland markets and allowing them to capture a higher share of the profit by eliminating middlemen. Tourism can create new sources of income for rural people who establish restaurants and homestays, as well as creating new employment opportunities for members of farm households to work as employees at enterprises catering to tourists. Because agritourism requires both suitable environment for growing temperate vegetables, flowers, and fruit, and suitable scenery to attract tourists, only a limited area has potential for further development of this highly profitable type of mountain agriculture.

Conclusions

Although Thailand's northeastern mountains cover only a relatively small share of the northeastern region, they support diverse types of agriculture. Because of their distinctive environmental conditions, the mountains offer unique opportunities for agricultural development, especially growing specialty crops, which can generate high income and serve as magnets for tourism. However, so far, only small areas have been used for this purpose, and most of the agricultural land in the mountains is still used for low-value crops, which can be grown equally well in the lowlands. Therefore, to develop agriculture in the mountains, farmers should be encouraged to take advantage of their unique agricultural environment by growing more specialty crops and establishing agritourism facilities. However, it must be recognized that limited supply of land and insecure land tenure remain serious obstacles to expansion of mountain agriculture.

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