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A preliminary classification of fruit-based agroforestry in a highland area of northern Thailand

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Abstract. Tree fruit crops are an increasingly important component of highland cropping systems in northern Thailand. A survey was conducted in three highland hill tribe villages in an upland watershed in Mae Hong Son Province to examine and classify the fruit-based cropping activities used by villagers. Members of ten households in each village were interviewed to establish activities and crop histories for each plot of land held by the household. From the sample of 85 'gardens' (plots with ten or more fruit trees), a field-level classification structure was developed reflecting function of trees, use and nature of herbaceous intercrops, and pattern of components. Through the classification process, four groups and 11 subsystems of highland tree fruit-based agroforestry were identified. The single most abundant subsystem was 'mixed home gardens'. A strong commercial element was also obvious. The survey indicates a very diverse 'customized' use of the fruit cropping system. The classification has potential for use in more extensive surveys of the nature of fruit cropping activities in the highlands and as a tool for further analysis in the study area.

Introduction

Farming and land use practices in the Highlands of northern Thailand are in transition. In response to many physical and socioeconomic factors, highland farmers, including ethnic minority 'hill tribes,' have been making a fundamental change from extensive forms of slash and burn agriculture to more intensive short rotation or permanent farming practices (Rerkasem and Rerkasem, 1994). This change is often accompanied by a shift in emphasis from subsistence to cash crops. A key element of this change in land use is the recent rise of fruit cropping and fruit-based agroforestry in many highland areas as observed and noted by Poffenberger and McGean (1993), Rerkasem and Rerkasem (1994) and Turkelboom et al. (1996).

There are a number of agroforestry systems now being used in the Highlands. Shifting and rotational agriculture are important traditional systems which emphasize annual crop production and which separate trees and annual crops in time. There are also some traditional systems which mix or utilize trees as crops in the production cycle, such as forest tea gardens ('miang'),

and some sparse orchards and home gardens in limited use by different ethnic groups (Del Castillo, 1990; C. Korsamphan, pers. comm. 1997). New practices which are part of the transition to permanent farming have also been introduced by development projects over the last couple of decades. Conservation Farming, including alley cropping, was vigorously promoted in several project areas (Enters, 1992). Tree fruit crops were also widely introduced in many areas and trees were frequently distributed to villagers in project areas (Roth et al., 1987; Sam Mun Highland Development Project, 1994). But the interest in and adoption of fruit production is not limited to project areas and the fruit system is now an important component of the broader Highland agroforestry picture.

The fruit-based agroforestry system in the northern Thai Highlands incorporates temperate, subtropical and tropical species. The system can be developed from many initial starting conditions and the geographic area which could potentially be converted to this use is large – extending over much of mainland mountainous Southeast Asia. The potential impacts may be large.

Of the crop options available to Highland villagers, fruit cropping appears attractive. In contrast to some agroforestry practices, the fruit-based system contributes products as well as services, some of which have economic potential as cash crops. Also, because of the many crop components and combinations possible, the fruit-based system is highly adaptable and applicable to a wide area and range of physical and social conditions, worldwide. Nair (1984) noted the potential of fruit trees as components of agroforestry systems, and the need to look beyond conventional monoculture research. With the exception of some interest in home gardens, there still has not been much work regarding fruit crop systems. In Mangwende, Zimbabwe, mangoes (*Mangifera indica* L.) were managed as multipurpose trees grown in association with herbaceous crops. The fruit was an important item of home consumption, but not an important source of income (Musvoto and Campbell, 1995). In the Tanzanian highlands, deciduous fruit trees were widespread and common in both fields and homesteads. Fruit trees were seen as contributing to family income, home consumption, land tenure establishment and erosion control (Delobel, 1991). Suryanata (1994) reported that Fruit-based agroforestry based on commercial production of apples (*Malus domestica* Borkh.) and oranges (*Citrus reticulata* Blanco) was well established in localized areas in highland Java. A change towards more simplified systems with less intercropping was being driven by existing tenure and market pressures. In northern Laos, hill farmers expressed interest in tree crops such as fruit or teak (*Tectona grandis* Linn.f.), but were restricted by market and infrastructure limitations. Commercial fruit plantings in northern Laos remained limited and most tree fruits raised were for home consumption (Roder et al., 1995).

The fruit-based system can be placed in a broader agroforestry classification structure described by Nair (1990) and generally described as an agrisilvicultural, production-oriented system used on sloping lands in a highland moist tropical ecological zone. Although common, the fruit-based system is not

uniform, but rather is made up of many different practices or subsystems. An important step in understanding the spread and possible impacts of the fruit-based cropping system is to classify and describe the subsystems in use. An objective of this survey is to develop a practical field-level classification structure for tree fruit-based agroforestry according to physical attributes and functions. The scope of the survey and classification is limited to the fruit-based system used in one watershed area in the Highlands and does not cover all agroforestry systems or all of northern Thailand. Many, but not all, of the fruit-based cropping practices observed are agrisilvicultural mixtures of fruit and other trees with annual crops. Some subsystems do not strictly fit common agroforestry definitions, but are still included to provide a complete picture of fruit cropping activities.

Methods

Survey

A survey was conducted in three Highland villages to examine the nature of tree fruit-based cropping practices employed by the villagers. The study villages were located in the Royal Forest Department's Tung Jaw Watershed Management Unit, Mae Taeng Watershed Management District (formerly part of the Thai-UN Sam Mun Highland Development Project). The Tung Jaw Management Unit was located about 100 km northwest of Chiang Mai city, at approximately 98°35′ E longitude and 19°10′ N latitude in Pai District, Mae Hong Son Province.

The three sample villages were chosen to include a range of environmental, social and ethnic conditions. Khun Sa Nai (KSN) is a Hmong village of about 445 people, lower Mae Muang Luang (LMML) a Karen village with about 380 people, and upper Mae Muang Luang (UMML) a Lisu village of around 130 people. Village elevations ranged from 900 to 1300 m.

Data were collected during a series of visits during the 1996 rainy season, primarily from July to September. Semi-structured interviews were conducted with key informants (i.e. the village head or village elders and medical personnel) to develop a historical overview of events within the village. Ten households were randomly sampled in each village. Semi-structured interviews were conducted with one or more adult members of each of the sample households. During the interviews, the number and location of each plot of land held by the family was established, as well as details of the cropping histories of each plot where tree fruits were grown. Site data on location, physical characteristics, species composition and species arrangement were collected in a survey of each plot of land following the interview.

Classification

This preliminary classification was based on upland farm plots with 10 or more fruit trees held by the 30 sample households. Groups of plots became apparent during the survey process. Key classifying variables were identified to distinguish the different subsystems and later used in a subjective process to revise and refine groupings. Classifying variables included:

- Size of planting (number of fruit trees);
- Number of tree species;
- Size of commercial tree species component;
- Presence of herbaceous intercrops (past or present);
- Nature of intercrops (subsistence or cash crops);
- Pattern of trees;
- Pattern of intercrops.

Many of the variables had continuous gradients of values rather than distinct groupings between which to make divisions. Some variables needed to be considered as an interactive group (number of trees, number of tree species and number of commercial trees) without a distinct point of division but rather representing a sliding scale. Therefore, there are no sharp lines of division between the different fruit cropping subsystems; there is a gradient of differences.

Results

The 30 households of the sample reported holding a total of 151 plots of land, including their home sites. Of these plots, 34 (22.5%) were rice paddy and 117 (77.5%) were upland (hillside) sites. Of the upland sites, 85 of the plots (72.6%) were 'gardens' (plots with ten or more fruit trees growing on them), another 12 plots (10.3%) had fewer than 10 trees and 20 (17%) had no fruit trees. Of the 85 garden sites, 41 were located in Khun Sa Nai, 23 in lower Mae Muang Luang and 21 in upper Mae Muang Luang (Table 1).

In the 85 gardens surveyed, there was a total of 113 cultivated species counted. This was certainly an underestimate of the number of species actually grown in the villages as the survey was not exhaustive and some plants were identified only to genus. Twenty eight species were considered 'perennial fruit trees' with bamboo, bananas (*Musa* sp.) and papayas (*Carica papaya* L.) included in this class although they are not strictly trees. There were also 19 other mostly indigenous tree or shrub species found in the gardens for minor products, living fences etc. There were also 30 herbaceous vegetable and root crops and 20 medicinal or culinary herbs identified. Herbaceous species were very common in gardens. Respondents indicated that 82.5% of all fruit tree gardens had some history of intercropping, and 62.4% still have some herbaceous crop component in the plot.

Table 1. Abundance of survey plots in sample according to the presence of fruit trees and whether upland or paddy, in Tung Jaw Watershed Management Unit, Mae Hong Son Province, Thailand. All three villages combined (ALL), Khun Sa Nai (KSN), lower Mae Muang Luang (LMML), upper Mae Muang Luang (UMML).

	ALL	KSN	LMML	UMML
Gardens with > 10 trees (basis of classification)	85	41	23	21
Uplands with < 10 trees	12	4	3	5
Uplands with no trees	20	8	2	10
Paddy	34	6	24	4
Total	151	60	51	40

The total number of crop species identified in individual gardens ranged from one to 55 species (average 12.5). The number of fruit tree species ranged from one to 20 per garden (average 6). The planting size, or number of trees in the garden, ranged from 11 to 381 trees in a garden (average 83), and the area from less than 0.08 ha to 1.92 ha. The single most abundant species in a garden (often a commercial species) ranged from three to 300 trees. The five most abundant tree fruit species were peach (*Prunus persica* (L.) Batsch), litchi (*Litchi chinensis* Sonn.), Japanese apricot (*Prunus mume* Sieb. et Zucc.), banana and mango (1651, 1354, 934, 714 and 650 trees each, respectively). The most frequently planted tree fruit species, by the percentages of all gardens in which they are growing, were mangos, jackfruit (*Artocarpus heterophyllus* Lam.), peach, banana and Japanese apricot (66%, 53% 53%, 51% and 51% respectively).

Eleven subsystems of the fruit-based agroforestry system were identified through the classification process (Table 2). These may be put together in four larger groups: A) Home Gardens, B) Home Garden-Like Agroforestry, C) Trees in Fields and D) Conventional Commercial Orchards. Each subsystem had between two and 18 garden plots in the group. Five of the subsystems were included in the survey sample in all three villages. Another five were found in two of the three villages. One was in just a single location (Table 3).

Within Group A, Mixed Home Gardens and Home Gardens (MHG and HG) had a small average planting size (34 and 23 trees) and the smallest planting area (0.21 and 0.17 ha) of the subsystems. Total crop species varied greatly between the two subsystems with 22 for the intercropped MHG and only five without intercrops (HG). The number of fruit tree species was intermediate (seven and five species) as was the time since establishment of fruit trees (garden age of 9.1 and 7.6 years) and age spread of trees in the garden (7.8 and 9.2 years). The number of the most abundant species was low.

In Group B, Mixed Commercial Home Gardens with subsistence intercropping and Mixed Commercial Home Gardens with cash intercropping had fairly large average planting sizes (116 and 99 trees respectively) and

Table 2. Classification of fruit-based agroforestry subsystems identified in the Tung Jaw Watershed Management Unit, Mae Hong Son Province, Thailand.

A. Home Gardens

1. **Mixed Home Gardens (MHG)**
   Subsistence oriented, generally small to medium size, with multiple (to many) tree species, but no commercial species abundant. Herbaceous intercropping, mixed and/or zonal, mostly subsistence, some market crops. Also tend to be irregularly spaced, multiple aged.
2. **Home Gardens (HG)**
   Like MHG, except trees only, no herbaceous intercropping.

B. Home Garden-Like Agroforestry

Commercialized Home Gardens

3. **Mixed Commercialized Home Gardens, subsistence intercropping (MCHG, si)**
   Tree component dual function: strong subsistence orientation but with significant commercial component. Generally small to medium size, with multiple (to many) tree species, but one or more commercial species abundant, with mixed herbaceous intercropping. Subsistence herbaceous intercropping only.
4. **Mixed Commercialized Home Gardens, cash intercropping (MCHG, ci)**
   Like MCHG, si, except with cash and subsistence herbaceous intercropping.

Garden-Like Orchards

5. **Mixed Garden-Like Orchards, cash and subsistence intercropping (MGLO)**
   Tree component dual function: market oriented but with significant home-use component. May be small to large size, with multiple (to many) tree species but with one or more commercial species dominant or abundant. With or without herbaceous mixed intercropping. Both cash and subsistence herbaceous intercropping.
6. **Garden-Like Orchards (GLO)**
   Like MGLO except trees only, no herbaceous intercropping.

C. Trees in Fields

7. **Scattered Trees (ST)**
   Fruit trees in herbaceous crop fields. Both annual crops and tree crops for either subsistence or market. Generally small remnants of larger plantings.
8. **Sparse Orchards (SO)**
   Fruit trees mixed in herbaceous crop fields. Trees generally market oriented (i.e. traditional Hmong peach orchards).

D. Conventional Commercial Orchards

9. **Conventional Orchards, subsistence intercropping (CO, si)**
   Tree component market oriented, very small or no subsistence orientation. May be medium to large size, one or more commercial species dominant or abundant, but may have many tree species. Generally also has regular pattern, few or spatially separate age classes. Subsistence intercropping only.
10. **Conventional Orchards, cash intercropping (CO, ci)**
    Like CO, si, except with cash and subsistence intercropping.
11. **Conventional Orchards (CO)**
    Like CO, si, except trees only, no intercropping.

Table 3. Frequency of different subsystems overall and in each of the three sample villages in the Tung Jaw Watershed Management Unit, Mae Hong Son Province, Thailand. All tree villages combined (ALL), Khun Sa Nai (KSN) lower Mae Muang Luang (LMML) and upper Mae Muang Luang (UMML).

Subsystem	Location			
	ALL	KSN	LMML	UMML
Mixed Home Gardens	16	1	13	2
Home Gardens	7	3	2	2
Mixed Commercialized Home Gardens, subsistence intercropping	8	2	3	3
Mixed Commercialized Home Gardens, cash intercropping	10	7	1	2
Mixed Garden-Like Orchards, cash and subsistence intercropping	6	6	0	0
Garden-Like Orchards	2	1	1	0
Scattered Trees	4	3	0	1
Sparse Orchards	6	3	0	3
Conventional Orchards, mixed subsistence intercropping	10	1	2	7
Conventional Orchards, mixed cash intercropping	10	9	0	1
Conventional Orchards	6	5	1	0
Total	85	41	23	21

intermediate area (0.44 and 0.64 ha). The total crop species (23 and 12 species) and number of fruit tree species (11 and eight species) were higher than for Home Gardens. The garden age was intermediate.

In the same group (Group B), Mixed Garden-Like Orchards and Garden-Like Orchards were similar to Commercial Home Gardens in many ways including intermediate garden area (0.48 and 0.68 ha), total number of species (15 and 12 species) and number of fruit species (nine and 10 species). However, the planting size was the highest of all subsystems with 160 and 265 trees, as was the abundance of dominant species in each garden (93 and 122 trees).

In Group C, Scattered Trees and Sparse Orchards had small planting sizes (16 and 45 trees), low total number of species (seven and seven species) and low tree species (three and three species), with an intermediate plot area.

In the final group (Group D), Conventional Orchards, subsistence intercropping, Conventional Orchards, cash intercropping and Conventional Orchards, had intermediate planting sizes of 63, 116 and 126 trees but the largest areas per plot (0.42, 0.83 and 1.07 ha). Total species (nine, eight and two species) and fruit tree species (three, four and two species) were low. Some selected characteristics are presented by fruit cropping subsystem in Table 4.

Table 4. Characteristics of 11 fruit-based subsystems identified in the Tung Jaw Watershed Management Unit, Mae Hong Son Province, Thailand. Includes subsystem average values for the number of fruit trees per plot (Planting Size), number of all cultivated species (Total spp.), number of fruit tree species (Tree spp.), number of trees of most abundant tree species (Abun. spp 1), years since establishment of garden (Garden Age), the age range of trees in garden (Age Spread) and size of the garden plot (Garden Area).

Sub-system	Planting size (trees)	Total spp. (spp.)	Tree spp. (spp.)	Abun. spp. 1 (trees)	Garden age (years)	Age spread (years)	Garden area (ha)
Mixed Home Gardens	34	22	7	16	9.1	7.8	0.21
Home Gardens	23	5	5	11	7.6	2.9	0.17
Mixed Commercialized Home Gardens, subsistence intercropping	116	23	11	45	6.9	6.3	0.44
Mixed Commercialized Home Gardens, cash intercropping	99	12	8	47	9.3	7.9	0.64
Mixed Garden-Like Orchards, cash and subsistence intercropping	160	15	9	93	10.5	7.3	0.48
Garden-Like Orchards	265	12	10	122	9.5	9.0	0.68
Scattered Trees	16	7	3	11	4.3	3.8	0.72
Sparse Orchards	45	7	3	34	7.0	2.7	0.80
Conventional Orchards, mixed subsistence intercropping	63	9	3	55	3.6	1.9	0.42
Conventional Orchards, mixed cash intercropping	116	8	4	84	7.4	5.2	0.83
Conventional Orchards	126	3	2	119	4.0	1.5	1.07

Mango was the most frequently grown fruit tree species in Mixed Home Garden, Home Garden, and both Mixed Commercial Home Garden subsystems (subsistence and commercial intercropping). Banana was second or third most frequent in these subsystems. Litchi was the most frequent species in the Mixed Garden-Like Orchards and Conventional Orchards, Japanese apricot in Scattered Trees and Conventional Orchards (subsistence intercropping) and peach in Sparse Orchards and Conventional Orchards (cash intercropping).

Figure 1 uses diversity indexes, the number of tree species and total number of crop species, both calculated on a per hectare basis, to highlight some of the patterns among the subsystems. First, the similarities within each of the four groups of subsystems (Table 2) are much greater than among the four groups or all 11 subsystems together. Second, there is a clear and strong trend of complexity of tree and crop species composition from systems with a commercial emphasis to systems dominated by home use.

Discussion

This survey and classification indicate a wide range of diversity within the fruit-based cropping system used in a highland area in northern Thailand. Villagers 'customize' the system to meet their own needs, which are reflected in subsystems which use different patterns and combinations of components. The classification is based on form and functional factors, relating to economic

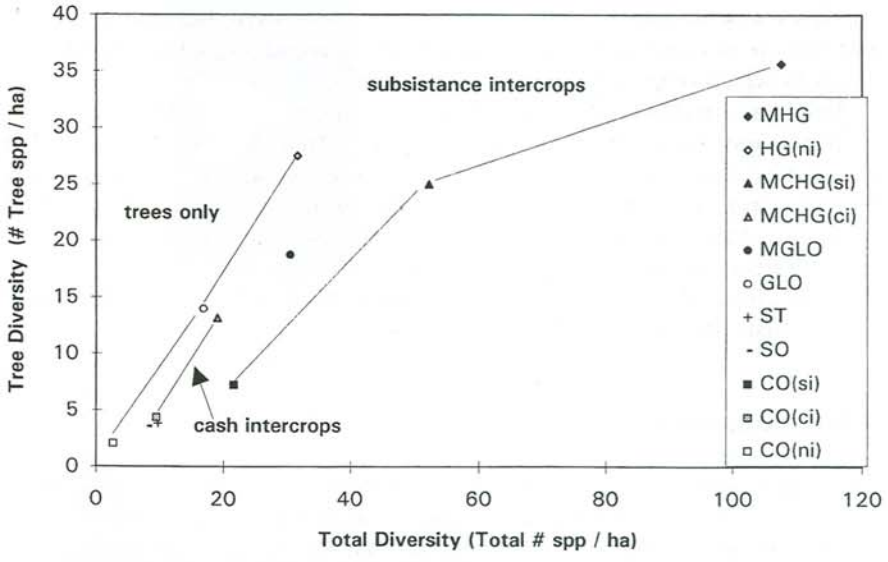

Figure 1. Relationship of tree species diversity and overall crop species diversity in 11 fruit-based subsystems identified in the Tung Jaw Watershed Management Unit, Mae Hong Son Province, Thailand.

objective, nature of crops grown, and structure and composition of whole gardens rather than a listing of individual crop species or combinations observed in the survey area.

Fruit cropping has been widely accepted in the study area, where the majority of upland farm plots are now some type of garden. Fruit is grown for both home consumption as well as for commercial reasons, both of which were project objectives of the Sam Mun Highland Development Project. Home gardens and home garden-like agroforests are very abundant and crop diversity is generally high. Economic objectives clearly also have an important role in Home Garden-Like Agroforestry as well as more conventional Commercial Orchard subsystems. Few of the commercial orchards have exclusively cash crops. The majority have some small home-use function as well. Most of the subsystems appear to incorporate dual home and commercial functions.

These systems are very dynamic, as indicated by the age structures and age ranges of the gardens. Composition and abundance of species are changed frequently through death and additional planting. Few gardens are established within a year. Many of the gardens are not yet 'mature' but are still in development. It can be concluded that many gardens' classifications would likely be different five years before and again five years after the current classification. The composition of young orchards does not necessarily indicate what the nature of the garden will be in the future. Although each subsystem represents a coherent group, there are no sharp lines of division between the different fruit cropping subsystems but rather a gradient of differences. These groups could be rearranged or further subdivided if the list of classifying variables was altered. Also, the survey is not exhaustive, but limited in area and not all possible patterns are encountered. However, a framework now exists to which other subsystems can be added.

This classification can be useful in two important ways. First, it can be used as a tool for further analysis in the study area. Second, it can be used as a survey tool to help develop a better picture of the nature of fruit cropping activities over a wider area of the Highlands in northern Thailand, mainland Southeast Asia, and perhaps elsewhere. Both uses are relevant to ongoing development and resource management activities in northern Thailand. In the next phase of this study, we will examine the economic, social and ecological costs and benefits of these systems.

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