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Technical options and strategies

for vegetable crops and tree fruits

in the farming systems of

Son La and Lai Chau provinces of Vietnam

Consultancy Report No 12

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Executive summary

This report examines the Technical Options for establishing fruit crops and vegetables in Yen Chau district (Son La province) and Tua Chua district (Lai Chau province) in the Song Da Watershed of NW Vietnam. It recommends Strategies and Actions needed to overcome constraints to implementation of a technical pilot programme by the Social Forestry Development Project (SFDP), Song Da. Many of the crop recommendations, strategies, actions and tasks needed to develop fruits and vegetables in Yen Chau (mostly Black Thai Ethnic Group) and Tua Chua (mostly Hmong Ethnic Group), will in most cases apply equally well, with some local modifications, throughout the Song Da Watershed.

Fruits and Vegetables

A step by step Methodology was used to identify **Fruits** suited to different climates, soils, irrigation and water supply situations, slopes etc. Then these fruits had criteria applied to them to identify fruits with Good Commercial Potential for Commercially Successful Development in the Given Regions. Both agro-ecological, technical and socio-economic criteria were used in the sieving analysis process. (**Appendix I** carries full Methodology details in an example for Thailand). 32 different fruit species have been documented for both districts and these are listed in **Appendix VI.**

The outcome of this analysis showed that for altitudes in Yen Chau and Tua Chua districts up to 800 m.a.s.l. the following crops are recommended for technical study and development viz. Banana, Jak Fruit, Longan, Lychee, Macadamia, Nectarine, Persimmon, Peach, Pummelo, Sweet Bamboo, Tamarind, and Avocado. (Although Sweet Bamboo is not a fruit its development as a crop along with fruit tree fits in well with fruit tree management and can be processed at fruit processing plants). All of these crops with the exception of Jak and Banana have market windows when grown in the highlands.

For altitudes in Yen Chau and Tua Chua districts at 900 m.a.s.l. the following crops are recommended for development: Banana, Longan, Lychee, Nectarine, Persimmon, Peach, Pummelo, Sweet Bamboo, and Avocado.

At 1500 m.a.s.l. in both districts Nectarine and Peach are the only fruits recommended for development at this time.

For each of the fruits recommended above for development the Development Opportunities and Potential Problems/Constraints have been identified. For fruits that are excluded from further development promotion at this time reasons for exclusion are given, as for example with Plum, Apricot and Mango below. (See also **Section 4. 5**). For assisting both fruit and vegetable development in the short term, organising simple home processing and storage for fruits and cool storage and collection points for fruits and vegetables will greatly assist with orderly distant marketing, quality maintenance and surpluses.

Plum and Apricot are not recommended for further development as overproduction and wrong cultivars in the case of apricot has led to a collapse of the market and low uneconomic returns to farmers. However, further promotion of good home processing methods for preserving fruits for home consumption and possible cottage industry sales is recommended. Large plantings in other districts nearer to Hanoi has been a major contributor to the market collapse.

Mango is not recommended for further expansion in Yen Chau and Tua Chua districts as firstly Mango is not adapted to the very humid climates in these districts. As a result Mango has severe infestations of the very serious flower, fruit, leaf and stem diseases of Anthracnose, a fungal disease and Bacterial Black Spot. Both of these diseases when so severe will commonly result in low or no fruit set as is the case in these districts. In addition Mango trees even at a young age have serious Leaf Hopper infestations which result in further flower damage and reduced fruit set. Very severe infestations Tip Borer, Branch and Trunk Borer reduce the health, productivity and lifespan of even young trees. Resolution of these very serious problems with low input management levels such as currently exist in the districts is not possible. Furthermore, it is very doubtful if high input levels to control the problem will be economic in view of the very poor quality green mango being produced which really only has local demand.

Fruits which have less commercial prospects for development in the near future but which are recommended for the household garden are: Carambola, Cherimoya, Custard Apple, Guava, Loquat, Papaya, Mulberry (fruit), Pineapple, Passionfruit, Sapodilla, Apricot, Plum, Pomegranate, Santol, Chestnut and Walnut according to altitude (**Tables 5 and 6**).

Vegetables

For **Vegetables** we have at this time no well developed methodology as we do for fruits so the recommendations for further development consideration derive from, what is currently grown in the districts, and what we know can be grown successfully in nearby Thailand at altitudes of 600-800 m.a.s.l. or more.

Currently, most of the Vegetable crops being grown in house gardens in the Hot Season are:

Chilli, Shallot, Taro, Egg Plant, Choko, Cucumber, Water Melon, Tomato, Yard Long Bean, Sweet Potato, Arrowroot, *Impomea aquatica*, Luffa, Chinese Cabbage, Green Bean (Mung), with various spices such as Turmeric, Ginger and other Medicinal plants.

The following vegetables can be grown **All Year** in the Highlands above 600-800 m.a.s.l.:

Radish, Carrot, Sweet Corn, Head Lettuce, Green/Bush/French/Beans, Japanese Onion, Leek, Baby Carrot, Vegetable Soybean, Chinese Cabbage, Purple Egg Plant, Spinach, Zucchini, Fennel, Celery, Cantaloupe, Water Melon, Tomato, Japanese Cucumber, Capsicum, Sweet Potato, Cos Lettuce, Asparagus, Spinach, Endive, Rhubarb and Globe Artichoke. Shitake mushroom can be grown on Oak logs at 800-1400 m.

For the **Wet Season** the following may be grown in the Highlands, above 60-800 m.a.s.l.:Beetroot, Turnip, Red Lettuce, Butterhead Lettuce, Potato, Red Cabbage, Kohl Rabi, Brussel Sprout, Capsicum, White Balsam Pear.

For the **Cold Season** the following may be grown in the Highlands above 600-800 m.a.s.l.:

Beetroot, Turnip, Red Lettuce, Butterhead Lettuce, Red Cabbage, Brussel Sprouts, Capsicum, and White Balsam Pear, Onion, . Prime Cabbage, Broccoli and Cauliflower will grow best in the Cool Season from October to March.

Cucurbit crops such as Squash, Pumpkin, Melons, Gourds, plus Chinese Mustard/Radish, Chilli, and Okra are well adapted to the **Hot Season.**

Section 5 of the report carries more details on vegetables and recommendations on how they may develop.

Strategies for Fruit Tree Development -A Pilot Scale Model for Further Project Development

Whether we are developing fruit trees, livestock, field crops, aquaculture, soil conservation, cottage industries or off-farm income generation, we need to have in mind a clear Strategy for development and the steps involved in implementation. Currently, most of the inputs to date in the project have been of a technical nature, or addressing broader issues of land allocation, land use etc., with most emphasis on forestry. Now that the project has another dimension, namely that of Farming Systems Development, the project needs a Strategy on how to research, extend and develop at the same time. The next steps must, no matter what the commodity being considered, involve the project personnel working closely with Extension and farmers backed by some specialised research, advice and marketing/economic studies. Initially this work will be on a Pilot Scale, which can be later extended to full implementation. Such issues as farm labour availability, risk, food security and crop option selection must be considered carefully in the crop diversification strategy and the whole farming system.

Apart from the specific inputs/tasks needed to develop fruit crops in Yen Chau and Tua Chua as given in **Table 10** the broader Development Strategy outlined, with suggested augmentation based on a Thailand Model, will apply to equally to fruits, field crops, livestock, vegetables, flowers, forestry, soil conservation, aquaculture and cottage industries.

It is recommended that SFDP set up a similar Strategy supported by appropriate manuals that delineate very clearly the development steps to be followed in working through from the watershed level to the village development plan, to the village agricultural development plan, to demonstration sites and eventually the crop expansion phase supported by a Village Revolving Fund. Unless such structures and systems are firmly established now and used by Extension staff over and over, with Government and farmers gradually meeting more of the implementation and the costs, then whole process will collapse when project support is withdrawn. **NB** The additional Strategies proposed do not change the overall Project Development Strategy of Figure 1, they simply add substance to the way in which the project will implement through working with extension and farmers.

Constraints to Task Implementation with Tree Fruits and/or Vegetables and Recommended Solutions.

Table 10 summarises the inputs needed to develop fruit crops in Yen Chau and Tua Chua districts while some of the issues to be considered in vegetable development are given in **Section 5.**

Change in any system involves the interaction of People, Technology and Resource issues with Policy and these together form a convenient framework to examine constraints to task implementation and the evolution of recommended solutions. Many of the comments apply equally well to vegetables as well as fruits, but major emphasis has been on the latter as these are longer term in nature and are more difficult to research, extend and develop.

Recommendations:

People

- It is recommended that for the SFDP to properly implement an Agricultural Program involving field, vegetable and tree fruit crops must have on-site as far as possible an experienced Full Time Expatriate Crops Extension Specialist who can work almost daily in the villages with local Extension people and is preferably fluent in the language. Based on a review of projected program workload perhaps one Full Time Expatriate Extension Specialist is needed in each district. Without such extension specialist/s the tree fruit programme should not proceed as outlined.
- The Extension staff and the Extension Specialist need to be supported part-time by inputs from both domestic research institutes such as the Phu Ho Fruit Research Institute and experienced Expatriate Short Term Research Specialists, according to the crop group, eg. fruit, vegetables, field crops, and maybe mushroom cultivation and floriculture etc., in the future. Such support is **recommended.** A major task will be to prepare Crop Field Guides/Technology Packages and further tasks will be to advise on management of crops, nurseries, demonstration plots, adaptation trials, mother tree plots and cultivars for importation and multiplication.
- Specialised inputs will be essential from an Expatriate Economist/Marketing Specialist on assembling Gross Margins for the various crops as an aid to providing farmers with cropping options in the future. Market intelligence will be another very important task of such a specialist and a Marketing Information System will be highly desirable. It is **recommended** that such inputs proceed to support the project development programme.
- It is **recommended** that the need for a Social Scientist be reviewed in the light of project implementation problems as and when they arise.
- As Livestock will be an important component of the Farming Systems in both districts and will impact on horticultural development, it is **recommended** that SFDP review the need for a Full Time Expatriate Livestock Extension Specialist in the project.
- Training needs for Extension Staff for fruit crops are summarised in Table 10. It is **recommended** that training proceed in the areas designated using both local and international personnel as appropriate.

Policy

- It is **recommended** that the SFDP project should not include mango in any fruit tree expansion programme and that only those tree fruits listed in **Tables 7, 8 and 9** be promoted.
- For Tua Chua district we could not get data on planned fruit tree expansion, but it is **recommended** that this issue be followed up in the light of findings presented in this report.
- It is **recommended** that, because of the large areas planted and proposed the marketing and processing of lychee and longan be carefully monitored as new plantings begin to come into production.. It is further **recommended** that Yen Chau concentrate on planting early season cultivars of lychee and longan which are likely to mature before other regions, except perhaps Hoa Binh. For Tua Chua being much cooler it is **recommended** that they should concentrate on late season cultivars that will mature after other areas have ceased to harvest.
- It is **recommended** that future plantings of fruits in both districts should take into account other Government promotion programmes such as those of the 327 Project.
- Policy issues which relate to credit availability, setting up of Village Revolving Funds run by villagers and not bureaucrats or cooperatives, subsidies for tree establishment or assistance with post harvest management pre-packing, collection and transport should be clarified as early as possible to avoid later confusion and debate. It is **recommended** that SFDP follow up on these issues with the appropriate agencies.
- It is **recommended** that the policy on numbers of extension officers which can be allocated to each district and with sufficient budgets to operate effectively, once the SFDP inputs are withdrawn, should be addressed now to avoid future collapse after the project concludes.

Resources

- It is **recommended** that to implement the proposed program for fruit trees requires a deal of resources that must be allocated by SFPD and Extension Department in the two districts. A list of Essential Equipment for each district is given in **Section 7.**
- To overcome technical, project implementation constraints it is **recommended** that an **Additional** Annual Budget of not less than $70,000 per district for per diems, fuel, travel, study tours, paper, printing, consumables, seeds, purchase of mother trees, chemicals, miscellaneous shade materials, equipment items, repairs, polybags for potting, potting materials, fertilisers, nursery construction, setting up demonstration plots and mother orchards, compensating farmers for use of land and labour. (Budget to reviewed based on Annual Work Plans and may considerably exceed the above estimate)
- It is **recommended** that a Small Lab facility in each district to test fruit samples, soil, water and weigh out chemicals and fertilisers, dry fruits etc.
- It is **recommended** that funds be allocated to support the full establishment of training nursery for fruits and assistance to development of four (4) farmer run nurseries in each district, perhaps by way of credit loans for the latter.

Technology

- It is **recommended** that a sum of at least $5000 should be set aside for each district to purchase Text/reference books, periodicals, manuals, videos etc., for upgrading the technical knowledge of Extension workers and for use in preparing training workshops for farmers. In follow up years allocate a sum of at least $2000/year.
- The senior author of this report brought a range of technical documents, manuals, field guides, reports and texts. It is **recommended** that at least two sets of these documents are provided to each district. One set for the Project office in each district and one set for Extension. Other text recommendations are held by SFDP office Hanoi.
- It is **recommended** that $15,000 be set aside for the importation of grafted mother trees and desired rootstocks and rootstock seed. Details on how these plants should be imported and where they should be held etc., are given in **Section 7.**
- It is **recommended** that the publication by the senior author entitled "General Key Requirements/ Extension Points for Growing tree Fruit Crops in Indonesia" be especially photocopied and used to train Extension officers and farmers as a starting point in the tree crop programme. The principles apply equally well to Vietnam as Indonesia.

- For tree fruit development it is **recommended** to proceed with Grass Strips as the easiest and cheapest to establish. Also, as trees become bigger grass strips do not interfere with tree development and management. Ruzi and Vetiver grass can be **recommended** based on Thailand experience. Napier and Dwarf Napier (Mott Grass, which the consultant brought for the project to multiply and use) will provide useful options for farmers needing additional fodder. Personally, I see no point in evaluating dozens of hedgerow options as there is no one answer anyway, since it will always remain a "Horses for Courses" decision. The important thing for fruit trees is to stop soil and water movement down the slope and let mini terraces form for 2-3 years behind the grass strip before planting of trees.
- It is **recommended** that the Land Use Options used by the Thai-Australia HASD Project for very successful agricultural and forestry development in sloping land in the Highlands of Thailand, be adopted as a standard for the SFDP Pilot Project. Options are described in **Sections 3.8 and 7.**
- As with most Shifting Cultivation Farming Systems that have had to cease and become Permanent Sedentary Upland Cropping or Mixed Farming Systems soil fertility will be an issue. Whatever solution are chosen, to address this issue, it is **recommended** that it must involve getting legumes into the cropping rotation, whether it be field crop, vegetable crop, fruit crop or pasture. This was one of the keys to success in the highlands of Thailand.
- It is further **recommended** that composting and collection of animal manures be promoted as essential prerequisites to successful tree establishment and that mulching must be practised along with careful weeding to ensure survival, especially in the early years.
- For longan, lychee, and high quality fresh peach and nectarine it is **recommended** that these be grown in areas near to water supplies for supplemental irrigation if and when required. This may be less important for longan which will mature well into the wet season.
- It is **recommended** that Demonstration Plots for field crops and vegetables and Adaptive Trial/Demonstration plots for fruit trees be kept as small as possible and spread over more locations. Section 7 provides details for these and Crop Improvement and Crop Expansion phases of the system.
- As farmers cannot be expected to wait for 6 years for results to arrive it is **recommended** that additional plants of each cultivar be raised at the same time as those raised for the trials and given out at cost to interested farmers, with a little information pack and /or practical verbal advice/training on how to care for the plants. The offer of trees should be on a first in-first served basis. In this way interest is generated in growing new crops and it is another way to make observations across a very wide range of sites under grower managed conditions to augment the more formal Adaption Trial work.
- It is **recommended** that the trial work on mango initiated by the Phu Ho Fruit Research Institute in Yen Chau district continue.
- Finally, it is **recommended** that inputs of chemicals be kept to a minimum, Integrated Pest Management use of Biopesticides, companion planting, rotations, zero cultivation and organic farming be practiced wherever possible, and that while chemical fertilisers are acceptable they should simply be augmenting an organic fertiliser base. All inputs essentially should be environmentally acceptable. Linking the VAC system to vegetable and tree crop development is highly desirable along with other innovations of home processing and even biogas generation in isolated villages with livestock.

1. Introduction

This document reports on the GFA/GTZ consultants findings on Technical Options and Strategies for introducing food/fruit tree crops into the existing farming systems of Son La and Lai Chau provinces of the Song Da Watershed.

The Social Forestry Development Project (SFDP) Song Da which involves Vietnamese-German Technical Co-operation is being implemented by GFA-AGRAR on behalf of German AID Assistance (GTZ) in co-operation with the Ministry of Agriculture and Rural Development (MARD).

The SFDP activities focus on two district namely YenChau (Son La province) and Tua Chua (Lai Chau province).

The findings reported here, while primarily focusing on Yen Chau and Tua Chua districts have much wider implications for development in the Song Da Watershed. Major differences will relate to climate, soils, slope, water supply and infrastructure, which vary with location.

In **Section 2** below are details of the Terms of Reference for the Food/Tree Crops International Consultant.

The report presents a Methodology for Matching fruits to land (details in **Appendix I**), developed by the senior author over a period of II years in a range of developing countries.

Potential Tree Fruits for development are then presented and discussed for the two districts including criteria for success, potential problems/constraints and development opportunities. The report then suggests a Strategy for Development of fruit crops in the project with input requirements noted.

The main focus of the Consultancy has been fruit crops as there have been producing greatest difficulties for both the project and MARD. However, other food crops' (agreed to be vegetables) for this input are mentioned in each district.

2. Terms of Reference for farming systems development—Food/tree crops expert

Background:

The Song Da Watershed comprises five provinces in the mountainous Northwest of Vietnam. More than 80% of the watershed's area (2.7 m ha) is located in the two provinces of Son La and Lai Chau. The majority of the population of ca. 1 m people belongs to various ethnic groups, such as Thai , H'Mong, Muong, and Dao. The average population density of 37p/km2 (with variation from 6 - 91) counts among Vietnam's lowest. Population growth is estimated at 3% p.a.

The population counts among the poorest of Vietnam with an estimated annual income of 40 USD. The people maintain their livelihood chiefly through subsistence oriented agriculture. Paddies are limited to the more favorable sides in valleys. Consequently the prevailing farming systems are complex and mainly based on shifting cultivation principles. The productivity in general is low. Food-shortages affect parts of the population. Markets are distant and the infrastructure is not developed, thus hampering a shift towards more market oriented production of any kind.

Most of the watershed's area (>90%) classifies as forest land, but the actual forest cover averages around 10% (=270.000 ha). Compared to 1965, this represents a loss of forest of appr. XXXX ha. This rapid decline was mainly caused through a combination of uncontrolled logging, shifting-cultivation, and the expansion of non-adapted lowland-agricultural systems into the uplands altogether leading to an over exploitation of the natural resource. The consequences of deforestation and unsustainable land-use practices are known: decreasing soil-fertility, decreasing water-holding capacity and therefore less stable availability of water, massive occurrence of erosion combined with flash-floods and land-slides.

The Social Forestry Project (SFDP) Song Da started its activities in May 1993. Basis for the project is the bilateral project-agreement between the SR Vietnam and the FR Germany on the establishment of a joint forestry project in the Song Da Watershed. Because of the watershed's complexity and difficult environment an initial phase - according to German planning terms an "open orientation phase" - was agreed to design and shape the following implementation.

The planning horizon foresees for the SFDP two implementation and one consolidation phase totalling ten years.

The Orientation Phase resulted in a joint planning workshop, which produced the agreed Project Planning Matrix (PPM, attached in ANNEX 1). The PPM shows SFDP's Purpose, Results/Outputs, Main Activities as well

as Indicators. The project's activities concentrate in two districts: Yen Chau (Province Son La) and Tua Chua (Province Lai Chau). Here in brief the most important features:

Core problem in Song Da watershed.

- Landuse systems in the Song Da watershed are not sustainable

Overal goal of the SFDP

- The Song Da project region is integrated into the mainstream of the National Economy and Development.
- The quality of life of the population in the project region is improved

Project purpose:

- The rural population in the Song Da project region applies economically and ecologically sustainable landuse systems

The Social Forestry Development Project will introduce:

- more suitable agro-forestry systems
- more effective management alternatives of forest and forest land

To regions with:

- Major smallholder upland landuse systems
- High pressure on land and forest
- Major ethnic groups: Thai and H'mong

The project implementation of ongoing Phase II is directly under the Department for Forest Development of the Ministry of Agriculture and Rural Development (MARD). Highest policy body is the National Steering Committee. The director of the a.m. Department is appointed National Project Director.

Since the start of the implementation phase field activities increased and the need for a gender specific approach became evident.

Duration of Contract:	1 month January or April 1997
Time Table:	four (4) days preparation in Hanoi sixteen (16) days field-visits to Yen Chau (Son La) and Tua Chua (Lai Chau) four (4) travel days for the a.m. programme four (4) days for report-writing and presentations
Responsibilities:	The short-term expert will be directly working under the SFDP team leader and his deputy
Language:	The SFDP's working language is English. For field-work the project will provide the necessary interpreter.
Reporting:	The final report of a maximal 50 pages is to be written in English language. As word-processing programme MS-Word-for-Windows 6 is required.
Objectives:	The Consultant's work will cover two main areas: 1. Analyse the potential (ecological and economical) for development and/or introduction of food and (fruit)tree crops in the existing farming systems of the project area 2. Elaborate practical recommendations for agricultural extension and a framework for on-farm research on new crops in the project area

3. Methodology—matching fruits to land and determining which fruits should be developed in Yen Chau and Tua Chua Districts of the Song Da Watershed

Methodology for matching perennial fruits to agro-ecological zones, developing a Potential List and using criteria for determining which will be Commercially Acceptable in a given region, is presented in detail in Appendix I, with examples given for the lower north of Thailand. Details will not be given here. However, first steps in the methodology are:

Define the Study Regions- regions of interest.

Define the Agro-ecological Zone/Zones of the Study Regions.

Define the Broad Farming Systems of the Study Regions (local description).

Examine in Broad Terms the Soils of the Regions.

Use the Climate Sieve (especially Mean Minimum and Mean Temperature for the coldest month (January) to define Potential Fruit Crops.

Determine Water Supply and Long Term Irrigation Requirements for the regions from local climate data available.

Examine Slope, Aspect, Wind and Relative Humidity considerations.

3.1 Study regions

The Project Study Regions in the Song Da Watershed of North West of Viet Nam lie in the districts of:

Yen Chau (Son La Province) approx. 230 35' N latitude and altitude 300 to 900 m a.s.l.

Tua Chua (Lai Chau Province) approx. 240 20' N latitude and altitude 700 - 1500 m a.s.l.

3.2 Agro-ecological zones of study regions

Both districts are defined as being in the Agro-ecological zone (AEZ) of the Warm Sub-Humid Sub Tropics with dominant summer rainfall, based on the FAO - AEZ Land Inventory, which denotes AEZ's on rainfed soil moisture availability in terms of Length of Growing Period (LGP) and temperature during LGP. The Warm Sub Humid Sub Tropics have a LGP of 180 - 270 days and a daily mean temperature during the growing period greater than 200 C, Anon (1992).

3.3 Farming systems of study regions

Farming systems of both Yen Chau and Tua Chua districts have been more than adequately described on a number of occasion recently (Ludwig, 1997) while Anon (1996) presents land use technology options for upland development, and land use limitations. Both provide an excellent background to Farming Systems and Land Use respectively.

In the recent past both Yen Chau and Tua Chua districts had major crops (rice or maize) based Smallholder Rainfed Shifting Cultivation Farming Systems, after Beets (1990). Some farmers had access to lowland paddy, which may have been rainfed, or irrigated in some locations, and most had livestock and household gardens. Increases in population, logging, pressure and policy changes from Government to cease upland shifting cultivation, and conserve forests and land, has led to a Permanent Upland Farming System as described by Ludwig (1997), who also recognises two Sub-Systems of Farming, namely:

Smallholder Rainfed Upland Farming and

Smallholder Mixed Permanent Farming

After Ludwig 1997, Smallholder Rainfed Upland Farming (up to 20% in Tua Chua) have activities that involve:

a. Cultivation

-Rainfed slope cultivation

b. Cropping

-Semi-permanent cropping with occasional fallows

-Single cropping

-Intercropping

c. Agroforestry

-Home gardens

d. Forestry

-Collection of non-timber products

Smallholder Mixed Permanent Farming

Activities:

a. Cultivation

-Rainfed slope cultivation

-Rainfed contour cultivation

-Rainfed terrace cultivation

-Irrigated terrace cultivation

-Irrigated pit cultivation (vegetables)

b. Cropping

-Semi-permanent cropping (occasional fallows)

-Single cropping

-Intercropping

-Multiple cropping (first/second crop)

-Ley farming

c. Agroforestry

-Home/Farm gardens

-Hedgerow cultivation

-Perennial inter-cropping (tea/coffee with shade trees)

-Fruit Gardens

d. Animal Husbandry

-Livestock raising

-Stabling of livestock

-Livestock transport support

-Manuring

e. Fisheries

-Fish breeding

-Fish farming

f. Forestry

-Collection of non-timber products

-Single timber tree planting (occasionally).

Based on rice, maize, cassava, cycle practically permanent cultivation of steep slopes (30-70%) is now taking place, and with low input farming and mostly no soil conservation measures fertility decline is inevitable in many instances. (see Anon 1996, Van der Poel 1993 and Ludwig 1997 for more on crops and land use).

Farmers in both districts are interested in crop diversification, especially into fruit trees to derive a cash flow and improve household nutrition. However, areas for high value fruit trees are somewhat limited as they are best grown near to roads and streams, where often soils are deeper, more fertile and close to water. The limitations on not permitting agriculture within 80 m of roads and streams is a major constraint to high value tree fruit crop development and perhaps need review for trees fruits. Currently, most fruit trees are grown in home gardens in both districts with some common plantings and a few more isolated hillside orchards.

Some tree fruit species may be cultivated on sloping land using grass strips (see later).

Essentially, fruit trees options reduce to household gardens and upland sloping agricultural lands in both districts. In the latter, Sloping Agricultural Land Technology (SALT) is an essential pre-requisite to fruit tree development, which may or may not be considered agro-forestry depending on the technology options employed.

3.4 Soils

Generally, for perennial trees fruits, soil physical characteristics are of major importance and soil fertility is usually of secondary consideration, as it is readily corrected at little expense relative to the high value of the fruit product. Soil physical defects are often difficult or expensive to correct. Depth, texture, drainage, structure and available soil water storage are most important. Fruit trees prefer lighter textured soils ranging from loamy sands through to silty clay loams/clay loams. Minimum depth of topsoil should be 1.0 m or greater, preferably 1.5 m. Sandy loams to loams are ideal for most fruit trees. For tree fruits depth to the water table should be 2.0 m or more, if trees are to be stressed o promote flowering in the dry season, especially on lowland soils at the bottom of a slope. Loams store about 150 mm of available soil water per metre of soil depth while sandy loams store 120 mm per metre.

Soils in the two districts include deep laterised acid Red Red/Brown ferralitic soils usually silty loam to clay loam in texture. Grey/Brown soils are formed from shales/ mudstones are usually of loam to clay loam in texture and of variable depth, often shallow in Tua Chua district. These relatively young Grey/Brown soils contain lots of free shale rock pieces from 5-15 cm in size and resemble a conglomerate in structure. These soils are highly erodable and paddy bunds and terraces made on such soils frequently collapse as do embankments and cuttings.

These Grey/Brown soils, when the topsoil is shallow (20-40 cm), overlay heavy clay sub soils with laterite. Such shallow soils are found usually higher up the sloping land and appear to have low fertility.

The lower slopes of Red Red/Brown soils and the Grey/Brown mudstones produce relatively deep Alluvial sandy loams to silty clay loams which are ideal for growing a very wide range of food, vegetable and fruit crops. Unfortunately these soils only constitute about 2-3% of the total area.

Red/Yellow humic duplex soils develop on the higher parts of mountains. These are shallow clay loam (40-50 cm of topsoil) acid soils of poor fertility overlay either clay or rock. They are not suitable for tree fruits and should not be used for annual cropping and are best left for natural grassland or forests.

Soils in both Yen Chau and Tua Chua districts will not prove to be a major constraint to food or fruit tree crops.

However, the shallow upland topsoils, mostly Grey/Brown mudstones, but also some shallow Red Red/Brown soils and alluviums should not be used for tree fruits. Most of the shallow topsoils are found on upper slopes firstly are skeletal in nature and also heavily eroded. In fact the soils with 30-40 cm of topsoils should not be used for cultivation at all.

Even wet lowland paddy alluvials may be used for tree fruits if raised beds 1-2 m high are formed before planting. However, because of the food securing problems, especially in Tua Chua district it found probably not be wise to use paddy areas for fruit trees at this stage.

Soil Fertility

Because of little use of fertilisers, continuous cropping and unsustainable practices (Anon, 1996) fertility in many areas of both Yen Chau and Tua Chua are declining. This is very obvious in the lower organic matter Grey/Brown mudstone soils, and especially the shallow soils on steep slopes. To develop tree fruits successfully. Attention to soil fertility will be required to ensure good tree health and higher returns per ha. Low soil pH may be a problem on some red/red-brown soils and alluviums. Most tree fruits prefer a pH of 5.5 to 6.5, so correction will be necessary with limestone or dolomite additions on some of these soils. Some alluviums here also showing growth of indicator plants that prefer low pH. Thus pH correction may be necessary on some heavily leached alluviums.

Additional phosphate will be essential to establish fruit trees especially on the red soils that are high in iron and which tie up phosphorus at low pH and release excess alluvium which results in aluminium toxicity.

Maintaining organic matter in fruit trees soils is essential for tree health, moisture conservation, rhizosphere microflora, soil structure and nutrient availability. Use of compost or organic manure, green manure and organic mulching are essential for fruit trees.

Addition of N, P, K fertiliser Ca and Mg and other micronutrients especially Zn, B and Cu will be required for higher management levels of tree fruits. Calcium induced Fe deficiency was observed in a number of isolated instances near to limestone karsts, where obviously there was free Ca in the soils. Also, near to such areas bamboo grows poorly with stem deformation.

In summary, soils in both Yen Chau and Tua Chua will not be a major constraint to fruit tree development, provided the shallow or very poorly drained soils are avoided.

3.5 Climate

When matching plants to land light, temperature, rainfall, evaporation and water deficit, waterlogging, relative humidity and wind are main considerations. Also, in the Yen Chau and Tua Chua districts frost may constitute a problem in deep valleys with poor air drainage. For Tua Chua spring hail storms are a regular recurring hazard for fruit trees.

Light

For light it is usual to consider day length and solar radiation (Hackett, 1988). however, most of the important species of fruit trees are day neutral with respect to flowering, so day length is not a constraint.

Solar radiation may be limiting in some of the project areas above 600-800 m.a.s.l. during the wet season. Most trees are C3 plants and require a minimum solar radiation

level. 25 Megajoules per m^2 per day for satisfactory production, which is about one-third the level of full daylight.

Temperature

Temperature, is clearly the most important determinant of tropical and sub-tropical tree fruit distribution, because of its critical effects on plant growth and performance and the fact that we have little control over temperature in the field.

Hackett (1988) has used various notional relationships to describe threshold temperatures and marginally suitable temperatures for brief and extended cold and cold damage and rates of development. However, for most tropical fruits these relationships are far from developed and for the present my preference is to use the simple approach of Watson and Moncur (1985), for determining where fruits will grow, namely the Mean Monthly Minimum Temperature for the coldest month.

Watson and Moncur (1985) proposed, Guideline Criteria for Determining Survival, Commercial and Best Mean Minimum July Temperatures for Various Tropical Fruit in Australia (Southern Hemisphere), (January – Northern Hemisphere). See Table 1 below.

The Mean Minimum Monthly Temperature data presented in Table 1 when applied to the coolest month (January), in various areas of the Project, will indicate areas where various tropical fruits will survive, grow commercially or perform the best.

Table 1. *Guideline Criteria for Determining Survival, Commercial and Best Production, based on Mean Minimum July (Coolest Month) Temperatures for Various Tropical Fruits in Australia (Southern Hemisphere). Extracted from a paper by B.J. Watson and M. Moncur (1985), Wet Tropics Regional Publication, Queensland, Australia, pp. 3.*

Fruit Species		**Mean Minimum Temperature (ºC) for Coolest Month**		
Common Name	**Botanical Name**	**Survival**	**Commercial**	**Best**
Abiu	Pouteria caimito	8-10	10 plus	12-18
Acerola	Malpighia glabra	6-8	8 plus	14 plus
Akee	Blighia sapida	10-12	12 plus	16 plus
Ambarella	Spondias cytherea	10-12	12 plus	14 plus
Babaco	Carica hybrid	?	6-12 ?	6-10 ?
Banana	Musa spp.	6-8	8 plus	16 plus
Bell fruit	Syzygium aqueum	8-10	10 plus	16 plus
Black persimmon	Diospyros digyna	6-8	8-18	6-14
Blueberry (L.Chill)	Vaccinium spp.	0-2 ?	1-12 ?	6?-10?
Bread fruit/Bread nut	Artocarpus altilis	14-16	16 plus	16 plus
Caimito	Chrysoplyllum cainito	8-12	12 plus	16 plus
Canistel	Pouteria campechiana	6-8	8 plus	14 plus
Carambola	Averrhoa carambola	6-8	8 plus	14 plus
Casimiroa	Casimiroa edulis	2-4 ?	4-14 ?	4-12 ?
Chempedak	Artocarpus polyphema	12-14	14 plus	16 plus
Cherimoya	Annona cherimola	4-6?	5-12?	6-10?
Cocoa	Theobroma cacao	12-16	16 plus	18 plus
Coconut	Cocos mucifera	8-10	10 plus	18 plus
Custard apple	Annona hybrid	4-6?	6 plus ?	10-14 ?
Durian	Durio zibenthus	14--16	16 plus	18 plus
Duku	Lansium domesticum	12-14	14 plus	18 plus
Guava	Psidium guajava	4-8	8 plus	14 plus
Jaboticaba	Myrciaria cauliflora	6-8 ?	8-18	10-15
Jack fruit	Artocarpus heterophyllus	6-10	10 plus	14 plus
Kiwifurit	Actinidia chinensis	?	?	?
Langsat	Lansium domesticum	12-14	14 plus	18 plus
Longan +	Euphoria Longana	4-8	8-18	8-14
Loquat	Eriobotrya japonica	2-4	4-14	6-12
Lychee +	Litchi chinensis	4-8	8-18	8-14
Mabolo	Diospyros discolor	8-14	14 plus	16 plus
Malay Apple	Syzygium malaccense	8-14	14 plus	16 plus
Mamey Sapote	Pouteria sapota	6-8	8 plus	14 plus
Mammea	Mammea americana	10-12	12 plus	16 plus
Mamoncillo	Melicoccus bijugatus	10-16	16 plus	18 plus
Mango	Mangifera indica	6-8	8 plus	12 plus
Mangosteen	Garcinia mangostana	10-14	14 plus	16 plus
Marang	Artocarpus odoratissimus	12-16	16 plus	18 plus
Matisia	Matisia cordata	12-16	16 plus	18 plus
Miracle fruit	Synsepalum dulicificum	8-12	12 plus	14 plus
Mulberry	Morus nigra	2-4?	2-18 ?	4-12 ?
Nectarine (L.C.)+	Prunus persica	2-4 ?	4-12 ?	4-10 ?
Nutmeg	Myristica fragrans	10-14	14 plus	16 plus
Papaw+	Carica papaya	6-8	8 plus	14 plus
Peach (L.C.)+	Prunus persica	2-4 ?	4-12 ?	4-10 ?

Pepper	Piper nigrum	12-14	14 plus	16 plus
Persimmon+	Diospyros kaki	0-2 ?	8-12 ?	8-12 ?
Pitaya	Hylocereus quatemalensis	12-14	14 plus	16 plus
Pineapple	Ananas comosus	6-8	8 plus	10 plus
Pulasen	Nephelium mutabile	14-18	18 plus	18 plus
Pummelo*	Citrus grandis	4-8	8 plus	14 plus
Rambutan	Nephelium lappaceum	8-12	14 plus	18 plus
Rollinia	Rollinia deliciosa	8-10	12 plus	14 plus
Rose apple	Syzygium jambos	8-12	12 plus	16 plus
Salak	Salacca edulis	12-14	14 plus	18 plus
Santol	Sandoricum koetjape	10-14	14 plus	16 plus
Sapodilla (Chico)	Manilkara zepota	6-10	10 plus	14 plus
Soursop	Annona muricata	6-10	10 plus	16 plus
Tamarind	Tamarindus indica	6-10	12 plus	14 plus
Taun (Daws)	Pometia pinnata	8-12	14 plus	16 plus
Uvilla	Pourouma cecropiaefolia	8-12	14 plus	16 plus
Vanilla	Vanilla planifolia	8-12	14 plus	16 plus
Wampi	Clausena Lansium	2-6	8-14	8-10
Wax jambu	Syzygium samarangense	8-10	10 plus	14 plus
Woolmi	Antidesma dallachyanum	8-10	12 plus	14 plus
Macadamia +	Macadamia spp.	4-6 ?	8-12 ?	8-10 ?
Palm oil	Elaeis guineensis	10-16 ?	16 plus	18 plus
Aloe Vera	Aloe barbadensis	?	8 Plus	14 plus ?
Cashew	Anacardium occidentale	8-10	12 plus	16 plus
Lime (W.I.)	Citrus aurantifolia	8-10	12 plus	16 plus

+ Cultivar reaction to "chill" temperature variable
* Quality downgraded if grown in cool conditions

N.B. The list may be further extended as more data become available on crops. (See also Hackett and Carolane, 1982)

The above technique is a method for sieving out environments where perennial fruits may be grown. However, with some fruits, e.g. Durian, Mangosteen and Rambutan, we know that a high humidity environment is necessary for success, even if the temperate range is satisfactory.

Similar limitations will apply to other fruits, and over time we hope to gather such information, so that the Minimum Temperature approach can be further refined. (See Paper II for more information).

This Minimum Temperature approach provides a broad 'Rule of Thumb' guide for distribution and testing of various fruit species. Where frost tolerance or tolerance to very high temperatures, cold winds etc. are known these should be used together with the 'Rule of Thumb' guide, to provide an intelligent guess at the best sites and location for particular tree fruits and cultivars.

Temperature is clearly one climate parameter over which we have little or no control. Thus, it is essential to select suitable areas with near ideal temperatures for production. Temperature is thus the Key Climate Factor governing distribution of tree fruits.

If there are no good temperature data are available it is possible to take temperature data from a near-by centre and extrapolate for elevation changes. In the tropics temperatures may drop by 0.5℃/100m increase in altitude (Burke, quoted by Hackett 1988, for Papua New Guinea) or 0.6℃/100m as suggested by Decourieux (1991), for the Bolovens Plateau in Laos. The temperature decrease with elevation increase is called the Adiabatic Lapse Rate. Geiger (1966), suggested that the Adiabatic Lapse Rate varies from 0.4 to 0.98℃ drop per 100m increase in altitude, depending on the saturation level of the air mass.

More recently, Edmodes, Corbett & Chapman (1992) at CIMMYT (Pers Comm.), have been using a Geographic Information Systems module, which will calculate temperatures for various elevations from known elevation and temperature data, and digitise them on a 16 sq. Km grid basis for the production of temperature maps, e.g., for Mexico. Such a tool can be used in conjunction with Mean Minimum Temperatures for the coolest month to produce Temperature Maps for Vietnam and other countries, to which may be fitted the various crops using the Mean Minimum Temperature model above. (The Senior Author of this report has begun such studies on a number of tropical crops in co-operation with CSIRO Division of Forest and Forest Product Research in Australia).

Henry Nix (pers comm) considers that where ponding of cold air occurs in the Highlands, in valleys or on plateaux, because of cold air drainage from surrounding high mountains, temperatures may be 5℃ lower than predicted using the Adiatic Lapse Rates. Percent slope, degree of exposure to cold winds and aspect (North versus South slopes), may also significantly affect temperatures. Personal experience in N. Thailand at elevations of around 1200m, has shown that temperatures at close to the same latitude and elevation may vary by up to 9.4ºC for different locations, due to ponding of cold air in valleys.

Thus, while it may be convenient to predict temperatures at various elevations using Adiabatic Lapse Rates, again there is no substitute for some hard site data, particularly where the terrain is broken and very mountainous.

Latitude also influences temperatures. However, for the Study Region areas, there is only about a one degree latitude range and this may account for only about a 1℃ drop in temperatures as distance from the equator increases.

In the Yen Chau and Tua Chua districts there are both gently sloping areas, plateaux and very flat areas as well as some steeper mountainous areas. Thus, altitude-temperature relationships may make sense in the former but will be highly variable in the latter. Thus, it is better to use temperature and not altitude as a guide and be very careful when selecting sites, e.g., do not choose a cold pocket / valley for a crop that prefers warm sites.

However, as indicated earlier, there is no substitute for on-site testing or observation of what is growing and producing well in a given location.

Climatic Data are given for Yen Chau and Tua Chua in Table 2. The recording station for Yen Chau has an elevation of 300 m.a.s.l at a latitude of 23°35" N and for Tua Chua 800 m.a.s.l. at a latitude of 24°20" N. If we take the Mean Monthly Minimum Temperature for January (coldest month) for Yen Chau in Table 2, namely 11.7ºC, and compare this with the values in Table 1 for the various crops, we find that a wide range of crops can be grown in the Yen Chau around 300 m elevation (Table 3). Similarly, for Tua Chua which has a Mean Minimum Temperature for the coldest month, (January) of 10ºC, we may repeat the process (Table 3).

Table 2. *Climate Data**
Yen Chau : Latitude 23 ^{0} 35' N; Altitude 300 m. a.s.l

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Mean Min ℃	11.7	13.6	16	19.7	22.2	23.3	23.4	23.1	21	19.3	15.8	12.2	18.6
Mean Max ℃	22.7	24.7	290	32.3	33.6	32.8	326	31.8	30.9	29	25.9	23.6	29.1
Mean Temp °	15.8	17.9	21.7	24.8	26.8	27	26.9	26.3	25.2	22.8	19.4	16.4	22.6
Max Rel. Humidity %	77	74	71	74	73	81	83	86	84	83	81	79	79
Av. R H %	60	56	51	55	62	69	71	70	66	62	62	61	62
Nº wet days /month	3.2	3	4.6	11.7	13.6	15.7	18.1	18.1	12.2	7.6	3.9	2.3	114
Evap (E) mm	87.9	104.4	141.3	133	129.9	90.4	78.8	62.5	63.9	68	67.5	75.7	1103.3
0.8 Evap (E)mm	70.3	83.5	113	106.4	103.9	72.3	63	50	51.1	54.4	54	60.6	
Rainfall mm	13.1	16.7	32.1	99.5	115.7	196.7	212.2	279.6	150	65.4	26.5	9	1217
(0.8 E) - R = I_L mm	-57.2	-68.8	-80.9	-6.9	+ 11.8	+ 124.4	+ 149.2	+ 229.6	+ 99.4	+ 11.0	-27.5	-61.6	209.9
Deficit/Surplus	-	-	-	-	+	+	+	+	+	+	-	-	290.9**

Table 2. *Climate data**
Tua Chua: Latitude 24°20'N; Altitude: 800 m. a.s.l .

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Mean Min ℃	10	11.4	14.7	17.1	19.1	20.4	20.2	20	19	16.7	13.3	10	16
Mean Max ℃	18.3	20.9	24.7	26.7	26.9	26.8	26.4	26.4	26.3	24.6	21	18.7	24
Mean Temp °	13.7	15	19.1	21.2	22.3	22.8	22.5	22.4	21.9	19.8	16.2	13.8	19.3
Max Rel. Humidity %	82	77	75	77	81	86	88	88	86	82	82	82	82
Av. R H %	60	56	51	55	62	69	71	70	66	61	62	61	62
Nº wet days /month	5	4.5	6.6	13	18.9	22.2	23.9	22.4	13.4	9.7	6.4	4.6	150.6
Evap (E) mm	75.9	103.7	148.8	123.5	88.2	55.9	49.3	51.3	64.5	81.4	72	70.6	985.1
0.8 Evap (E)mm	60.7	83	119	98.8	70.6	44.7	39.4	41	51.6	65.1	57.6	56.5	
Rainfall mm	30.2	36	50.7	151.8	214.3	351	364.9	359.4	156.4	97.7	55.5	23.8	1891.7
(0.8 E) - R = I_L mm	30.5	-47.6	-68.3	+53.0	+143.7	+306.3	+325.5	+318.4	+104.8	+31.6	-2.1	-32.7	108.6
Deficit/Surplus	-	-	-	+	+	+	+	+	+	+	-	-	108.6**

Extreme minimums– 1.5℃ for Yen Chau (Dec and Jan), and 1.3℃ for Tua Chua

** Deficit to be made up (water requirement)

Source: Meteorological data of Vietnam Climate 1989 (for varying records ranging from 1957–1985 to 1979–1985)

Table 3. *Potential Tree Fruit Crops for Yen Chau and Tua Chua as determined by using the Mean Monthly Minimum Temperature for the Coldest Month (January) and Table 1.*

Potential Crop List for Yen Chau 300 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 11.7ºC for Potential Commercial Production	**Potential Crop List for Tua Chua 800 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 10ºC for Potential Commercial Production**
Abiu	Abiu
Acerola	Acerola
Babaco	Babaco
Banana	Banana
Bell Fruit	Bell Fruit
Black Persimmon	Black Persimmon
Blueberry (L. Chill)	Blueberry (L. Chill)
Canistel	Canistel
Carambola	Carambola
Casimiroa	Casimiroa
Cherimoya	Cherimoya
Custard Apple	Custard Apple

Guava	Guava
Jaboticaba	Jaboticaba
Jak Fruit	Jak Fruit
Longan	Longan
Loquat	Loquat
Lychee*	Lychee*
Macadamia	Macadamia
Mammey Sapote	Mammey Sapote
Mango	Mango
Mulberry	Mulberry
Nectarine	Nectarine
Papaya	Papaya
Persimmon	Persimmon
Peach	Peach
Pineapple	Pineapple
Pummelo	Pummelo
Sapodilla	Sapodilla
Sweet Bamboo**	Sweet Bamboo
Tamarind	Tamarind
Wampi	Wampi
Wax Jambu	Wax Jambu
Aloe vera	Aloe vera
Passionfruit (P. edulis and hybrids)	Passionfruit (P. edulis and hybrids)
Additional Fruits which may be grown in Yen Chau, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I**
Apple	Apple
Apricot	Apricot
Asian Pear	Asian Pear
Avocado	Avocado
Chestnut	Chestnut
Citron	Citron
Grape	Grape
Grapefruit	Grapefruit
Japanese Apricot	Japanese Apricot
Lemon	Lemon
Mandarin	Mandarin
Orange	Orange
Pear	Pear
Plum (Japanese and Wild local)	Plum (Japanese and Wild local)
Pomegranate	Pomegranate
Rough Lemon	Rough Lemon
Santol	Santol
Tahiti Lime	Tahiti Lime
Tangelo	Tangelo
Tangor	Tangor
Walnut	Walnut

**Sweet Bamboo, although not a fruit, has been added to the Potential Fruit Crop list, as it combines well with fruit crop production, marketing and processing in highland areas of tropical Asia.

As indicated, the above is a list of Potential Fruit Crops that may be grown in the defined regions. It is important to remember that, the Table 3 list does not represent the Actual crops with Commercial Value that should be developed in the region. It is important to note that in both districts, based on temperature, the Potential Fruit Crop range is essentially the same. However, while this is so for some crops the cultivar range will be wider in one district than the other and some crops will grow better in one district than the other based on various microclimates in the each district.

Note: Appendix I contains some temperature models which can be used to identify potential low-chill stone fruits and pome fruits, sites for multiple cropping of apple and peach, and sites for high-chill stonefruits and pome fruits sites. These models show that by taking the Mean Temperature for the coldest month of January for Yen Chau (15.8° C) and Tua Chua (13.7℃)and reading off the Accumul ated Chill Unit in Figure 1 of Appendix I Yen Chau has approximately 180-200 Chill Units at 300 m.a.s.l. and an estimated 400 Chill Units at 900 m.a.s.l. Tua Chua approximately 280-300 Chill Units at 800 m.a.s.l. and an estimated 580 Chill Units at 1500 m.a.s.l. Then consulting Table 6 of Appendix I shows that it is possible to grow a wide range of Apple, Pear, Asian Pear, Apricot, Nectarine, Plum, Persimmon and Peach cultivars in both Yen Chau and Tua Chua districts.

Altitude ranges in the various communes of Yen Chau district from approximately 300-900 m.a.s.l., while in Tua Chua the range is from 700-1500m. As altitude affects temperature Table 4 has been prepared for altitudes of 900 m.a.s.l. and 1500 m.a.s.l. the two extremes for both districts. Temperatures have been reduced by 0.6℃ for each increase of 100 m.a.s.l. for each district.

Table 4. *Potential Tree Fruit Crops for Yen Chau and Tua Chua as determined by using the Mean Monthly Minimum Temperature for the Coldest Month (January) and Table 1.*

Potential Crop List for Yen Chau 900 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month estimated at 9.4ºC for Commercial Production-	**Potential Crop List for Tua Chua 1500 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 5.8ºC for Commercial Production**
Acerola	Blueberry (L. Chill)
Babaco	Casimiroa
Banana	Cherimoya
Black Persimmon	Loquat
Bluebery (L. Chill)	Mulberry
Canistel	Nectarine
Carambola	Peach
Casimiroa	
Cherimoya	
Custard Apple	
Guava	
Jaboticaba	
Longan	
Loquat	
Lychee*	
Mammey Sapote	
Mango	
Mulberry	
Nectarine	
Papaya	
Persimmon	
Peach	
Pineapple	
Pummelo	
Sweet Bamboo**	
Wampi	
Aloe vera	
Passionfruit (P. edulis and hybrids)	
Additional Fruits which may be grown in Yen Chau, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I**
Apple	Apple
Apricot	Apricot
Asian Pear	Asian Pear
Avocado	Chestnut
Chestnut	Citron
Citron	Grape
Grape	Grapefruit
Grapefruit	Japanese Apricot
Japanese Apricot	Kiwi Fruit
Lemon	Lemon
Mandarin	Mandarin
Orange	Orange
Pear	Pear
Plum (Japanese and Wild local)	Plum (Japanese and Wild local)
Pomegranate	Pomegranate
Rough Lemon	Rough Lemon
Tahiti Lime	Tahiti Lime
Tangelo	Tangelo
Tangor	Tangor
Walnut	Walnut

It is notable form Table 4 above, that as altitude increases and temperatures fall the tree fruit crop range decreases considerably, compared to lower altitudes in Table 3.

Again, it should be remembered that temperature and altitude limitations are only a 'Rule of Thumb' guide that need some intelligent interpretation, when specific crops are considered for Commercial Production.

Summarising, for the present, Mean Minimum Temperatures for the Coldest Month (January), are perhaps the best and simplest model presently available for determining where tropical and sub-tropical fruits may be grown. Elevation also provides a guideline, but is likely to be less reliable due to site to site variations at the same altitude, especially in very broken mountainous country such as in Vietnam, N. Thailand and parts of Laos.

This 'Rule of Thumb' method is not perfect, and needs to be applied with some knowledge about the individual crops. However, with intelligent use of the model, combined with other known limiting factors, such as frost, humidity, water supply, high temperatures, rain at flowering and so on, we can predict with reasonable accuracy which crops can be grown in the two districts. For more details about crops and their tolerance of various environments, and edaphic factors, such as minimum temperature (survival, growth), maximum temperature, drought tolerance, frost tolerance, drainage tolerance, pH tolerance and so on, see Hackett and Carolane (1982) and Ecocrop 1 an interactive computer database, released by FAO in December 1996.

Other Climatic Components are considered in the following sections. (These components are important in determining the Commercial Success of Potential Fruits, rather than in developing the Potential Lists above).

3.6 Water supply and Long Term Irrigation Requirements (I_L)

1. Water Supply, (Rainfall, Evaporation and Water deficit), are topics that can be treated as a group. Hackett (1988), treats this topic in some detail.

2. Excessive Rainfall may cause problems with flowering, pests and disease, fruit quality at maturity and water-logging. Many tree fruits require a period of dry and/or cold to stop growth and allow flower initiation to occur. If these conditions are not met, trees may fail to flower completely or adequately. High water tables may also stop trees from being stressed when needed to induce flowering in tree fruits.

3. Waterlogging is especially important in crops such as Avocado, Citrus, Lychee, Peach, Pineapple, etc., where longer term waterlogging causes death by anaerobic soil conditions, or pre-disposes plants to disease. If soils are well drained, waterlogging should be rare, unless high water tables are present.

Water Deficits can be calculated by many methods, taking into account, rainfall, evaporation and soil water storage, (see Hackett, 1988). Weekly data produce more accurate calculations. Monthly data often indicate that demand for water is much less than it really is.

For tree fruits, where under-tree irrigation is often used, as this method is the most efficient in applying water, the formula below can be used to calculate water requirements and irrigation demand, (Chapman and Turner, 1990), and, using various factors, modified for sprinkler or flood irrigation. Chapman and Turner (1990), give a detailed treatment of water requirements of plants, including Peak Irrigation Requirements and Long Term Irrigation Requirements. The latter is of chief consideration here and may be calculated as follows for under tree (Localized Irrigation Systems).

3.7 Long term irrigation requirement

$(I_L) = F2\ F3\ F1\ (0.8\ E_{USPAN} - \text{Rainfall})$ (mm/year)

where:

- E_{USPAN} is monthly, (or better still), weekly average evaporation from a US Class A Evaporation Pan.
- 0.8 is the factor relating evaporation from a free water surface to a US Class A pan.
- F1 is a crop factor (use only if known - if not known assign a value of 1.0)
- F2 is a factor, to allow for deep percolation losses by various types of irrigation systems and soil types, (for clay loams and loams F2 = 1.0).
- F3 is a factor for evaporative loss of water applied; for localised (drip, trickle and mini-micro jet irrigation) F3 =1, or 1.25 for spray irrigation.
- Rainfall is actual monthly rainfall (use 30 year average if available) or better still weekly rainfall.

For the example, (I_L) simplifies to:

$I_L = (0.8\ E_{USPAN} - R) \times A$

where A = Area of land irrigated, e.g. Hectares or Rai (1 Rai = 1600m²)

The sum of I_L's for each month are added, to provide a yearly Long Term Irrigation Requirement.

For assessing Storage Requirements and Annual Water Allocations, I_L values are used with probability data to determine these values. See calculations in Table 2 above.

For Yen Chau the Long Term Irrigation Requirement is 290.9 mm per year or 2.9 Mega Litres of water per Ha per year for the six month deficit period of November to April.

For Tua Chua the Long Term Irrigation Requirement is 180.6 mm per year or 1.8 Mega Litres of water per Ha per year for the five month deficit period of November to March.

However, in reality for tree crops water may be only needed for 2-3 months per year as Stored Soil Water will take care of at least November and December. In addition, many fruit trees will not need water in the really cold months of December and January as trees at this time are at vegetative rest, which is a prerequisite for flowering, (exceptions being Sour and Sweet Tamarind). From flowering onwards in a number of crops soil moisture will be critical especially during February, March and April.

With horticultural crops, values of product are higher, and net returns per Ha are much greater than for all field crops and cereals, thus the reliability of the storage or allocation, has to be very much better. A 1 in 10 year failure is usually acceptable for horticulture crops, while for field crops and cereals, designs usually plan for a 1 in 4 failure or shortfall in supply.

The Long Term Water Requirement (IL) Calculated above is the requirement if the whole area (one hectare or 10,000 sq.m.) is watered on the surface.

For trees using microjet or minispray localised irrigation systems the water requirement of fully developed trees, which rarely cover more than 50% of the area is much less. When the Ground Cover Factor (Chapman and Turner, 1990) is taken into account, e.g., for 100% application efficiency and ground cover of 50%, water requirement is 75% of the calculated IL above.

Where flood irrigation systems are involved in applying water, IL may vary from 20% to 100% more than the IL calculated above, as water percolation losses, evaporative losses and water conveyancing losses may be very high in some systems. However, when just applying water to a basin the size of the canopy from a hose (as is often done in Asia) the IL values will be quite close to the actual use.

In the above calculation we have neglected Soil Water Storage and included light falls of rain which may be ineffectual. However, once the effective root zone is wet (say 1.5m for many trees) any excess is lost to deep drainage and run-off. A Water Balance approach using Soil Water Storage, may reduce the above values even further, as I have noted above.

Evaporation

Where evaporation data are unavailable from Standard U.S. Class A Evaporation Pans or records, other methods can be used to calculate crop evapotranspiration from standard meteorological data to give crop water requirements. Doorenbos and Pruit, 1977 give detailed standard methods for making such calculations.

Where only limited meteorological data are available, evaporation may be calculated roughly using a "Rule of Thumb" formula below:

E = 0.5 Tm

Where:

- E = Monthly Evaporation in cm
- Tm = Mean Monthly Temperature in Degrees Celsius

Special Note

The Climatic Data available for Yen Chau and Tua Chua to make the above calculations were only complete up to 1985 for periods ranging from 1957-1985 and 1979-1985. There is probably far less forest cover now in the watershed than in 1985 and perhaps the rainfall now is 20-30 percent less than in the years leading up to 1985 and temperatures have probably risen by a few degrees, as the author has witnessed in the nearby Boloven's Plateau in Laos as a result of deforestation around Paksong.

3.8 Slope, aspect, wind protection

Slope

The Thai-Australia HASD Project has developed land use categories based on land use options and slope percentages. Such options include perennial tree crops viz:

Slope percent	Options	Land use options
0-5%	All	1 Paddy
6-15%	2,3,4,5,6,7	2 Terraced Paddy
16-35%	3,5,6,7	3 Pasture
36-55%	3,6,7	4 Fish ponds
56-85%	7	5 Field Crops
> 85%	7	6 Tree Crops
		7 Forest

Source: TA-HASD Watershed Development Programme-Principles and Practices, 1991.

Thus, using the above guideline, perennial tree fruit crops, may be utilised in areas where slopes range from flat land (0%) to 55%. Unbroken slopes of less than 15% are preferred for machinery operations in tree crops, if mechanisation is envisaged. The same guideline may be used for the upland sloping lands of Yen Chau and Tua Chua, provided topsoils are reasonably deep—1m or more.

All slopes require soil conservation interventions such as contoured grass strips, graded layouts, interception drains, ground cover, waterways, platform terraces, bench terraces, etc., and such technology is well developed. However, in many areas throughout the tropics, such soil conservation measures are not used and erosion of soils may be very serious, e.g., in Lao, Vietnam, Indonesia and parts of N. Thailand. In the project areas of Yen Chau and Tua Chua few soil conservation measures are currently used, erosion is often severe and as a result fertility is declining as little or no fertiliser is used.

There are many views on what is the best intervention measure to be used. The answer is that the option chosen should provide the farmer with what he needs and can afford and act as a true erosion control intervention. The task of the project and MARD hand-in-hand with farmers on-farm, is to advise on the pros and cons of the various options to provide farmers with a choice, dependent on individual circumstances. As Bunch (1997) has stated farmers can do a lot of their own experimentation if simply provided with some ideas and/or seeds. Many different erosion control measures were observed in both Tua Chua and Yen Chau. However, in many instances interventions were not being effective in providing true erosion control.

If tree fruits are to be established on sloping land then a very effective intervention will be grass strips which are quick and relatively cheap to establish and really do trap higher fertility topsoil and water moving down the slopes, and in 3 years develop into the beginnings of a simple bench terrace 50-75 cm deep uphill of the grass strip. This simple terrace will greatly benefit the establishment of the fruit trees, as we found in Thailand and make future management of the trees much easier as the operations of pruning, thinning, weeding, mulching, spraying, harvesting etc., can be performed easily while standing vertically. Intercropping of the trees can continue for some years if desired, or alternatively a permanent legume ground cover may be established in the inter-row space.

If legume tree (Gliricidia, Leucaena, Calliandra, Sesbania, Tephrosia etc.,) hedgerows are to be used, again they must first and foremost provide erosion control. Many of the hedgerows seen in the Song Da watershed were not providing such control. Legume trees will in the longer term tend to compete with the fruit trees if used exclusively and it is more desirable to use them as perimeter fences around fields, houses, lanes etc., or maybe one in every three or four contour rows on sloping land.

Vetiver grass and Ruzi grass (Bracharia ruzariansis) have proved to be very effective for contour grass strips in Thailand. Ruzi is now less preferred as it tends to creep and spread into cultivated fields and thus needs more maintenance. The vertical spacing is 3m between contour grass strips on moderate slopes and 2m on steep slopes. With good ground cover or with In-row tillage of inter-crops a 3m spacing should be sufficient even on steep land. Vetiver grass if established properly with a 10 cm space between plants in a single row will quickly begin to trap water and soil and while the grass has limited use for handicrafts, roofing, and poor quality roughage for ruminants it is essentially almost totally non-competitive with tree or food crops, which can be grown to within a few centimetres of the grass and show no ill effects. Vetiver does not spread by seed and is tolerant of frost, fire, drought, salinity and low pH. Fire and frost tolerance may be quite important in the Yen Chau and Tua Chua districts.

More productive grasses may be grown as hedges eg. Sugarcane, Napier Grass, Mott Grass (a more digestible high yielding Dwarf Napier), King (Baner Grass) etc. Such grasses may have more application for animal feed, but they are more competitive and require fertiliser or compost inputs for best performance. Again these grasses must first and foremost provide effective erosion control. Hedges nearest to the household may be more appropriately sources of human food or fodder to reduce problems of distance, care and security.

The options are virtually endless for sloping lands and Bunch (1997) and Gibson (1997) provide many options and recommendations for hedgerows, grass strips including pastures and green manure cover crops. However, as a word of caution some tropical grasses and some tropical pasture legumes which seed profusely or scramble may become serious weeds of orchards and cultivated lands.

The In-row tillage of Bunch (1997) has a lot to commend it for inter-cropping of fruit trees and encouraging Zero Tillage practices. Non-climbing leguminous green manure cover crops are ideal in orchards provided that the area under the tree canopy is kept free of the cover crop and mulched with dry cover crop or weed residues. Ideally the cover crop should have food or fodder value for maximal benefits. A number of species mentioned by Bunch (1997) and Gibson (1997) should be tried. Mulching of fruit trees with weed and crop residues will be essential for all fruit trees in the districts, to ensure moisture conservation, reduce erosion, encourage rhizosphere microflora development and improve availability of nutrients and retain soil structure. However, the farmer needs to be aware that crop residues and weeds in the inter-row and under the trees in the dry season may provide a serious fire hazard in some of the isolated areas. Firebreaks are essential to protect tree fruits especially on sloping land.

(For extra reading on tree fruit establishment key points see Appendix I).

Aspect, Wind Protection and Relative Humidity

In the Northern hemisphere, southerly aspects are much warmer than northerly aspects, while the reverse is true in the Southern hemisphere. Thus, generally speaking Southerly slopes will be the preferred slope/aspect for tree crops in the Northern Hemisphere, unless extra chilling is being sought for a chilling requirement specie, such as stone or pome fruits.

Almost all fruit trees grow and produce more and better quality fruits when protected from winds, particularly hot dry winds and very cold winds. Thus, selection of sites protected from such winds is essential.

Generally, the winds prevailing in the hot season (March -June/July) are from the SW Monsoon, while in the wet season (April-October) are from the SE Monsoon and those in the cool season (November -March) are from the NE Monsoon. However, destructive winds from hot season storms may eddy from almost any direction especially in Tua Chua district. The districts is protected from destructive typhoons by the mountainous terrain and distance from the sea. While windbreaks are very effective for 8-10 times their height on flat to gently sloping country, hillsides of 10% slope or more are difficult to protect. Under such conditions and in exposed sites both wind tolerant species, windbreaks and pruning/support systems are needed to ensure tree survival, especially from hot season storms.

The use of windbreaks in an orchard helps to 'uncouple' the micro-environment in the orchard from the surrounding environment. Also, as the trees develop, windspeed in the orchard decreases and relative humidity increases. This is especially true in very dry monsoonal climates and in tropical/sub-tropical areas, where ambient relative humidity may be low. High relative humidity is particularly important for some tropical species such as Durian, Rambutan and Mangosteen.

Other advantages of wind protection may involve reduction in disease incidence, e.g., Black Spot in Mango in Australia, (Whiley, A.W. and Meiers, P. pers comm.), and fruit damage, e.g., Persimmon (A.P. George, pers comm.).

Windbreaks of Sweet Bamboo would be ideal around the perimeters of orchards and are productive trees for structural timber, fresh and dry food, bamboo shoot canning, and paper pulp. Tall hedgerows of bamboo on the contour may be used at spacing of 80-100m if desired.

3.9 General comments

In some locations local frosts may occur occasionally and these can be, at times, disastrous for frost sensitive species, either as killing frosts or damage at flowering time – the latter is very important with stonefruits, apples, pears, almonds etc. Thus, if local knowledge is available on where the frost-line is, frost sensitive species should not be planted below this line. Tall hedgerows which trap the downslope movement of cold air can cause frosts to occur on slopes where frosts do not normally occur.

3.10 Interim methodology summary

The Methodology presented above provides us with a Potential List of Tree Fruits for Yen Chau and Tua Chua districts at a range of altitudes. This is the first step in developing new fruits in new regions. The next steps are to:

- define Criteria for Selecting Fruits with Commercial Value (Economical Potential), for Commercially Successful Development in each location, and
- select fruits with Commercial Value (Economic Potential) from the Potential List, for Commercially Successful Development or household use in each district.

Note: Details of these next steps are given in Appendix I. A Methodology is given for selecting fruits with Commercial Value, from a Potential List, for Commercially Successful development in a given district or region. The Methodology follows a number of defined steps, and uses the Lower North of Thailand example to illustrate actual constraints and opportunities at a local regional level. The Methodology draws upon the studies of Hackett (1988), criteria of Cull (1984), and actual assignments in Indonesia, Chapman (1986); Laos, Chapman (1992 and 1993); Sri Lanka (Chapman and Pinto (!992); Thailand, Chapman (1993A, 1994A); and Pakistan, Chapman (1994).

4. Methodology—selecting fruits with commercial potential for commercially successful development in given regions

Selecting tree fruits of **Commercial Value for Commercially Successful Development** in a given region involves a number of sequential operations, viz:

1. Generate a Potential List of Fruit Species.
2. Apply Selection Criteria to determine Commercial (Economic) Potential of potential species.
3. Develop Specific Criteria for determining Commercial Success of tropical fruits in a given region, and apply to the list of fruits with good Commercial Potential. Apply Liebig's Law of the Minimum.
4. Define Development Opportunities and Potential Problems/Constraints of fruits most likely to be Commercially Successful in a given region.
5. If appropriate, list General Key Extension Points required to ensure Commercial Success of tree fruits in a given region, (usually an essential step in Developing countries).

4.1 Generating a list of potential tropical fruit species

Specific Lists of Potential Tree Fruit species have been developed for a specific regions using the ADZ, Soils, Climate, Water supply, etc. sieving approach, as given above for various altitudes in Yen Chau and Tua Chua, **Tables 3 and 4** above.

4.2 Selection criteria for determining commercial (economic) potential of fruits for development

For the Potential Tree Fruit Lists (**Tables 3 and 4**) the next step is to decide which fruits have **Commercial (Economic) Potential** for development. Cull, (1984), has listed the factors important in assessing the Commercial Potential of tropical tree fruit species for Australian horticulture. This extensive listing may be summarised as follows:

Fruit for development should possess:

- Good Consumer Potential
- Good Product Marketing Characteristics
- Good Environmental Adaptability
- Good Production Potential
- Good Economic Potential
- Other Uses

Cull (1984), further sub-divides these factors into broad categories (listed), and sub-components (not listed), as follows:

Consumer Potential

- Quality
- Buyer Confidence
- Market Development
- Competition with Other Fruits
- Place in Dietary Chain
- Ease of Consumption
- Ability to Promote
- Ability to Sell on Particular Markets
- Processed Product Market

Product Marketing Characteristics

Fresh Fruit

- Fruit Life
- Fruit Storage
- Packaging
- Transport
- Trade Barriers

Processed Fruit

- Type of Supply
- Type of Processing
- Processing Plant Siting

Environmental Adaptability

- Ability to Adapt to a Wide Range of Climates
- Ability to Adapt to a Wide Range of Soils
- Ability to Extend Production Season

Production Potential

- Bearing Capacity
- Tree and Crop Management
- Crop Loss
- Ease of Harvesting

Economic Potential

- Likely Grower Returns
- Capital Investment
- Integration with Established Crops

Other uses

- Pharmaceutical Drug Potential
- Timber
- Processing of Discarded Parts
- Ornamental Appeal
- Back-yard Production

If we use these factors as a "check list" for thinking, rather than comparing scores between one crop and another, we readily come to a conclusion about the likely Commercial Potential of a tree fruit specie. (For further reading, see Cull, 1984). Popularity of various species elsewhere in the World may be an indicator of good Commercial Potential. Applying the above Criteria to the Potential Lists of tree fruits in Tables 3 and 4 produces the following lists of fruits with Commercial Potential for the various altitudes, Tables 5 and 6 below.

Table 5. *.Potential Tree Fruit Crops with Good Commercial Potential for Yen Chau and Tua Chua as Determined by Applying the Criteria Above to the Potential List of Table 3 Above.*

Fruits with Good Commercial Potential for Yen Chau 300 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 11.7ºCFruits with Good Commercial Potential for Tua Chua 800 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 10ºC	
Banana	Banana
Blueberry (L. Chill)	Blueberry (L. Chill)
Carambola	Carambola
Cherimoya	Cherimoya
Custard Apple	Custard Apple
Guava	Guava
Jak Fruit	Jak Fruit
Longan	Longan
Loquat	Loquat
Lychee*	Lychee*
Macadamia	Macadamia
Mango	Mango
Mulberry	Mulberry
Nectarine	Nectarine
Papaya	Papaya
Persimmon	Persimmon
Peach	Peach
Pineapple	Pineapple
Pummelo	Pummelo
Sapodilla	Sapodilla
Sweet Bamboo**	Sweet Bamboo
Tamarind	Tamarind

Passionfruit (P. edulis and hybrids)	Passionfruit (P. edulis and hybrids)
Additional Fruits which may be grown in Yen Chau, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I**
Apple	Apple
Apricot	Apricot
Asian Pear	Asian Pear
Avocado	Avocado
Chestnut	Chestnut
Grape	Grape
Grapefruit	Grapefruit
Japanese Apricot	Japanese Apricot
Lemon	Lemon
Mandarin	Mandarin
Orange	Orange
Pear	Pear
Plum (Japanese and Wild local)	Plum (Japanese and Wild local)
Pomegranate	Pomegranate
Rough Lemon	Rough Lemon
Santol	Santol
Tahiti Lime	Tahiti Lime
Tangelo	Tangelo
Tangor	Tangor
Walnut	Walnut

Table 6. *Potential Tree Fruit Crops with Good Commercial Potential for Yen Chau and Tua Chua as Determined by Applying the Criteria Above to the Potential List of* ***Table 4*** *Above.*

Fruits with Good Commercial Potential for Yen Chau 900 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month estimated at 9.4ºC Fruits with Good Commercial Potential for Tua Chua 1500 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 5.8ºC	
Banana	Bluebery (L. Chill)
Bluebery (L. Chill)	Cherimoya
Carambola	Loquat
Cherimoya	Mulberry
Custard Apple	Nectarine
Guava	Peach
Longan	
Loquat	
Lychee*	
Mango	
Mulberry	
Nectarine	
Papaya	
Persimmon	
Peach	
Pineapple	
Pummelo	
Sweet Bamboo**	
Passionfruit (P. edulis and hybrids)	
Additional Fruits which may be grown in Yen Chau, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I**
Apple	Apple
Apricot	Apricot
Asian Pear	Asian Pear
Avocado	Chestnut
Chestnut	Grape
Grape	Grapefruit

Grapefruit	Japanese Apricot
Japanese Apricot	Kiwi Fruit
Lemon	Lemon
Mandarin	Mandarin
Orange	Orange
Pear	Pear
Plum (Japanese and Wild local)	Plum (Japanese and Wild local)
Pomegranate	Pomegranate
Rough Lemon	Rough Lemon
Tahiti Lime	Tahiti Lime
Tangelo	Tangelo
Tangor	Tangor
Walnut	Walnut

Note: All of the above fruits, listed in Tables 5 and 6, could be grown commercially at the altitudes specified in Yen Chau and Tua Chua. However, **at the present time** there are many constraints to commercial production and by applying the Specific Criteria for Determining Commercial Success of Tree fruits in a Given Region, **Section 3.** below, a short list of fruits (Tables 7 and 8) for development is produced for the various altitudes in the two districts. As circumstances change, infrastructure improves, technical information and better cultivars become available, R&D is more complete, and cool chain transport, processing and post harvest management etc., etc., improve, many more fruits may be developed for commercial marketing and processing in Yen Chau and Tua Chua districts and other districts in the Song Da Watershed.

4.3 Specific criteria for determining commercial success of tree fruits in a given region

Agro-ecological Criteria

- Likely altitude range (m)
- Specific climatic requirements or constraints
- Specific soil limitations
- Topographic limits (slope, aspect, wind protection)
- Irrigation requirement and level
- Known crop performance in the districts of Yen Chau and Tua Chua Districts or similar AEZ's

Socio-economic Criteria

- Future market potential (local, domestic, export) forecasting.
- Presence/absence of niche or out-of-season market when grown in the districts of Yen Chau and Tua Chua (competition with other areas and other fruits).
- Import substitution opportunities.
- Infrastructure requirements for production, post-harvest management, processing, distribution and marketing.
- Road access (all seasons) required: good, poor, nil.
- Incentives for development.
- Development policy (political will).
- Investment support/credit availability.
- Government strategy/tactics for development.
- Management level required (high, medium, low).
- Availability of fertilisers and essential agro-chemicals.
- Availability of desired cultivars and rootstocks.
- Level of agro-chemical (pest and disease management) and fertiliser inputs required.
- Post harvest management, treatment and packaging level requirement.
- Harvesting time and length of harvest season.
- Farm gate price.
- Number of years to break-even on investment.
- Comparative regional advantage.
- Gross margin and returns to capital and labour inputs.
- Productive life in years.
- Risk of recouping investment and sustaining profit.
- Inter-cropping potential.
- Diversification potential.
- Mixed orchard potential.
- Consumption patterns and market demand.
- Current production and market supplies.
- Direct costs of distribution.
- Politics of trade and protectionism.
- Importance of the crop for food security.
- Importance of the crop as cash income for farmers.
- Importance of the crop in environmental sustainability.
- Likely equity or percent of small farmers growing the crop.

Technical Criteria

- Completeness of R & D in region and elsewhere
- Extension information available (worldwide)
- Research, development, extension support available
- Probability of needed R & D success
- Economic efficiency of R & D
- Expected adoption rate of technology developed by R & D
- Expertise, facilities and costs of R & D needed

When the above criteria are applied to the fruits with Good Commercial Potential that may be grown in Yen Chau and Tua Chua (Tables 5 and 6 above) the crops most likely to be commercially successful in the region reduce to the lists contained in Tables 7 and 8 below.

Table 7. *Potential Tree Fruit Crops with Good Commercial Potential and Good Prospects for Commercial Development in Yen Chau and Tua Chua Districts as Determined by Applying the Specific Criteria for Determining Commercial Success in a Given Region (Section 3 Above) to the Potential List of Table 5 Above.*

Fruits with Good Commercial Potential and Good Prospects for Commercial Success in Yen Chau at 300 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month 11.7ºC	**Fruits with Good Commercial Potential and Good Prospects for Commercial Success in Tua Chua at 800 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest**

	Month 10ºC
Banana (Specific Cultivars only)	Banana (Specific Cultivars only)
Jak Fruit	Jak Fruit
Longan	Longan
Lychee*	Lychee*
Macadamia	Macadamia
Nectarine	Nectarine
Persimmon	Persimmon
Peach	Peach
Pummelo	Pummelo
Sweet Bamboo	Sweet Bamboo
Tamarind	Tamarind
Additional Fruits which may be grown in Yen Chau, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I**
Avocado	Avocado

Table 8. *Potential Tree Fruit Crops with Good Commercial Potential and Good Prospects for Commercial Development in Yen Chau and Tua Chua Districts as Determined by Applying the Specific Criteria for Determining Commercial Success in a Given Region (**Section 3** Above) to the Potential List of **Table 6** Above.*

Fruits with Good Commercial Potential and Good Prospects for Commercial Success in Yen Chau at 900 m.a.s.l. Mean Minimum Monthly Temperature for the Coldest Month estimated at 9.4ºC Banana	Nectarine
Longan	Peach
Lychee*	
Nectarine	
Persimmon	
Peach	
Pummelo	
Sweet Bamboo**	
Additional Fruits which may be grown in Yen Chau , based on nearby regional observations in Thailand and Laos and Chill Unit Model of Appendix I	**Additional Fruits which may be grown in Tua Chua, based on nearby regional observations in Thailand and Laos and Chill Unit model of Appendix I**
Avocado	NIL at the present time

The Specific Regional Criteria are not used to develop ratings for each and every Potential Commercial Crop. Rather they are used to identify a Key important factors deficient in a crop or cultivar that may, in spite of all positive factors, render that crop useless or unsuitable in a given region with a given set of conditions, i.e.,

Liebig's Law of the Minimum or Limiting Factor/s.

For example, A mango cultivar susceptible to flower and fruit Anthracnose and Bacterial black Spot in a environment conducive to the disease, such as Yen Chau and Tua Chua, may totally preclude its successful cultivation, without high levels of fungicide and bactericide application from flowering to harvest, (12-14 applications may be needed). Such a cultivar would be totally unsuited to lower management levels, e.g., in Tua Chua and Yen Chau.

The reasons for excluding the following crops with good Commercial Potential for Recommended Development in Yen Chau and Tua Chua (applying Liebig's Law of Limiting Factors), are as follows:

Blueberry- because a high level of management and post harvest technology is needed and R&D is incomplete.

Carambola- fruit borer will be a major problem and a high level of post harvest management is required, while little is known of cultivar performance in the districts. Household production is quite possible, with fruit bagging.

Cherimoya (*Annona cherimola*) and Custard Apple (*Annona atemoya*) will probably grow well in the two districts, but because both need relatively sophisticated production and post harvest management they have been excluded at this time. Household fruit production is possible.

Guava- can easily be grown commercially with a relatively low level of management, but market demand, fruit fly control, good cultivars and low prices may restrict expansion. Red fleshed acid guavas can be processed into a range of excellent products but there is no processing facility nearby. Household production of Guava is recommended as a good Vitamin C source.

Loquat- can be grown commercially as a spring fruit. However, fruit fly, absence of good cultivars and good post harvest management and transport restrict its further development at this time. Household production with fruit bagging is possible.

Mango-further **expansion** of mango in either district **is not recommended** at this time. The climate in both districts is unsuitable for mango and is conducive to the development of the two very serious mango diseases, namely, Anthracnose and Bacterial Black Spot. In addition trees are suffering severely from tip, stem and trunk borers and leaf hoppers are present to further attack the flowers. Mango can only be successfully further developed with high inputs to improve tree health and with on-going spraying programmes to control pests and diseases. It is possible that carefully managed orchards may be successful, but the economics for green mango production will probably be marginal. Some other green mango cultivars such as Pimsen Mun and Kau from Thailand for processing and Rade and Nong Sang and Fa Lun for eating green could be introduced and tested. Keow Sawoey a green eating cultivar from Thailand is susceptible to Anthracnose. The status of the others with respect to disease tolerance is not known at this time, but may be advised in the future. Performance cannot be guaranteed in the humid climates of both districts and testing is essential.

The spraying, pruning trials being conducted in Yen Chau under direction from Phu Ho Fruit Research Centre, should give a good idea of the level of inputs needed to produce mango in Yen Chau. The days of planting mango and forgetting about the tree are gone unless pest and disease tolerant cultivars are found.

Mulberry fruit (*Morus nigra*)- is a very nice home garden, delicate fruit which is unsuited to marketing even at the village level. Household production is recommended.

Papaya - commercial production in either district cannot be recommended because of severe Necrotic Ringspot Virus, which is widespread throughout the watershed. Only recommended for household production.

Pineapple- only backyard production of pineapple is recommended and especially on the more acid soils. The rough leaf types of the Queen group will be preferred for their sweetness for fresh eating. To produce processed pineapple large tracts of gently sloping land and high technology management are needed to survive in the World market with Smooth Cayenne pineapples. Neither district can provide such land and support the construction of a high technology canning plant. The Nang Lair pineapple, from a village between Chiang Rai and Mae Sai in N. Thailand, could be grown at elevations of 200-400m to produce a large very sweet eating pineapple in small enterprise farming. Such an introduction should be made from Thailand. Recommended for household production.

Passionfruit –the purple passionfruit hybrids would grow very well in the region up to about 1200 m.a.s.l. if markets can be found. Successful Passionfruit production depends on being able to grow and market fresh fruit at a high price and have a honest processing outlet for excess and second grade fruit. Recommended for household production only at this stage.

Sapodilla-is unlikely to have any comparative advantage over other areas of Vietnam and has only limited Commercial opportunities. Sapodilla is a hardy plant and should be promoted for household use.

Apple- can be produced at all altitudes in the two districts. However, the humid climate will be more conducive to disease development and because of later maturity than plum, apricot and peach will be more susceptible to the regularly occurring hail storms in the spring. It is doubtful if the area would be able to compete successfully with imports of apples from the cooler areas of China. If tried early maturing cultivars will be essential.

Apricot and Japanese Apricot, Plum and Japanese Plum- are currently over-planted in the Song Da watershed area and further plantings should not be promoted for the present time. There are improved Apricots and Plums available that will grow in both districts. These may be gathered for testing but further plantings should be discouraged at the present time. Extension workers should acquire the technology for cottage processing of Apricots and Plums to help resolve the production wastage currently experienced. Small processors may also be encouraged to process Apricots and Plums in the districts or the provinces.

Asian Pear- grows particularly well in Tua Chua district but the quality of the fruit is considered poor and their is virtually no market for this fruit. Perhaps if some of the better early maturing cultivars were introduced and tested the Asian Pear may be able to find a market before the imports arrive from the cooler areas of China.

Grape- is not suited to the very humid climates of both Yen Chau and Tua Chua. Diseases are excessive and commercial production would be extremely difficult without very high inputs for spraying and careful management.

Grapefruit, Lemon, Orange, Rough Lemon, Tahiti Lime, Tangelo and Tangor-cannot be recommended for commercial development in Yen Chau and Tua Chua districts because of the occurrence of severe Greening Disease, which is very widespread throughout Vietnam. Tristezia, Phytophthora, and Trunk Borer simply add to the very serious Greening Disease problem that kills most trees in 2-3 years. With very high levels of management it may be possible to produce these fruits, but the economics would be very doubtful. **Pummelo** seems to be the only citrus specie that can be recommended for development in areas up to about 600 m.a.s.l. Pummelo seems to be able to tolerate Greening Disease and still produce acceptable quality and yields.

Pomegranate-is better adapted to very dry climates and productivity as well as demand for this fruit is likely to be low. Suited to household planting.

Santol- is a popular fruit in Thailand and is grown both commercially and as a housegarden tree. The tree is adaptable to a wide climatic range over 0-800 m.a.s.l. Santol trees grow to a huge size and take up a lot of room in a house garden. If people like the fruit then this is no problem. It is suggested that good cultivars be introduced for testing, before any expansion is encouraged. Santol trees grow without much care. but fruits should be bagged prior to harvest to protect against pests.

Chestnut and Walnut- may be grown for household supplies and marketing of surplus production. Chestnut is reasonably successful as a village product in the nearby plateaux of Burma. Better cultivars may be collected for testing in both districts. The main focus in the near future will probably be the village markets and larger domestic markets. Any exports will have to compete with high input farming from other countries. As nuts are high in energy and protein and can be stored they will be very helpful in raising the nutrition standards in village households.

NB. Appendix VI lists 32 fruit species currently found in Yen Chau and Tua Chua districts.

4.4 Development opportunities and potential problems/constraints of fruits most likely to be commercially successful in Yen Chau and Tua Chua districts

For the fruits listed in **Tables 7 and 8** the following Development Opportunities and Potential Problems/Constraints were identified for the districts of Yen Chau and Tua Chua. Opportunities and Constraints are region specific, i.e., they will differ from one region or AEZ to another. Such Opportunities and Constraints serve to highlight issues to be addressed by technical, (extension and research), and socio-economic interventions to ensure Commercial Success.

Table 9. *Development Opportunities and Potential Problems / Constraints of Fruits Most Likely to be Commercially Successful in Yen Chau and Tua Chua Districts.*

Development opportunities	**Potential problems / constraints**
LONGAN	
• Good processing demand for fresh, canned and dried products. • Good domestic and export market demand. • Robust, generally easy to grow fruit tree with few production problems. • Adaptable, and Yen Chau should have an advantage of being able to harvest fruit earlier than the traditional areas further North. • Established markets and production technology. • Easy to handle, transport, market fresh or processed - a versatile fruit and less perishable than Lychee. • Marketing window when grown in Highlands.	• Pest control required with most cultivars, especially Stink Bug and Stem borer, Psyllid. • Irrigation is desirable to increase yields and fruit quality. Trees require good care and fertilising for good quality and yields. • Trees requires good wind protection and support structures unless it is grafted onto seedling rootstocks. • Biennial bearing, if crop control is not practised. • Information needed on cultivar performance in the Lower North. • Selection from the vast number of seedling longans planted will be essential to standardise quality for fresh fruit and processing. • Simple drying technology must be extended. • Extension officers must be trained to do the selection work and how to graft longan. • Complete Technology information package needed along with a gross margin for longan production. • Over-production could result from over expansion in longan planting's.

	• Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of planting's.
PUMMELO	
• Attractive returns, comparatively low labour inputs and easy to manage. • Good post-harvest life and handling characteristics. • Good local market prospects and possible increasing export markets and some processing. • Generally better tolerance to pests and diseases than most other citrus. • Good to moderate expansion prospects for Pummelo in the both districts for out-of-season market and for Tet.	• Irrigation is desirable for best production in the region up to about 600-800 m.a.s.l. • Deep well drained soils essential to help avoid Phytophthora Trunk/Root Rots. • Citrus Canker may need to be controlled by spraying. • Fruit wrapping is essential to avoid pest damage as fruit matures. • Planting material, free of major pests and diseases, of good cultivars needs to be used to establish new orchards. Current cultivars are not of acceptable quality. New cultivars need testing. • Complete Technology information package needed along with a gross margin for pummelo production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
SWEET BAMBOO	
• Easy post-harvest management. • Good processing demand - A preferred crop for processing. A versatile commodity that can be sold for bamboo shoots or poles and many other uses. • Easy crop to grow and manage. Drought tolerant and adaptable to wide elevation range (0-1300m). Liked by people to eat fresh or for drying and storage for the household. Tua Chua has very little natural bamboo forests, compared to Yen Chau. • No dry season irrigation requirement. • Break-even point in third year. • High returns/ha and low cost of production. • Good domestic and export markets as there is a world shortage of canned bamboo shoots.	• Palm Weevil Borer is a very serious pest of bamboo and while not seen on the visit it is probably present in Vietnam. Early and frequent harvests and other practices reduce the problem but a more complete control is urgently required. • Other cultivars need testing in the region. (Mostly the Green bamboo and not the Black bamboo was seen in the two districts. • High labour requirement could be a constraint for some farmers. • A Complete Technology information package is needed along with a gross margins for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
LYCHEE	
• Suited to altitudes from 0-1200m. Lower altitude areas in Yen Chau will produce early market fruit ahead of traditional growing areas in the north. • Simple drying technology can be used to overcome fresh fruit marketing constraints. • Can be developed for fresh fruit, domestic and export markets and processing. Good domestic demand and good prospects for increasing exports of processed products. • Returns to labour inputs and investment are good. • Thanh Hoa cultivar already performs well in the area. • Good local fresh fruit and dried product demand and good export demand, especially for dried product.	• Pest control measures for Stink Bug, Fruit Borer, Stem Borer and Erinose mite are essential. • Will require some dry season irrigation at fruit set and to fill fruit nearer to harvest. Lowland alluvial soils near to water are preferred. • New cultivars need testing in the region. Focus on early maturing cultivars such as Heung Lom for Yen Chau, late maturing cultivars for the high colder areas of Tua Chua. • Good post-harvest management is essential along with good packaging for fresh fruit marketing. • Extension staff must be trained to graft lychees and how to help selected farmers establish a nurseries. • A Complete Technology information package is needed along with a gross margins for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
SOUR AND SWEET TAMARIND	
• A versatile largely drought tolerant plant. • World market potential could readily be expanded. • Easy plant to grow with good prices for the product. • Easily stored and transported with long post-	• Cultivar selection is important for quality, yield and reduced fruit splitting. New cultivars must be acquired and tested. • Pests may be important in some areas, including leaf webbers.

harvest life and a number of processed product options • No dry season irrigation requirement. • Good yield potential. • Dry season harvest period. • Suited to inter-cropping or grazing between trees. • Adaptable - (0-1200m altitude range) • Sour Tamarind is easy to process at the village household level into a range of value-added products.	• More information needed on performance and management in the two districts. • Yields will be down in very dry areas and would benefit from limited irrigation and planting in areas with contour grass strips. • Development of better export markets needed. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
BANANA	
• The ABB banana cultivar Day (meaning Foreign) is similar to Pisang Awat is adapted to the sloping lands of both districts up t o 800-900 m.a.s.l. It is more tolerant of Fusarium in the cooler climate and does not appear to succumb to Bunchy Top. • Opportunities exist in the area for expansion of Day banana to replace Cavendish and others. • Bananas provide much quicker returns than other tree crops and may be grown as a nurse crop for more permanent tree crops. • Banana gives a relatively good return to labour and management. • Local demand and exports of fresh fruits from Lai Chau to China can be expanded, if quality is improved.	• Longer term production trends and market prospects need to be well researched before wholesale expansion of plantings are promoted in the project area. • For good commercial production banana needs well drained soils at least 1.0m deep. • The Goldfinger high quality hybrid banana should be introduced and tested in both districts. Goldfinger's resistance to Fusarium will stop the spread of this serious disease in the watershed. • Better packaging for transport to Hanoi is essential to reduce post harvest losses. • Planting of banana on the contour above grass strips should be encouraged to reduce soil and water loss on sloping land. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
JAK FRUIT	
• Easy plant to grow and widely adaptable to a range of climates • A hardy plant suited to rainfed conditions-often grown in back-yards of houses • No irrigation required but irrigation will increase yield and fruit quality • Good yield potential • Can be grown on boundary lines as a windbreak or inter-cropped at wide spacings • Can be eaten fresh or processed • Easy to transport • Well known cultivation practices • Reasonably low input requirements	• Stem and trunk borers and fruit borers can be a problem in some areas. • Marketing opportunities and existing production in need close examination before recommending major extension of plantings. • Propagation of better cultivars by grafting should be undertaken. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production.
MACADAMIA	
• Good long-term export market prospects. Crop is undersold in the World market. Attractive prices for the product. • Performs well in rainfed areas of nearby N.Thailand in the highlands. • Domestic market currently under-supplied • High Gross Margin returns at maturity. Low-moderate labour input and high return to labour inputs. • Easy simple crop to manage in the highlands. • High value product able to be stored for long periods if desired. • Adaptable -Altitude range 400-1300 m.a.s.l., best performance likely above about 500-600m. • Pest and disease sprays are unlikely to be needed if performance in Thailand is a good guide. • Suited to both small farms, household gardens and plantations. • No competition from any areas in Vietnam.	• Good cultivars not yet evaluated in the Project areas. Such cultivars will need to be imported, preferably from Australia. • Nurseries must be established and care must be taken in the nurseries to avoid Phytophthora Trunk Canker. • Local Demand may be good but not large, initially.. • Rats and squirrel damage can be serious and prevention measures will be essential. • Export market from Vietnam must be developed. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production. • Irrigation will improve yields and fruit quality. • Fertiliser inputs will generally be required. • Training of extension workers and farmers in propagation, nursery

	management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
PERSIMMON	
• Good domestic market demand. • Good export and domestic markets for dried persimmon. • Simple drying technology that ids suited to household processing. • Best altitude range from 500-1500 m.a.s.l. • High priced product with a good return to labour inputs. • Will mature before Chinese competitors.	• More cultivar evaluation trials needed in the region. • Require careful attention to produce high quality fresh fruits. • *Diospyrous kaki* (Oriental persimmon) should be used as the rootstock for both astringent and non-astringent cultivars as it is more compatible with scions and is resistant to Crown Gall. • Sprays needed for fruit fly or fruits must be bagged before colouring begins. • Pollinator cultivars must be planted with producing plants. • Damage from birds can be serious and may need control measures. • Irrigation and fertilising is recommended. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.
PEACH and NECTARINE	
• Future market potential should be good as incomes in Vietnam rise. • Peach even in the immature form is readily processed into a number of oriental products by drying, salting or syruping. • Peach and Nectarine are harvested in the dry season and can be more readily transported over poor roads than in the wet season at present. • Processing is simple for peach and can be easily adapted to household or cottage industries. • Good scope to grow a wide range of new high quality low chilling cultivars of peach and nectarine n the districts of Yen Chau and Tua Chua. Such peaches and nectarines will be in the market place well ahead of the traditional cooler areas of China. • Possible exports of high quality early fruit to China. • No competition from China and other lowland areas for high quality Peach and Nectarine.	• Irrigation in the dry season will boost yields probably by 30-40%. • Fruit fly , Rust and Leaf curl will require control by spraying and generally a higher level of management will be needed for new high quality fresh peaches and nectarines. • Altitude range 300-1400 m.a.s.l. • Special transport and packaging will be needed for new fresh fruit cultivars. • Short productive life 8-10 years. • Currently no processing of peach is done in the districts. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production.
AVOCADO	
• Very long harvest season of up to 11 months. • Good post harvest life and keeping quality. • Highly nutritious fruit for households. • Performs well in the highlands of the region with a relatively low level of management, but responds well to improved management. • Adaptable and will grow from 0-1200 m.a.s.l. • Better cultivars grow above 500 m. • Attractive returns to investment. • Good production potential. • Can be sold fresh or processed. • Grows well in the highlands at Son La and in nearby Thailand. • Market prospects to China could be good in the future. • No competition from other areas of Vietnam.	• Irrigation will improve performance. • Deep -1.5-2.0 m and well drained lighter soils are absolutely essential for Avocado. Soils heavier than a silty loam should not be used for Avocado. • *Phytophthora* root rot can be devastating if introduced to orchards usually by unclean nursery plants. • Good cultivars should be introduced from a clean nursery in Australia of USA. • Market development and promotion will be essential. • A Complete Technology information package on growing, processing and post harvest management is needed along with a gross margin for production. • Training of extension workers and farmers in propagation, nursery management and production, processing and post harvest technology is a pre-requisite to expansion of plantings.

4.5 General key requirements/extension points essential to ensure Commercial success of fruits in a given region

In addition to identifying specific Development Opportunities and Potential Constraints (**Section 4** above), it will be necessary, to define General Key Extension Points that will ensure Commercial Success of Tree Fruits in a Yen Chau and Tua Chua districts as new tree fruits go into adaptation/demonstration plots and begin to be planted by farmers in their fields or in the household gardens. (**Section 5. in Paper II. of Appendix I** carries a list of General Key Extension Points for Perennial Fruits. This list was established for Thailand but the guidelines are equally applicable to most developing countries wishing to develop tree fruits). Chapman (1997) has updated the original guidelines, for use in Indonesia along with illustrations and a copy of "General Key Requirements/Extension Points for Growing Tree Fruit Crops in Indonesia" Resource Booklet No. 2, copies of

which have been left with the SFDP Office in Hanoi. Extension officers in both districts should be provided with copies.

Finally, the Strategy for Development will be discussed in Section 6. below.

5. Vegetable crops for Yen Chau and Tua Chua Districts—An overview

As indicated in the Introduction, most of the agreed focus of the Consultancy has been directed to fruit trees as these pose more difficult problems with respect to testing, multiplication, development and extension , production management, post harvest management marketing, processing. Also, because trees are more costly to establish, and grow and because they are perennial wrong decisions about what trees to promote can be very costly.

However, during the Field Visits to Yen Chau and Tua Chua and observations throughout the Song Da Watershed most of the Vegetable crops being grown in house gardens in the Hot Season were:

Chilli, Shallot, Taro, Egg Plant, Choko, Cucumber, Water Melon, Tomato, Yard Long Bean, Sweet Potato, Arrowroot, *Impomea aquatica*, Luffa, Chinese Cabbage, Green Bean (Mung), with various spices such as Tumeric, Ginger and other Medicinal plants. On some occasions larger plots of vegetables were being grown near to houses in the fields adjacent to the paddy.

Currently, most vegetables seem to be produced just for the household, with some excess being sold in villages and towns. No Extension Programme is proposed at this time to expand vegetable production within the SFDP at the present time.

Vegetable production for households can be improved considerably by greater use of compost and animal manures, better quality non-hybrid seeds and planting materials and using techniques of companion planting, mixed inter-cropping to reduce pest and disease incidence, more legumes in the rotations and use of *Brassica* vegetables (Cabbages, Broccoli, Leaf Mustard, Rape Seed etc.) to reduce soil diseases. Introduction of Bio-pesticide solutions made from Neem leaves and seeds, *Stemona tuberosa*, Ginger, Citronella Grass, Siamese Ginger (Galangal), Garlic, Castor Bean Seeds, Derris roots, Papaya leaves etc. (See Bourne, 1990 for some recipes and compost making-a copy of his report is held in the SFDP office). Bourne's Vegetable Extension Handbook for the Highlands of Northern Thailand is recommended for use by Extension Officers as a Technical Support Package for Highland vegetables. It also gives an excellent treatment of Gross Margins for 38 different vegetable crops suited to Highland cultivation.

The following vegetables can be grown **all year** in the Highlands above 600-800 m.a.s.l.:

- Radish, Carrot, Sweet Corn, Head Lettuce, Green/Bush/French/Beans, Japanese Onion, Leek, Baby Carrot, Vegetable Soybean, Chinese Caggage, Purple Egg Plant, Spinach, Zucchini, Fennel, Celery, Cantaloupe, Water Melon, Tomato, Japanese Cucumber, Capsicum, Sweet Potato, Cos Lettuce, Asparagus, Spinach, Endive, Rhubarb and Globe Artichoke. Shitake mushroom can be grown on Oak logs at 800-1400 m.

For the **Wet Season** the following may be grown in the Highlands, above 60-800 m.a.s.l.:

- Beetroot, Turnip, Red Lettuce, Butterhead Lettuce, Potato, Red Cabbage, Kohli Rabi, Brussel Sprout, Capsicum, White Balsam Pear.

For the **Cold Season** the following may be grown in the Highlands above 600-800 m.a.s.l.:

- Beetroot, Turnip, Red Lettuce, Butterhead Lettuce, Red Cabbage, Brussel Sprouts, Capsicum, and White Balsam Pear, Onion, Prime Cabbage, Broccoli and Cauliflower will grow best in the Cool Season from October to March.

Cucurbit crops such as Squash, Pumpkin, Melons, Gourds, plus Chinese Mustard/Radish, Chilli, and Okra are well adapted to the **Hot Season.**

Highland Herb Crops

A number of Temperate Herb Crops can be produced in the Highland districts of the Song Da Watershed. Their cultivation will be largely determined by market opportunities and whether Ethnic people wish to use these products in the household.

Herbs such as Fennel, Mint, Dill, Chives, Bay Leaf, Rosemary, Sage, Tarragon and Thyme are perennial and should grow at altitudes above about 600 m.a.s.l. Other herbs such as Basil, Sorrel and Marjoram may also be grown in the Highlands.

In Summary, there is no shortage in the range of vegetable crops that may be grown in the Highland districts and it will be largely, market windows, access to irrigation, quality seeds and inputs, road conditions and transport times to market, post harvest management and packaging, pre-cooling, storage and availability of cool chain transport or freezing, that will determine which crops can be successfully developed. Crops with most prospects for development will be those of a **temperate** nature which have with a comparative advantage over Lowland areas near to large markets such as Hanoi and this will usually mean off-season production, particularly of the more temperate species. Initially most vegetable crops will be developed on a small scale for household use and with some surplus for sale in villages and larger towns.

N.B. It is recommended that in choosing Vegetable Crops for Demonstration site testing the above constraints and opportunities should be carefully analysed as more data become available particularly on market niches that will suit relatively isolated Highland areas.

When the roads and infrastructure improves development of vegetable crops in Highland districts will quickly outstrip the fruit tree development, both in terms of returns/ha and rate of expansion, as it did in Thailand some years ago.

Again the major pre-requisite for vegetable production on sloping land will be grass strips or similar non-intrusive hedge rows, as well as access to irrigation or mountain streams for off-season production.

Finally, at all times Extension officers and farmers should be made acutely aware of the **environmental issues** associated with increasing use of pesticides and fertilisers that will be inevitable with increased vegetable crop development in Highland watersheds.

6. Strategies for development of fruit crops in Yen Chau and Tua Chua Districts of the Song Da Watershed

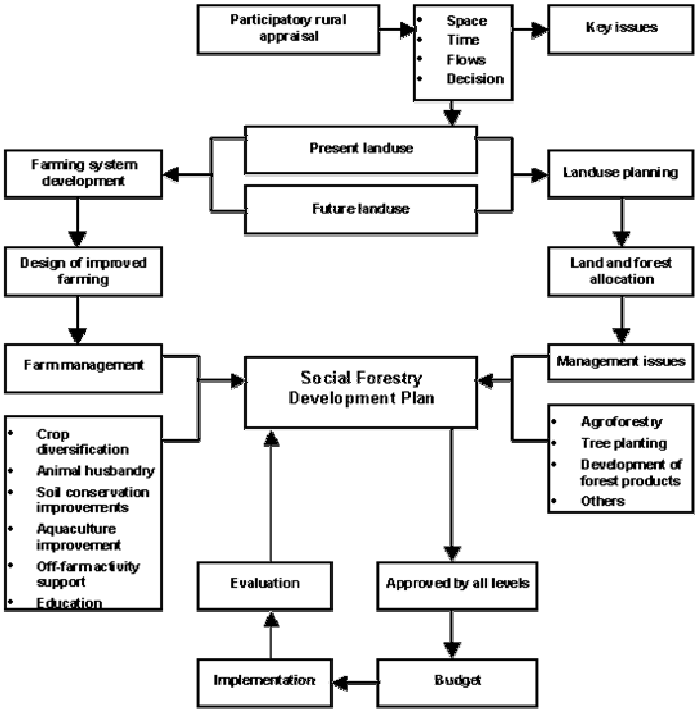
Sections 3 and 4 above concentrate on developing a List of Fruits of Good Commercial Potential with good prospect for Commercially Successful Development at various altitudes (Tables 7 and 8 above)in the Yen Chau and Tua Chua districts of the Song Da Watershed. In addition Development Opportunities and Potential Problems/Constraints to be addressed for each individual fruit crop has been summarised in Table 9.

Other fruits for household use only, have also been identified viz. Carambola, Guava, Loquat, Mulberry, Papaya, Pineapple, Passionfruit, Sapodilla, Apricot, Plum, Pomegranate, Santol, Chestnut and Walnut at the various altitudes recommended in Tables 5 and 6.

This Section concentrates on Strategies for Development of the fruits identified for Commercial Development, although many remarks will apply equally well to vegetable crop development.

Ludwig (1997) has clearly identified a **Project Development Strategy** (Figure 1 below) that nicely shows how Farming Systems Development integrates with the SFDP Social/Community Forestry Development Plan of Anon, 1994. The project intervention with fruit trees fits in with Ludwig's Crop Diversification Strategy, but must be intimately linked to Soil Conservation Strategy, as Contour Grass Strips (preferably) or Hedgerows are an absolutely essential pre-requisite for establishment of fruit trees on sloping land. Fruit tree development will also link closely to the Crop/Livestock Based Permanent Upland Farming Systems Improvement Strategy of Ludwig, particularly with respect to manure production and collection and a common linkage to grass strips. Livestock development has very good prospects for development in the Highlands and in the longer term Livestock along with Horticulture are likely to produce the best economic alternatives for agricultural development in the Highlands.

Figure 1. Project development strategy



Project interventions:	**Project intervention:**
a) On-farm trial assistance	a) Training assistance
b) Training assistance	b) Applied research
c) Extension service assistance	c) Extension service assistance
d) Market information system design	d) Market information system design
e) Opportunity cost & benefit analysis of agricultural & agroforestry commodities	e) Credit, incentive

Furthermore, the Project Interventions envisaged by Ludwig (Figure 1) will also have a central role in fruit crop development:

- On-farm trial assistance
- Training assistance
- Extension service assistance
- Market Information System Design/Use
- Opportunity Cost and Benefit analysis of agriculture and agroforestry commodities.

Based on the constraints identified in the Field Visits to Yen Chau and Tua Chua, **Table 10** below has been compiled to summarise the inputs needed to develop the 12 fruit crops identified for development these districts. **Appendix VI** lists the fruit species found in the areas of Yen Chau and Tua Chua districts.

Table 10. Summary of inputs needed to develop fruit crops in Yen Chau and Tua Chua

Fruit crop ****	Use Local Cultivars (CVs)	Introduce other Vietnam CVs or Exotic CVs in VN	Select better CVs in Districts	Introduce Improved Exotic CVs	Train Extn & Farmers in Propagation	Train Extn & Farmers in Nursery Management	Establish Mother Tree Orchards (Extn)	Establish Training Nursery (Extn)	Establish Farmers Managed Nurseries	Prep. Prod'n & P.H Mang't & Processing Tech. Packages	Prepare Gross Magin Analysis	Undertake District Adapt. Trials/Demo Plots	Train Extn & Farmers in Crop Estab. & Management	Set up a key watershed Extn Strategy for Working with Farmers	Provide Key Nursery Research & Extn Equipment & Input	Use & Train Farmers to use grass strips or hedgerow on Sloping land	Train Extn & Farmers in P. Harvest Management & Processing	Convince Govt. to Support Dev. Proces. including Credit
Banana	Yes*	Yes**	No	No	No	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Jak	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Longan	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Lychee	Yes	Yes	No	No***	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macadamia	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Persimmon	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peach	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pemmelo	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sw Bamboo	Yes	Yes	No	No	Yes	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Tamarind	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Avocado	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nectarine	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* Expand using "Tay" CV

** Bring in "Goldfinger" CV

*** Already held at Luc Ngan State Farm and Phu Ho Fruit Research Center.

**** Promote manure gathering composting and mulching to fertilize all fruit trees

NB. Further marketing studies for fresh and processed products essential for all proposed fruits for development including documentation of imports from China and Export opportunities (Dr. J. H. D Ludwig currently undertaking marketing studies for the SFDP and making a proposal to set up a Marketing Information System)

These inputs constitute the various broad tasks that must be undertaken in the SFDP on a Pilot Scale with the Agricultural Agencies, Extension in particular (with co-operation from Research Institutes and Consultants) and the Village farmers. To implement these tasks, even on the Pilot Scale envisaged there has to be People, Policy, Resources and the Technology all in place together with a Watershed Development Extension Education Process, such as given in **Appendix II** for a similar project in Thailand.

Then the linkages between Extension and Training must be developed as they are closely related (See **Appendix II** which shows such a relationship).

A Development Process then has to be set up for Key Village Demonstration Plots which lead sequentially from Evaluation Sites through a series of important steps to a Crop Expansion Phase supported by Credit, preferably from a Village Revolving Fund, managed by villagers, with initial assistance to start the fund from the Pilot Project or later from other sources.

A Cropping Option Decision Chart for Watershed Development (example for Thailand given in **Appendix II**) needs to be developed prior to setting in place Key Village Demonstration Plots that are expected to lead to Crop Expansion in the village lands.

Crop Management Field Guides/Technology Packages then have to be developed for each crop along with projected Gross Margins for each crop. The Crop Field Guides are used to prepare the Annual Detailed Action Work Plan that is budgeted and provides for recording of data on all activities. The Work Plan lists all operations from land preparation, planting, weeding, fertilising, mulching, etc., with a Diary for when the work is to be done. Rates of seeding, fertilising etc., are given along with a materials supply list for each Demonstration Plot. Budgets and work input hours, yields and returns can the be used to verify the Gross Margin and provide a guide for Credit lending to grow a particular crop.

Appendix II shows a very successful example of a Development Process Used in Thailand for Long Term Key Village Demonstrations which lead through to Crop Expansion. Key Village Demonstrations and Crop Expansion is then replicated with farmers from other villages who see and discuss the process with Key Village people to learn what they can do in a similar situation.

Appendix II also presents an example of the Activity Planning Schedule involved in the Watershed Development Process in Thailand as an example of the activities involved in developing Annual Costed Plans for Development Approval.

In summary it is recommended that SFDP set up a similar strategy supported by appropriate manuals that delineate very clearly the development steps to be followed in working through from the watershed level to the village development plan, to the village agricultural development plan, to demonstration sites and eventually the crop expansion phase supported by a Village Revolving Fund. Unless such structures and systems are firmly established now and used by Extension staff over and over, with Government and farmers gradually meeting more of the implementation and the costs, then whole process willl collapse when project support is withdrawn. Finally, such issues as labour availability, food security, risk and crop option selection must be carefully considered in the Crop Diversification Strategy and the whole Farming System.

(For Extra Reading see the Thailand-Australia Highland Agricultural Social Development Project publications: "Highland Systems Technical Manual-Long Term Village Demonstrations," October 1988, "Watershed Development Programme-Principles and Practices," April 1991, and Extension Manual, Crop Manuals, Crop Field Guides, Work Plans etc. which may still be available from AusAID in Canberra, Australia). **N.B.** Copies of the first two Manuals are held by the SFDP Project Office in Hanoi along with various Tree Fruit Field Guide examples, prepared by the author of this report.

7. Constraints to task implementation with tree fruits and/or vegetables and recommended solutions

Change in any system involves the interaction of People, Technology and Resource issues with Policy and these together form a convenient framework to examine constraints to task implementation and the evolution of recommended solutions.

People

- Yen Chau and Tua Chua have few Extension Officers that are qualified and well trained, especially in the management of tree fruits and working with farmers. These and many of the points which follow are supported in the Yen Chau Agriculture Extension Plan (SFDP Consultancy Report No. 2, April 1995).
- To implement Demonstrations and Adaptive trials and crop expansion requires a lot of technical and organisational skills that are not available in the project or indeed, probably not in Vietnam. It is **recommended** that for the SFDP to properly implement an Agricultural Program involving field, vegetable and tree fruit crops **have** on-site as far as possible an experienced **Full Time Expatriate Crops Extension Specialist** who can work almost daily in the villages with local Extension people, preferably fluent in the language. Based on a review of projected program workload perhaps one **Full Time Expatriate Extension Specialist** is needed in each district. These Extension Specialists would be expected to work on the total crop spectrum of field, vegetable, and fruit crops. Ideally, encouraging international students to undertake field studies leading to a higher degree and working with the project team would further augment to technical implementation of project tasks.
- The Extension staff and the Extension Specialist need to be supported part-time by inputs from both domestic research institutes such as the Phu Ho Fruit Research Institute and experienced Expatriate Short Term Research Specialists, according to the crop group, e.g. fruit, vegetables, field crops, and maybe mushroom cultivation and floriculture etc., in the future. Such support is **recommended.** A major task of research inputs is to prepare the essential Field guides/Technology Packages on selected crops for development. A further task will be to advise on manegement of crops, nurseries, demonstration plots, adaption trials, mother tree plots and cultivars for importation and multiplication.
- Specialised inputs will be essential from an Expatriate Economist/Marketing Specialist on assembling Gross Margins for the various crops as an aid to providing farmers with cropping options in the future. Market intelligence will be another very important task of such a specialist and a Marketing Information System will be highly desirable. It is **recommended** that such inputs proceed to support the project development programme.
- Inputs from a full-time Social Scientist maybe very important in the early stages for developing close working relationships with farmers and Extension. It is **recommended** that the need for such a person be reviewed in the light of project implementation problems as and when they arise.
- As Livestock will be an important component of the Farming Systems in both districts and will impact on horticultural development, it is **recommended** that SFDP review the need for a Full Time Expatriate Livestock Extension Specialist in the project.
- Training needs for Extension Staff for fruit crops are summarised in Table 10. Other training will involve daily work with the Extension Specialist and farmers in the villages and inputs from Short-Term Research and other Specialists, plus appropriate study tours and short courses in specialised areas such as, home processing methods, post harvest handling, extension methods etc., It is **recommended** that training proceed in the areas designated using both local and international personnel as appropriate.

Policy

- The plan to have 1000 Ha of additional fruit trees (mango, lychee and longan) by 2000 and 1500 additional Ha by 2005 in Yen Chau district needs serious debate. Of the 1500 ha 1200 ha have been planned for mango. As our findings suggest elsewhere in this document mango should not be further developed in either Yen Chau or Tua Chua because of very serious diseases and pests in a climate unsuited to mango production. It is **recommended** that the SFDP project should not include mango in any fruit tree expansion programme and that only those tree fruits listed in **Tables 7, 8 and 9** be promoted.
- For Tua Chua district we could not get data on planned fruit tree expansion, but it is recommended that this issue be followed up in the light of findings presented in this report.
- Data in the SFPD report of Rake et al 1993 are of major concern for Yen Chau and Tua Chua. The report states that Hoa Binh Province in 1993 had planned to establish 50,000 Ha of fruit tree plantations by the year 2000, of which 30% apricot, 20% orange, 20% longan and lychee, 15% banana and guava and 155 pineapple and other fruits. This large area of Lychee and Longan (10,000 Ha) if proceeded with added to the newly established 6000 Ha of Lychee in Luc Ngan ,plus large existing plantings of older trees may be a problem in the future unless aggressive domestic and export marketing are undertaken quickly and processing capacity is

expanded. Fortunately, Vegetexco already has big contracts for sale of canned lychee and lychee juice for Europe and already they have begun to export fresh lychee to Japan. Dry lychee is only for domestic consumption but there is a good demand from China for dried longan. Canned longan has an increasing market share in Europe. Thus it is **recommended** that , the marketing and processing of lychee and longan be carefully monitored as new plantings begin to come into production. It is further **recommended** that Yen Chau concentrate on planting early season cultivars of lychee and longan which are likely to mature before other regions, except perhaps Hoa Binh. For Tua Chua being much cooler it is **recommended** that they should concentrate on late season cultivars that will mature after other areas have ceased to harvest.

- It is **recommended** that future plantings of fruits in both districts should take into account other Government promotion programmes such as those of the 327 Project.
- Policy issues which relate to credit availability, setting up of Village Revolving Funds run by villagers and not bureaucrats or co-operatives, subsidies for tree establishment or assistance with post harvest management pre-packing, collection and transport should be clarified as early as possible to avoid later confusion and debate. It is **recommended** that SFDP follow up on these issues with the appropriate agencies.
- It is recommended that the policy on numbers of extension officers which can be allocated to each district and with sufficient budgets to operate effectively, once the SFDP inputs are withdrawn, should be addressed now to avoid future collapse after the project concludes.

Resources

- To implement the proposed program for fruit trees requires a deal of resources that must be allocated by SFPD and Extension Department in the two districts.

It is **recommended** that the following Essential Equipment inputs be provided for each district:

1 x Dual Cabin 4WD Pick-up utility vehicle

4 x Additional Trail Motor Bikes

10 x Grafting/Budding Knives

10 x Pairs of Secateurs

5 x Each of Spades, Hoes Rakes, Shovels, Machettes, Pruning Saws, Mattocks

1 x Tool shed/potting/storage shed for each training nursery

2 x Pumps (1 x electric and 1 x petrol engine driven)

for each training nursery 50mm suction and delivery, Total head 30 m delivering about 10,000 L/hr.

1 x Binocular Zoom Stereomicroscope for pest and disease identification

10 x 10 Power hand lenses.

2 x pH Colorimetric Test Kits

4 x Knapsack sprayers 15-18l

1 x SLR Camera with Macrozoom and flash

1 x Set of assorted glassware for simple lab tests

1 x Lab/Bench pH meter with temperature compensation and buffers plus spare electrodes

! x Voltage stabiliser for lab use

2 x Hand refractometers from 0-35 Brix

1 x Set of glassware for titrating fruit juice samples

1 x Top loading balance for weighing chemicals fruit etc, 0-500g +/- 1g accuracy.

2 x Set of Suspension Spring Scales 0-25 kg for measuring crop yields

1 x Simple drying oven for dehydration of fruits

1 x Dumpy Level and staff

1 x Clinometer for measuring slopes

2 x 100m Fibreglass tapes

1x Computer

1x Printer

1 x Phone/Fax

1 x Generator

1 x Permanent water tank at each training nursery for breakdowns in water pumps

1 x Permanent well or bore at each training nursery

1 x Photocopy machine plus additional toner etc.

1 x Conductivity meter

1 x Altimeter

1 x Overhead projector

1 x Slide Projector

1 x Video Camera

1 x Video cassette recorder/player

1 x Portable Whyteboard

5 x "A" Frames for setting out key contour lines across slopes

1 x Vernier Calipers

1 x Refrigerator

1 x Shrink wrap machine

1 x Polybag sealer

3 x Cooler boxes (insulated)

4 x Thermometers 0 - 50 ^{0} C +- 0.5

1 x Thermohygrograph

1 x Soil auger 1.5 m

1 x Small water distillation unit

1 x Water filter

- To overcome technical, project implementation constraints it is **recommended** that an **Additional** Annual Budget of not less than $70,000 per district for per diems, fuel, travel, study tours, paper, printing, consumables, seeds, purchase of mother trees, chemicals, miscellaneous shade materials, equipment items, repairs, polybags for potting, potting materials, fertilisers, nursery construction, setting up demonstration plots and mother orchards, compensating farmers for use of land and labour. (Budget to reviewed based on Annual Work Plans and may considerably exceed the above estimate)
- It is **recommended** that a Small Lab facility in each district to test fruit samples, soil, water and weigh out chemicals and fertilisers, dry fruits etc.
- It is **recommended** that funds be allocated to support the full establishment of training nursery for fruits and assistance to development of four (4) farmer run nurseries in each district, perhaps by way of credit loans for the latter. **Appendix V** lists nursery requirements needed for Yen Chau and Tua Chua districts,

Technology

- A number of the Technology Constraint issues have been addressed under the People Constraints Section above, both with respect to training and expatriate assistance in key areas. In addition it is **recommended** that a sum of at least $5000 should be set aside for each district to purchase Text/reference books, periodicals, manuals, videos etc., for upgrading the technical knowledge of Extension workers and for use in preparing training workshops for farmers. In follow up years allocate a sum of at least $2000/year.
- The senior author of this report brought a range of technical documents, manuals, field guides, reports and texts. It is **recommended** that at least two sets of these documents are provided to each district. One set for the Project office in each district and one set for Extension department in each district. In addition another set should be made available to the Phu Ho Fruit Research institute that is co-operating closely as local consultants to the project. Recommended lists of texts from which appropriate books can be selected has been left with the project. The text listings cover production, post harvest management, simple processing and nursery management.
- Procurement of improved cultivars of tree fruits is an essential prerequisite for all fruits identified for future development (See **Table 10** above). In some cases cultivars are available in the district, in others they may be brought in from elsewhere in Vietnam (See **Appendix IV)** and in still other cases selection within the districts e.g. with longan and jak fruit will be desirable. For longan, macadamia, peach, pumello, tamarind, avocado and nectarine new improved cultivars must be introduced from overseas to ensure maximum benefit is derived from the project. It is **recommended** that $15,000 be set aside for the importation of grafted mother trees and desired rootstocks and rootstock seed in the case of macadamia, peach, avocado and nectarine. At least 12 trees of each cultivar and rootstock should be purchased along with 12 kg of rootstock seeds. **Appendix III** lists important cultivars and rootstocks that should be introduced from overseas). Great care should be taken on where the plants are imported from because of the possibility of diseases and pests. Australia has the key cultivars of most of the above fruits that need to be imported except for tamarind and pummelo. Because Australian nurseries by-law must not sell diseased or pest infested nursery trees it is an ideal nearby country to import clean planting material from as Vietnam has done in the past with Lychee and citrus species and rootstocks. Tamarind can be brought in safely from Thailand , but the famous Thai pummelos should not because of the disease status. All trees should be brought in either bare-rooted or with roots in an inert material other than soil and for absolute security well packaged for carrying as accompanied baggage. When such plants are brought in to Vietnam it is **recommended** that they should not only be located in the Project District Mother Orchards but also located in the Phu Ho Fruit Research Institute, which has an excellent track record for caring for plant collections and keeping good records of the identity of fruit trees. This centre already holds the Vietnam banana collection for INIBAP the International Institute for Bananas and Plantains. Four (4) trees of each cultivar and rootstock should go to each district mother orchard and 4 tree of each to Phu Ho Fruit Research Institute. Similarly 4 kg of each roostock seed should be split up the same way. As Phu ho is already co-operating closely and very effectively with the project these recommendations should pose no problems.
- It is **recommended** that the publication by the senior author entitled "General Key Requirements/ Extension Points for Growing tree Fruit Crops in Indonesia" be especially photocopied and used to train Extension officers and farmers as a starting point in the tree crop programme. The principles apply equally well to Vietnam as Indonesia.
- For tree fruit development it is **recommended** to proceed with Grass Strips as the easiest and cheapest to establish. Also, as trees become bigger grass strips do not interfere with tree development and management. Ruzi and Vetiver grass can be **recommended** based on Thailand experience. Napier and Dwarf Napier (Mott Grass, which the consultant brought for the project to multiply and use) will provide useful options for farmers needing additional fodder. Mott is more digestible than Napier or King (Barner) Grass and is a far better fodder sources for livestock, including ruminants and pigs. Personally, I see no point in evaluating dozens of hedgerow options as there is no one answer anyway, since it will always remain a "Horses for Courses" decision. The important thing for fruit trees is to stop soil and water movement down the slope and let mini terraces form for 2-3 years behind the grass strip before planting of trees in the deeper, fertile better watered area up-hill of the strip. The unstable Grey/Brown Mudstone soils are somewhat unstable and prone to terrace collapse so only small terrace up to about 0.5m should be allowed to form on these soils and individual platform terraces with full ground cover in between may be a useful option on some of the deeper soils of this type.
- It is **recommended** that the Land Use Options used by the Thai-Australia HASD Project for very successful agricultural and forestry development in sloping land in the Highlands of Thailand, be adopted as a standard for the SFDP Pilot Project viz.

Slope percent	Options	Land use options
0-5%	All	1 Paddy
6-15%	2,3,4,5,6,7	2 Terraced Paddy
16-35%	3,5,6,7	3 Pasture
36-55%	3,6,7	4 Fish ponds
56-85%	7	5 Field Crops
> 85%	7	6 Tree Crops
		7 Forest

Source: TA-HASD Watershed Development Programme-Principles and Practices, 1991.

- As with most Shifting Cultivation Farming Systems that have had to cease and become Permanent Sedentary Upland Cropping or Mixed Farming Systems soil fertility will be an issue. Bunch (1997) and Gibson (1997) have offered ideas on how this issue may be addressed. However, whatever solution is chosen, it is **recommended** that it must involve getting legumes into the cropping rotation, whether it be field crop, vegetable crop, fruit crop or pasture. This was one of the keys to success in the highlands of Thailand.
- It is further **recommended** that composting and collection of animal manures be promoted as essential prerequisites to successful tree establishment and that mulching must be practiced along with careful weeding to ensure survival, especially in the early years.
- For longan, lychee, and high quality fresh peach and nectarine it is **recommended** that these be grown in areas near to water supplies for supplemental irrigation if and when required. This may be less important for longan which will mature well into the wet season.

- It is **recommended** that Demonstration Plots for field crops and vegetable be kept as small as possible. about 800 sq.m is ideal. In the Crop Improvement stage it is **recommended** that trial site be kept to about 3200 sq.m -100 m across a slope and 32 m down a slope on land less tha 35% slope. This site should be cropped for 3 years using where possible farmer's practice (if there is one)and the project's recommended practice. Both of the above stages should be supported with project funds and technical advice. In the first stages of Crop Expansion (3200 sq.m up to about 1.5 Ha for field and vegetable crops the project budget is used and money is returned to the Village Revolving Fund, which is managed by villagers with guidance. The next stage is further Crop Expansion with only Revolving Fund Support.
- For Tree Fruit Adaption Trials it is **recommended** that these should be kept as small as possible and spread over a range of at least three (3) altitudes, according to specie, and if practical at least two (2) major soil types, at least in some sites. Trials will usually have to be run for at least six (6) years, with at least three cropping seasons, to assess the performance of a range of cultivars. A standard 5m x 5m spacing although not ideal can be used for all tree species, for the 6 year period. To try to collect good relevant data, each plot should contain 4 trees of each cultivar with say a maximum of 4 cultivars, laid out in a Complete Randomised Block with external guard trees all the way around the trial. Thus the maximum size for a site will be 900 sq.m and involve 16 datum trees for testing and 20 external guard trees of the one cultivar. Wider spacings would be ideal but will take up more land. Adaption trials will be essential with lychee, macadamia, peach, tamarind, avocado and nectarine, and new pummelo cultivars. They are optional for Persimmon and not needed for banana, jak and longan. It is further **recommended** that these Adaption Trials be used as Demonstration Plots with close farmer involvement throughout the whole period. The task of co-ordinating and running these trials involves a huge commitment in time and inputs and while both districts will be involved the total task could involve 24 or more trials. Good on-site supervision by a full time international extension specialist with good research advice will be essential to undertake this programme.
- As farmers cannot be expected to wait for 6 years for results to arrive it is **recommended** that additional plants of each cultivar be raised at the same time as those raised for the trials and given out at cost to interested farmers, with a little information pack and /or practical verbal advice/training on how to care for the plants. The offer of trees should be on a first in-first served basis. In this way interest is generated in growing new crops and it is another way to make observations across a very wide range of sites under grower managed conditions to augment the more formal Adaption Trial work.
- It is **recommended** that the trial work on mango initiated by the Phu Ho Fruit Research Institute in Yen Chau district continue, to give some measure of the cost and possibility of controlling mango diseases and pests and the economics of such an intervention.
- Finally, it is **recommended** that inputs of chemicals be kept to a minimum, Integrated Pest Management use of Biopesticides, companion planting, rotations, zero cultivation and organic farming be practised wherever possible, and that while chemical fertilisers are acceptable they should simply be augmenting an organic fertiliser base. All inputs essentially should be environmentally acceptable. Linking the VAC system to vegetable and tree crop development is highly desirable along with other innovations of home processing and even biogas generation in isolated villages with livestock.

N. B. The Technical Training mentioned above in other sections is **recommended** to upgrade the skills and knowledge of farmers.

Acknowledgements

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Program of visit

Mon 21 April	Dep. Jakarta. Arr. Bangkok. Apply for visa.
Tues 22 April	Procure Visa for Vietnam
Wed 23 April	Dep. Bangkok
	Arr. Hanoi-Meeting with Paul van der Poel SFDP and office staff including Mrs. Van, Mr. Mau, Mrs. Hue and Miss Kim Lien.
Thurs 24 April	Procuring documents and preparing itinerary for field visit.
Fri 25 April	Meeting with counterpart local consultant Mr. Le Dinh Danh and Paul van der Poel re: field trip and TOR. Dep. with Mr. Le Dinh Danh to Phu Ho Fruit Crops Research Institute of which Mr. Danh is Director.
Sat 26 April	Inspect fruit trees and nurseries at Phu Ho FCRI and discuss how the Institute is and will link with SFDP in the future. Visit farms in nearby area to inspect Lychee and Longan, especially the early regular bearing good quality cultivar of Lychee, Heung Lom.
Sun 27 April	Travel to Luc Ngan State Farm to examine Lychee Nurseries of imported cultivars of Lychee established by the UNDP/FAO Vie/86/005 project. The Luc Ngan area now has 6000 ha of Lychee with 300 Ha on the State Farm. Most is of Thanh Hoa cultivar. Return to Hanoi PM.
Mon 28 April	Travel to Yen Chau with counterpart consultant Mr. Danh and Miss Quyen translator. Meet with Mr. Trie Van Co of MARD who is working with SFDP.
Tues 29 April	a.m. Meeting with Mr. Thuc Vice Chairman of Peoples Committee in Yen Chau and Mr Danh, Mr Co and Mrs Vu Tai Tam Head of Extension and Miss Quyen translator.
	p.m. Field Visit Mr. Thuc, Mr. Co and the consultants to Chieng Dong commune to visit 3 farms.
Wed. 30 April	a.m. Visit with same Team to 6 farms in Chieng Pan commune. PM. Visit to 1 farm in Chieng Khol commune to inspect lychees.
Thurs. 01 May	a.m. Visit with Team to Tu Nang commune Mango forest. PM. Visit Paieng Khoh commune to inspect fruits and 2 farms.
Fri 02 May	a.m. Meeting of Team to discuss conclusions from the field visits, observations and discussions. PM. Meeting between Team and Secetary of District Mr. Hang Tri Thuc, President of Technical Dept. Mrs. Truong, Secretary for President Mr. Lia, Head of Extension Mrs. Vu Tai Tam, Agricultural Dept. Mr Phien, Vice Secretary for President Mr. Triam, to present findings and discuss fruit and vegetable development.
Sat 03 May	Meeting with Mrs. Tam and Mr Co, to discuss extension needs and visit nursery to discuss development of the nursery for fruit trees.
Sun 04 May	Travel to Son La.
Mon 05 May	Meeting with Mr. Hung Head of Dept. of Agriculture in Son La province and Mrs Twa Head of Extension to brief them on findings in Yen Chau and discuss issues.
Tues 06 May	Travel to Tua Chua and meet with Mr Xuan to arrange programme.
Wed 07 May	Travel to Xing Phinh Commune , meet with Sec. of Peoples Committe and visit to farms, accompnaied by Mr. Tuan.
Thurs 08 May	Visit with same Team to Muong Banh commune farms to inspect fruits and vegetables.
Fri 09 May	a.m. Visit by team accompanied by Mr. Cay Head of Extension to a range of farms in nearby Tua Chua lowland areas and sloping lands. PM. Debriefing meeting with Mr. Cay and Mr. Amynh Vice Chairman of Agriculture Dept.
Sat 10 May	Travel to Yen Chau. Met again with Mr. Thuc and also a Oxfam Group headed by Mr. Do Thanh Lam examing methodologies used by a range of projects in the Highlands including SFDP.
Sun 11 May	Travel to Hanoi
Mon 12 May	Debriefing with Team Leader and Report Writing and discussions with Dr. Ludwig on project issues relating to development and marketing of fruits and vegetables.

	Hanoi
Tues 13 May - Thurs 15 May	Report Writing-Hanoi
Fri 16 May	Visit to Vegetexco in Hanoi with Dr. Ludwig and Mrs. Hue project interpreter to discuss with Dr. Le Pham Trung Director of Centre for Consultancy and Investment to processing of fruits and vegetables, local and export markets, prices and future prospects for processing involvement in the Son La province.
Sat 17-Sun 18 May	Report Writing- Hanoi
Mon 19 May	Presentation on findings of the Consultancy input at Ministry of Agriculture and Rural Development in Hanoi. Report adjustments.
Tuesday 20 May	Final Report Writing and printing.
Wed 21 May	Dep. Hanoi
	Arr. Bangkok
Thurs 22 May	Dep. Bangkok
	Arr. Jakarta