CHAPTER IV

A CASE STUDY OF NONGWANG VILLAGE

The Rural Community Development Model is applied to Nongwang village as a case study of gasification technology introduction. The model is used to simulate the use of energy resources available and the economic activities of the village. Determination of optimal development strategies particularly with reference to income and utilization of natural local resources such as biomass is emphasized.

Location of Nongwang Village

Nongwang Village is a community in Sawang Daengdin district, Sakhon Nakhon Province. Nongwang is bounded to the North by Nong Bua Ram Community, Wanorn Niwas District, to the South by Thon Community, Sawang Daengdin District, to the East by Kiksang Community, Wanorn Niwas District and to the West by Dongbak Community, Sawang Daengdin District.

The distance from Nongwang to Sawang Daengdin district is about 40 kilometres by road. There are three roads that lead to Nongwang,one from Wanorn Niwas District, one from Banmuang District and one from Sawang Daengdin District.

Demography (1982 data)

Nongwang Village is a Community of about 1,500 people with an average number of persons per household of 6.0. Population growth is about 2 percent per annum. There are about 669 children (aged 0-14 years old) or 44.6 percent of the total population, and 831 adults of which 570 are unskilled labors.

Most people are farmers with the major crops being rice, glutinous rice, kenaf, cassava and cotton. Vegetables are grown only for home use.

Nongwang Village has only one school which gives most children in the village only a primary school education. There is only one small health service center and one Temple in the Village.

Nongwang was one of the area under the influence of communist guerillas up to 1965 and from then on to 1973, the Government developped the area including Nonwang. As a result of such development efforts, the people in Nongwang became very development conscious. People's participation for community development has always been good at Nongwang. As a result the potential of achieving optimal implementation of development strategies is very promising in this particular village.

The average household income in Nongwang was estimated to be about 16,200 Baht per year (in 1984) or 2,700 Baht per capita compared to about 5,200 Baht per capita for Sakhon Nakhon Province in 1982 as reported by the National Economic and Social Development Board (NESDB).

Activities in Nongwang Community

For ease of application of the RCDM, Nongwang's basic community structures and activities may be classified into subsystems as follows :

1. Land Subsystem

As shown in Figure 4.1, Land has been classified into upland, lowland, pasture land, natural forest, and land for household use. Upland and lowland can be used for cultivation. Cultivation may occur in either wet or dry seasons depending on crops and geographical area. Pasture land is used for animal husbandary. Natural forests can be made to deplete at a normal rate or can be controlled by allocation of land types over the planning period. The available natural forests yield fuelwood to the Community. In addition, upland, lowland, pasture land, and land for households can be used for fast growing tree project to yield additional fuelwood.

Based on an NEA report, Nongwang has a total area of about 9000 rais (6.25 rais per hectare). It is composed of 1500 rais of lowland ; 3,328 rais of upland ; 3,450 rais of forest land ; 100 rais of pasture land ; 200 rais of housing land ; 22 rais for the temple and 400 rais for one public reservoir. Out of the total forest land 3,000 rais of land are forests in paddy and glutinous fields which is a typical characteristic of Northeastern Thailand, (see Table C.1.1 in the Appendix C).

2. Household Subsystem

A household subsystem includes people in the Community classified as skilled labor, potential skilled labor, unskilled labor, children and retired persons. The potential skilled labor includes people who could be trained, perhaps through a development program to become skilled labor.

People in the Community basically require transportation, energy (e.g. shaft power, lighting, cooking, and occasionally heating), but they also consume agricultural products (e.g. vegetable), and others (e.g.egg, milk and clothes). These consumptions per capita are shown in Table C.2.1 in the Appendix.

Skilled and unskilled labor available for economic activities are derived from people both in the Community itself and from other communities as well. People in Nongwang can work outside the community (exported labor). These labor are available in any seasons for agriculture, animal husbandary, processing, fertilizer, energy, forest, transport and development subsystems.

Population in the Community was estimated from a preliminary survey on Nongwang village undertaken by the NEA assuming a 2 percent population growth. From national statistics these were classified into types based on educational level and age as shown in Table C.2.2.

Imported labor wage rates for skilled and unskilled labor are assumed as in Table C.2.3.

3. Agriculture Subsystem

The agriculture subsystem includes crop growing activities with five major crops (paddy, glutinous paddy, cotton, cassava, and kenaf) included in the model.

To grow paddy as shown in Figure 4.3, one requires unskilled labor, energy (for land preparation, growing, harvesting and threshing), land (i.e. lowland and upland), water, and fertilizer. Transportation is required to transport the harvested product.

Since there exists a positive relationship between level of fertilizer used and crop yield, three possible levels of using fertilizers are incorporated into the model for different marginal increases of production. Crop yields response to fertilizer would increase at decreasing rates of use until the marginal yield becomes zero. The data used was obtained from the Division of Agricultural Economic Research, Office of Agricultural Economics.

The agricultural products would be either consumed within or sold outside the Community (exported). Products may be imported into the Community in case of a shortage. Products can also be sent to processing centers inside and outside the Community. Field residues could become inputs to biogas/fertilizer, animal feed, and energy subsystems.

Allocations of manpower, cow and buffalo power used for land preparation, growing, harvesting and threshing are estimated from a report prepared by Ministry of Agriculture and shown in Table C.3.1.

Average land use in the hypothetical model, in rai per ton, is estimated from national statistics in 1979-1983. Then yields per rai may be obtained from Table C.3.1.

Typical cultivation is based on rain-fed. Irrigation may not be required if rain fall provides water in excess to the minimum water required for the crop. At the minimum water requirement level, farmers would obtain minimum crop yields per rai. Additional water, distributed through irrigation system (with or without pumping), would increase yield.

4. Animal Husbandary Subsystem

In general, animals would be used as livestock, to produce animal proteins (e.g. milk, egg), and shaft power. They also produce residues (dung) as a by product. (see Figure 4.4)

To raise animals, one requires water, unskilled labor, animal feed (i.e. crude protein, metabolizable energy, and dry matter) as shown in Table C.4.1. Transportation is required to transport livestock and animal products to market.

Livestock could be imported, processed in the Community for meat, and consumed in the household. Such animal products in turn could also be sold or consumed. Cattle could also be used as an energy source for shaft power, traction or transportation. Dung will typically be used as inputs for fertilizer and biogas digester. Imports of animals are also possible if required by the Community.

Among animals raised in Nongwang are 728 buffaloes, 222 cows and 230 pigs (1985 survey).

Estimates of dung collected from animals are shown in Table C.4.2.

Animal feed provides digestible crude protein, metabolizable energy, and dry matter to animal husbandary subsystem as shown in Table C.4.3.

5. Industrial Subsystem - (Rice Mill)

As shown in Figure 4.6 rice mills operate in both wet and dry seasons. The by products of rice processing are husk, hulls, and bran as processed residues. The processing activity needs paddy and glutinous paddy as major raw material, plus labor and shaft power. In addition, transportation is also considered a delivery mean in processing rice to final consumers. To maximize income of the community, paddy may be imported to be used for rice milling.

Glutinous rice is consumed by domestic households and non-glutionus rice is exported. Process residues can be used as energy inputs, animal feed and other industry subsystems.

The existing capacity of the rice mill in Nongwang is 2,358 tons of products per year. The mill efficiency is 0.55 tons of product/ton of paddy and requires shaft power of 118.86 hp-hr/ton of paddy. Other parameters used in the model are shown in Table C.5.1.

Prices of rice and glutinous rice in a community are estimated from NEA's preliminary survey in Nongwang (see Table C.5.2).

6. Small Industry Subsystem (Animal Processing or Slaughter house)

As shown in Figure 4.6, animals (e.g. buffalos, cows, and pigs) would be the inputs to animal processing activities. The processing would require both skilled and unskilled labor. Similar to many other subsystems, transportation is required.

Output from the animal processing subsystem are meat and hide. Both products could be exported. Meat is consumed by households in the community.

Animals and meat could be imported to fulfill requirements of animal processing and household consumption respectively.

Average weight of buffalos, cows and pigs are estimated from agriculture statistics. Meat conversions are based on META SYSTEMS INC. Life of animals are based on estimated values.

Purchase prices and selling prices for exported and imported meat as well as transportation required are assumed as shown in Table C.5.2.

7. Biogas/Fertilizer Subsystem

As shown in figure 4.7, fertilizers could be produced from residues mainly from agriculture, and animals (dung). It requires unskilled labor. Dung could be used directly as fertilizer or as input to biogas digesters yielding sludge usable as fertilizer and biogas for energy. Fertilizers provide nitrogen, phosphate and potassium for crop growing in the agriculture subsystem. Transportation is required for delivering raw material, purchase chemicals and domestically produced fertilizers.

Values of parameters incorporated into the model are as follows :

7.1 Contents of nitrogen, phosphate and potassium in crop residue and dung are estimated based on Meta System as shown in Table C.7.1.

7.2 Biogas digesters yield sludge having contents of nitrogen, phosphate and potassium as those of dung.

7.3 Biogas digester investment cost and operating costs are estimated according to Meta System as shown in Table C.7.2. Note that the digester yields biogas at the rate 0.25 cubic meters per kilogram of dung.

Most people in Nongwang prefer to use residues from agriculture as fertilizers rather than to use animal dung and sludge from digesters as fertilizers.

8. Energy Subsystem

As shown in Figure 4.8, rural community energy is related to activities in other subsystems. All activities require energy in different forms.

Energy demands in households and services are for cooking, lighting, shaft power (for household water pumping etc.), and heating. Agriculture and irrigation subsystems require traction, threshing, and shaft power. Processing subsystem requires shaft power to convert raw materials to finished products.

Major energy conversions for cooking are wood/charcoal stoves. Investment and technical coefficients of cooking stove types are obtained from investigations and estimations as shown in Table C.8.1.

Lighting in Nongwang generally utilizes kerosene lamps. Average lighting consumption per head is 22 KWH/YEAR., or a total consumption for the community of 34.34 MWH/YEAR in 1985. Investment and technical coefficients of lamp types are also from investigations and estimations as shown in Table C.8.2.

Gasoline engines and diesel engines are used to provide shaft power espectially in processing and irrigation subsystems. Investment and technical coefficients of shaft power engines from investigations and estimations are shown in Table C.8.3.

Most traction and threshing in Nongwang use animal labor (buffalo and cattle) as sources of power.

Energy system could be considered as a conversion process of energy in intermediate form to energy in end use demands. The conversion factors used are summarized in Table C.8.4.

Purchased prices of petroleum products and electricity from battery are listed in Table C.8.5.

9. Forest Subsystem

Forest subsystem yields wood for energy subsystem. Abundance of forest supply still exists in Nongwang. The cost of fuelwood is about equivalent to opportunity cost of labor in collecting fuelwood. Scarcity of fuelwood can be checked by considering labor time in collecting fuelwood. Labor time for collecting fuelwood in dry and rainy season is about 0.055 and 0.075 man-hour per kilogram of fuelwood respectively and average round trip distance is 2.25-2.35 kilometers.

Abundance of forest supply brings inefficient charcoal making methods and inefficient cooking stoves. Therefore, efficient charcoal making and efficient cooking stoves should be introduced with some urgency.

10. Irrigation/Water Resources Subsystem

Irrigation/Water resources subsystem as shown in figure 4.10 provides water to the agriculture subsystem. Availability of water from natural resources vary in wet and dry seasons. The availability would be determined by multiplying numbers of days in seasons to average flow (in cubic meters per day) in each season. The water from this resource is a source of unelevated water in seasons which require pumping.

In Nongwang there is an unelevated reservoir which captures rain water during the wet season.

Availability of water from this source is calculated by multiplying total area of unelevated reservoir to average annual rainfall (in meters), and availability in dry season in determined from reservoir capacity (in cubic meters) which is adjusted by a factor of 0.9 with an assumed loss factor of 0.33.

The net water available would be the gross avilability of water multiplied by 0.67.

In Nongwang there is no more than 500 kilocubic meters of water from natural sources in the wet season and 928 kilocubic meters from the existing unelevated reservoir. The reservoir has enough water all year round for villager needs, but no water pumping for irrigation system yet. The villagers propose to dig the public reservoir in the dry season in order to make it one meter deeper with Government help. They expect to have more water for a second rice crop, and for vegetable growing.

11. Transportation Subsystem

As shown in Figure 4.11, demands for transportation come from household travelling within and outside the Community and for the transportation of raw materials and produced goods from agriculture, processing, animal husbandary, and fertilizer/biogas subsystems. Types of vehicles in Nongwang include motorcycles, minibuses, trucks, and axles. Each type requires different inputs, for instance, axle transport require animals (buffalo and cattle) the supplies of which varies depending on seasons. Fuel used for vehicles are gasoline, diesel, and LPG. Skilled and unskilled labor are required to provide transportation services.

Most of data on average number of persons per vehicle are assumed from investigations and are shown in Table C.11.1. The average load of vehicles are also assumed as in Table C.11.2.

Table C.11.3 shows cost of investment in the transportation subsystem, while Table C.11.4 shows the energy consumption for vehicles.

12. Development Project Subsystem

In 1985-1989, there will be some development projects proposed by the villagers and subsidized by the government. These projects concern the digging of the public reservoir to increase its holding capacity by an additional 320,000 cubic meters each year, raising fish in this natural reservoir for the villagers' need, and promote activities such as textile weaving and spinning, handicraft making, mat weaving, pottery making, cocoon-silk feeding, silk weaving and spinning. The flow diagrams of which are shown in Figure 4.12. Table C.12.1 shows the imported and exported prices of these products.

Introduction of Gasification Technology (Energy Development-Project

From the description of Nongwang's basic structures and its activities we can see that

1. Nongwang is relatively far from the Provincial Electrical Authorities (PEA) distribution system. At the

present time, the villagers still utilize kerosene lamps as the main source of lighting in households. This is one of the main factors that obstruct rural development.

2. There is no water pumping for irrigation. As a result, agricultural crop yields are still quite low.

3. There are large amounts of rice husk unused and sometimes simply burned in the fields. Rice husk is a process residue found in the existing rice mill in the Community which utilizes diesel engine as shaft power for milling.

4. Fuelwood from the natural forest supply will remain abundant between 1985-1989.

5. Abundance of labor especially in dry season is a typical problem in Nongwang. Creation of jobs in the Community should help increase income of villagers and decrease exported labor.

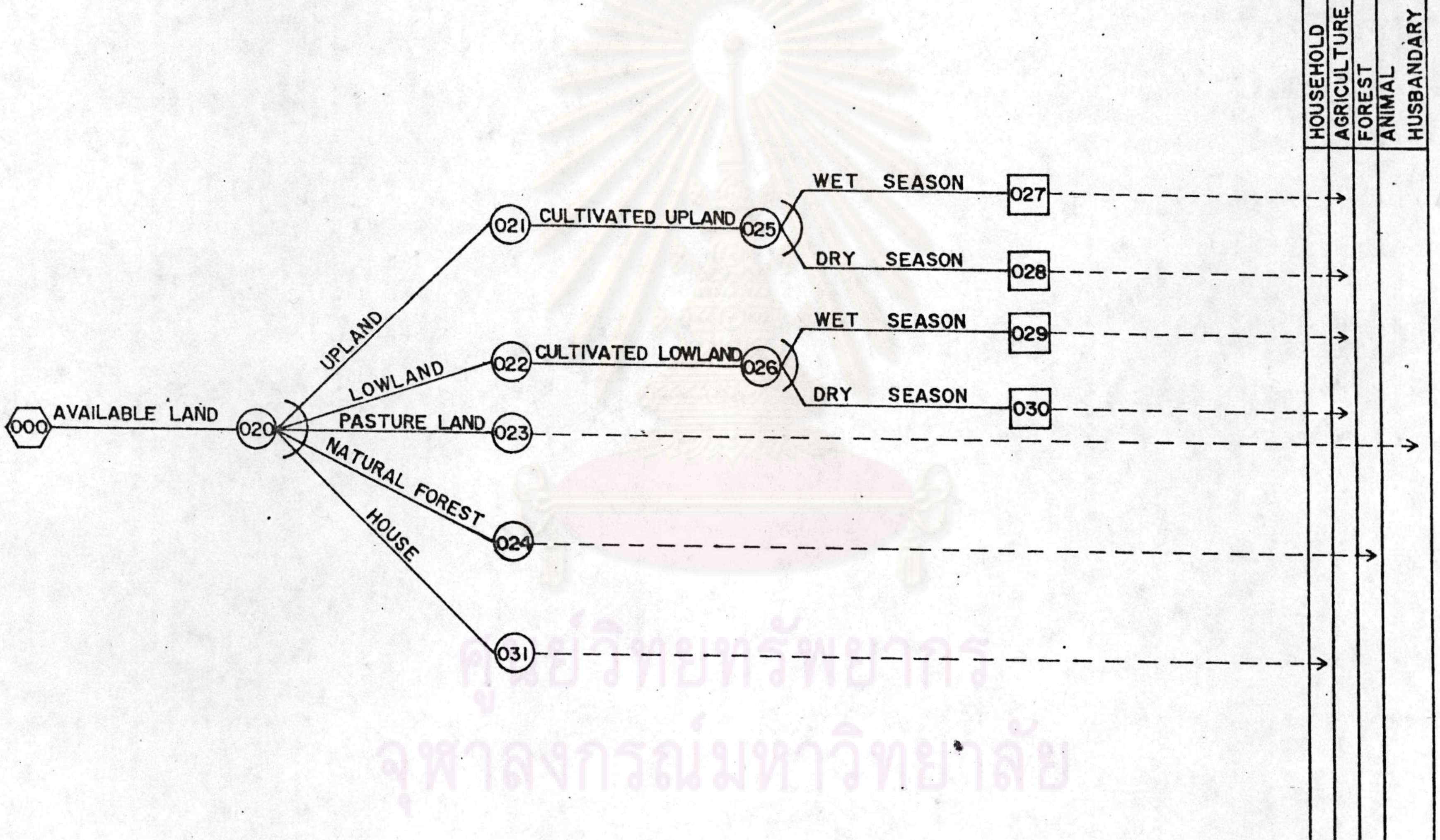
For these reasons, it is interesting to introduce biomass gasification to Nongwang for electricity generation which will substitute mostly kerosene for lighting; water pumping for irrigation to increase crop yield ; and shaft power for the existing rice mill to reduce use of petroleum fuels.

RCDM can be used as a decision making tool for introduction of gasification for the above mentioned activities, taking into account income, economic conditions, occupations of villagers and resources in the community for the period of 1985-1989.

operated with diesel or gasoline engines in different capacities and different biomass resources (charcoal, wood, rice husk) are introduced and compared to liquid fuel usage only (such as gasoline or diesel). The model then selects the most economic system for the community and tell us the maximum investment and variable costs acceptable by the villagers for each system.

In order to test the influence of variations in baseline assumptions, a sensitivity analysis of biomass prices, diesel and gasoline prices was performed. The model would show the optimum operating hours for the gasifier and arrange some activities to maximize income of the community in a five years period at specific conditions.

FIG. 4.1 LAND SUBSYSTEM



FIX. 4.2 HOUSEHOLD SUBSYSTEM

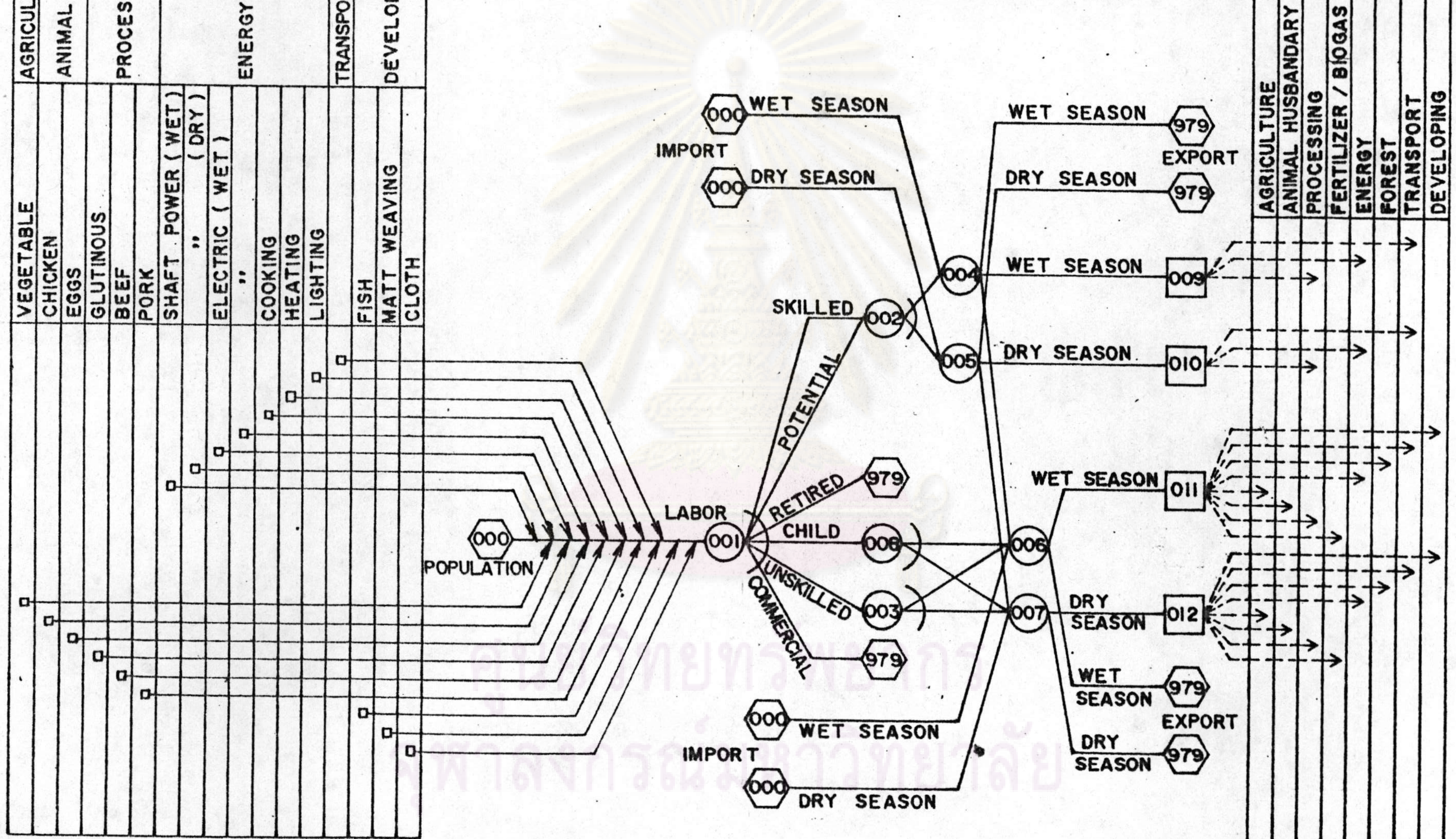
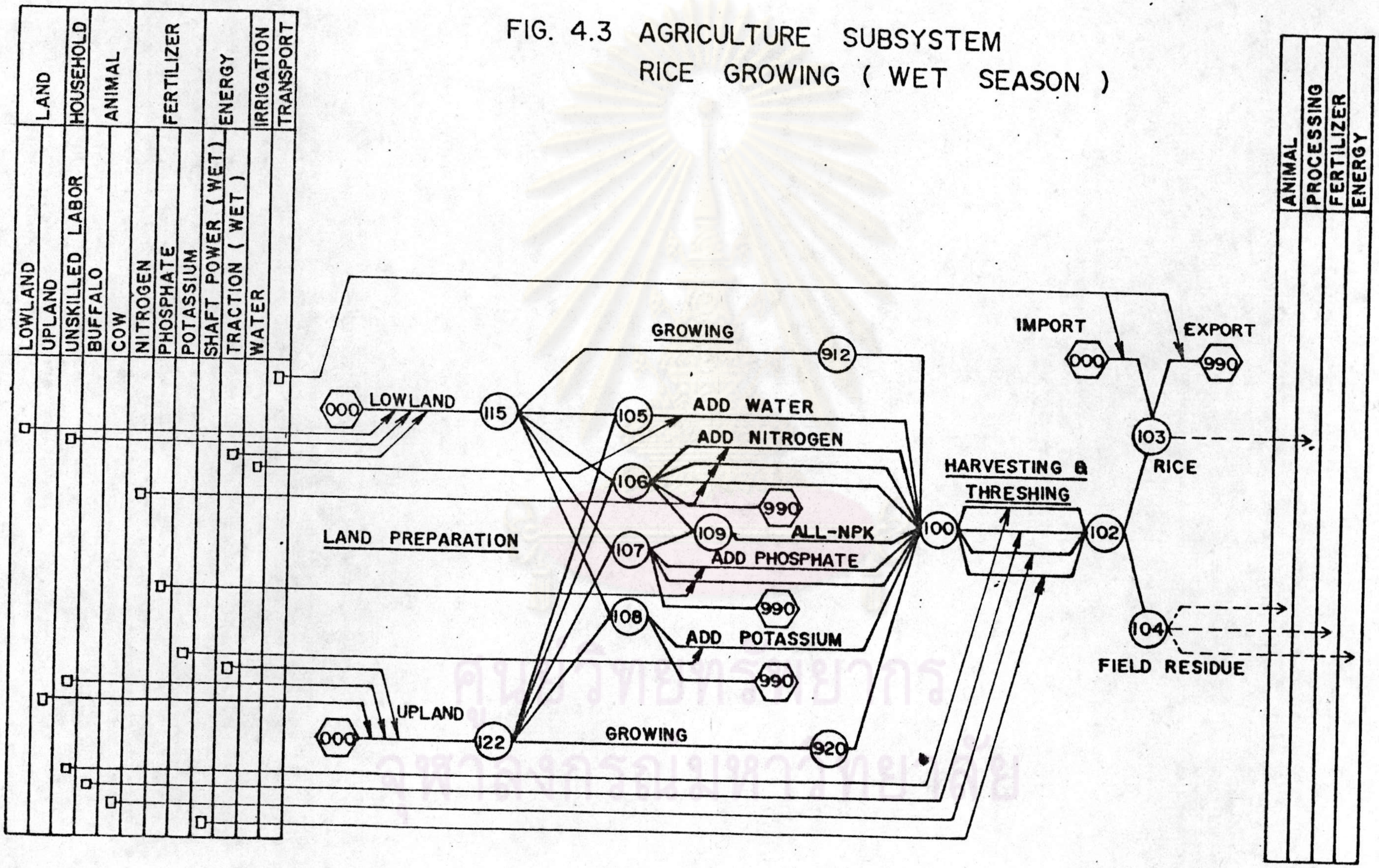


FIG. 4.3 AGRICULTURE SUBSYSTEM
RICE GROWING (WET SEASON)



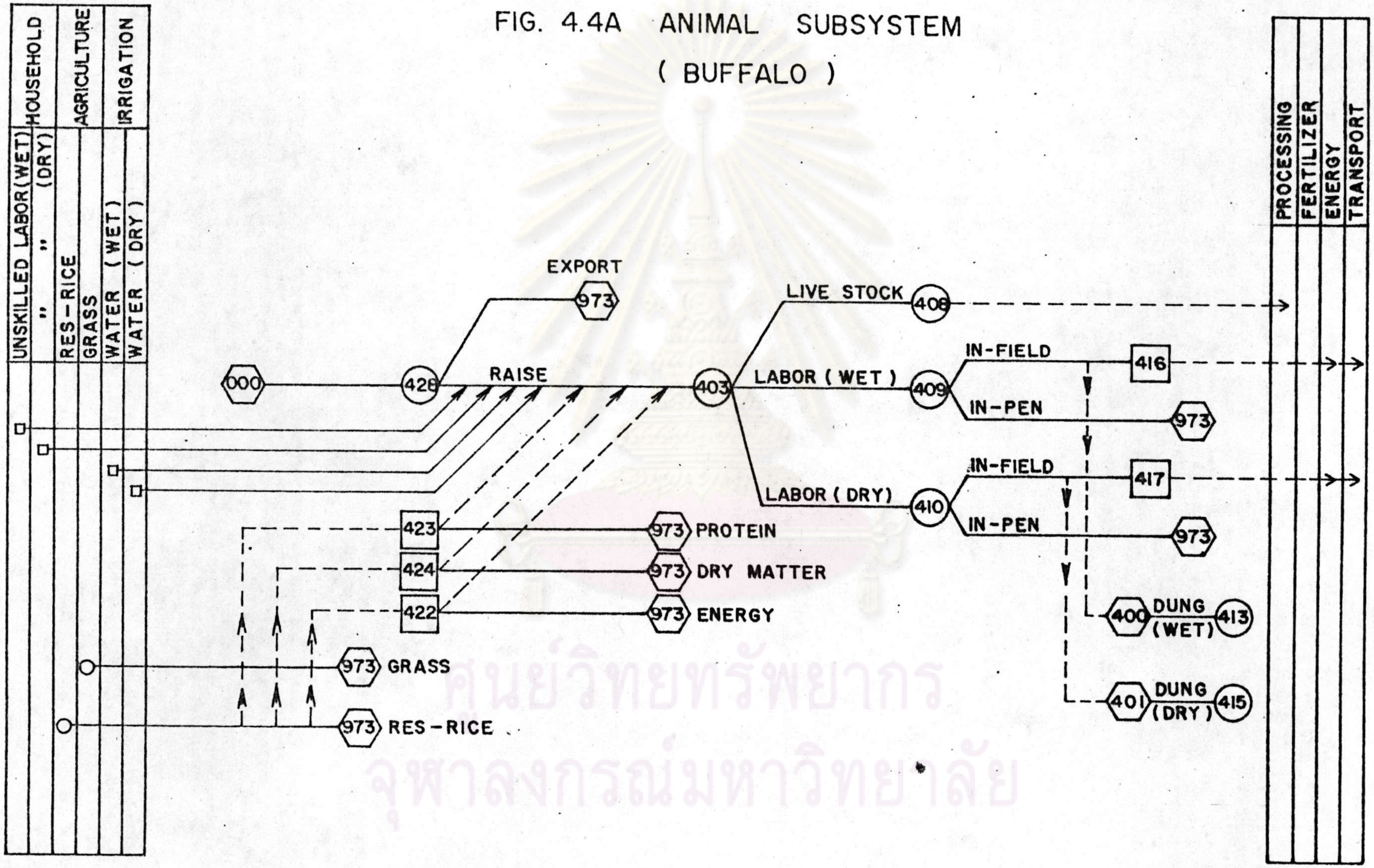


FIG. 4.4A ANIMAL SUBSYSTEM (BUFFALO)

FIG. 4.4B ANIMAL SUBSYSTEM
(PIG)

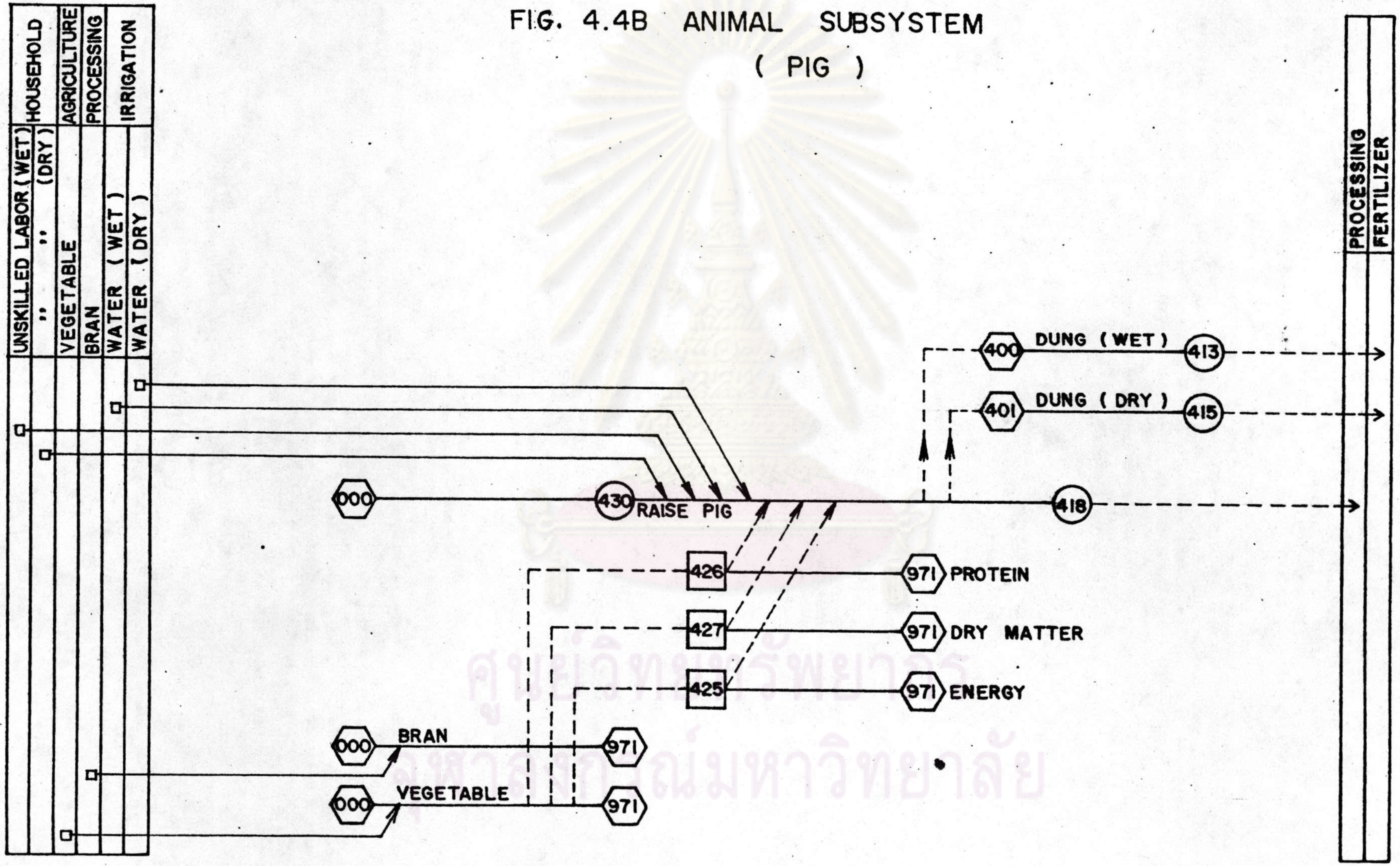


FIG. 4.5 PROCESSING SUBSYSTEM
(RICE MILL)

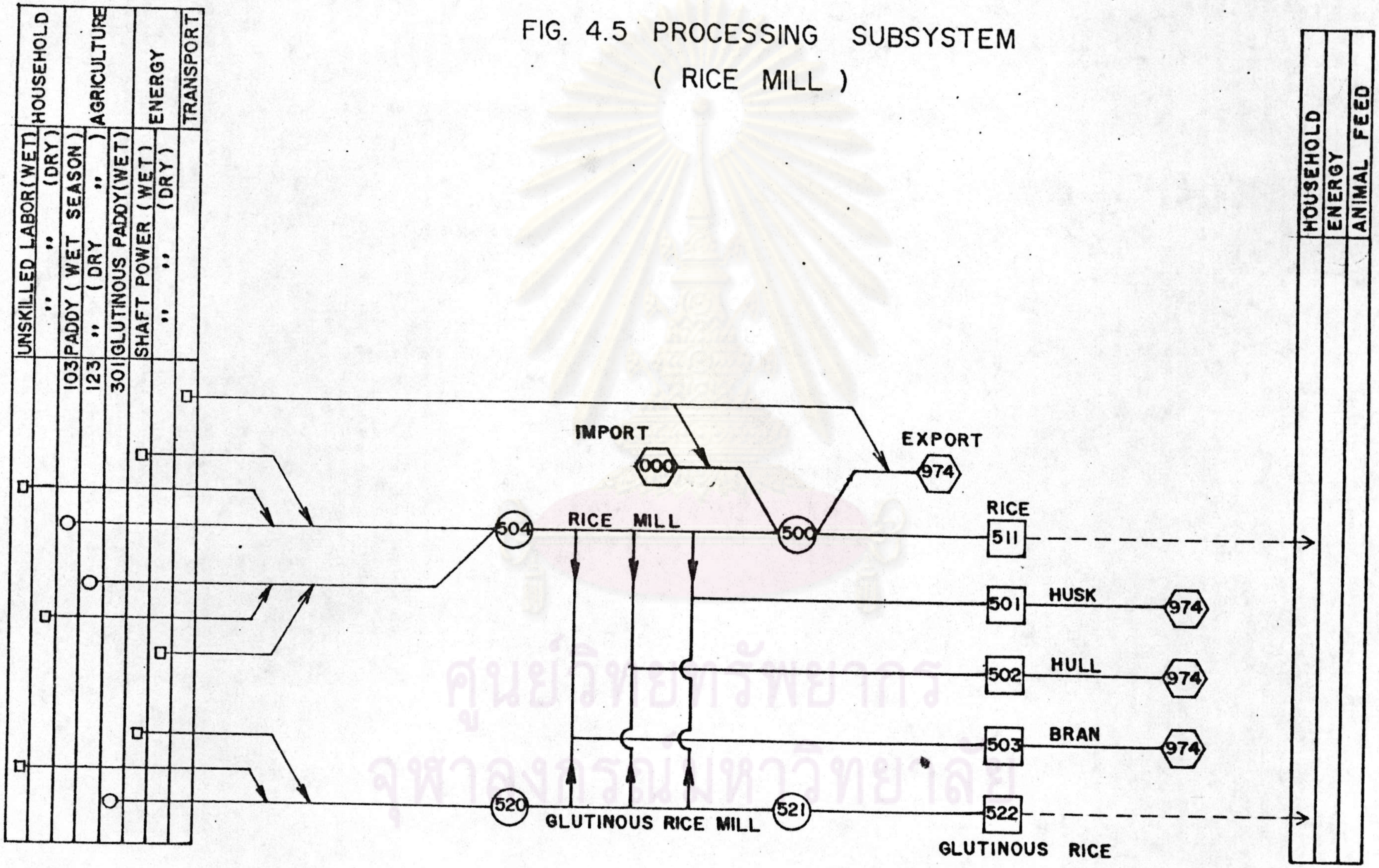


FIG. 4.6 ANIMAL PROCESSING SUBSYSTEM

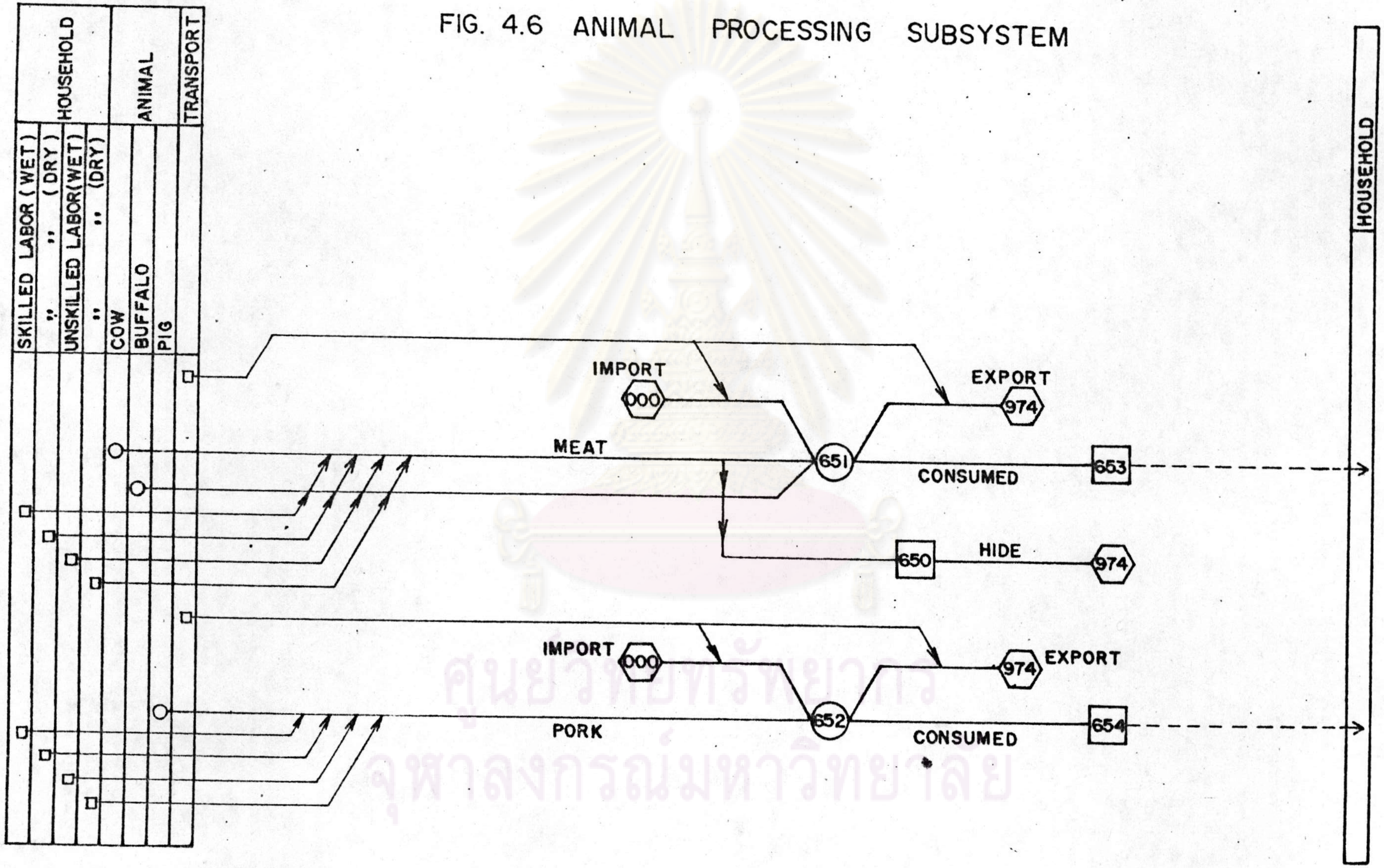


FIG. 4.7 FERTILIZER / BIOGAS SUBSYSTEM

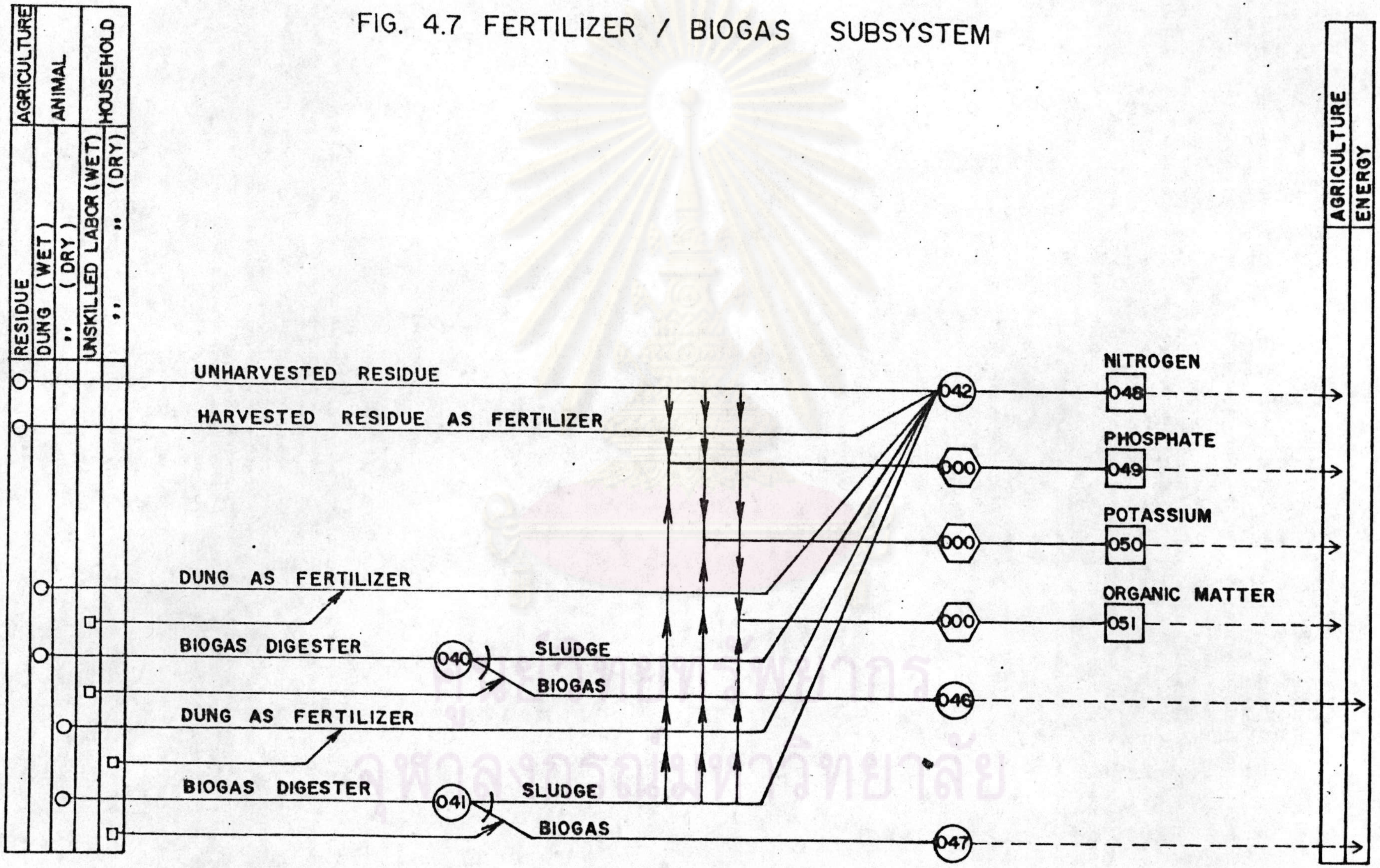


FIG. 4.8 ENERGY SUBSYSTEM

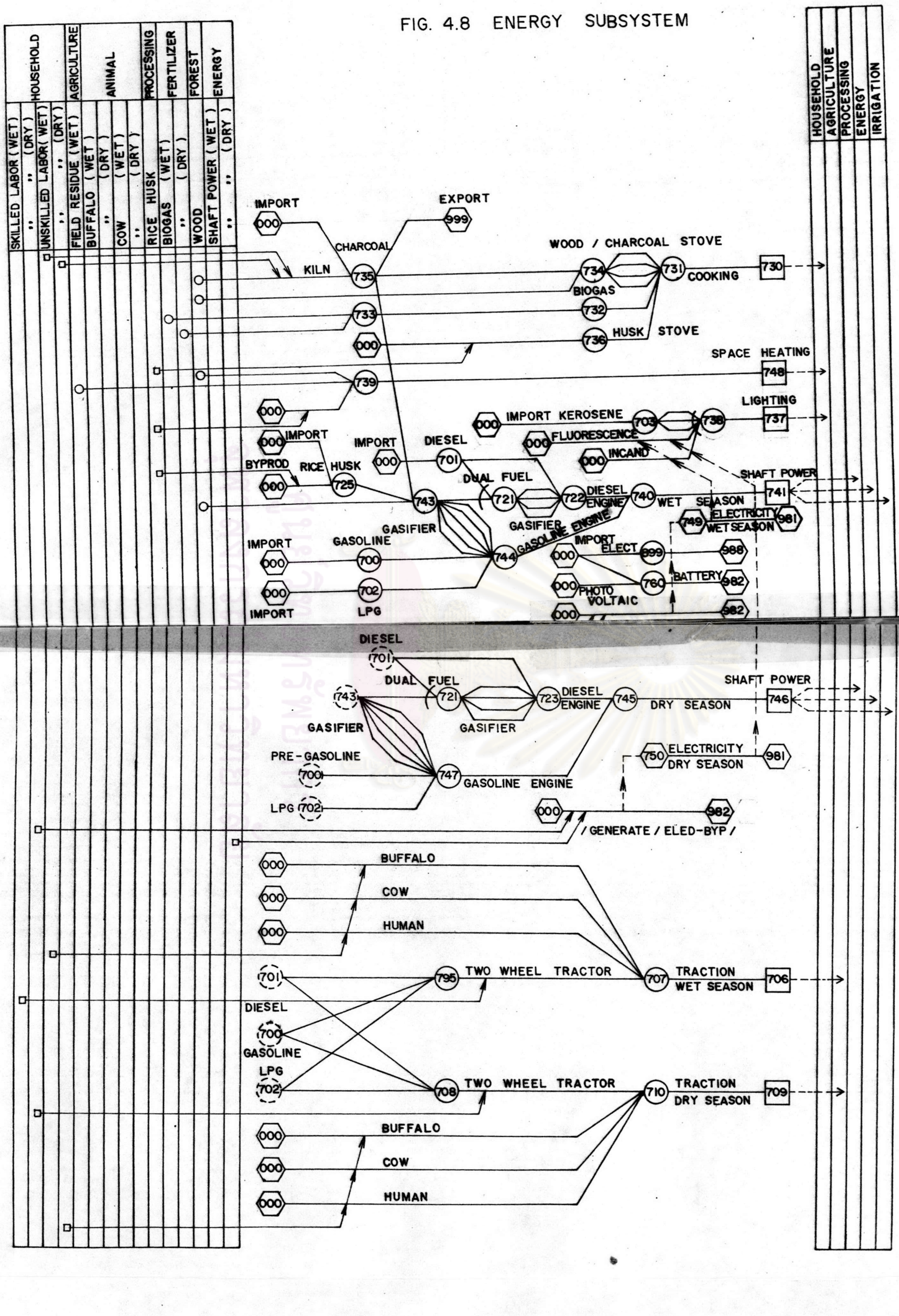


FIG. 4.9 FOREST SUBSYSTEM

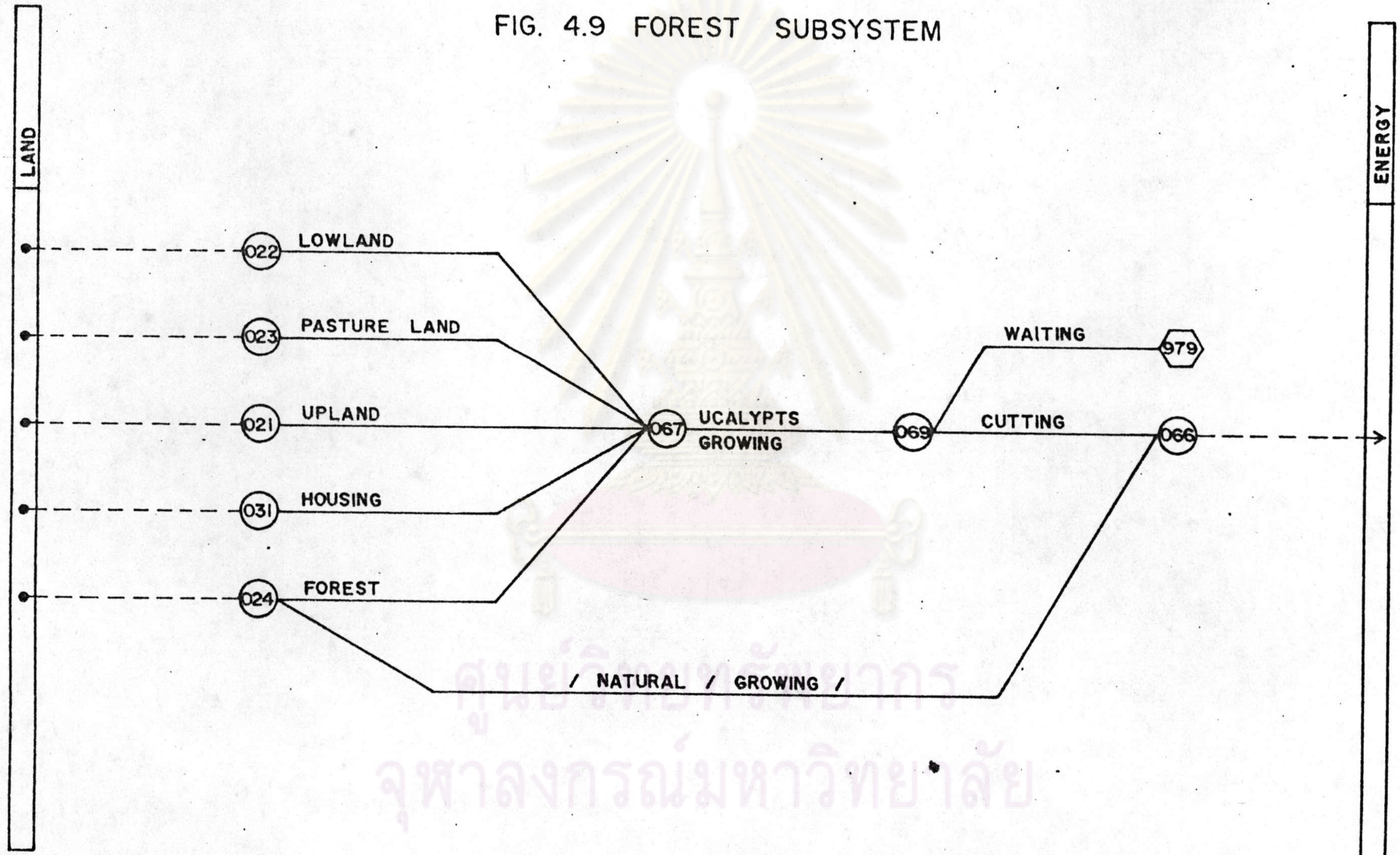


FIG. 4.10 IRRIGATION / WATER RESOURCE SUBSYSTEM

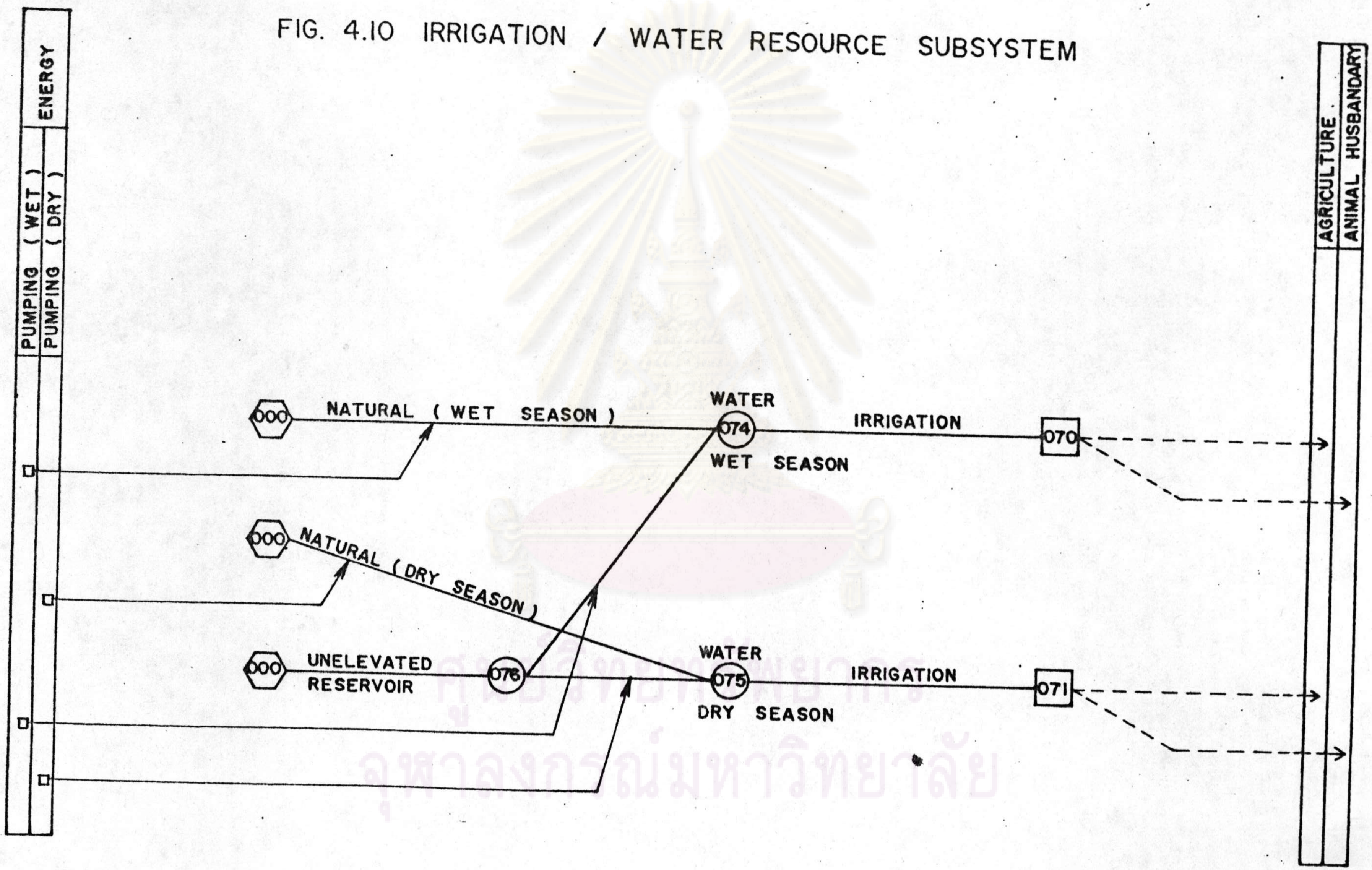


FIG. 4.11 TRANSPORTATION SUBSYSTEM

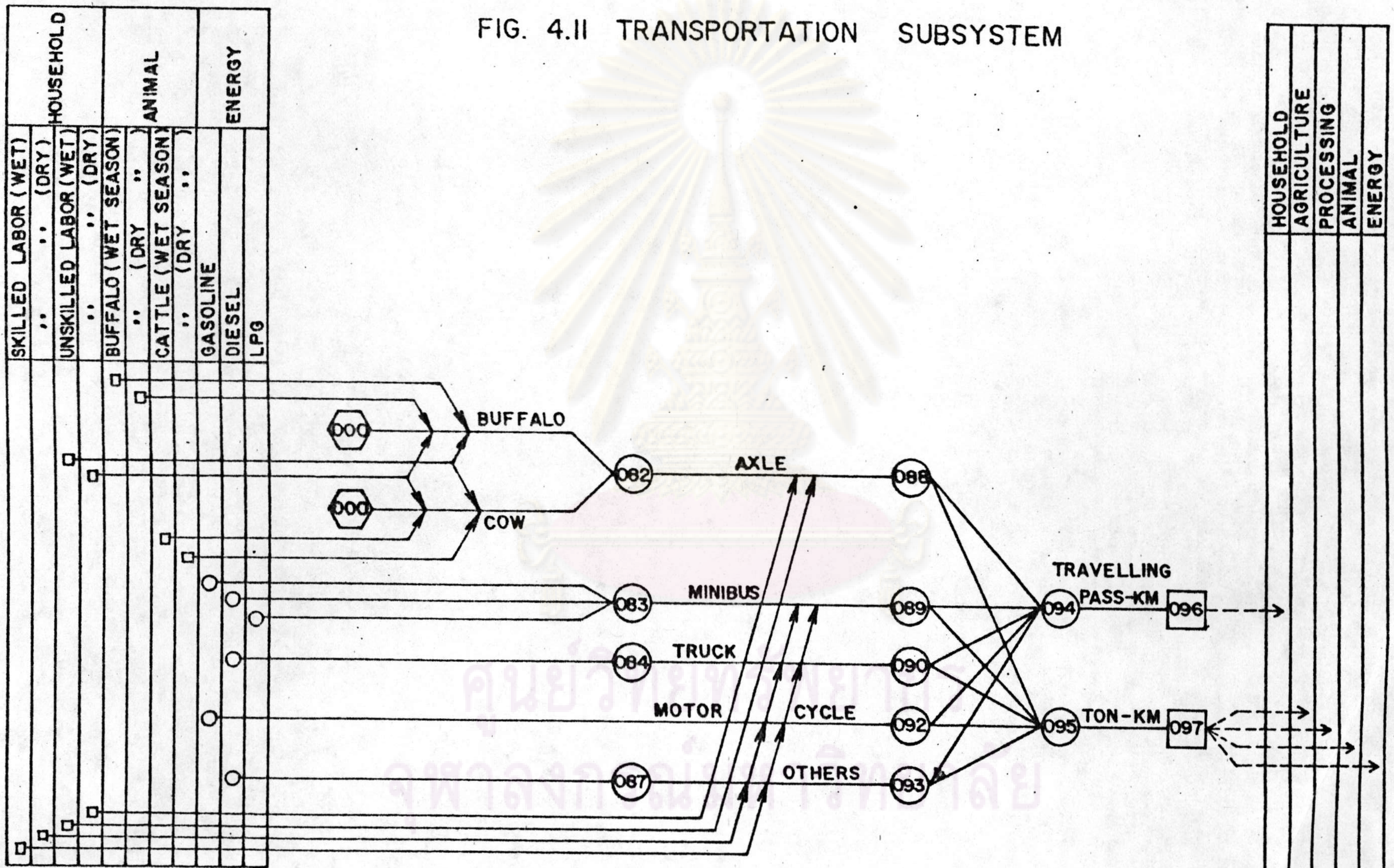


FIG. 4.12 DEVELOPMENT PROJECT
(COTTAGE INDUSTRY)