Cost-Benefit Analysis of Vegetable Production in Thai-Vietnamese Homegardens in Northeast Thailand

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ABSTRACT: Homegardens have been widely promoted as highly sustainable low input agroecosystems that provide food, materials, cash income, and ecological services to poor rural households. However, there have been only a few attempts to assess their productive efficiency by measuring inputs of labor, cash and materials and outputs of food and other products. This study was designed to record all inputs and outputs for a period of 10 days of a sample of 9 homegardens of Thai-Vietnamese farmers in a village in Northeast Thailand. Short production cycle crops, e.g., lettuce, edible morning glory, and sweet corn, were the most commonly grown crops. Most garden produce is sold in the market but some is consumed by the farm households. The imputed cost of family labor accounted for 85% of total input costs while electricity used to power the pumps for irrigating the homegardens and manure each accounted for 6.8% of total input costs. Expenditures on fuel for hand tillers, chemical insecticides, and seed were small. The output values of the homegardens depended on the kinds of vegetables grown and their yields. On average, each household obtained gross income of 852 Baht (USD 26.4) and net return of 619 Baht/day. Productive efficiency was high with an average net return on input cost (net benefit - cost ratio) of 2.7:1, which is much higher than for rainfed rice, which is the main alternative agricultural system in the area. Productivity per labor hour was high with an average net return per labor hour of 117 Baht. Net benefits per unit area were also quite high with an average net return of 1.3 Baht/m^2 of planted area per day. Not surprisingly, the Thai-Vietnamese farmers have largely abandoned cultivating rainfed rice in order to concentrate on their much more productive homegardens.
Keywords: productive efficiency, vegetable gardening, tropical homegardens, input-output analysis, agricultural intensification

Introduction

Homegardens have been widely promoted as highly sustainable low input agroecosystems that provide food, materials, cash income, and ecological services to rural households in developing countries (Stoler, 1981; Soemarwoto, 1987; Gajaseni and Gajaseni, 1999; Trinh et al., 2003; Kumar and Nair, 2004; Galhena et al., 2013). However, because of severe methodological constraints, there have been only a few attempts to actually assess the productive efficiency of these systems by measuring inputs of labor, cash and materials and outputs of food and other products. Most existing studies on the economic value and yield of homegardens have been done in temperate home vegetable gardens in the United States (e.g., Stall 1979; Stephens et al. 1980; Cleveland et al. 1985). There have been only a few input-output studies of tropical homegardens: Stoler (1981) reported a range of cash values of production per hectare and the average return per labor hour for homegardens in Java, Indonesia; Pandey et al. (2007) described the gross annual income per total cost of inputs of homegardens in the Andaman and Nicobar

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islands of India; Mohan (2004) presented estimates of the annual mean value/m^2 of all products harvested from homegardens in Kerala, India; Alam (2012) estimated the total annual benefits and costs of agroforestry gardens in Bangladesh; and Cuanalo de la Cerdo and Mukul (2008) made estimates of the annual value of inputs and outputs for producing different kinds of crops and livestock in Maya homegardens in Yucatan, Mexico. Most previous studies of productive efficiency have been based on recall interviewing of farmers about the value of products and costs of inputs in the preceding year so are necessarily rough approximations at best. We have been unable to find any detailed analyses based on daily record keeping of the value of all of the inputs and outputs of homegardens in either the tropics or the temperate zone. Therefore, we conducted a detailed field study to record all inputs to and outputs from a sample of homegardens of the Thai-Vietnamese farmers in Najok village in Northeast Thailand. In this paper we present an analysis of all inputs and outputs and assessment of the productive efficiency of vegetables and other short cycle crops produced in these gardens

Homegardens are found in virtually all of the world's cultivable regions, including both tropical and temperate zones (Niñez, 1987). They are seen as being a highly sustainable component of the farming systems of smallholders that conserve soil and water resources and protect biodiversity (Soemarwoto, 1987; Karyono, 1990; Torquebiau, 1992; Gajaseni and Gajaseni, 1999; Trinh et al., 2003; Kehlenbeck and Maass, 2004; Mohri et al., 2013). In general, homegardens are located in the immediate vicinity of the farmers' houses. They commonly incorporate a mixture of annual and perennial agricultural crops and livestock that provide food, services and income to the households. Homegardens are managed with the part-time labor of family members and are characterized by having low inputs and outputs (Fernandes and Nair, 1986; Niñez, 1987; Hoogerbrugge and Fresco, 1993; Landreth and Saito, 2014). There have been many studies conducted on homegarden systems in various parts of the world that have generally concluded that the main benefits of homegardens are to ensure and enhance household nutrition and food security and provide some ecosystem services (Huai and Hamilton, 2008; Mohri et al., 2013; Galhena et al., 2013). Homegardens usually only provide a supplementary source of food and income but in some cases they are a main source of household income.

Materials and Methods

The 9 sample households used in this study were selected from a larger sample of 20 households in Najok village in Nakhon Phanom province. The ecological structure of these gardens had previously been studied by Timsuksai (2014). This sample was used because of the availability of detailed information about the ecological structure and functioning of their gardens (Timsuksai 2014; Timsuksai and Rambo 2015; 2016). These 9 households were the only ones from the initial sample of 20 that had continued to actively cultivate vegetables in their homegardens and were willing and able to be interviewed.

Data collection was done using questionnaires, semi-structured interviews and informal discussions with farmers about their household economies and their homegardens. Information about gardening inputs and outputs was gathered by having each household complete a daily record sheet. The record sheets included information on: 1) Type of activities in homegardens and who performed them for how long; 2) Type, amount and cash value of material inputs (e.g., manure, fertilizer, fuel) used in homegardens; 3) Amount and cash value of products produced for daily household consumption; 4) Amount and cash value of products produced for sale. Because this study is focused on analysis of inputs and outputs in the production of short cycle vegetable and flower crops, long production cycle crops such as fruit trees (e.g., dragon fruit, jackfruit, banana, and pomelo) and spices are not included in this analysis.

Record sheets were kept by all sample households for 10 days from 26 March to 5 April, 2014. Although 10 days is a relatively short period, because all of the households had many beds in their gardens in various stages of the production cycle, all of the various activities involved in garden cultivation, including land preparation, cultivation (seeding, transplanting, weeding and irrigating) and harvesting were performed in all of the sample gardens during this period.

Data were entered into an Excel database and were analyzed using standard descriptive statistic. The calculation of the cash value of inputs and outputs in these homegardens was based on the following factors:

1) The cost of hired labor equals 300 Baht/day (8 hours).

2) The cost of irrigation was based on calculating the cost of the number of kWh of electricity used to power the pump used for watering the homegarden.

3) Food produced for home consumption was assigned a cash value based on the market price of the relevant items on the recorded day.

4) The cash value of products for sale was calculated based on the market price of the specific items on the recorded day.

The returns on production in homegardens were calculated using the following formulas:

- Return on input cost = $\frac{Net\ return}{Total\ variable\ cost}$
- Return on planted area (Baht/m^2) = $\frac{Net\ return}{unit\ planted\ area\ of\ land}$
- Return on labor (Baht/labor hour) = $\frac{Net\ return}{Labor\ input}$

Results

Study site

The study was conducted in Najok village, Muang district, Nakhon Phanom province in Northeast Thailand (17°22'38.09"N and 104°45'45.10"E) (**Figure 1**). This village was settled by immigrants from Central Vietnam beginning in the 1880s (Timsuksai, 2014). Although the inhabitants are now Thai citizens, they maintain many aspects of Vietnamese culture, including speaking Vietnamese within their homes.

The total surface area of the village is 116 ha with a population of 303 people. The terrain is mostly a gently sloping plain with an average elevation of 156 m above mean sea level. The

dominant soil in the village is silt with low to moderate fertility and good to moderate drainage. The area has a tropical savanna climate. The mean temperature varies from 21.8°C to 31.8°C, with the minimum in December and the maximum in April. Average annual rainfall is 2,347 mm. Most of the rainfall (95%) falls between April and October, whereas the four months from November to February are relatively dry. Relative humidity ranges from 67% to 88% with the lowest level in the dry season (Thai Meteorological Department, 2014).

The Thai-Vietnamese living in Najok village have a long tradition of cultivating homegardens. Until recently their homegardens were an integral component of a complex farming system that included paddy fields, upland crops fields, and livestock, but in 2012 most households stopped engaging in other agricultural activities in order to concentrate on homegarden production. Their gardens are mostly devoted to growing of high value short cycle crops including vegetables, sweet corn, and flowers. Some of these crops are consumed by the households themselves but sale of garden produce in the market has become the main source of household income.

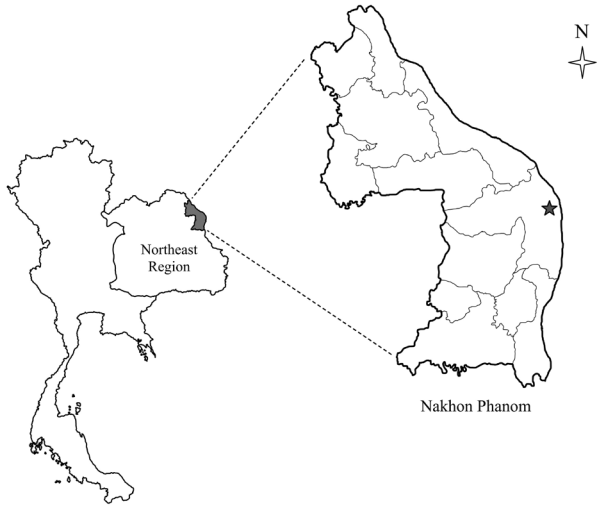

Figure 1 Map showing location of study site

Area of homegardens, number of planting beds, and labor force

The average area of the homegardens was 3,168 m^2, with a range from 1,600 to 7,200 m^2. Most of the areas in front of the houses, which accounted for 27% of the total homegarden area, were used for production of short cycle crops including leafy vegetables, sweet corn, beans and flowers. The mean area planted to short cycle crops throughout the whole year was 2,448 m^2, ranging from 1,230 m^2 to 3.970 m^2.

On average, a household had 2 beds undergoing land preparation; 9 beds under cultivation; 7 beds being harvested; and 7 beds in fallow after harvesting (**Table 1**).

Table 1 Activities being conducted in the different vegetable beds in the sample homegardens in the Thai-Vietnamese homegardens in Najok village (n=9 homegardens for 10 days)

Household	Total no of beds in garden	Land Preparation	Cultivation	Harvesting	Fallowed
1	29	4	15	3	7
2	36	4	10	16	6
3	20	2	7	4	7
4	29	2	13	7	7
5	19	0	4	8	7
6	26	3	12	7	4
7	16	0	3	3	10
8	14	2	4	4	4
9	32	4	10	10	8
Mean	25	2	9	7	7
Total	221	21	78	62	60

The average of number of laborers per household was 2, ranging from 1 to 4 laborers.

The vegetable production cycle

Table 2 shows the major types of vegetables planted in the gardens, the months when they are grown, and the number of production cycles per planting season. The kind of vegetables grown depends on market demand and the season. Most kinds are grown from late August until early April but some are grown all year round.

Table 2 Short cycle crops planted in Vietnamese homegardens in Najok village (n=9 homegardens)

Common English name	Scientific name	Vietnamese name	Planted area (m^2) in 9 sample gardens		Percent of total vegetable area (%)	Cultivation period	No of Cycles/ year
			Mean	Range			
Lettuce	*Lactuca sativa* L.	Xà lách	1245.0	0-2650	50.9	September-April	4-5
Morning glory	*Ipomoea aquatic* L.	Muống	536.7	0-2160	21.9	August-September; March-April	1-2
Sweet corn	*Zea mays* subsp. *saccharata*	Ngô ngọt	474.4	0-800	19.4	May - mid-July	1
Other vegetables	-	-	192.2	0-370	7.9	September-April; Whole year	1-4

During the period of study in March-April, lettuce (*Lactuca sativa*) occupied half of the total area planted to vegetables, with an average area of 1,245 m^2/garden. Lettuce was grown in all of the homegardens because of high market demand, good price, and especially because it is well adapted to the climatic conditions in the area between September and April. The full cultivation cycle for lettuce lasts for about two months (one month for growing the seedlings is a special nursery bed and around one more month after the seedlings are transplanted into

one of the main beds until they are harvested). The farmers all have multiple vegetable beds in their gardens so they use one bed to raise seedlings during the whole season. When they are ready, seedlings are transplanted into whatever bed is available at the time. By using this staggered planting of different beds, farmers ensure a steady flow of production throughout the growing season.

Edible morning glory or water spinach (*Ipomoea aquatic*) was the second most important kind of vegetable with an average planted area of 537 m^2/household, accounting for about 22 percent of the total planted area. The area was smaller than that of lettuce because of the season when the survey was done. Morning glory does better in hot weather (from August to September and from March to April). Although the production cycle of morning glory is shorter than that of lettuce (25-30 days), most households grow only 1 or 2 cycles/year, although there was one household that grew edible morning glory throughout the rainy season.

The planted areas of Chinese spinach, jute mallow, cabbage, broccoli, mustard greens and other vegetables and flowers were all small (less than 1 percent each of the total area of vegetables) because these vegetables can only be grown in certain limited periods during the year. For example, jute mallow and Chinese spinach can be grown only in the hot season and cabbage and garland chrysanthemum only in the cool dry season. Also, market demand for these crops was not high so that only a few farmers planted them and they were grown for only one cycle/year. Black gram and yard-long beans were grown on small areas in some homegardens, but were not popular crops in this village.

In the rainy season, almost all of the plots which had been used for vegetable production in the preceding dry season were used to grow sweet corn from late April to the end of July. During this season, households planted only small vegetable plots for family consumption.

Input costs

Table 3 shows the costs per day of all inputs used for growing vegetables and other short cycle crops. The imputed cost of family labor accounted for 85% of total input costs. Household spent on average 5.3 hours /day, ranging from 1.5 hours to 10 hours/day, working in their gardens (**Table 4**). Labor was expended on land preparation, planting, applying manure, watering, erecting shade cloth, weeding, and harvesting. During the period of data collection, many of the vegetable crops in their homegardens were ready to be harvested, and all households engaged in harvesting activities, so that this activity accounted for 43% of labor costs. Because it was the dry season, watering accounted for the second greatest amount of labor costs (35%). There were 7 households doing land preparation, applying manure and planting, but only in small plots, so preparing land (5%), applying fertilizer (2%), planting (4%), and erecting shading for vegetable beds (1%) represented only small shares of total labor input costs.

Electricity used to power the pumps for irrigating the homegardens accounted for 6.8% of total input costs. Because it was the dry season, the vegetables needed to be watered every day (for an average of 1.8 hours/day). Manure represented 6.8% of input costs. Because manure was the main fertilizer used in these gardens there was almost no expenditure on chemical fertilizer. Expenditures on chemical insecticides were also

small. Expenditures on seed and fuel (diesel for hand tillers) represented the smallest share of input costs. Most of the seeds used in these gardens were saved by the farmers from previous crops, or bought cheaply from the local shops in their village. The fuel cost was low because almost all of the activities in the gardens were done by human labor. Farmers only used two-wheeled tractors once each year when they started preparing land for the new planting season. For subsequent crops they used hoes to cultivate the soil.

Table 3 Input costs (Baht/day) for all types of short cycle crops produced in Thai-Vietnamese homegardens in Najok village (n=9 homegardens)

Kind of inputs	Daily mean	Daily minimum	Daily maximum
Manure	15.8 (6.8%)	0.0	40.0
Seed	1.6 (0.7%)	0.0	12.5
Fuel	1.4 (0.6%)	0.0	9.0
Irrigation (electricity to run pumps)	15.9 (6.8%)	2.2	42.0
Labor	198.6 (85.2%)	55.3	376.9
Input cost/100 m^2 planted area	49	21	78

Table 4 Labor expenditure (hours) per day in Thai-Vietnamese homegardens in Najok village (n=9 homegardens)

Activities	Mean	Min	Max
Land preparation	0.3 (5%)	0.0	0.7
Fertilizer Application	0.1 (2%)	0.0	0.3
Planting	0.2 (4%)	0.0	0.8
Erecting shade cloth	0.1 (1%)	0.0	0.1
Watering	1.8 (35%)	0.8	4.0
Weeding	0.5 (10%)	0.0	1.7
Harvesting	2.3 (43%)	0.4	6.2
Total	5.3 (100%)	1.5	10.0

Output values

The output values of homegardens depended on the kinds of crops grown and their yields. On average, each household obtained gross income of 852 Baht/day, and an estimated 125,652 Baht/year. Average input costs/year, not including value of household labor, were estimated by farmers at 29,761 Baht. The daily mean cash value of outputs/100 m^2 of planted area was 179 Baht, ranging from 69 to 313 Baht (**Table 5**).

The output value of vegetables was calculated by first multiplying the quantity produced of each species by its market price and then adding together the values of all different types of vegetables to get the total value of vegetable production. Because they had good yields and prices, vegetables had the highest output value of all garden crops, accounting for 89% of the total output value of homegardens. The daily output value of vegetables /100 square meters of planted area was also the highest, with an average value of 190 Baht, ranging from 37 to 351 Baht. The output values of sweet corn and other crops were not very high because they were grown on much smaller areas and their prices were lower than for vegetables.

Table 5 Gross output values of short cycle crops in Thai-Vietnamese homegardens in Najok village (n=9 homegardens)

Components	Mean	Minimum	Maximum	Total for 9 gardens
Output values (Baht/day)				
Vegetables	762.3 (89%)	140.0	1752.5	6860.5
Sweet corn	76.1 (9%)	0.0	640.0	685.0
Others	13.8 (2%)	0.0	124.0	124.0
Total product value	852.2 (100%)	142.0	1752.5	7669.5
Product value (Baht/100m^2/day)				
Vegetables	190.0	37.0	351.0	1,710
Sweet corn	117.0	0.0	180.0	1,053
Others	64.0	0.0	124.0	576
Whole garden	179.0	69.0	313.0	1,611

The costs and returns of the homegardens

Although input costs are high because of high labor costs, the net return of homegardens was also high. On average, the net return of the homegardens was 619 Baht/day, with a range from 40 to 1,325 Baht/day during the 10 days that were recorded (**Table 6**). Although the input costs to the homegardens were also quite high, the overall average net return on input cost (net benefit - cost ratio) was positive at 2.7:1. Productivity per labor hour was high with an average net return per labor hour of 117 Baht. Net benefits per unit area were also quite high with an average daily net return of 1.3 Baht/m^2 of planted area.

Table 6 Input costs and output values of Thai-Vietnamese homegardens in Najok village (n=9 homegardens)

Productive efficiency	Unit	Mean value	Minimum	Maximum
Total input costs/day	Baht	233.3	57.9	426.8
Total product value/day	Baht	852.2	142.0	1752.5
Net return/day	Baht	618.9	40.0	1325.7
Net return per planted area/day (Total area 476.2 m^2)	Baht/m^2/day	1.3	0.3	2.4
Net return per labor hour (Total labor time =5.3 hours/day)	Baht/hour	116.8	21.1	281.4
Ratio of net return/input cost		2.7	0.4	7.2

Discussion

The homegardens of the Thai-Vietnamese farmers of Najok village are highly productive and enjoy a very favorable ratio of inputs to outputs. Labor represented by far the highest input cost of homegarden production, confirming the findings of previous studies of homegardens elsewhere in the world. For example, Jacob and Alles (1987) reported that in Sri Lanka 87.8 percent of total cash inputs were for labor while Stephens et al. (1980) found that in vegetable production in homegardens in North Florida in the USA, labor costs accounted for more than 50 percent of total input costs. However, farmers in Najok village, probably because they sold most

of their produce for cash, expended many more hours in total than is typical for homegarden production elsewhere in the world. On average, the households spent 5.3 hours/day for vegetable production in their gardens, compared to the one hour or less/day that Hoogerbrugge and Fresco (1993) reported in their review of research on labor inputs in homegardens in different parts of the world.

The net return to labor of the Thai-Vietnamese homegardens was 117 Baht/hour, which is much higher than the net returns per labor hour of commercial vegetable farms in Chiang Mai in northern Thailand that obtained only 54 to 109 Baht/labor-day (Kawasaki and Fujimoto, 2009). The net benefit-cost ratio of the Thai-Vietnamese homegardens, which averaged 2.7:1, ranging from 0.4 to 7.2, was also much higher than for other systems, such as commercial vegetable production in Northern Thailand which ranged from 0.1:1 to 0.9:1, depending on species grown and production technology used (Kawasaki and Fujimoto, 2009). It was also much higher than for other small-holder agricultural systems commonly found in Northeast Thailand, such as the rainfed rice production system which had an estimated net benefit-cost ratio of only 0.15:1 (Arayaphong, 2012).

Conclusions

Although tropical homegardens are commonly considered to be low input-low output systems, requiring minimal investment of labor and material inputs in their cultivation but also having relatively low yields, the Thai-Vietnamese homegardens in Najok village have both high inputs and high outputs. Despite having high input costs, they have much higher costs and returns than rainfed rice, which is the main alternative agricultural system in this locality. Consequently, it is not surprising that most the Thai-Vietnamese farmers in Najok village have recently abandoned cultivation of rainfed rice in order to concentrate their limited household labor supply on much more profitable homegarden production. Despite these advantages, however, the area of homegardens cultivated by these farmers is relatively small. Further expansion of this system appears to be constrained by the limited supply of household labor and the high cost of employing hired laborers. Finding ways to reduce the labor time needed to manage the homegardens might allow households to expand production and increase their incomes.

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