The agroecosystem of the village Panayakurichi consisted of 161.008 ha of croplands divided into 418 plots of diverse shapes and sizes. Input-output analysis of energy was examined on these croplands using the technique of Mitchell (1980). The inputs into the croplands consisted of:

i. Solar input. The solar energy data for Panayakurichi were furnished by the Deputy Director General of observatories, Pune (Table 3).

ii. Biotic inputs consisted of seeds, rootstocks and stem cuttings used to plant the crops.

iii. Fossil fuel inputs. The fossil fuel inputs to the agroecosystem consisted of the fertilizers and pesticides. The quantity of fertilizers and pesticides used for the crops was estimated by rampant surveys (Tables 4 and 5).

iv. Manures. The manures applied in the crop lands consisted of farmyard manure and oil cakes. The quantity of farmyard manure and oil cake applied was estimated by surveys (Tables 4, 5).
v. Labour. The agricultural operations in the crop lands were performed by the muscular power of the human beings and bullocks. The inputs of human labour were divided into mandays and womandays.

The input of bullock labour was computed as bullock-days. The work norms in terms of the number of mandays, womandays and bullockdays for each crop were strictly under the regulation of workers union and hence it was easy to estimate the labour input into the agroecosystem. A bullock cart drawn by two bullocks and driven by a man pulled 350 kg load. A bullockcart in a day made 5 trips for applying farmyard manure.

The output of the cropland consisted of the aerial net primary production (ANP) of the crops. The ANP consists of the above ground vegetative parts namely the stems, leaves and seeds. For the input-output analysis a detailed tracing of the flow of the ANP was performed through the ecosystem by separating the ANP into specific categories according to the use to which they were being put. The use categories of the ANP consisted of:

1. Grains, fruits and other edible parts used by humans (croppers)
2. Stems and leaves used as fodder by the cattle (grazers) and
iii. Residues available for fuel or fibre.

The following four crops were grown in the village Panayakurichi: Paddy, banana, gingelly and betelvine plantation.

Each of the above four crops are scrutinised in detail after a brief summary of the inputs and outputs for each is given. The norms are in terms of hectare.

1. Paddy: Two varieties of paddy are planted in Panayakurichi: the short term variety and the long term variety.

Short term paddy: The variety grown in ADT 31. This paddy is of 105 days duration. The biotic inputs are: 111.15 kg seeds.

The labour inputs are: 57.12 mandays + 84 womandays + 73.36 bullock days. The fossil fuel inputs consist of 123.5 kg urea, 988 ml of endrine and 49.4 kg of B.H.C. The yield is 2372.4 kg rice, 1277.5 kg bran and 4707.5 kg fodder.

Long term paddy: The variety grown is ponni. This variety is of 135 days duration. The biotic inputs are 86.45 kg of seeds. The labour inputs are: 56.18 mandays, 84 womandays and 66.48 bullock days. The fossil fuel inputs consist of 123.5 kg complex (17:17:17), 61.75 kg urea, 61.75 kg ammonium sulphate, 1.112 litres of endrine and 49.4 kg of B.H.C. 1000 kg of farmyard manure is applied. The yield
is $28^{+8}.2$ kg of rice, $1479.8$ kg of bran and $11^470$ kg of fodder.

2. Banana: The variety of banana grown in the village is poovan. It has a duration of 15 months. Planting is started in October/November and harvesting in February. The biotic input consists of 2470 stocks weighing a total of 4940 kg. The labour inputs are: 327 mandays + 112 womandays and 52 bullockdays. The fossil fuel input consists of 333.5 kg of ammonium sulphate, 210 kg of potash and $148.2$ kg of complex (17:17:17).

Manures applied are: 5000 kg of farmyard manure and 125.3 kg of oil cake.

Yield consists of 32221.2 kg of fruits and 48412 kg of fuel.

3. Gingelly: Gingelly is a summer crop planted in March. The duration of the crop is 85 days. The biotic input consists of 6.175 kg of seeds. There are no fossil fuel inputs since no fertilizer is applied.

The labour inputs are: 32 mandays, 18 womandays and 62 bullockdays.

Yield is: 247 kg of oil, 370.5 kg of oil cake and 12858.2 kg of fuel.

4. Betelvine plantation: In the betelvine plantation, *Sesbania, Erythrina* and *Moringa* are planted along with
betelvine. The crop duration is 3 years. Biotic inputs are 17.3 kg of betelvine stem cuttings + 18 kg of *Sesbania* seeds + 18 kg of *Erythrina* seeds + 7.3 kg of *Moringa* seeds. Labour inputs are 9954 mandays + 520 womandays + 32 bullock-days.

There are no fossil fuel inputs.

The manures applied are 15,000 kg of farmyard manure and 4446 kg of oil cakes.

The yield of edible matter consists of: 17309.8 kg of betel leaves; 13320 kg of *Moringa* leaves and 6675.7 kg of *Moringa* fruits.

The yield of cattle food consists of: 28703 kg of *Sesbania* leaves and 7224.8 kg of *Erythrina* leaves.

The yield of fuel consists of 64837.5 kg of *Sesbania* stem; 1852.5 kg of *Erythrina* stem and 8336.3 kg of *Moringa* stem.

A detailed observation of the above four crops is as follows:

1. Paddy:

   There are two varieties of paddy namely the short term paddy and the long term paddy. The short term paddy is planted either during the monsoon or the summer. The short term crop in monsoon is called kuruvai; that of summer is called navarai. The long term crop is the winter crop and is called samba. If the long term crop is started as a second crop, after the harvest of kuruvai, it is called thaladi. Therefore, four patterns of paddy cropping are seen:
a) Samba only; b) Kuruvai + Thaladi; c) Kuruvai + Thaladi + Navarai and d) Kuruvai only. The following practices are common in each pattern of cropping. The norms are for 1 ha.

a) Samba only: The longterm paddy of the variety Ponni is used. Farmyard manure at the rate of 1000 kg ha\(^{-1}\) is applied (Fig. 29) at an energy cost of 0.6 bullock cart day (0.6 manday + 1.2 bullock days). Land preparation (Fig. 30) needs 29.64 ploughs (29.64 mandays + 59.28 bullock days).

86.45 kg of seeds are used for seeding. The labour cost for seeding is 2 mandays + 2 bullock days. An insecticide spray is made at the seedling stage with 123.5 ml of endrine at an energy cost of 1 manday.

The seedlings are collected from the seed bed at an energy cost of 17 womandays. 123.5 kg of complex fertilizer (17:17:17) is applied and the energy cost is one manday. Transplantation of the paddy seedlings (Fig. 31) is accomplished at an energy cost of 37 womandays. After the transplantation, the soil is shored up and the energy cost for this is 4.94 mandays. 61.75 kg of urea is applied at an energy cost of 1 manday. Weeding is done twice in the course of the growth, with 5 women each time. The energy cost of weeding is 10 womandays. During the crop growth, 2 sprays of 494 ml each of endrine are made at a total energy cost of 2 mandays. Ammonium sulphate is applied at
a rate of 61.75 kg with an energy cost of 1 manday. When the grains are formed, a dusting of 49.4 kg of B.H.C. is made at an energy cost of 1 manday. Harvesting (Fig. 32) and threshing (Fig. 35) is done at an energy cost of 12 mandays + 20 woman-days + 4 bullock days.

The yield is 2748.2 kg of rice; 1479.8 kg of bran and 11470 kg of fodder.

b) Kuruvai + thaladi: In this pattern of cropping, short term paddy (kuruvai) is planted in August and harvested in November, and immediately a second crop of long term paddy (thaladi) is started in November itself.

Kuruvai: Farmyard manure at the rate of 1000 kg ha\(^{-1}\) is applied at an energy cost of 0.6 manday + 1.2 bullock-days. A total labour cost of 34.58 mandays + 69.16 bullock-days is invested in ploughing and preparing the land. Seeds are sown at the rate of 111.15 kg ha\(^{-1}\) and the labour involved is 2 mandays + 2 bullockdays. A total labour of 17 woman-days is invested in collecting the seedlings. The seedlings are transplanted at an energy cost of 37 woman-days. The seedlings are planted only in 0.950 ha for every ha of land. The remaining 0.050 ha of land is kept in reserve as the seedbed for the succeeding thaladi crop.

The soil is shored up now at the energy cost of 4.94 mandays. A total labour cost of 20 woman-days is needed
for weeding operations. Urea is applied twice at the rate of 61.75 kg ha\(^{-1}\) each time and the total energy cost is 2 mandays.

Two insecticide sprays, 494 ml of endrine each are made at a total energy cost of 2 mandays. At the time of grain formation a dusting of 49.4 kg of B.H.C. is made and the energy cost is 1 manday. Harvesting and threshing takes place in November. The labour involved in harvesting and threshing is 10 mandays + 10 womandays + 4 bullockdays. The yield is 2372.4 kg of rice, 1277.5 kg of bran and 4707.5 kg of fodder. This yield is obtained only from 0.950 ha, the remaining 0.05 ha being reserved for the succeeding thaladi crop.

Thaladi: The seed bed for thaladi is started in October itself. The energy cost of preparing the seed bed is 1 manday + 2 bullockdays. Seeding is accomplished with 86.45 kg of seeds and a labour cost of 2 mandays + 2 bullock-days. A spray of 123.5 ml of endrine is made in the seedling stage at an energy cost of 1 manday. In November, after kuruvai paddy is harvested, the land is ploughed. The ploughing and preparation of land cost 24.7 mandays + 49.4 bullockdays. The seedlings are collected at an energy cost of 17 womandays. 123.5 kg of complex (17:17:17) is applied, and the energy cost is 1 manday. Transplantation of the seedlings is done at an energy cost of 37 womandays. Now the soil is shored up by investing a
labour of 4.94 mandays. A total of 42 woman-days is spent in weeding operations. Then urea and ammonium sulphate at the rate of 61.75 kg ha$^{-1}$ each are applied at a total energy cost of 2 mandays. During the growth 2 sprays each of 49.4 ml of endrine are made and the total energy cost is 2 mandays. At the time of grain formation a dusting of 49.4 kg of B.H.C. is made, the energy cost being 1 manday.

A total labour of 12 mandays + 20 woman-days + 4 bullock-days is needed for harvesting and threshing. The yield is:

- 2748.2 kg rice
- 1479.0 kg bran
- 11470 kg fodder.

C. Kuruvai + thaladi + navari:

Some of the lands are planted to three crops of paddy, the third being called navarai. The three crops are planted as scheduled below:

- August - November - kuruvai
- October - February - thaladi
- March - June - navarai.

The operations for kuruvai and thaladi are as described above. The operations for navarai are as follows:

Land is ploughed and prepared in March at the energy cost of 29.64 mandays + 59.28 bullock-days. Seeding is done with 111.15 kg seeds and 17 woman-days. Transplantation is done at a labour cost of 37 woman-days. For shoring up the soil 4.94 mandays are needed. Two weedings are done at a
total energy cost of 10 womandays. Urea is applied, twice at the rate of 61.75 kg ha\(^{-1}\) each time and the total labour involved is 2 mandays. Two sprays each of 494 ml of endrine are made and the total energy cost is 2 mandays. At the time of grain formation, one dusting of 49.4 kg of B.H.C. is made and the energy cost is 1 manday. A total labour of 10 mandays + 10 womandays + 4 bullockdays is invested in the harvesting and threshing operations.

The yield is 2497.3 kg of rice + 1344.7 kg of bran + 955 kg of fodder.

d) Kuruvai only:

Rarely, some farmers cease their agricultural operations with just one crop of paddy - a kuruvai. The details of the operations involved are exactly the same as described above.

2. Banana:

Banana (Fig. 40) is a 15 month crop. The variety grown in the village is called poovan. Planting of banana rhizomes is started in the month of October/November. Preparation of the land is done at an energy cost of 10 mandays + 20 bullockdays.

2470 root stocks weighing a total of 4940 kg are planted (Fig. 37) and a total labour of 15 mandays + 4 bullockdays are needed for this operation. On the fifteenth
day, farmyard manure at the rate of 5000 kg ha\(^{-1}\) is applied at an energy cost of 19 mandays + 62 womandays + 28 bullockdays.

On the 20th day, the soil is turned in and this operation needs 55 mandays. On the 25th day irrigation channels are made at an energy cost of 25 mandays. Irrigation is done once in 15 days for the entire duration of 15 months. Therefore the labour for irrigation for the entire crop period is 60 mandays. On the 80th day the soil is turned and the labour cost for this operation is 20 mandays.

In the month of April a mixture of 123.5 kg of ammonium sulphate + 61.75 kg of oil cake + 123.5 kg of potash + 86.45 kg of complex (17:17:17) is applied (Fig. 38) at an energy cost of 20 mandays. After this the soil is turned in at an energy cost of 25 mandays.

In the month of August, fertilizers are applied again at the rate of 61.75 kg oil cake + 86.45 kg potash + 25 kg complex (17:17:17) and the energy cost for this operation is 25 mandays. Again the soil is turned in at an energy cost of 25 mandays. In November 123.5 kg of ammonium sulphate is applied, the labour cost being 5 mandays. Then the banana shoots are all propped up with bamboo supports (Fig. 39) and its labour cost is 14 mandays.

The harvest begins in February. The harvest of all the
plants does not take place at the same time but if such an event is visualised, the estimate of energy cost is 14 mandays + 50 womandays.

The yield is: 32221.2 kg of fruits + 7039.6 kg of central axis + 642.2 kg of flowers, which are all edible.

In addition, 48.12 kg of leaves are formed, from which the total of 28899 kg of banana sticks may be produced for use as fuel.

Apart from this a total of 8682 kg of miscellaneous parts are found which are used as fibres.

3. Gingelly:

Gingelly plants are started in the month of March, after paddy has been harvested. For ploughing and preparing a total of 30 mandays + 60 bullock days are needed.

Seeding is done at the rate of 6.175 kg of seeds and the energy cost is 2 mandays + 2 bullockdays. There is no fossil fuel input. Irrigation is not necessary. Harvesting is done after 85 days and the labour needed is 10 womandays. Threshing needs 8 womandays of labour. The yield is: 247 kg oil + 370.5 kg oil cake and 12858.2 kg of fuel.

4. Betelvine plantation:

Betelvine plantation (Fig. 41) is a three year cropping system. Sesbania, Erythrina and Moringa are the plants which are grown along with betelvine plants.
In October, the land is ploughed and prepared and the labour needed is 112 mandays + 10 bullockdays. Seeding is first done by planting 37 kg of *Sesbania* seeds + 37 kg of *Erythrina* seeds + 15 kg of *Moringa* seeds. Cuttings of betelvine are planted only in December. 27,050 cuttings of betelvine each weighing 25 g, are planted at a total energy cost of 148 mandays.

Irrigation is done once in every two days for the entire duration of 3 days. Therefore the total labour involved in irrigation for the entire 3 year period of crop duration is 547 mandays. Once every 25 days the vines of the betel plants are tied to the support. The total labour needed for this operation alone throughout the crop period is 74 men x 44 times = 3,296 mandays. Once every month the soil is shored up. The total labour cost for this operation for the entire crop period is 37 men x 36 times = 1,332 mandays. Farmyard manure is applied twice at the rate of 7,500 kg each time. The total energy cost for this is 9 mandays + 18 bullockdays + 520 womandays. Oilcake is applied twice at the rate of 2,223 kg ha$^{-1}$ each time and the labour cost is 221 mandays + 4 bullockdays.

Harvesting starts in the August of the second year. Harvesting takes place every 21 days once, and it takes 100 mandays each time.
There are 38 pluckings and therefore the total labour cost for plucking leaves is $110 \times 38 = 4180$ mandays. The yield of betel leaves is 118560 kg.

Harvesting of *Sesbania* leaves starts three months after the seeds have been sown. The total yield of *Sesbania* leaves is 106704 kg. *Erythrina* begins yielding after 10 months after the seeds have been sown. The total yield is 28899 kg. *Moringa* yields after six months of seeding. The yield of leaves is 55272.67 kg. A total of 28899 kg of fruits is harvested.

At the end of the third year, the plantation is cut off. The total weight of the betelvine stem is 694609 kg. The stems of the other three plants are dried and used as fuel. The yield of fuel is: 64837 kg of *Sesbania* stems + 1852.5 kg of *Erythrina* stems + 8336.3 kg of *Moringa* stems.

This chapter describes the procedure by which the input-output analysis was done on the croplands. The inputs considered in this chapter are: biotic inputs, fossil fuel (fertilizers and pesticides) inputs, organic manure inputs, and the labour inputs of the humans and the cattle. The output of the cropland is the ANP of the crops. The ANP is separated into the following use categories: human food, cattle food, and fuel. The outputs of the croplands are used by the humans and the cattle of the village.