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THE FOOD-ENERGY SYSTEM IN THE PEOPLE'S REPUBLIC OF CHINA

by

Yingzhong Lu
Director, Institute for Techno-Economics
and Energy Systems Analysis
Beijing, PEOPLE'S REPUBLIC OF CHINA

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Food-Energy System in the PRC

Prof. Lu Yinghong
Inst. of Techno-economics and
Energy System Analysis
P.O. Box 1021, Beijing, China

1. Backgrounds and Issues

The People's Republic of China is a large developing country with a huge population over one billion. In years before liberation, over 90% people lived in the rural region where poverty and starvation had been considered as epidemic diseases due to the backward production level and socio-economic system. Food supply had always been the number one headache problem put before the government, and no real solution could be found under that regime. However, the rural economy has been developed very fast after liberation as shown in Tab.1, in particular after 1980 when the rural economical reform had taken place and the new rural policies implemented. The self-reliance of all kinds of food has been realized, and starvation has no longer been a menace to this one fifth of the world population. The total productions of main foods occupy the foremost places in the world as shown in Tab.2, though the per capita consumptions are still very low as compared with many developed countries.

Rural energy issue is one of the major limiting factor

for the development of food production and the people's daily life, which bears some peculiar features as shown in the energy structure scheme of Fig.1. The energy consumed in the household sector is much more than that in the production sector, while biomass constitutes the major part in the household energy consumption. The agricultural wastes account for 44.1% of the household consumption, while the fuelwood accounts for 37.8% of the total. Such an energy structure reflects the backwardness of the rural production technology as well as the serious situation of energy shortage in the rural region. [illegible] biomass, in particular the agricultural wastes, has resulted in serious ecological unequilibrium of the recycling of organic materials, and hence a sort of vicious cycle has been triggered as shown in Fig.2. Energy shortage causes the deforestation and the decrease of the organic content in soil. The former will lead to severe erosion of the land and abnormal climate while the latter result in the decrease of the fertility of arable land. These factors would result in the decrease of production of biomass fuels and hence aggravate the energy shortage. Such a vicious cycle became worse and worse before 1980 when Chinese energy experts made a series of proposals to the government on taking serious steps to get rid of the dangerous situation. A series of positive policies were formulated and vigorous actions taken, including both technical and institutional measures.

Great progresses have been made since then, but there is

still a lot to be done due to the new situation encountered during the rural economical reform . The responsibility system implemented in the rural region opens to the Chinese peasants more opportunities to be engaged in non-agricultural activities, and hence a wave of local industrialization is sweeping across the rural region which demands enormous commercial energy supply. A profound structural change is now underway in the rural region and the energy situation may be changed further in the coming decades.

Three characteristics could be noticed in the Chinese food-energy nexus, namely:

(1) The huge demands of food and energy in the PRC and the impacts of the relevant self-reliance policies;

(2) The consumption of large amount of biomass as fuel and the resulted vicious cycle of ecological equilibrium;

(3) The impacts of economical reform on both food and energy situation in the rural region.

These factors should always be born in mind when we discuss the following energy issues in food production, food processing and food consumption.

2. Energy Needs in Food Production

Energy inputs to food production consist of two parts: the direct energy consumption in various food production processes such as cultivation, irrigation, harvesting, threshing, etc., and the indirect energy inputs such as the

energy consumed in fertilizer and pesticides production. A diagram indicating all these energy inputs to the food production is shown in Fig.3.

The geographical variation in food production in the PRC should be emphasized since China is a big country in which both the local climates and the terrains vary substantially. In Tab.3 the varieties of crops cultivated in different areas are shown which implies diversified demands in energy inputs. The variation in terrains will not only changes the requirements of irrigation but also determine the size of the cultivated land and hence the applicability of machines. However, only national or regional average data will be considered below in order to simplify the discussion.

(1) Direct energy inputs to agricultural production

The major energy inputs to agricultural production are those consumed in irrigation, ploughing, harvesting, threshing, drying etc. More and more farm machinery are being used as shown in Tab.4 in which it is noted that in 1984 a total of 265 million hp of farm machinery were in use, including 854,000 large and medium-size tractors of unit power more than 20 hp and 3,300,000 walking tractors and other miniature ones. The human and animal power altogether amount only to 67.1 million hp---barely one third of the total horse power supplied by the tractors and the pumps for irrigation. It is estimated that about 40% of the cultivated land was ploughed with tractors and 56% irrigated by pumps.

The average number of tractors per unit area of arable land is higher in the PRC than those in the United States and the USSR; however, the utilization factor of the farm machinery is low as compared with either of the latter countries. Only 30% of the total farm tasks are performed with machines in the PRC, in contrast to over 70% in the USA and the USSR. Besides the existence of enormous low cost labor, the energy shortage is one of the major factors accounting for such a situation. The annual average working hours of all these tractors is only around 200, or 40-50% of the real capacity of these machines.

In the recent years of rural economical reform, more and more labors have been freed from the land and engaged in local industrial and commercial activities. In some model rural regions, only a small fraction of the total labor force takes the responsibility of agricultural production, and hence the utilization of farm machinery is intensified. As a result, the demand of commercial energy, in particular the liquid fuels, is increasing. For instance, in Daqiu Village, Tianjing, 34 out of 1480 labors (2.3%) are contracted to the total 320 hectares cultivated land in 1986, and produced 2150 tons of grain---an 80% increase in total production and 6200% increase in labor productivity respectively as compared with the year 1978 before rural economical reform. All these agricultural families have already been listed among the ten-thousand-yuan-annual-income families in that village. In Yuanhe Village, Jiangsu, 4 women set up four farms consisting

of 27 labors, about 2% of the total labor force there, and took the responsibility of cultivating 45.8 hectares of land with all kinds of farm machinery. The annual production of grain attained 11.25 tons in 1984, again an increase of 50.0% in labor productivity over the previous year. Such a tendency of the large scale mechanization of Chinese agricultural economy as illustrated in above two examples implies that huge amount of commercial energy supply will be required not only by the consumption in the farm machinery itself, but also by the associated expansion of rural industries and transportation activities caused by the 90% plus freed labor force. In Daqiu Village, 37 local small factories employing 3000 labors (including those from the neighbor villages) have been set up in 1986, and a total of 110 million yuan of products was produced which is almost 100 times over the revenues from the local agricultural production. Such examples depict the future perspectives of the Chinese rural economical reform, though the emphasis of this article will be put on the energy needs for food production only. The labor-intensive agriculture is now being replaced by the energy-intensive one, so the energy structure shown in Fig.1 is now changing rapidly.

(2) Indirect energy input to food production

The indirect energy inputs to food production consist of the energy consumed in the production of fertilizers, pesticides and farm machinery, among which the energy

consumed in fertilizer industries occupy the first place. The annual consumptions of chemical fertilizers in the past years are listed in Tab.5, in which a very high growth rate is noted -- some 200 times increase from 1952 to 1984, and a 70% increase within the recent five years from 1979 to 1984. A total of 17.4 million tons of effective ingredients (corresponding to 84.84 million tons of "standard" fertilizers) was consumed in 1984, or an average of 120.6 kg effective ingredients (or 591 kg of "standard" fertilizers) per hectare. It is estimated that almost one half of the nation's grain production attributes to the application of chemical fertilizers. However, the consumption of chemical fertilizers per hectare in different regions varies substantially all over the country, and the highest figures in the most advanced part of China have always been 4-5 times over the national average. Besides, the right proportion of various fertilizer ingredients (N:P:K) and the ratio of non-organic to organic fertilizers have great influence on the relative efficiency of the chemical components. A statistics of the structure of fertilizer ingredients is shown in Tab.6 and 7, and that of the relevant efficiencies in Tab.8. It is seen that the efficiencies of chemical fertilizers under different non-organic to organic ratio vary widely in different counties, e.g., from 0.5-2.3 kg grain to one kg chemical fertilizer applied.

The specific energy consumption of various fertilizers, including the organic ones, are listed in Tab.9. In this

table the energy inputs or outputs of all factors relevant to food production are also included which can be used to calculate the total energy balance of food production system in the next section. It is noted here that the nitrogen fertilizer consumes more energy than all other ingredients, and the total amount of consumption of the former is also much higher. A large fraction of primary energy is consumed in fertilizer production in the PRC: in 1982 about 59 million tons of raw coal, 6 million tons of crude oil and 4.2 billion cubic meters of natural gas consumed for this purpose corresponding to 8.85%, 6% and 5.4% of the national output respectively. Such a high level of energy consumption accounts partly for the existence of numerous small fertilizer plants which almost consumed twice the energy per unit product in large modern plants.

(3) Total energy input to food production

The total energy input per hectare to food production in various regions of the PRC is shown in Tab.10. The total energy input ranges from 25.4 to 155.0 gigajouls per hectare while the national average lies around 64.3 gigajouls. The share of organic energy input is low (60.5%) in the high yield region and it is high in the poor yield region. Since the grain productions per hectare differ substantially in these regions, the relevant efficiencies defined as energy output of the crop (including both the grain and straw

produced) to the total energy inputs are calculated and listed in Tab.11. It is seen that the efficiency in the rice rich region attains 40% while that in the poor rice region is only 14% . The comparison of the relative efficiencies of rice raising in different countries are shown in Tab .12 . It is noted that the efficiency of rice production in the PRC is some 60% lower as compared with either Japan or the United States . Hence very great potential of increase of productivity is there and the rice production can be increased when energy inputs are properly increased and superior seed strains adopted as in the developed countries . Proper arrangement of crop rotations according to the local conditions is also of importance to the productivity of land and efficiency of energy input. For instance, in sandy soil the output of wheat is only 750 kg/ha in certain areas but that of peanut may attain 1500 kg/ha in the same region, and the latter crop requires less investment, labor and fertilizer . The new rural responsibility system gives more freedom to the peasants for their own choice of crop, so more reasonable cultivation system could be adopted and the efficiency of energy input increased accordingly.

3. The Energy Needs for Food Processing

The energy needed for food processing includes those consumed in various food processing factories, transportation

and cooking . The components of the commercial energy consumption in a food flow system in the PRC are listed in Tab.1?, in which it is noted that the energy for cooking constitutes the major part of the total consumption---a share of 58.8% in the year of 1983. If the consumption of non-commercial energy is also taken into account, the share of cooking energy will be even more larger---some 195 million tce biomass was consumed in rural region in 1983, giving a total cooking energy consumption of 288 million tce, or 71.7% of the total energy input including both commercial and non-commercial ones but excluding the human and the animal power used. This peculiar characteristics of the energy structure in Chinese food flow system may be explained by the diet habit on warm, well-cooked meals and hot drinks in Chinese families as well as the very low efficiency of most traditional household cooking stoves still in use extensively all over China . It is therefore considered that the improvement of cooking stoves has the greatest energy conservation potential in the food flow system.

On the other hand, the commercial energy consumed in various food production processes only amounts to 20.2% of the consumption of the total system, while that consumed in food processing industries and transportation constitutes only 10.1%. Further increase of energy intensity either in food production or in food factory processing will therefore not influence the total consumption as much as the decrease in household cooking energy with fuel-saving stoves.

4. Energy Generated in the Food Production Cycle and the Justification of the Adoption of the Eco-agriculture

One of the peculiar characteristics in Chinese food flow system is the large amount of energy generated by the agricultural wastes as the by-products of food production. The outputs of straw and stalks depend not only on the output of grain crops but also on the straw-grain ratios which may very substantially with the species of the crops. The proper choice of seed strains of the crops and the patterns of cultivation are therefore important for increasing both the grain crops and the biomass fuels. For instance, some high yield species of rice with very short stem could not be popularized in Middle China due to their low yield of straws for household fuel. On the other hand, certain tall stalk cotton was adopted in San-cheng county, Shandong province, for its high yield of stalks which solved the local energy supply problem as shown in Fig.4. In the integral rural planning, the equilibrium of biomass is considered the focus point of the whole analysis.

However, the excessive burning of biomass as fuel causes the loss of organic fertilizer and decreases the organic content of the soil. A vicious cycle is resulted as shown in Fig.2 and a series of measures have already been taken to prevent further deterioration of the soil quality. Many analyses and experiments have been carried out in order to

find out the most favorable scenario for protecting the rural ecological environment . The so-called "Eco-agriculture" which put much emphasis on the equilibrium of organic materials within the food flow system and hence preserving the ecological environment. The most interesting concepts in eco-agriculture is the cyclical use of biomass. The simplest sample is the use of agricultural wastes together with the excrement of pigs in biogas digesters. Part of the organic material (mainly hydrocarbons) is turned into biogas (methane), and the remain slug in which most of the nitrogen compounds are retained is used as high quality fertilizer.

A more complex multiple-use cycles is the "rice straw--mushroom--beef--biogas" cycle as shown in Fig.5. The rice straw is used first to raise mushroom and then used as the feed of calf to raise beef, and the dung is in turn used for biogas generation, and finally the slug from biogas pit is used as fertilizer . The monetary revenue of such a cycle amounts to some 1000 yuan for every 50 kg of straw input, while that of the direct use of straw as fertilizer is worth only 2.5 yuan, thus the former corresponds to a 400 time increase. Another cycle worth mention is the "pig--mushroom--earthworm--hen" cycle as shown in Fig.6. Every 12 heads of pigs can feed and raise 200 kg of mushroom and 100 heads of hens. The advantage of such eco-agriculture cycles lies not only in the increase of monetary income but also in the improvement of the ecological environments. And, besides, it saves a lot of energy through the multiple-use of the

biomass.

4. Policies Towards an Integrated Rural Economy

Positive policies and measures have been adopted to establish an integrated rural economy in which the target of the development of rural economy could be in consistence with the energy supply and the ecological equilibrium. The major vectors of the relevant rural energy policies are as follows:

(1) The promotion of afforestation to increase the output of fuelwoods and at the same time to improve the environmental quality. A target of almost double the fuelwood supply by the year 1990 as compared with 1981 was set up as shown in Tab.14, and the new policies encouraging the private- and collective-owned fuelwood and other types of forests have been implemented. It is noted in this table that the increase of the fuelwood from the fuelwood forest will increase some 300% by 1990 as compared with 1981 and provide about one half of the total fuelwood supply.

(2) The increase of grain productivity through the improvements on cultivation patterns and technologies as well as the adoption of superior seed strains. The rapid increase of Chinese grain production attributes mainly to the increase of productivity from unit area of land. For instance, the productivity of hybrid rice per hectare was 2.615 tons in 1950 with simple water cultivation, and then increased to

3.391 tons when the technique of moisture nurturing had been adopted. Further increase of the productivity per hectare up to 4.073 tons was achieved in 1970 when the plastic-film seed preservation technique for seedling had been adopted. It is estimated that when one or two new superior seed strains will be developed and popularized, the unit productivity may be further raised to some 4.8 tons and thus increase the total rice production and reduce the specific energy consumption cosiderably.

(3) The popularization of the fuel-saving stoves and conservation of the biomass fuels. Since the energy utilized in cooking constitutes over 70% of that of the whole rural system, the energy saving resulted in this area is of first importance. Hundreds of different designs of fuel-saving stoves based on local materials and experiences which needs very little subsidy are now being popularized throughout the country. About 35 million such stoves have been already popularized already and a target of 60 million by the year of 1990 has been set up. With an average increment of thermal efficiency of 30%, it is estimated that the total amount of biomass fuel consumed in rural region will not increase by the year 2000 as compared with today.

(4) The popularization of the biogas digesters. Over 5 million family size biogas digesters have been built and a target of 7.5 million has been planned by the year 1990. The biogas program is considered in the PRC not only an energy project but also an environmental one both in ecological and

sanitary sense. However, recent structural change of rural economy gives rise to some uncertainty of the future prospects of such a plan. since more and more peasants are going to be engaged in the local industrial and commercial activities and less and less families prefer to raise pigs in their own houses. However, the change of rural economical structure of the whole country has still a very long way to go, the biogas program will therefore continue to be an important one at least within this century.

(5) Exploitation of local small coal mines as the source of commercial fuel supply to rural region. Since more and more commercial energy will be required as the modernization of rural economy proceeds, small local coal mines play the most important role in the supply of commercial energy to rural regions. In Fig.8 the rapid increasing share of local coal mines is seen, the output of which has attained 466 million tons in the year 1985, or 53.4% of the total. In fact, such a quantity has far exceeded the demand in the rural region and hence the local mines have become also an important source of coal supply to urban region. The major difficulty of rural coal supply lies in the under-developed infrastructure for distribution of such a huge amount of coal to the vast countryside, in particular the long distance transportation from the coal production bases in North China to other regions. The future rural energy structure will therefore be also a coal-dominant one, with less and less share of biomass as the second

important fuel.

(6) Electricity by means of minihydro-power stations. Minihydro-power resources exist in many part of the PRC, so the development of such power stations was rather fast before 1980 as shown in Tab.15. However, it is noted that such a tendency approached a saturation around 1982 when the easily exploitable resources had been exhausted. The regional electricity grids had to supply more and more power to rural region, in particular during the seasons for irrigation. Rural power shortage has therefore become more and more serious in recent years due to the mushrooming of the local industries, so numerous small fossil power plants, even miniature diesel units, were set up in rural region to fill the gaps.

(7) Increase of the liquid fuel supply. This is indispensable due to the rapid mechanization of agricultural activities in the course of the rural economical reform. Besides, the development of transportation needed by local industries requires also large amount of liquid fuel supply. All these will exert increasing pressure on the domestic petroleum market as well as on the infrastructure of oil distribution. It is estimated that around the year 2000 China may no longer be an oil exporter, or even become an oil importer, which will surely have some impacts on world oil market.

(8) Development of other renewable energies according to local conditions. Solar, wind, geothermal and tide energy

have great potential of development in certain regions in the PRC. Solar cookers have already been popularized in some desert region while wind power generater found application in nomadic regions. However, large-scale application for vast rural region is considered less liable within the next two or three decades.

6. Forecast to the Year 2000

According to the targets for the Seventh Five-Year Plan adopted by the People's Congress in April 1986, a forecast of the rural energy demand up to the year 2000 has been carried out in ITEESA. Regression models were used to estimate the economic growth and grain productions, and the relevant energy consumptions calculated based on the available data. The results are summarized in Tab.16-20. Since the rural economy structure is now undergoing abrupt change, the regression based on historical data seems not so adequate. These results should therefore be considered only as the lower limits. Moreover, even the scopes of statistics and categories of rural economy may be changed substantially, since less and less peasants will be engaged in agricultural activities while the gross value product of local industries will possibly be many times higher than that of agricultural products in most villages. However, the forecasted food consumptions in Tab.18 will be more reliable since these values depend on both demand and supply and hence are not

subjected to abrupt changes. It is seen in Tab.20 that the energy demand in food chain by the year 2000 when all means of energy conservation have been taken into accounts will amount to 155.8 million toe, only a 40% increase over the 1983 value (110.7 million toe).

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Tab.1. The Development of Chinese Rural Economy

(Unit: 100 million Yuan)

Year	Gross Agricultural Production	Year	Gross Agricultural Production
1949	326	1968	928
1950	384	1969	948
1951	420	1970	1,058
1952	461	1971	1,107
1953	514	1972	1,124
1954	535	1973	1,220
1955	575	1974	1,277
1956	610	1975	1,343
1957	537	1976	1,378
1958	566	1977	1,400
1959	497	1978	1,567
1960	457	1979	1,896
1961	559	1980	2,180
1962	584	1981	2,460
1963	642	1982	2,785
1964	720	1983	3,123
1965	833	1984	3,790
1966	910	1985	4,580
1967	924		

Tab.2. The Outputs of Major Foods in 1985

(Country/Output in Million tons)

Item	①	②	③	World Total
Grains	USA/346.88	PRC/342.50	USSR/180.61	1843.08
Meats	USA/ 17.83	PRC/ 17.55	USSR/ 14.17	112.36
Soybean	USA/ 57.94	Brazil/ 18.30	PRC/ 10.51	100.20
Peanut	PRC/ 6.66	India/ 5.60	USA/ 1.95	20.49
Rapeseed	PRC/ 5.61	Canada/ 3.46	India/ 3.03	18.68

Tab.3. Zonation of Grain Production in PRC

Zone	Provinces	Main Crop Rotation	Sown Area
Rice-Rice	Zhejiang, Fujian, Jiangxi Hunan, Guangdong, Guangxi	Rice(Rape)-Rice Rape-Rice-Rice	20.8%
Rice-Wheat	Jiangsu, Hubei, Sichuan Yunnan, Guizhou, Anhui Shanghai	Wheat(Rape)-Rice	29.2%
Wheat-Maize	Beijing, Tianjing, Hebei Henan, Shanxi, Shandong Shaanxi	Wheat-Maize	29.1%
Maize-Other Grains	Liaoning, Jilin	Single Crop	5.5%
Wheat-Other Grains	Heilongjian, Inner Mongolia, Gansu, Quinhai Ningxia, Xinjiang, Tibet	Single Crop	15.3%

Tab.4. Possession of Agricultural Machinery in the PRC

Year	Total Power (10⁴ kw)	Number of Agricultural Machinery			
		Large & Medium Tractor	Small & Walking Tractor	Large/Medium Implements	Irrigation Pumps
1952	250	1,307			
1957	1,650	14,674			
1962	10,290	54,938	919	192,000	367,000
1965	14,940	72,599	3,956	258,000	588,000
1978	159,758	557,359	1,372,000	1,192,000	5,023,000
1979	181,910	666,822	1,571,000	1,313,000	5,384,000
1980	200,490	744,865	1,874,000	1,369,000	5,630,000
1981	213,190	792,032	2,037,000	1,390,000	5,672,000
1982	225,890	812,447	2,287,000	1,374,000	5,803,000
1983	245,030	840,776	2,750,000	1,308,000	6,077,000
1984	265,090	853,914	3,299,000	1,235,000	6,150,000
1985	284,330	852,357	3,824,000	1,128,000	6,163,000

Tab.5. Consumption of Chemical Fertilizers in the PRC

Year	Consumption (10⁴ tons)	Year	Consumption (10⁴ tons)
1952	78*	1980	12,964
1957	373*	1981	13,349
1962	630*	1982	15,134
1965	1,942*	1983	16,598
1978	8,840	1984	17,398
1979	10,863	1985	17,758

* Quantity sales.

Tab.6. Structure of Fertilizers Used in the PRC (1982)

(Effective Content, in 10^4 tons)

Content	Total	Chemical Fertilizer		Organic Fertilizer		Green Fertilizer	
		Quantity	%	Quantity	%	Quantity	%
Nitrogen	17,550	11,430	65	5,446	31	68	4
P_2O_5	7,530	3,090	41	4,440	59		
K O	5,630	350	6	5,280	94		
Total	30,710	14,870	48	15,160	49	68	3

Tab.7. Organic and Non-organic Ratio of Fertilizers in Different Regions of the PRC

Ratio		National	Shanghai	Henan	Gansu
Energy,	Organic/Non-organic	3.70	1.95	5.41	8.83
Nitrogen,	Organic/Non-organic	1.45	0.57	2.61	2.08
P_2O_5	Organic/Non-organic	3.86	2.87	9.04	4.48

Tab.8. The Efficiency of Chemical Fertilizer with Respect to Non-organic/organic Ratio

Sample County	Sown Area % Green F.	Chem. F. kg/hectare	Non-organic/ Organic Ratio	Efficiency: kg Crop/1 g CF.
1	54	450-525	1 : 1.5	2.3
2	48	675	1 : 1	2.1
3	17	480	1 : 0.83	1.8
4	14	2025	1 : 0.43	1.0

Tab.9. Energy Conversion Factors Used for Calculation

Item	Unit	Conversion Factor
1. Non-organic Energy Input		
Farm Machinery	10^6 J/kg	210
Diesel Oil	10^6 J/kg	45.0
Electricity	10^6 J/kWh	12.5
Chemical Fertilizer		
Nitrogen	10^6 J/kg	91.0
P_2O_5	10^6 J/kg	12.4
K_2O	10^6 J/kg	9.0
Pestcides	10^6 J/kg	102.0
2. Organic Energy Input		
Human Power	10^6 J/cap-year	3500
Animal Power	10^6 J/head-year	21000
Seed	10^6 J/kg	16.0
Organic Fertilizer	10^6 J/kg	13.5
3. Energy Output		
Grain Crop	10^6 J/kg	16.0
Straw	10^6 J/kg	13.5
Soybean	10^6 J/kg	20.7

Tab.10. Organic/Non-organic Energy Input Structure in Typical Region of China, 1979 (in %)

Region	Non-organic					Organic					Total Input
	Agr. Mach-ine	Fuel Oil	Elec-tri-city	Chem. F.&I.	Sum	La-bor	Ani-mal	Seed	Fer-til-izer	Sum	10^9J/ ha
High Yield	6.8	7.5	3.1	22.2	39.5	11.1	1.4	7.7	40.3	60.5	155.0
[illegible] Yield	3.7	5.3	1.0	12.6	21.6	17.2	17.2	3.9	39.3	78.4	[illegible]
Poor Yield	2.4	4.8	1.3	4.6	13.2	17.5	22.6	9.4	37.7	86.8	25.4
Average	2.5	5.1	2.2	12.5	22.9	12.6	16.5	8.2	39.8	77.1	[illegible]

Tab.11. Energy Inputs/Outputs and Relevant Efficiencies in Different Rural Regions

Region	Unit Yields	Energy Inputs (10^9J/ha)			Energy Outputs (10^9J/ha)		Efficiency %
	kg/ha	Total	Org.	Non-org.	Total	Grain	
High Yields	10142	124.4	86.2	38.2	301.1	162.4	242
Medium Yields	4902	74.5	54.1	20.4	147.3	79.4	197
Low Yields	3376	54.6	42.2	12.1	99.6	54.0	177
Poor Yields	2016	40.1	34.8	5.4	57.3	32.5	140
Average: 1979	4275	64.3	49.6	14.7	126.1	68.6	195
1965	2160	38.1	36.2	2.0	63.7	34.6	167
1952	1684	30.1	30.1	0.06	49.7	26.9	165

Tab.12. Energy Output/Input Ratio Comparison for Rice Production in Different Countries

Country	Energy Input (10^6kcal/ha)			Rice Yeild	Output/Input
	Field Work	Irrigation/ Fertilizer	Total	ton/ha	Ratio
India	5	2	7	1.4	2.7
PRC	5	3	8	3.0	5.1
Japan	3	5	8	5.5	7.1
USA	3	5	8	5.1	5.4

Tab.13. Commercial Energy Consumption in Food Flow System in China in 1983

Item	Energy Consumption 10^8 tce (10^8 toe)	Share of Total, %
Direct use for agricultural Production	22.0 (15.4)	13.9
Indirect use:	25.89 (18.12)	16.3
for chemical fertilizer	23.87 (16.7)	
for chemical insecticide	0.7 (0.49)	
for agricultural machinery	1.3 (0.91)	
Food Industry	15.50 (10.85)	9.8
Grain and food transportation	1.8 (1.26)	1.1
Cooking for livel hood: total	93.0 (65.1)	58.9
for peasant's families	56.0 (39.2)	
for urban areas, in which:	37.0 (25.9)	
for resident's families	23.6 (16.52)	
for collective cofeteria	10.3 (7.21)	
for restaurant	3.1 (2.17)	
Total	158.2 (110.74)	100.0

Tab.14. Current and Planned Fuelwood Supply

(in Million Tons)

Fuelwood Supply, by Types of Forest	1981	Early 1990s (Planned)
Timber Forest	33	37
Shelter Forest	1	
Shrub Land	16	41
"Four-around" Plantation	19	32
Fuelwood Forest	21	82
Total	90	170

Tab.15. The Development of Rural Minihydro-power Station and the Consumption of Electricity

Year	Electricity Consumption	Rural Minihydro-power Station	
		Number	Total Capacity
	TWh		MWt
1952	0.05	98	8
1957	0.14	544	20
1962	1.61	7,436	252
[illegible]	[illegible]	[illegible]	[illegible]
1978	25.31	82,387	2,629
1979	28.27	83,224	2,763
1980	32.08	80,319	3,208
1981	36.99	74,017	3,360
1982	39.69	66,256	3,530
1983	42.81	62,328	3,463
1984	46.40	60,062	3,615
1985	50.89	55,754	3,802

Tab.16. GNP in 1990 and 2000

(in 1980 constant price)

	1985		1990		2000	
	10⁸yuan	%	10⁸yuan	%	10⁸yuan	%
GNP	712.5	100	1023	100	1667	100
Primary Sector	226.6	31.8	280.3	27.4	369.4	22.9
Secondary Sector	334.1	46.9	484.9	47.4	789.9	47.1
Tertiary Sector	151.8	21.3	257.8	25.2	507.7	30.0

Tab. 17 People's Average Expenditure per Capita per Year

(in 1980 Comatant Price, Yuan)

	1980	1985	1990	2000
Expenditure, Average:	227	338	434	702
For peasant	173	281	360	592
For non-peasant	468	579	711	1072
Ratio:Non-peasant/Peasant	2.7	2.06	1.98	1.81

Tab.18. Demand Forecast of Main Food product in 2000

		Consumption per capita kg/ca	total Final Demand Y 10^6ton	Total Grain Yields X 10^6ton
Grain:	Rice		135.2	183.7
	Wheat		80.5	110.0
	Yam		28.5	38.5
	Maize		47.8	96.8
	Sorghum		7.8	10.5
	Millet		6.4	8.7
	Soybean		10.0	19.3
	Others		5.0	21.9
	Total:	250	321.2	495.7
Meats		26	35.1	35.1
Fish		8.0	10.0	11.5
Milk		28.0	38.5	90.7
Eggs		12.5	16.3	17.7

(Population : 1.25 Billion)

Tab.19. Structure of Fertilizers in 2000

(Effective Content, 10^4 ton)

Nutrient	Total	Chemical F.		Organic F.		Green F.	
	Quantity	Quantity	%	Quantity	%	Quantity	%
Nitrogen	30	13.64	46	10.00	33	6.36	21
P_2O_5	14	5.00	36	8.00	57	1.00	7
K_2O	30	1.36	5	22.00	74	6.64	22
Sum Total	74	20.00	27	40.00	54	14.00	19

Ratio of Nutrients: N : P_2O_5 : K_2O

Chemical F. 1 : 0.37 : 0.10

Organic F. 1 : 0.80 : 0.22

Total 1 : 0.47 : 1

Ratio of Non-organic to Organic Fertilizer: 1 : 2.7

Ratio of Non-org. Nitrogen to Organic Nitrogen: 1 : 1.2

Tab.20. Commercial Energy Demand Forecast in Food Flow System of the PRC in 2000

Item	Energy Consumption		Share
	10^{8} tce	10^{8} tce	%
Direct Use in Agricultural Production	35.42	50.76	22.8
Indirect Use:	14.35	20.50	9.2
(1) Chemical Fertilizer	(3.65	5.20	2.3
(2) Farm Machinery manufacture	(0.7	1.10	0.5
Food Industry	19.18	27.40	12.3
Transportation	1.58	2.25	1.0
Cooking:	85.12	121.60	54.5
(1) In Peasant's Families	(35.00	50.00	22.5)
(2) In Urban Families	(31.92	45.60	20.5)
(3) In Restaurants	(14.00	20.00	9.0)
(4) Catering	(4.20	6.00	2.7)
Total	155.79	222.55	100.0

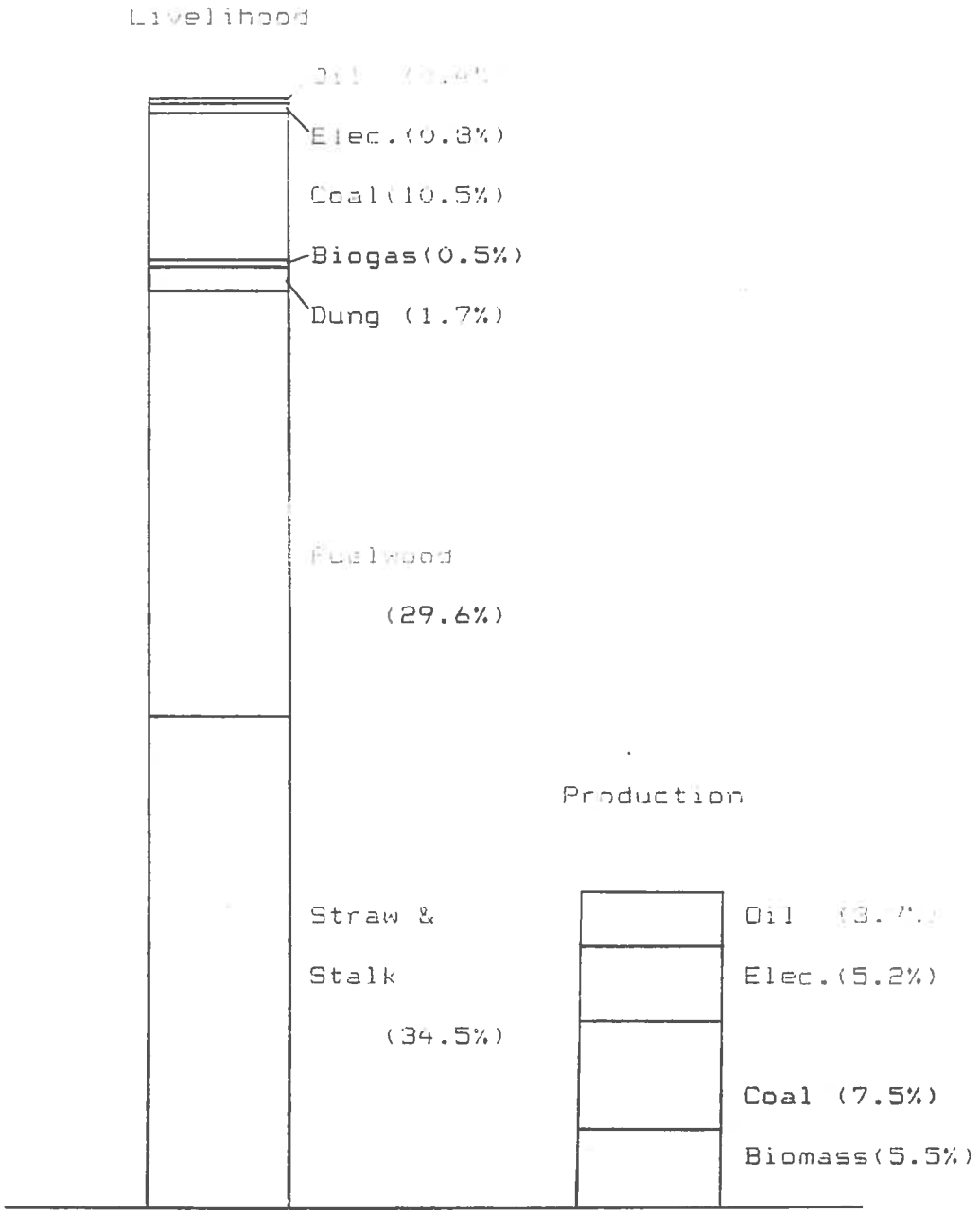

Fig.1. Rural Energy Structure in the PRC, 1980

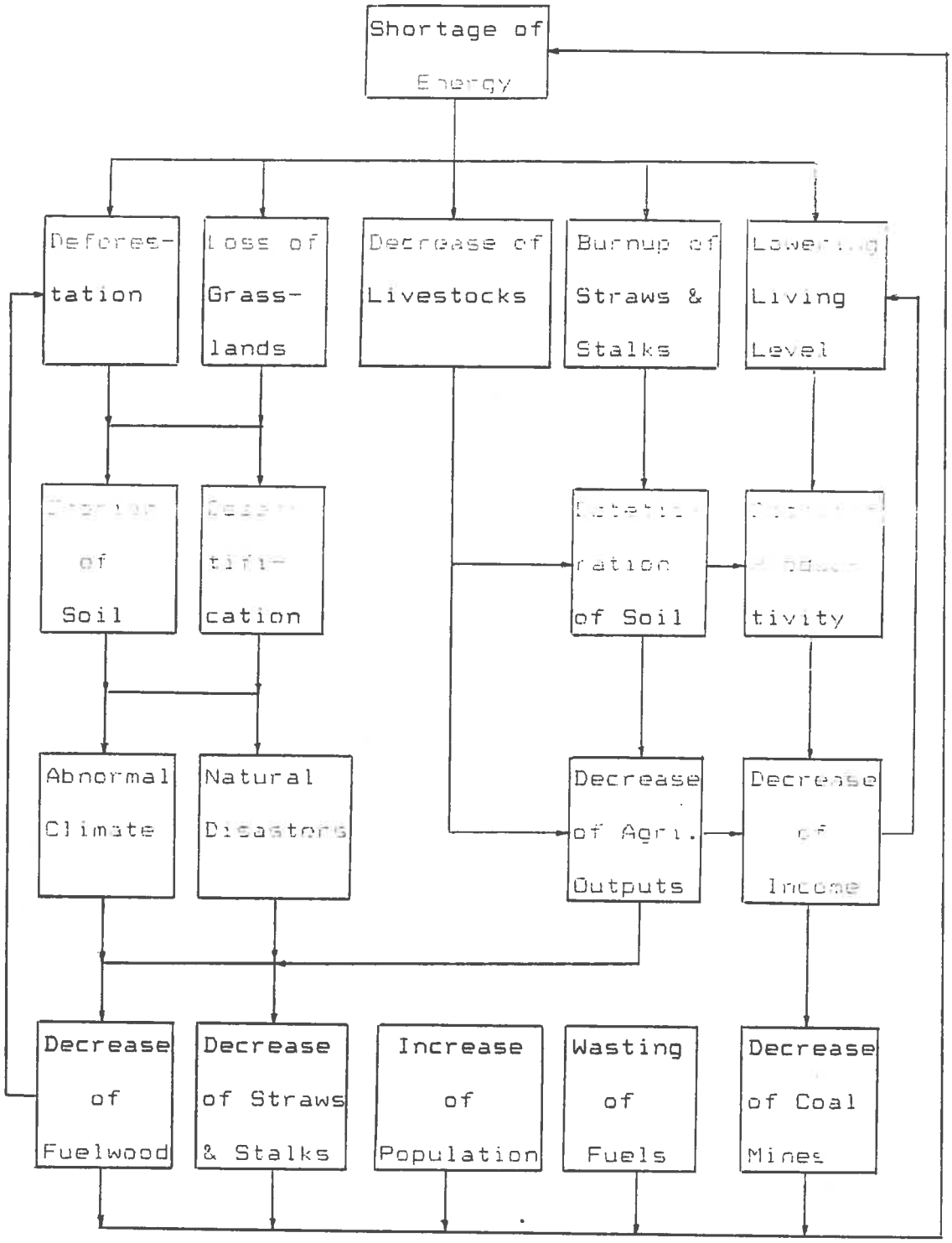

Fig.2. Vicious Cycle in Rural Region due to Energy Shortage

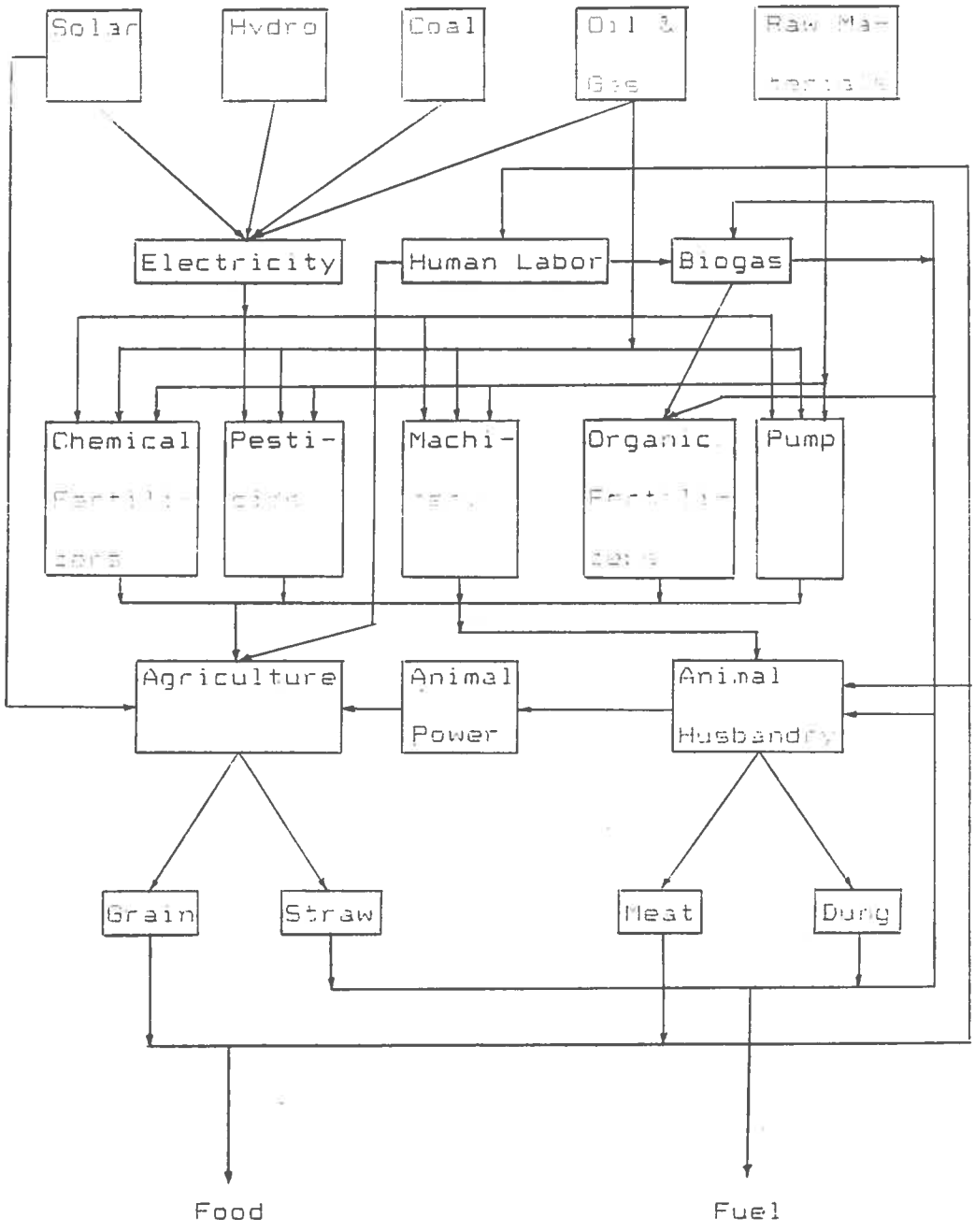

Fig.3. Energy Inputs to Food Production

Legend:

A. Productivity of Cotton, kg/Mu (1/15 Hectare)

B. Total Production of Cotton, 10^4 ton

C. Fuel (Cotton Stalk) per Family, kg/yr

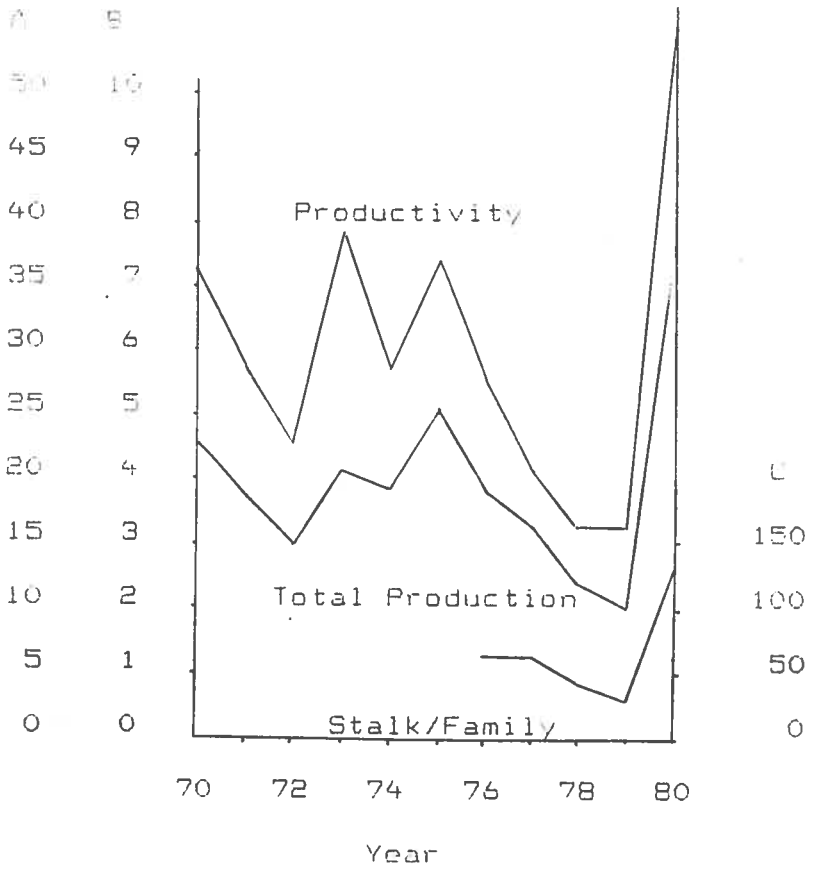

Fig.4. The Increase of Cotton Stalks in Sancheng

Sancheng County, Shandong.

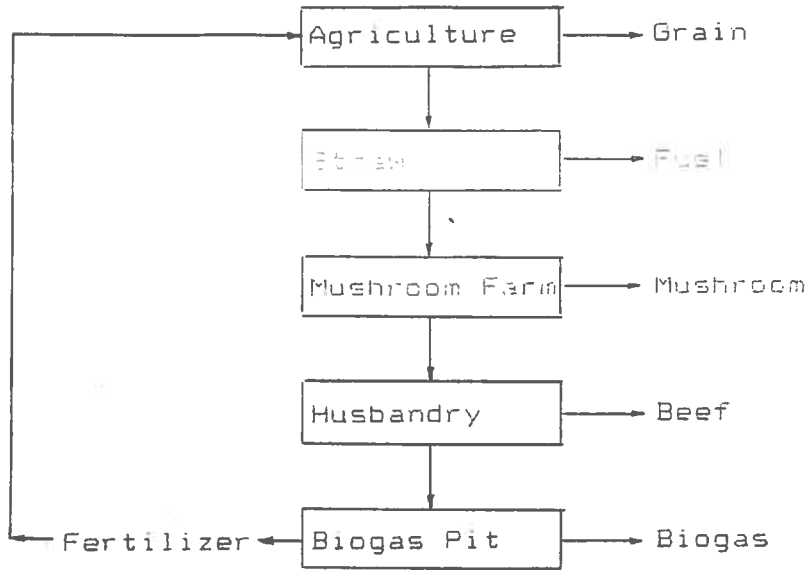

Fig.5. The Cycle of Organic Materials.

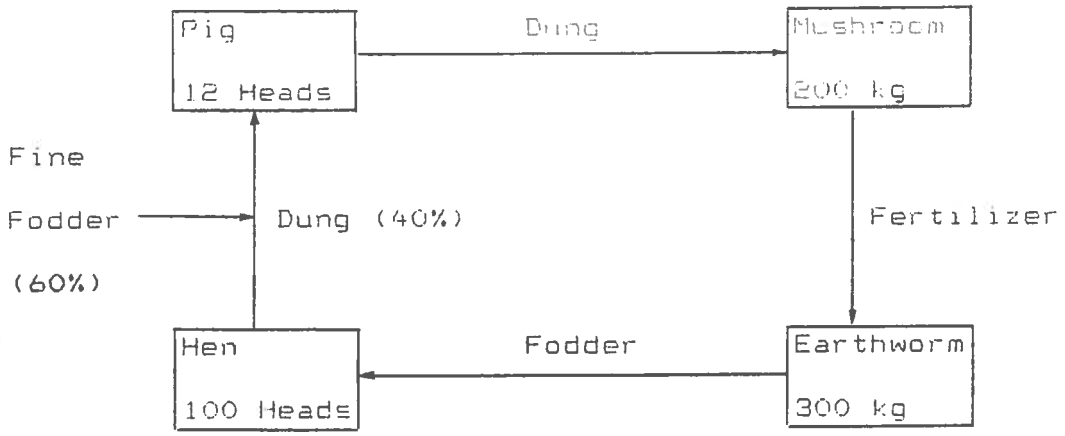

Fig.6. The Alternative Biomass Cycle for Eco-agriculture.

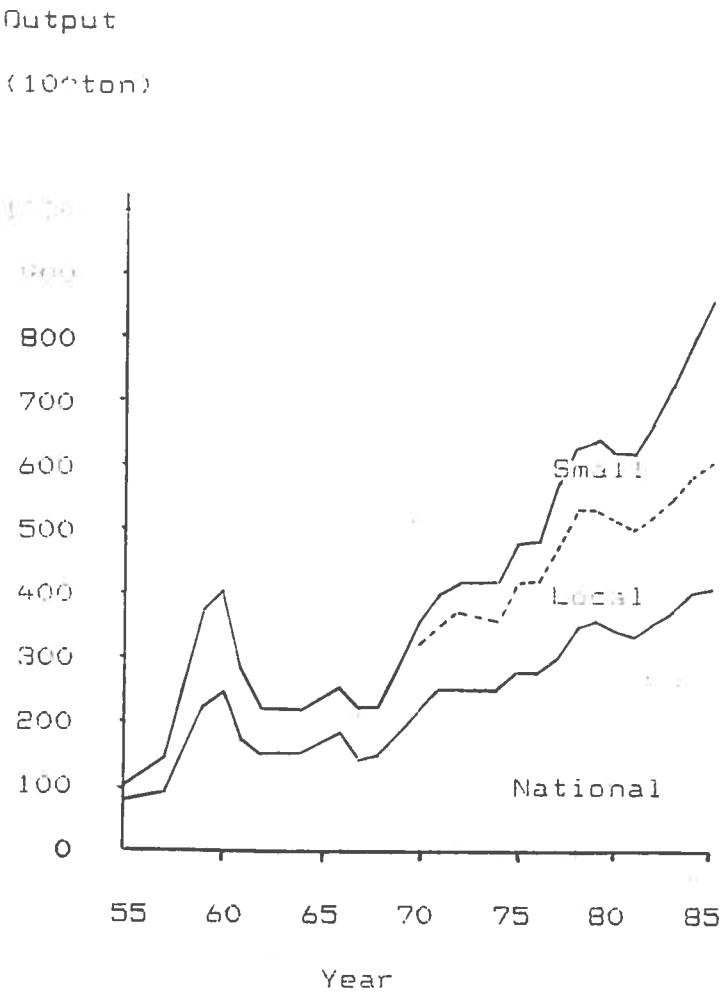

Fig.7. The Development of the Local Coal Mines.