RICE CULTIVATION IN BALI: AN ENERGY ANALYSIS

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DEDICATION AND DECLARATION

This Thesis is dedicated to Dewi Sri, the Balinese Rice Goddess, and my mother, Pixie Foley.

The work described in this thesis was conducted in Bali, Indonesia, during 1979 and is the independent work of the author, except where specifically acknowledged in the text. Neither the present thesis or any part thereof has previously been submitted to any other University.

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ABSTRACT

This study applies the methods of Energy Analysis to rice production in Bali, Indonesia, where the new HYV's of rice have been introduced during the last 10 years in an attempt to increase per hectare yields. Two major surveys were conducted in the Dam Ubud area of South Central Bali to measure the differences in inputs and outputs used for the cultivation of Traditional and HYV's.

The results of these surveys showed that labour inputs were effectuvely the same for traditional and HYV's; that the mean yield for the most modern of the HYV's (IR-36) was only 9% (168 kg/ha) higher than that of the highest yielding of the traditional varieties (Cicih Beton); mean fertilizer use for IR-36 was found to be 158 kg/ha, whilst that for Cicih Beton was found to be 10 kg/ha. Energy Ratios were calculated for each of the seven varieties sampled in the surveys; the ER of IR-36 was found to be 1:2.71, and that of Cicih Beton 1:5.85. The energy content of fertilizer application was found to account for 88% of the difference in energy inputs between IR-36 and Cicih Beton.

Data from historical and contemporary studies of Balinese rice production were examined. The results of this analysis showed that the ER's for the cultivation of traditional varieties not using fertilizer (Urea) sampled during this study were comparable with those for rice cultivation in 1934 and 1918; and the ER's for the sample of IR-36 was comparable with that for IR-36 grown in other parts of the island.

The average yields per hectare for Bali were found to have increased by only approximately 100Kg/Ha between 1934 and 1978, whilst the use of Urea fertilizer had reduced the ER for rice cultivation from approximately 1:7 (1934 and 1948) to approximately 1:3 (1978). These comparisons showed that efforts to increase per hectare rice yields by extending cultivation of HYV's had been only marginally successful, and that the use of nitrogenous fertilizer had halved the ER for rice production. Two policy recommendations were made; the initiation of a rice breeding programme to develop insect resistant varieties not requiring nitrogenous fertilizer; and the initiation of experimentation using green manures and compost to maintain soil fertility and improve soil structure.

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CHAPTER 1

INTRODUCTION

1 . 0

Introduction

Between now and the year 2000 U.N. estimates suggest that world population will have increased by between 2 x 10^9 (low estimate) and 2.5 x 10^9 (Licklider, 1978), and that the demand for food in the Third World will rise at the rate of 3.6% per year (Biswas and Biswas, 1975). This mans that in the year 1985 Third World food demand will have increased 45% over 1974 levels, and by the year 2000 will have doubled. During this period all but one-sixth of this increase in demand will come from population increases (De Bivot, 1975). To meet this increase in demand the 1974 World Food Conference proposed that the area of land under cultivation in the Third World be expanded by 12% by the year 1985 (Biswas and Biswas, 1975). If yields per hectare remained stable this expansion in cultivated land would supply less than one-third of the needed increase in food production , the remainder having to come from increases in the yield per hectare.

De Bivot (1975) estimated that to achieve this increase in yield/hectare requires a doubling of nitrogenous fertiliser production to 2.2 x 10^6 tonnes p.a. and a five fold increase in pesticide production to 8 x 10^6 tonnes p.a. Increases of this magnitude are heavily dependent upon the availability of fossil fuels necessary for the manufacture of agrochemicals. The nine fold rise in petroleum prices since 1973-4 has put great financial strains on the economics of developing countries dependent upon petroleum related products, including agrochemicals.

These economic problems have been compounded by political instability in the Middle East, the area from which the majority of the petroleum comes, and by the projection that by the 1990's a wide gap in the supply and demand for oil will exist. (An encyclopedic analysis of these problems and their inter-relationships, their possible consequences and solutions has been made by Ehrlich, Ehrlich and Holdren (1977)).

This increasing cost and scarcity of fossil fuel supplies underlines the importance of energy efficiency in agriculture. Leach (1975) has shown that the transition from a solar based traditional form of agriculture to the type of agriculture practiced in the developed nations results in a decline in the efficiency with which energy inputs are used. For example, the production of a tonne of rice in the Philippines, using largely traditional cultivation practices requires only one quarter of the energy required to produce a tonne of rice in the U.S., using energy intensive industrial cultivation techniques. Using the example of maize production in the U.S.Pimentel *et al* (1973) emphasised that this process of industrialisation once begun continues to reduce the efficiency of energy use in agriculture.

1.1

Methods of Energy Analysis

Energy Analysis has been developed in recent years in an effort to quantify the increasingly important role of energy use in agriculture and industrial production (Chapman, 1974;

Roberts, 1978; Newcombe, 1975; Leach, 1976). Three different, though complementary, methods of undertaking an energy analysis can be distinguished:

1.1.1

Input-Output Table Analysis

This method is an adaptation of economic analytic methods applied to static input-output energy exchanges between sectors of a national economy. It shows the f low of products, in units of energy, between sectors of an economy, and allows the identification of both the direct and indirect energy inputs for any given set of commodities. By summing the direct and indirect inputs, the total energy required to produce a unit of the commodity under consideration is obtained. In general Input-Output Tables are useful in analysing the energy content of broad categories of commodities, e.g. capital goods, imports, exports. Bulland and Nerenden (1975) have detailed its limitations, the main one being analytic output is usually based on data that is already five years old.

1.1.2.

Statistical Analysis

Using information from national production statistics this method is used to determine the average costs of a unit of output from a given industry, The analytic boundary is the national economic system. Its advantage as a method lies in being able to determine the requirements - of the domestic and commercial sectors from national statistics, whilst avoiding the complexity of having to ascertain the 'technical' energy efficiency of each of the steps in producing a commodity. Its main drawback is its inability to partition the energy costs of goods and services produced by the same system, and low relative accuracy. (Chapman, 1974) .

1.1.3

Process Analysis

Using some similar sources of information as the previous described, this method is used to analyse energy inputs and flows in selected production systems. The boundary of the system being analysed may be as large as the national economy, as small as an individual production plant, or the cultivation of a given crop. Roberts (1978) has commented that this is the most accurate and useful method. available at present, and it was identified as the preferred method of energy analysis by the "First Workshops on Energy Analysis" held under the auspices of the International Federation of Institutes for Advanced Study (IFIAS) in August 1974.

On the vital question of defining the boundaries of a process under study, the 1974 IFIAS Workshop defined four regressive levels of system boundary across which inputs are measured, each level encompassing the preceding level. Level I is the direct energy requirements of the final production process; Level 2 the energy used to produce the inputs to Level 1; Level 3 the energy requirements of producing the capital; and Level 4 (and higher levels) continuing the regression. The Workshop recommended that "analysis be carried back to the Level at which contributions are comparable with the uncertainties in the contributions from preceding levels". (IFIAS, 1975).

Chapman (1974) identified three stages in applying this method:

i) The identification of the network of processes that contribute to the final output;

ii) Analysis of each of these processes to identify all inputs (equipment materials and energy);

iii) The assignment of an energy value at each input.

The flexibility of this method in determining the 'technical efficiency' of automobile manufacture, was demonstrated by Berry and Fels (1973). Using process analysis they were able to suggest criteria for identifying the particular production processes, where improvements in energy efficiency would yield significant energy savings.

Same of the problems associated with process analysis are:

i) The definition of the appropriate subsystem boundary, so that processes under comparison have a standard set of inputs;

ii) The assigning of energy values to inputs, particularly when industries are strongly linked, and a substantial fraction of one industry's output constitutes another industry's input. In these cases simultaneous equations, expressing process interconnections are solved, in order to correct first approximations;

iii) Ensuring the incorporation of all significant inputs, automatically documented in Input-Output and Statistical methods, requires the positive identification of all elements in the process (Chapman, 1974; Roberts, 1978).

Process Analysis provides an analytic tool whereby all the processes which contribute to the production of a good or service may be identified and isolated thermodynamically, making possible incremental improvements in net system energy efficiency. In addition, it permits the determination of First and Second Law of Thermodynamics “figures of thermodynamic merit”. Such indexes encompass both the efficiency of the process used and the 'match' between energy quality (entropy) and the task to be performed (Rutty and Van Artsdalen, 1978).

Energy Analysis aims to provide a description of existing and potential uses of energy, thus showing the potential available for energy conservation. Its use lies in describing and analysing one set of relevant constraints for deriving optimum allocation rules, linking resource depletion to the production of output (Commoner, 1976). Odum (1974) maintains that a knowledge of real energy costs is a “pre-requisite” for rational long-term policy formulation, and “... (it) could be a valuable all-purpose tool in the hands of policy makers.”

1.2

Study Objectives

This study applies the method of Energy Analysis, in particular Process Analysis, to rice production in Bali, Indonesia.

In the last 10 years, new varieties of rice developed in the Philippines and Java have been introduced to Bali in an attempt too increase the total production available from the relatively fixed area of wet-rice fields (*sawah*). The introduction of these "High Yielding Varieties" (HYV's) has required the application and importation of energy intensive nitrogenous fertilizers, not previously used for rice cultivation in Bali. By expressing all the inputs and outputs involved in rice production in a common energetic an index of enemy efficiency, the Energy Ratio, can be calculated. By applying the method of Process Analysis the relative energetic efficiencies of the Traditional and HYV' s are compared.

1.3

Population and Food in Bali

Increased production of the main staple rice is necessary if the expanding population of Bali (see Appendix A1.5) is to be fed adequately; and if Bali is to have a rice surplus sufficient for export to areas of Indonesia where local food production is insufficient to feed the local population (e.g. East Timor).

In 1971 the total population of Bali was 2.1 million (Biro Pustat Statistik, 1972),and average population density 377/km^2, and the population density in South Bali 445/km^2 . Between 1920 and 1971 island-wide population density had increased by 133% and in Southern Bali had increased by 103% (see Appendix A.1.2 for details of population in 1920 and 1930). Population Registration (1976) recorded the total population as 2,340,704 (see Appendix A1.3), giving an average population density of 416/km^2 and by 1976 urban population had increased to 234,070 and represented 10% of the total population (see Appendix A1.4) (Biro Pustat Statistik, 1978).

Of more importance for the island community of Bali is the ratio of population to agricultural land, and in particular the ratio of population to sawah (wet-rice fields). Bakker (1934) gives the total area of sawah in South Bali as 71,861 ha (mid-1930's) , using the figure for population in 1930 (0.88 million), yields a ratio of population/sawah of 11.5 persons/ha. For the same region in 1971, the area of sawah had increased to 76,547 ha and population was 1.54 million, yielding a ratio of 20.3 persons/ha. This represents an increase of 76% from 1930's to 1971. Taking the area of cultivated land as a base (1930's 230,048 ha) yields 3.83 persons/ha; and 1971 (261,502 ha) 5.89 persons/ha, an increase of 54% in the density of population as a function of cultivated land in approximately 40 years.

Since 1974/75, when an active export programme began, exports of rice from Bali have increased from 6,300 tonnes to 35,300 tonnes (1978/79) of milled rice (Bulog, Bali, 1979), these exports now represent approximately 9% of total rice production (see Appendix Al.l). The increase in exports of rice from Bali has led to a reduction in the amount of rice per capita available for local consumption. In 1974 the amount of rice available for domestic consumption was 359,080 tonnes (6,300 tonnes exported) in 1978 the amount was 376,822 tonnes (35,300 tonnes exported) an increase of 4.9% over 1974. During this period the population of Bali increased from 2,194,188 to 2,339,874 (estimated) an increase of 6.6%. The result of these two changes was that rice available per capita in Bali was slightly reduced from 164 kg/year to 161 kg/year (1.6%). Had rice not been exported per capita consumption in 1974 would have been 167 kg/year, and in 1978 176 kg/year, an increase of 5.8%.

The increase in rice production, necessary to meet these two demands, has been achieved in two ways:

i) By increasing the area of land that is double cropped.

Between 1974 and 1978 the area of sawah planted has increased by approximately 13% (see Appendix A6). As the absolute area of sawah has remained nearly constant at about 100,000 ha (Bulog, 1979), the main increase in rice production has come from an increase in cropping intensity. This has been made possible by irrigation projects that had prior to 1978, increased the supply of water available during the dry season (May - October) over approximately 53,000 ha (Asian Development Bank, 1978). The additional irrigation has made possible the planting of a second rice crop during this dry period, when the sawah would otherwise be fallow or planted with secondary crops (*Palawija*) .

In the period from the 1930's until the present the area of (irrigated rice fields) sawah has increased from about 76,000 ha to 100,000 ha. This expansion has required considerable investments of capital, resources and labour. (Asian Development Bank, 1978).

ii) By intensification of production.

In conjunction with the extension of irrigation the government has also expanded the area in which the package of cropping inputs (HYV seed and fertilizer) and agricultural credit are available. Farmers have taken advantage of this intensification programme (BIMAS/IMMAS) using the credit to purchase the new inputs necessary for the cultivation of HYV's. Between 1968/69 and 1978 the area in which this credit was used expanded from 15,200 to 135,300 ha, and each season HYV' s are now planted an approximately 2/3 of the sawah in Bali (see Appendix Al). The use of credit provided by this programme has resulted in large increase in the use, and hence importation to Bali of inorganic fertilizers. Between 1974 and 1978 imports of urea fertilizer have increased from 17,940 tonnes to 24, 200 tonnes almost of which have been distributed through the BIMAS/IMMAS programme.

1.4

Primary Research Area

The Primary Research Area (PRA) chosen is located in an area intermediate between the low lying coastal plain region, in which the cultivation of HYV's predominates and the high altitude regions, in which Traditional Varieties predominate. In this intermediate area both Traditional and HYV's are cultivated on adjacent plots of sawah . The choice of this PRA minimises the effects of other variables, such as soil type and climate, on per hectare yields. In addition, a recent upgrading of the dam supplying irrigation water to this area, Dam Ubud, has ensured adequate water supply, thus eliminating any differential effect on HYV's of water shortage (Yoshida, 1976).

The area in which this study was carried out is located in South Central Bali (see Figure 1.2). The PRA forms part of the administrative region known as Kabupaten Gianyar.

Kabupaten Gianyar

The total area of Kabupaten Gianyar is 402 km^2, and in 1976 the total population was 293,699, and average population density 730 persons/km^2. In 1976 of the total area 41% (14,393 ha) was wet-rice fields (*sawah*), and a further 35% (14,393 ha) was cultivated dry land (*tegalan*) (see Appendix A1.10). Details of the total production yields of staple crops between 1974 and 1978 are given in Appendix A1.11 (A) and (B).

Desa Ubud

Desa Ubud, which the PRA spans, is near the western boundary of Kabupaten Gianyar. Its population in 1978 was 6,737 and the population density was 1,659 persons/Km2, the highest in the Kabupaten. The area of the Desa is 406 ha, approximately 80% of that of the PRA. The majority of the farmers who own and work land in the PRA come from the group of villages (*banjar*) clustered about the four traditional palaces situated on the main road through Ubud. Desa Ubud is the locus of administration for the next administrative level (Kecamatan) that covers an area of 42.2 km2 (see Appendix A1.12 for details).

The Dam Ubud Area

The area irrigated by water from Dam Ubud is the Primary Research Area, and covers approximately 494 ha of sawah. Within this area are the 19 *subak*, irrigation societies (see Chapter 2 for details), in which the surveys necessary for the investigation of rice production were carried out. The PRA extends approximately 5 km north to south, and at its widest is approximately 1.5 km east to west.

The main supply of irrigation water enters the PRA from the northwest, and on entering the PRA is divided in two: the western division (201 ha) supplies (sequentially) water to the fields of Subak Jati, Bungkuan, Sukawayah, Sakti, Juwukmanis and Semujan; the eastern division (293 ha) has two branches: the eastern most supplying water to Subak Legung Landau, Angkeran and Padang Tegal and the western supplying Subak Benekaon and Muwa.

Landforms

The PRA falls within the middle altitude range of sawah, with altitudes between 200-400 m (approx.) It is bounded on the west by the deep valley of the eastern tributary of the River Oos (Tukad Yeh Oos), and on the other sides by subak areas irrigated by other dams. The landform is gently upward sloping from south to north, and divided into relatively narrow ridges by the rivers that arise within the area, and carry away irrigation and rainwater runoff. South of the village complex of Ubud (Subak Semujan, Padang Tegal and Juwukmanis) the ridges are somewhat broader, and the overall gradient slightly flatter, though the terrain is still cut by deep river valleys.

Overall the area is a transition zone between the higher, cooler plateau-like areas to the north, and the humid coastal lowlands to the south. The river tributaries that flow through the PRA divide the area into three long ridges and the divisions in the irrigation system reflect this partitioning. Every space within the PRA that is accessible to irrigation is irrigated, and where the fall of the land is too steep for sawah, it is terraced for the cultivation of dryland crops (e.g. cassava, sweet potatoes, coconut palm). Uncultivated sloping land is generally covered with a thick growth of *alang-alang* (*imperata cylinderica*).

OVERVIEW

Part A

Chapter 2 of this study presents a description of the social organisation of Balinese rice cultivation and village life. Chapter 3 gives an overview of some macroscopic features of sawah ecology, and describes in some detail the traditional technology used in rice cultivation.

Part B

In Chapter 4 the survey methods and the results of the four surveys undertaken are discussed in detail, and in Chapter 5 these results are analysed, and the survey methods and results analysed. Chapter 6 uses data drawn from other contemporary and historical sources to show the general relevance of these results in changes in the energy efficiency of rice cultivation in Bali. Finally, in Chapter 7 the conclusions of this study are presented, and two recommendations for agricultural policy made.

CHAPTER 2

THE ORGANISATION OF THE *SUBAK* AND THE *BANJAR*

2.0

Introduction

Balinese agriculture is a synthesis between science and art. The science, accumulated from hundreds of years of practical experience, the art from the attention to detail, and the value which the Balinese farmer places on the beauty of his fields. The earliest records of Balinese agriculture date back to the last millennium (Raka, 1955), (records of land transactions and the building of irrigation tunnels); the social matrix, in which their agriculture is embedded, reaches back to a similar period. Although undoubtedly modified over the passing centuries, the Balinese have maintained the same forms of agri-social organisation noted in the scattered records that have been unearthed by archeologists (Ravenholt, 1973).[1]

Although it is possible that the *subak* is the best known aspect of Balinese agriculture, other aspects, which bear closer resemblance to more conventional forms of agricultural organisations, in which farmers make cultivation decisions without reference to their neighbours, should be noted. Outside the organisational forms imposed by the *subak*, an organisation devoted exclusively to the cultivation of rice in flooded fields, Balinese agriculture differs little from more conventional agriculture in Indonesia.

In this chapter, an overview of some of the main organisational features of the *subak* (the irrigation society) and the *banjar* (the village) are presented. The aim, in presenting this material, is to make available some information on the social context of Balinese wet rice cultivation. Although both the *subak* and the *banjar* share common features, e.g. leaders are elected from amongst the membership, the roles of these social institutions, vis-à-vis agriculture, are very different. The major role of the *subak* is to ensure an adequate and equitable supply of water for each farmer's rice crop; the role of the *banjar* is to provide labour for the cultivation of the rice crop. The rice farmers are members of both institutions, whilst hired labour and harvesting teams are members of the *banjar* only.

On another level, the *sawah,* and hence the *subak,* is the locus of rice production, and the *banjar* the locus of rice consumption. The nature of the exchange between the *subak* and the *banjar* is: food for labour, and many of the interactions between the two take the form of barter transactions e.g. the harvesting teams *(seka)* receive a proportion of the rice harvest in 'payment' for their labour power. So intimate is the interaction between the *subak* and the *banjar* that Geertz (1972) comments that the *subak* can be seen as a kind of "wet village", whilst the *banjar* is the "dry-village" in which the people reside.

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[1] The references given in this and the following chapter are for the purpose of comparison only. With the exception of the data concerning landuse and 1978 staple crop production, all the material presented in these two chapters is based upon observations made by the researcher, the material presented is not a summary of material drawn from other sources.

2.0.1

Cropping Systems

Four types of Cropping Systems co-exist in Bali

i) *Padi Sawah* - irrigated rice fields, which constitute the system under the coordination/control of the *subak* (see below).

ii) *Tegalan* - dry-land cultivation of rice and other staple crops and vegetables. These occupied approximately 27% of total land area in 1970. The 1978 edible yield of staple foods from dry-land were (in metric tonnes): Corn 86,026, Cassava 272,719, Sweet Potato 158,553, Groundnuts 9,414, Soybeans 11,557, Kidney Beans 1,958 (Dinas Pertanian, 1979). This system of cultivation is practiced on the sides of river valleys and close to the borders of the villages. (see Appendix Al.)

iii) *Pekerangan* - these are household vegetable gardens, and although common in Java, occupying upwards of 15% of cultivated land and supplying possibly 40% of household calorific requirements (Stoler, 1978), they are not a major cultivation system in Bali.

iv) *Estates* - these occupy 19% of total land area (Bulog, 1979), growing coffee, tobacco, kapok, cloves, cotton, citrus and pepper, largely for export. The estates are situated on the higher, cooler areas unsuitable, by virtue of slope or dryness, for

2.0.2

Agriculture - Organisational Boundaries

There is a sharp division between the control of wet-rice agriculture and the ordering of domestic affairs within the villages *(ban jar)* (Geertz, 1967). The members of a village are likely to be linked together in a variety of ways by family, social and occupational ties, (Geertz, 1959) whilst for the members of a *subak* the basis of their linkage is the ownership of *sawah* in the same *subak* (Geertz, 1972). This division of control cuts across familial and social ties of the densely populated village, separating domestic decision-making from socio-technical problems of wet rice agriculture.

The *banjar* and *subak* share common organisational features: leaders are elected without regard to their caste, or wealth, in both the *banjar* and *subak* (Birklebach, 1973); there is an ascending hierarchy of organisation for both, in which small local units form larger groupings at the regional and island-wide levels (Geertz, 1972); both share the tradition of *gotong royong* (mutual self-help) (Liefrinck, 1887), with labour for tasks requiring large numbers of workers, being organised on a *banjar* or *subak* basis.

However, the *baniar's* connections on the broader levels of the organisational hierarchy are based solely on ancestral ties, linking them to the area from which the first settlers came. On the other hand, the ties of the *subak* flow up and down the river to other *subak* who draw their irrigation water from the same river, thus forming links based on the natural, geographical, topographical arrangement of the island (Geertz, 1972).

2.1

The *Subak*

The core of the Balinese agricultural system is the *subak,* which provides the physical and organisational framework for the cultivation of rice in flooded fields, the *sawah.* Although *sawah* occupies only a relatively minor proportion of the islands land surface (17.8%); its energetic output in 1978 constituted 58% of the staple crop food energy, and 59% of the staple crop vegetable protein (based on Dinas Pertanian, 1979)(see Appendix Al.)

2.1.1

Social Organisation

The *subak* is a cooperative agricultural society whose sole responsibility, in the physical world, is the organisation of wet-rice agriculture. Its direct temporal power ends at the edge of the *sawah* (rice fields). The *subak* draws its membership from those owning, and in some cases renting, land within the boundary of an area irrigated by one major irrigation canal *(saluran).* The role of the *subak* is to ensure the adequate delivery of water to the *sawah,* or if water is insufficient at any period, to ensure its equitable rationing among the members of the *subak* (Birklebach, 1973).

At a higher level of integration the leaders *(pekaseh)* of a group of *subak* drawing water from one major dam *(empalan),* meet to elect an overall coordinator, the *Klian Pekaseh,* and plan the seasonal cycle of water distribution. The next level of integration draws together representatives, *Klian Pekaseh,* of all the *subak* drawing water from a section of a major river. This grouping, called the *Pesederhan,* is nominally headed by the government appointed tax collector, the Sederhan. For a major water-shed, e.g. River Oos in Gianyar, the groups of Sederhan meet once yearly to plan the year's overall irrigation and, indirectly, the planting and harvesting schedule of the rice crops (Geertz, 1972).

The physical structure of the *subak* is the network of irrigation canals, encompassing the river, dams, distribution channels, dawn to the level of the water inlet to each farmers plot (*sekut*) of *sawah.* Here the power of the *subak* ends, and each farmer, individually or in company with other family members, has private title to their *sekut* of *sawah* (Geertz, 1972) The *subak's* function is to act as the moderator of one farmers actions upon another, and it achieves this in a variety of ways. The most direct of these is via the *subak* constitution *(awig-awig Subak),* in which the responsibilities of the *subak* members *(anggota)* are spelt out, negative injunctions far outnumbering positive exhortations.

The *awig-awig Subak* defines the roles of the elected officials of the *subak,* the *pekaseh* and his assistants; the levels of contributions by *subak* members to the *subak* treasury, for the temporal and spiritual responsibilities which the *subak* meets collectively (Grader, 1972). It also sets out the level of fines for transgressions upon one's farmer neighbours; non-attendance at the monthly (35 days) *subak* meetings *(rappart subak);* the non-payment of *subak* dues; and the non payment of fines imposed by the *subak* (Geertz, 1972).

The *subak* constitution of the *Ubud Area (Awig-Awig Yeh Oos Kajanan)*, for example, concerns itself mainly with detailing the particular fines, and the cumulative sanctions, that could be imposed, for their non-payment. The penultimate sanction is the stopping of irrigation water; the ultimate, the seizure of the offenders land until the original fine, now doubled and redoubled, is paid in full. In agricultural terms this is equivalent to religious excommunication or domestic exile. The offender is severed from the *subak,* losing religious connection with the *subak's* temples, and life-support from the *sawah* (Bateson, 1949). This level of sanction is rarely imposed, yet every Balinese farmer seems to be aware that such sanctions could be unhesitatingly applied, long disuse since their last imposition notwithstanding.

The network of *subak* owned canals is maintained by the cooperative labour of the *subak* members. Each member is required to supply an able bodied person, with the necessary tools and/or work materials, for scheduled group work *(gotong royong)* (Liefrinck, 1887). Today, in most *subak,* the Indonesian Government, via the Irrigation Service *(Dinas Pengairan),* is responsible for the irrigation network from the main dam *(empalan)* until the final division of water immediately prior to the water entering the territory, or network, of the *subak.* Usually maintenance work is undertaken after the harvest is in, and involves the repair of damage done to the walls of distribution channels by livestock and erosion and the repair of the walkways and earthen roads that come within the boundary of the *subak*.

The farmers that farm within a *subak* come from villages *(banjar)* located geographically within, though organisationally separate from the *subak*, and from villages located some kilometers away (Geertz, 1967). In the *Dam Ubud* area, for example, the 19 *subak* have members from 35 villages, the majority close-by, the furthest some 10 km distant from the geographical 'centre' of the 19 *subak*. As *subak* members the farmers leave behind them all their status, power derived from caste, other official positions or membership in domestic organisations. Each member has only one vote in decisions taken by the *subak*, and the richest is bound as strictly as the poorest farmer member (Birklebach, 1973).

2.1.2

Religious Obligations

Each of the *subak* members have religious duties in common with their fellow farmers, and owe dues and labour, or money in lieu, for the religious festivals associated with the cultivation and well-being of each season's rice crop (Grader, 1972; Geertz, 1972). Each *subak* maintains its own temple, usually situated close to the geographic centre of the *subak*, or at a point of religious significance, e.g. a holy spring supplying water to the *subak*.

If a *subak* suffers unusually severe devastation from insects or rodents (collectively called *hama)* the leaders, *pekaseh*, their assistants and/or other *subak* members, will make a special pilgrimage to the appropriate temples to make offerings and offer prayers for respite from the infestation. This may require visits to four, or more, major temples by a group of up to 100 individuals, and involves extensive traveling (+150 km/day).

The individual farmer may choose their level of religious activities or formality within their plot of *sawah*. They cannot, however, evade their collective religious responsibilities to the *subak* (Liefrinck, 1887). Like other transgressions (e.g. *awig-awig),* non-fulfillment of religious obligations attracts, a fine to be paid to the *subak*.

2.2

The *Banjar*

2.2.1

Social Organisation

The focus of life for the majority of the Balinese, even those who live in the towns and cities, is the *banjar*. The *banjar* is the collective of all the people who live within one village. The inhabitants, via the Village Council, collectively own the land on which the structures in the family compounds *(kampungan)* are erected. The *banjar*, and thus its inhabitants, are also responsible for a number of temples *(Pura)*, local and distant; the public buildings of the *banjar;* and the public services, drainage channels and paths within the village. The council is composed of at least one member from each household in the village, the usual practise being for the oldest married male of a family group *(kepala keluaraga)* to take the role of council member (Geertz, 1959). This person acts as the family representative in the village council.

The *banjar* is in a very real sense a community organism, with the opinions of its members reflected in the variations on the ‘groundrules’ set by the *Banjar Adat* (traditional law and its developed precedents) (Geertz, 1967). The *Banjar* Council elects a leader, the *Klian Banjar* and other village officials from among its members; if elected they must serve, though they are subject to recall by the council. Through the *klian* and his assistants, and in cooperation with other villages when necessary, the village's physical, social and religious obligations are organised, with each family group supplying labour and materials as required.

All decisions or conflicts that affect the village are discussed and decided upon by the council. If there remains outspoken opposition to a decision, after prolonged discussion, decision making is postponed until a later meeting. The intervening time provides opportunities for politicking and private discussions amongst village members.

The *banjar* is the source of agricultural labour for the rice fields *(sawah),* and other agricultural activities, those who own land generally drawing on the labour power of their own families first, and then the labour of other *banjar* members in preference to workers from other villages. The primary agricultural labour falls on the men of the village, and the women's role is very minor except during the harvest. At harvest time, if members of the *banjar* own large areas of *sawah,* the labour power of the whole village may be used.

2.2.2

Physical Organisation

The landforms of Bali have imposed their own pattern on the layout of the *banjar,* particularly in the hillier regions. The 'main street' of the *banjar* is usually a hard packed earthen path some 10 m wide, and on either side are ranged the straw-topped earthen walls that enclose the family compounds. At intervals there are breaks in the facade of earthen walls for alleys *(gang),* plantations of bamboo and public buildings.

At about the geographic centre of the village are the public buildings, the *bale banjar* (meeting place) which is used for council meetings and general social intercourse by the men; the village *Pura* (temple), set back from the main path by an open forecourt; the *kul-kul,* the tower housing two tuned, split logs, that form the village communication system; usually a few small stores *(toko)* that sell basic consumer goods necessary for day-to-day needs; and, depending on the days events, few or many path side stalls *(warung)* selling a wide variety of foods and drinks (Geertz, 1967; Tan, 1967).

The *banjar* is not cut off from the irrigation network of the rice fields, and water is easily redirected to the channels that criss-cross the village. In general, given a reasonable head of water, it is possible to bring flowing water to any desired area within the village. This permits the growing of vegetables within the confines of the village, and the flushing of refuse and leaf litter that accumulate in the earth drains that line the pathways in the village.

2.2.3

The Children

The *banjar* of Bali are 'overflowing' with children today, and it is rare to see a main pathway through a village empty of children. The children form their own peer group society, with the older children responsible for attending to the needs of their younger siblings. Once past the age of about six years the activities of the children become more differentiated, with the girls attending the womenfolk in domestic tasks, and the boys working with their fathers in the fields or craftwork.

From an early age the Balinese child is expected, and trained, to be able to play an active part in the day-to-day domestic, craft and agricultural work. Thus, by the time they reach early adolescence, they have become skilled in the use of many simple hand tools, practised in the care of gardens and livestock, and familiar with the use of many of the naturally occurring plant species that grow in and around the village. Additionally, they have become familiar with the religious calendar of the village, and have learnt much of the religious mythology from the dramas, dances and shadow puppet plays (*wayang kulit*) that form the basis of traditional education and entertainment.

2.2.4

The Animals

Several species of animals inhabit the *banjar* in close association with the humans. Pigs and dogs are the most prominent mammals; ducks and fowl the most common avians. Almost every household has a dog or three, they form the main scavengers of the village, eating food scraps, offerings and rodents. Pigs are owned and raised by the women, and in many cases are fed a diet of cooked greens, food scraps and cassava; other pigs free-range in the paths and compounds of the village, scavenging in competition with the dogs. Cats are the unseen members of the village community, as they spend most of their time within the walls of the family compound. Their role i s the guarding of the rice barn *(1umbung)* and the surrounding ricefields against rodents, which form a major part of their diet.

Fowl in the village are free-ranging, acting as predators of insect pests in the vegetable gardens and close by dry-land crops. No special housing is provided for them, and they roost in the trees at night to avoid predators, e.g. snakes. The ducks spend most of their time in the rice fields, returning in the evenings.

Despite the competition for food, the animals that inhabit the village are at peace with one another, and attacks of one species upon another, e.g. dog versus fowl, are exceptionally rare; dog fights are however common and noisy. The humans and their animals live in close proximity, and the flaw of nutrients and ‘waste products’ seems to provide a niche for each of the species. These animals, except cats and dogs, provide a major source of animal protein for the humans, and thus make efficient use of vegetable and animal matter that would otherwise be unavailable for human consumption.

CHAPTER 3

THE *SAWAH*: ECOLOGY AND CULTIVATION TECHNOLOGY

3.0

Introduction

The aim of this chapter is to provide a descriptive background, to facilitate understanding of the context in which the five field-surveys of rice production in the *Ubud* area were undertaken. The chapter is divided into two parts:

Part A: *Sawah* Ecology presents an overview of some macroscopic features of *Sawah* ecology, in particular the role of domesticated and food producing animals in the *sawah.*

Part B: The Technology of *Sawah* Cultivation, outlines the sequence of operations necessary for the cultivation, harvesting and processing of rice.

3.1

PART A *Sawah* Ecology

Only an overview of the ecological processes that take place within and adjacent to the *sawah* can be given here, due to lack of detailed data, and the complexity of the interrelationships between factors.

3.1.1

Sawah Landforms

The *sawah* in Bali extends from close to the coast to the highlands (800 m). From the coastal plain to an altitude of about 200 m, landforms are gradually sloping and the river valleys relatively shallow. Between about 200 m and 500 m the land rises more steeply, the river gorges become very deep and narrow. For example, in the U*bud area,* except for the large rivers, the gorges are 20 to 30 m deep, and the distance between ridges less than 100 m. Frequently the gorge is only visible as a deep fault, with a glint of water 20 to 40 m below. On the land above 500 m the wider ridge crests make the *sawah* visually similar to the lowland *sawah;* what is hidden, however, are the deep valleys, and the long canals, used to channel the water to the lower *sawah.* From a distance the landform appears as undulating, on closer inspection it becomes obvious that the gently sloping ridges are separated by extremely deep river valleys.

On the coastal lowlands the internal subdivisions, within a privately owned plot of *sawah,* are less frequent, and the size of individual holdings somewhat larger (Geertz, 1967). This makes the *sawah* easier to cultivate, and mechanisation a somewhat more attractive and practical alternative to hand tillage. (Sinaga et al, 1977). To balance this relative ease of cultivation, the coastal *sawah* in some areas (e.g. *Badung, Tabanan),* suffer from a shortage of irrigation water during the dry months of the year (May to October). This *sawah* is planted with secondary, dry-land crops *(palawija),* or left fallow during this period. The government-initiated agricultural development projects are aimed at alleviating the dry season water shortage in some of these areas, by building weirs and distribution systems, to bring water from middle altitude areas to the coastal plain to allow cultivation of two, or more, rice crops annually (Sir M. MacDonald & Partners, 1978).

In the middle altitudes the landforms restrict the sawah to the relatively flatter areas on the crests of the ridges. Where steeply sloping land is farmed the construction and maintenance of terraced patches of sawah, following the contours of the landscape, is necessary. Whilst the sides of the ridges are steep, the crests of the ridges form a gently sloping area; along the crest runs the minor canal supplying water to the *sawah* on either side of the crest-line. All of the irrigation is gravity-fed, and the diversion of water from a river or main canal that is supplying several *subak*, is located from 10 km (for a dam) to 2 km (for a major canal), above the highest point of the area to be irrigated.

In many areas of Central Bali above the 500 m contour, the landform is plateau-like, the river valleys are still very deep, though less frequent. The ridges between the valleys are wide and more gently sloping. Thus the pattern of irrigated land, the *sawah*, must accommodate itself to a variety of widely different landforms. The landforms on which *sawah* has been developed, range from: 0 - 3% slopes of the coastal plain to 200 m; undulating land 3 - 5% slope to 500 m; and rolling with slopes of 5 - 8% from 500 to 800 m (Dai & Rosman, 1970).

3.1.2

Terrestrial Vegetation

The *sawah*, low, middle or upland, has the appearance of serried rows of terraces following the contours of the hillsides. Isolated clumps and 'walls' of coconut palms, in the middle and higher areas, prevent broad vistas in most places, so the *sawah* appears as smallish areas of cultivated land, bordered by seemingly impenetrable stands of coconut palms and other vegetation. The appearance is deceptive. Within the stands of coconuts are the villages, set in the cool provided by the foliage. Bordering the villages and along the valley-sides are the home gardens *(perkerangan)* and dry-land *(tegalan)* used to grow a range o f vegetables and root crops for local consumption.

Within the *sawah* proper very few trees are allowed to grow, and many *subak* constitutions *(awig-awig)* either forbid the growing of trees, or prescribe penalties for debris that fall from the trees and damage another farmers crop. Shading caused by foliage impedes the growth of rice during the vegetative growth phase (Yoshida, 1978) and where a patch of *sawah* is shadowed by foliage, or the wall of a building, the plants are noticeably smaller than those receiving full sunlight. Thus the *sawah* area is exclusively for the cultivation of rice, and any natural or human activity that reduces the effectiveness of this process, if not forbidden outright, is closely regulated.

3.1.3

Irrigation

Water is delivered to the *sawah* through a branched network of canals, the division being arranged in binary fashion, and accommodating itself to the contours of the land, the arrangement of villages and other obstacles. The water flow is divided and sub-divided by the use of simple, small weirs, at the outlet side of which a notched coconut palm log forms the weir wall. The width and depth of the notches correspond to the area of land to be irrigated and the whole system is arranged so that water may be let in at the top end of a *subak*, and without further attention, each farmer will receive the correct allotment of water. Each farmer receives his water 'directly' from the main channel, i.e. in its journey form the river to his *sawah*, it does not pass through the *sawah* of any other farmer.

Subak Mangening, in the Tampiksiring area to the north-west of Ubud, for example, is supplied by water that flows through a 1.5 km tunnel, built some 400 years ago, to conduct water from a Holy spring to the rice fields on the lower, flatter ridges. This tunnel, hewn from moderately soft volcanic tuff, was constructed without the use of air and light vents to the surface overhead and is approximately 2 m by 1m in cross-section. Where the landform permits the irrigation water is directed in open channels along the contour lines of the valley walls, sometimes passing through short tunnels or carried across gorges by pipes or troughs. So gentle is the slope of many canals, that in some places, the water appears to be running uphill. At the water inlet *(tetek)* to his land the farmer has a long (10 m), relatively deep (+1m), 'buffer' channel. This forms a settling pond for the unwanted volcanic sand (*pasir*) and pebbles, and a fermentation compost pit into which organic materials settle, and into which cow dung and other organic matter is placed. Each season, during land preparation, the farmer digs out this pit, separating the layers of sand from decomposed matter, applying the compost to his *sawah*. Whilst the rice is growing water is distributed within the *sekut* after passing through the settling pond, the flow being regulated by opening and closing the internal inlets and outlets with lumps of mud and grass cut from the retaining walls of the sawah The water level is controlled by adjusting the depth of outlets, using mud, stone or wood to achieve the required water level.

3.1.4

Aquatic Vegetation

The initial phase of *sawah* preparation involves cutting dawn the rice straw from last season, flooding the field, hoeing, and raking the soil to flatten it. Immediately before the transplanting of the rice seedlings, the walls of the sawah terraces are trimmed back to bare earth. The mixture of soil and grass is spread over the sawah, and stamped-down into the mud.

During the period of land preparation a number of water-adapted plants and algae may grow in the sawah. The main plants are two species of water-hyacinth (Eichornia), these plants (local name *biar-biar*), are either dug into the soil or harvested for use as pig food. Several species of rhizomous water plants, (Local names *Emping*, *fahdi* and *kapu-kapu*), were found on the *sawah* surface, only one of which can be positively identified as *Azzola pinnata* (*emping*).

Azzola pinnata

Associated with this plant is a nitrogen-fixing blue-green algae, *Anabaena azollae*, which resides in the cavities in the leaves, in symbiosis with the host plant. The use of this plant as a fertilizer was first demonstrated by Khien (1957). The plant is capable of fixing large quantities of atmospheric nitrogen (312 kg/ha/yr) also supplying considerable amounts of green matter (200 to 300 tm/ha/yr, in tropical conditions) and facilitating the growth of heterotrophic nitrogen-fixing organisms (FAO, 1977).

Whilst its properties have only recently been appreciated by agricultural scientists (FAO, 1977), the Balinese farmers have long associated this plant with good soil and high rice yields. The *emping* sometimes covers 3/4 of a rice field prior to the transplanting of rice seedlings, and is allowed to coexist with the rice plants until the *sawah* is drained for the first time, about 12 to 15 days after transplanting. No systematic efforts are made to promote the growth of this, or other nitrogen-fixing plants, in the *sawah*.

3.1.5

Domesticated Animals

Two domesticated animals play a major role in the ecology of *the sawah*, namely cattle and ducks. Their roles are, in part, associated with the supply of nutrients (manure) to the soil whilst they are within the confines of the *sawah*.

Cattle

The cattle *(Bos bibos)* were domesticated in prehistoric times, and, as the importation of cattle to Bali is banned, have remained a pure breed (Robinson, 1977). These cattle, having been bred for their efficiency as draft animals, provide the motive power for pulling ploughs, rakes and harrows. As the amount of time spent by cattle in any one *sawah* is relatively small, when compared with the total time taken for land preparation, one pair of cattle is able to meet the draft labour requirements of many farmers. Most farmers rent draft labour, the contract being for cattle, equipment and operator.

Due to physiological constraints upon the cattle they are only able to work for 4 to 5 hours per day, during this period a pair is able to harrow or rake about 10 to 15 Are (0.1 - 0.15 ha).

The farmer who owns the cattle, or the hired operator, must spend considerable time each day caring for his stock. Balinese cattle consume 60 to 80 kg (wet) of fodder each day, about half this total is collected by the farmer, who trims roadsides and *sawah* bunds. The collection and transportation occupy approximately 2 to 3 hours for the amount quoted above. In addition the washing of the cattle, and travel to and from the work site, may take another 1 to 2 hours per day. Currently, the cost of a team and operator is about Rp 3,000 per day in the *Ubud* area. (1979 Rp 692 = AUD 1.00)

Ducks

(Family: *Anatidae)* play a major role in the *sawah* throughout most of the preparation, cultivation and harvesting operations. Two or three types of ducks *(Lombok, Tega1* and/or *Alabio)* are to be found in the *sawah.* Prior to the transplanting of rice seedlings the ducks occupy the *sawah* from morning to evening, and only during the 40 days after transplanting are they not allowed in the fields. From then on, except during the application of fertilizers and/or pesticides, they are to be found catching prey in amongst the growing rice plants. The diet consists of small frogs, insects of all types, and three or four species of water dwelling snails. The traditional role of ducks, as insect controllers, is often commented upon by the farmers. The farmer are also consciously aware of the dangers to their duck flocks posed by the application of insecticides.

Within in the Balinese hierarchical ranking of all animals and. insects, the duck (*bebek*) ranks second highest (below geese), and cooked duck is the only meat sufficiently sacred for offerings at a temple. The duck's amiable habits and lack of intraspecies aggression, serve as a model of animal behaviour, in Balinese eyes. Thus the ducks are provided with a *'rumah bebek'* literally 'duck house' in which they are secured each night, and fed high quality foods, such as corn and rice bran.

So popular are ducks as a source of income, from the sale of eggs and live ducks for food, that a tradition of specialization exists for the process of hatching, rearing to adolescence, and the shepherding of ducks. The Muscovy duck *(Entok)* is used for hatching eggs by those who specialise in breeding day-old chicks *(meri).* The demand for *sawah*, in which the ducks can feed, exceeds the supply o f that available in many areas. At harvest time the ducks are 'one step' behind the harvest team, foraging intensively on the animal species dislodged by the harvest. So as to make better use of the *sawah* available at harvest time, large flocks of ducks are herded in the *sawah* being harvested and temporary accommodation built for them, and a night watchman employed. During the day the ducks forage in the nearby *sawah*, each owners flock being identified by a dab of paint or piece of cloth. Where foraging is insufficient, the flocks are often walked several kilometers to *sawah* located in other non-contiguous *subak* .

Wildlife - Beneficial

A large wading bird, the Lesser Heron (genus: Ardea), finds most of its food in the *sawah*, feeding on similar prey to the ducks. The farmer is again aware of the role played by these birds in insect control. Many species of insects and small reptile-eating birds feed in the *sawah* during the growth of the rice plant. The Balinese farmer co-operates in aiding the birds access to prey. He achieves this, by keeping the grass on the terraces trimmed short, thus reducing the protective cover available to insects and small reptiles.

Eels

Two species of eels (*lindung*) inhabit the mud of the *sawah*, and are a highly-regarded source of food protein among the Balinese. One of the species is sought in the bunds, the hunter (usually a farmer) digging a hole in the mud and soil, sometimes to arm's length, in the pursuit of the larger of the two species. The smaller of the two species is sought in the shallow water of the *sawah* by adolescents and adults, using pressure lanterns to light their way, and long-handled bamboo tongs to pluck the swimming eels from the water. This species is also captured during the first hoeing of the sawah after harvest, the workers picking them out of the newly turned mud/soil, and stringing them on a thin strip of bamboo. The eels captured whilst swimming are kept alive in water, and sold live in the markets.

Ants

During the development of the rice plant the sawah is drained on three occasions to encourage deeper root development. As soon as a relatively dry pathway to the rice stem exits, streams of small black ants emerge from their nests in the *bunds,* and move in amongst the stems. They feed on insect eggs that have been laid between the lower stems of the rice plant, e.g. the Brown Plant-Hopper. It is difficult to judge their effectiveness as a pest control agent, though the farmers speak of them with some respect, and are conscious of the assistance, and the damage that is done to the ants when insecticides are applied to the *sawah.*

3.1.9

Wildlife - Pests

Birds

In the three weeks leading up to the harvest, whilst the rice panicle is filling and ripening, the farmers attitude changes to one of bird scaring *(menghalu burung*, literally "to shout at birds"). The farmers employ scarecrows, noisemakers of amazing ingenuity, and loud shouting to scare away the masses of very small grain-eating birds. Two or three species feed on the ripening grain. Being extremely light-bodied and agile, they are capable of flying within the upper foliage of the rice plant. Some farmers have observed that the high 'flag leaf' of the HYV's, especially IR-36, deters the birds somewhat, and that the birds feel more 'secure' when feeding from the 'observation post' afforded by the exposed grain-heads of the traditional varieties.

Rodents

Rodents are a major pest throughout the rice-growing areas of Bali. So old is their association with the rice fields that they have a specific origin myth and are regarded as a sacred reflection on the fallen state into which humans could fall. The farmer is unwilling to actively pursue or poison them, though they recognise their role as competitors for the rice. The role of rodent control falls mainly on the domestic cats and dogs, for whom the rats and mice constitute a major diet item.

Insects

The introduction of the High Yielding Varieties in the late 1960's brought with them new species of rice pests. Prominent amongst them was the Brown Plant-Hopper (BPH), one of the three biotypes of the species found in Indonesia. The insect attacks the stem of the rice plant, boring holes in the culms (stems) to obtain its food, and thus undermining the plant's ability to circulate the nutrients necessary for maintenance and growth.

In 1975 a major outbreak of the pest occurred throughout the southern 'rice bowl' of the island. The high yielding varieties of rice developed within Indonesia *(Pelita , Gembira) ,* and varieties developed in the Philippines at I.R.R.I. (IR-8, IR-5), and the traditional Balinese varieties were all susceptible to attack by the pest. Initially control methods were restricted to the application of insecticides (application equipment for which was in extremely short supply), and the island suffered a serious decline in total rice production during that and the following year (Bulog, 1979).

Further development work at I.R.R.I. resulted in the varieties IR-26, IR-34 and IR-36, which are resistant to attack by Brawn Plant-Hopper. The variety IR-36 is also resistant to the virus 'grassy stunt', a disease for which the Brown Plant-Hopper is the vector (Hargrove, 1978). Control now relies on the planting of resistant varieties (IR-36) , and the use of pesticides to control outbreaks in non-resistant varieties.

3.2

PART B

Technology of *Sawah* Cultivation

All of he agricultural implements used in the cultivation of the *sawah* can easily be carried by one person, and are transported on the shoulder or head of the farmer or a family member. The implements are simple, although a close examination of the struc'ural relationships of a plough, for example, reveals a good understanding of design principles, and a great economy in the use of materials. The ploughs, harrows and rakes drawn by the draft animals, cows working in pairs, are of wooden construction, with steel or iron used only for the cutting edges. Only when a *sawah* has been fallow for a season is a plough employed to break-up and aerate the soil prior to flooding.

The majority of the other implements used for cultivation and harvesting fall into a broad group usually characterised as knives. These are used for trimming the grass growing on the banks of irrigation channels, and the boundary walls of the *sawah (pematang).* At harvest time a specialized form of knife, called an *ani-ani,* is used for harvesting the ripe grain of traditional varieties of rice.

3.2.1

Land Preparation

One to two weeks after the harvest, the cycle of land preparation begins anew, with the cutting down of the rice straw that is still standing, and the flooding of the sawah prior to hoeing. Only where water is insufficient for a second crop of rice, secondary crops (*palawija*) grown. Thus in most sawah areas there is a continuous monoculture of rice.

The soil, once flooded, is allowed to stand and 'ferment', before being broken-up and turned with a four-fingered hoe (*sigi empat*). Farmers usually work in co-operation with one another, each farmer assisting the others in turn with no payment, beyond coffee and cigarettes, involved (Grader, 1972). Following hoeing the *sawah* is allowed to stand, in a flooded condition, for some days to encourage the anaerobic decomposition of weeds and other organic matter. The soil is usually turned twice by hoeing, and after each hoeing and fermentation period, raked flat using a rake or harrow drawn by a pair of cattle.

Where rice is continuously cultivated, as is common today, the rakes and/or harrows are used to level the *sawah* after hoeing, and a plough is not used at all. For weeding the sawah, during the growth phase of rice cultivation, a long-handled weeding device is used. This is constructed wholly from wood, the head sized to fit between the rows of the rice plants its short wooden, peg-like teeth, are used to uproot small weeds, and build-up a small hillock of soil close to the stem of the rice plants. Other weeding activities are carried out by hand; after uprooting and the weeds are stamped into the sawah mud.

3.2.2

Seed Germination

All the varieties of rice grown in Bali, except dry-land rice (*padi gogo*), are initially grown in specially prepared seedbeds. A small portion of the *sawah* is especially cultivated, fertilized and flattened to receive the seed, and to ensure the rapid growth of the seedlings. Different methods of germination are employed for traditional and HYV's. The traditional varieties, stored on the stalk, are heads of rice selected by the farmer from the last harvest, these are carefully sun-dried prior to germination. The complete heads of rice, still in *padi* form, are laid out in rows across the seedbed, the rows spaced about 10 cm apart. When this process is complete a small offering to *Dewi Sri*, the rice Goddess, is placed in the north-eastern corner of the seedbed. A fence of woven coconut palm fronds is erected around the seedbed to keep out ducks.

The HYV's are germinated from seed purchased from the government *(Dinas Pertanian)* stocks, and costs Rp 180/Kg. These are initially germinated in wet sacks, after sprouting they are transferred to the seed bed, and the newly-sprouted seeds covered with a thin layer of fine, fertile soil. The seeds are spread evenly over the seedbed, and thus may be easily distinguished from the neat rows of the traditional varieties.

3.2.3

Transplanting Seedlings

Transplanting the seedlings takes place from 15 to 45 days after germination, the HYV's requiring 15 to 25 days of vegetative growth prior to transplantation. The seedlings are cut from the seedbed by a knife blade passing about 1cm beneath the surface of the soil; the tops of the seedlings are then trimmed, to reduce wind resistance and encourage apical growth. The small bundles of seedlings are then carried to the planting team in the *sawah,* who separate out 3 to 5 stems and press them into the *sawah* mud to a depth of about 3 cm.

The interplant spacing is based on experience, and the minimum distance is set by the head-width of the long-handled weeding tool; the interrow spacing used for traditional varieties is approximately the spacing required for the HYV's (20 cm) to achieve maximum yield. No string lines, or other aides are used to ensure that the rows are regular, evenly spaced lines. It is rare, however, to see a *sawah* in which the row spacing differs appreciably from a very regular pattern.

3.2.4

Vegetative Growth

Throughout the vegetative growth phase of the rice the water level in the *sawah* is carefully controlled, excess depth being the main problem. On several occasions the *sawah* is drained to encourage deeper rooting and stronger tiller development, as the plant seeks water from the deeper layers of the mud in which it grows. The *sawah* is also drained for one day prior to the application of fertilizer and/or pesticides, and reflooded 2 to 3 days after application. During these periods all the ducks are removed from the *sawah,* and only return 10 to 14 days later, after the chemicals have been dispersed, degraded, or incorporated in the plants.

Other than irrigation control, weeding and the application of chemicals, the farmers spend little time in the *sawah* until the plants reach the reproductive growth phase, and grain begins to form. At this time bird-scaring becomes necessary and the *sawah* are dotted with people shouting and making loud noises to scare away the flocks of small grain-eating birds that feast on the ripening grain. During the final weeks of seed ripening the *sawah* is dried out, weather permitting, so that by harvest time the ground has a firm surface for the harvest workers to move about on.

3.2.5

Harvesting

During the harvest, the *sawah* is occupied by scattered groups of harvest teams *(seka),* and, as the harvest within each *subak* takes place at about the same time, it is the period in which the *sawah* engages the labour power of the largest number of people. These teams, which are 10 to 30 strong, form happy, noisy groups whose work time seems to be roughly divided between conversation and harvesting. The teams draw their membership from all age groups, and for their younger members provide an opportunity to get acquainted with members of the opposite sex and assess the working abilities of potential marriage partners.

With traditional varieties, each head of rice is cut close to the top of the stem, the knife held in the right hand, the fingers drawing the stem of the plant across the blade, whilst the left hand holds the rice already harvested. The collected rice is made up into bundles *(seping),* using the grasping circumference of the thumb and forefinger as a measure. These are tied with a twist of split bamboo, and groups of 6 to 8 of these are bound together to form a larger bundle, called an *ikat.*

With the introduction, in the last decade, High Yielding Varieties (HYV) of rice, the harvesting methods have had to be modified to accommodate a different morphology and shattering tendency (the loss of ripe grains due to the movement of the head of rice), of these new varieties (Birklebach, 1973). Currently, the HYV's IR-36 and *Pelita* are harvested using a sickle. The rice plants are gathered into a bundle by the left hand, and cut-off close to the earth (±5 cm) by the sickle. The bundles of rice are then gathered and carried to the threshing tables, located within the *sekut* being harvested, for threshing. These threshing tables have a large canvas spread out beneath them, to catch the grains released by threshing. Having been threshed once against the table, the stems are again threshed using wooden cudgels to release any grains still attached to the panicle. The threshed rice, now called *gabah* is carried from the *sawah* in bags *(zak),* or in deep bamboo baskets.

For both the traditional and modern (HYV) rice the bundles *(ikat)* sacks or baskets are carried home to the village. The women carrying the loads on their heads and the men using a carrying pole *(pikul),* made from strong, seasoned and flexible bamboo. This pole is pushed into the *ikat* of padi (rice on the stalk), having a diagonally sharpened end to facilitate penetration. Where the grain is already threshed and in baskets, a special carrying pole is inserted into holes let into the baskets. The load, as *padi* or *gabah,* is placed on both ends of the pole and carried on the shoulder, being shifted from shoulder to shoulder to ease the strain.

Commonly the ikat and bags weigh about 25 to 30 kg, this being considered the standard adult load. The baskets of gabah, however, may weigh up to 60 kg and only the strongest members of the harvest team are capable of carrying them for any distance. All the rice is carried back to the home of the owner, and there divided. The distances involved may vary from a few hundred metres of several kilometres.

The division of the harvest between the owner and the harvest team (*seka*) is carried out on the basis of volume . Where the grain is in *ikat,* a given proportion of the ikat goes to the harvester. Where the grain is in the form of *gabah,* baskets are used to apportion the harvesters' share. The share accruing to the harvesters varied from 1/8 to 1/12, in the Ubud area. Within the group each member receives an equal amount, the division again being accomplished by volume, using a basket as a measuring device.

3.2.6

Post-Harvest Processing

Grain is sun dried, the traditional varieties still in *ikat,* and the HYV's as loose grain, prior to threshing or milling. Prior to the introduction of the HYV's all rice was hand pounded to render edible rice *(beras)*. With the arrival o f the HYV' s and due in particular to their different milling qualities, almost all rice is now mechanically milled in small mills (*selip*), located in the villages. The traditional varieties, once sufficiently dry, are stored in ricebarns located within the farmers family compound and the rice (*padi*) is taken in rotation, oldest first from the ricebarn (*lumbung*) just prior to its consumption.

The *padi* is hand pounded using a mat and pestle ., or stone mortar and pestle, depending on the variety, to render it to *gabah*. Except in a few locations all the traditional varieties of rice are still hand pounded to render *gabah*. The work is carried out by the women of the family, and prior to the widespread availability of rice mills, the further process of hand pounding the *gabah*, using a heavy wooden pestle and stone mortar, to render edible rice *(beras)*, was carried out in the family compound, or on the pathways adjacent to the compound.

The process of milling the *gabah* results in two edible products: *beras*, the grain of rice minus the bran coatings; and *wot*, a mixture of the inner and outer layers of the bran. Both carried home from the mill, the beras being consumed by humans, and the *wot* being fed to pigs and poultry. The hulls of the rice,

wotsak, accumulates at the mill site and finds use as a fuel for firing bricks and the cooking of smoked duck *(bebek betutu)*. The mill charges a proportion of the *beras* as payment for milling, commonly 1 kg of *beras* for every 30 kg of *gabah* milled. Given the yield rate (average) of about 65% of *beras* from a given amount of *gabah*, this milling charge represents about 5% of the edible yield of rice. Where a fee is charged for milling, usually only in the larger commercial mills, the fee ranges from 3 to 5 Rupiah per kilo of *gabah*.. Most mills, large or small, are willing to buy *gabah* or *beras* from those milling rice at the mill, paying a price based on the current market value for the particular quality of rice, the traditional varieties obtaining a higher price than HYV’s.

The ability to immediately exchange rice for cash is particularly important for the landless members of the harvest team, and those having to repay loans obtained from the Government or private lenders. The former in same cases, sell their rice and later buy rice, or less expensive staple foodstuffs, in the local market; the latter, after the harvest, must repay not only moneys advanced for agricultural inputs, but also find money to pay their land tax.

Rice mills, mainly the larger ones, sell milled rice to the Government via the government-financed milling facilities set up in each area. This rice is exported from the local area, and stored in large warehouses, run by food and storage procurement and distribution agency Bulog (Biro Logistik). This rice is later transported to cities within Bali, e.g. Den Pasar, Singaraja and Jakarta, Surabaya, Timur Timor, Sulawesi and Kalimantan outside Bali. In all instances the rice is packed in sacks holding 50 kg, capable of being carried by a strong person and transported by large (7 tm) trucks to stores and wharfs. Currently Bali is exporting approximately 35,000 tonnes of *beras* per annum (Bulog, 1979).

CHAPTER 4

SURVEYS: METHODOLOGIES AND RESULTS

4.0

Introduction

This chapter outlines the approach to fieldwork in the Primary Research Area (PRA). The methodologies for each of the field surveys are described in detail; methods used to analyse the data collected during the surveys are detailed, and the results of each of the field surveys are presented. All the surveys were carried out between March and September 1979 in the area centred on *Desa Ubud in Kabupaten Gianyar, Bali.* During this period 5 surveys were undertaken, relating to the agricultural inputs and outputs of wet-rice agriculture. These surveys were: Rice Hand pounding Surveys (village and controlled) ; Rice Milling Survey; Harvest Survey; and *Sawah* Labour Inputs Survey.

To aid the reader in following the interaction of the survey methods and results, the survey methods, analytic methods and results have been presented in one chapter. The same order is followed in each section viz: Aims, Survey Methods, Analytic Methods and Results. Each of the surveys is dealt with in this manner and the last section (4.5) draws together the separate survey results, and uses them to calculate the input-output energy ratio for each of the rice varieties.

These five surveys sought to quantify the inputs and outputs of processes involved in the cultivation of rice, and its processing to edible form. Two main surveys provided the body of the data on inputs and outputs (Harvest Survey and *Sawah* Labour Inputs Survey), whilst the other surveys aimed to determine empirically the yield factors for each of the elements of processing the harvested rice into edible form.

4.1

Rice Hand Pounding Surveys

The four Traditional Varieties of Rice (TVR) : *Cicih Beton*, *Cicih Kapuk*, *Ketan Gadis* and *Ketan Bali,* and one Nationally Improved variety, *Gembira,* are all transported home from the *sawah,* dried and stored as bundles *(ikat)* . Before these varieties can be rendered to edible rice *(beras)* the grains of rice must first be separated from the stalk. This is done by hand pounding the 'dry stalk rice' *(padi)* with a wooden or bamboo pestle *(1u)* to separate it form the straw (*soma*), and winnowing away any small pieces of remaining straw. This yields *gabah* (unhulled rice), suitable for further processing, either by further handpounding or by machine.

4.1.1

Aim

The aim of these two surveys was to determine the yield of unhulled rice *(gabah)* from dry stalk rice *(padi)* for the five rice varieties reduced to *gabah* by hand pounding.

4.1.2

Survey Methods

Two separate surveys were conducted to determine the yield of *gabah* rendered by hand pounding *padi* (dry-stalk rice), for each of the above rice varieties: i) Village Survey, and ii) Controlled Survey.

The main methodological difference between the two surveys was the type of instrument used for weighing the rice samples. In the Village Survey a 50 kg beam balance was employed to weigh samples with relatively small weights (1 - 2 kg) ; the Controlled Survey employed a set of 2 kg spring scales to weigh samples of 1 - 2 kg.

i) Village Survey

Nine women hand pounding *padi* in the villages *(banjar)* of the PRA were surveyed whilst they were hand pounding rice and the weight of *padi*, (prior to hand pounding) and of the resulting *gabah* (after hand pounding), using the same beam balance (50 kg) employed in the Harvest Survey and the weights recorded.

ii) Controlled Survey

Using *ikat*, which were obtained during the Harvest Survey, of each of the five varieties of rice processed to *gabah* by hand pounding, sample weighings were carried out under controlled conditions using a set of household scales capable of weighing to 2 kg in 5 g divisions. Measurements of the starting and finishing weights were made for 4 - 6 samples of each rice variety processed in this way.

4.1.3

Analytic Methods

To determine the variety-specific *path* to *gabah* yield factors the finishing weight of gabah was divided by the starting weight of padi. In each of the two surveys the yield factor was determined by this method. In each survey, the individual yield factors were added and a mean conversion factor and standard deviation calculated for each rice variety.

Hand pounding Conversion Factor = kg *Gabah* output / kg *Padi* Input

4.1.4

Survey Results

The results of the two Hand pounding Surveys are presented below:

i) Village Survey

Conversion factors for 9 samples, for 3 rice varieties were obtained in this survey.

TABLE 4.1

Village Hand pounding Survey *Ubud* Area: *Padi* to *Gabah* Conversion Factor for 3 Varieties of Padi.

Variety	N*	Padi – Gabah Conversion Factor	
		Mean	S.D.
Gembira	3	0.89	0.02
Cicih Kapuk	3	0.78	0.07
Ketan Bali	3	0.89	0.02

*N = No. of Samples

ii) Controlled Survey

Table 4.2 presents the results of the controlled survey of *padi* to *gabah* yields for 23 samples of 5 varieties of rice.

TABLE 4.2

Controlled Hand pounding Survey *Ubud* Area: *Padi* to *Gabah* Conversion Factors for 5 Varieties of Rice.

Variety	N*	Padi – Gabah Conversion Factor	
		Mean	S.D.
Gembira	4	0.83	0.04
Cicih Beton	5	0.83	0.01
Cicih Kapuk	6	0.80	0.03
Ketan Gadis	3	0.86	0.03
Ketan Bali	5	0.66	0.05

*N = No. of Samples

Because of the larger sample obtained, and the use of a more precise set of weighing scales used in the Controlled Survey (Table 4.2) of *padi* to *gabah* processing, the conversion factors from this survey were selected for use in later calculations.

4.2

Rice Milling Survey

Whilst the Harvest Survey was in progress the rice mills *(selip)*, within and adjacent to the PRA, were visited and the yield of milled rice *(beras)* from unmilled rice *(gabah)* for each rice variety was measured.

4.2.1

Aim

The aim of this survey was to ensure that accurate conversion factors *(gabah to beras)* were available for computation of the milled yield of edible rice *(beras)* for all the rice varieties grown within the PRA.

4.2.2

Survey Methods

Four rice mills (*selip*) were visited in this survey. The *gabah*, brought to the mill in baskets or sacks for milling, was weighed prior to milling and the variety of rice determined. After milling, the *beras* (edible rice) and wot (rice bran), for each sample of *gabah*, were again weighed. All measurements were made using the set of scales owned by the rice mill. These scales are normally used for weighing incoming *gabah* so that the milling charge may be calculated.

4.2.3

Analytic Methods

To determine the yield of *beras* f ran *gabah* for each rice variety, the weight of processed *beras* was divided by the weight of the *gabah* prior to processing. The individual yield factors were added and the mean and standard deviation calculated for each variety of rice.

Milling Conversion Factor = kg Milled Rice Output / kg Unmilled Rice Input

4.2.4

Survey Results

From the four rice mills surveyed variety-specific milling conversion factors were calculated (Table 4.3) using the equation set out above.

TABLE 4.3

Milling Survey *Ubud* Area: Milling Conversion Factors for Machine Processing of *Gabah* to *Beras* for 7 Varieties of Rice.

Variety	N*	Padi – Gabah Conversion Factor	
		Mean	S.D.
IR-36	66	0.65	0.04
Pelita	27	0.64	0.06
Gembira	2	0.62	0.06
Cicih (Beton & Kapuk)	12	0.70	0.10
Ketan (Gadis & Bali)	10	0.70	0.08

*N = No. of Samples

4.3

Rice Harvest Survey

This survey constituted the major measurement program carried out within Primary Research Area (PRA), occupying approximately three months of the research period. The majority of the survey work was undertaken by my research assistant, who was assisted by a labourer. After instruction in the techniques required, periodic checks were made to ensure that the methodology was being adhered to. In this three month period all but one of the 19 *subak* that constituted the PRA were surveyed during the harvest period. The harvests from 221 individually owned 'farms' *(sekut)* were measured using simple methods.

The total area measured during the survey was approximately 13% (65 ha) of the total area in the PRA, the area irrigated by *Dam Ubud.*

4.3.1

Aim

The aim of this survey was to collect harvest data from within the PRA so as to allow a comparison of the agricultural inputs and outputs to be made between the Traditional Varieties of Rice (TVR), Nationally Improved Varieties (NI) and High Yielding Varieties of Rice

4.3.2

Survey Methods

The survey was begun during the first week of June and continued until the completion of the 1978/79 harvest in September. In all 221 plots were surveyed using a 30 m fibre tape measure, a beam balance capable of weighing to 50 kg and a rice moisture metre (borrowed from BULOG). The instruments used were identical to those used by Dinas Pertanian when measuring harvest yields.

Initially it was planned to select a sample of farmers by statistical methods, and later during the harvest return to measure their harvests. This sample was selected prior to the start of the harvest period. However, it proved impractical to make use of this approach due to the unpredictability of the exact harvest date for each farmer. The harvest date was dependent upon such factors as weather, speed of ripening of the grain and labour availability.

Thus the approach adopted was to measure harvests as they were encountered in the field each day; while ensuring that all rice varieties in each *subak* were sampled and that samples were drawn from the whole area of the subak using a large scale (1:5,000) map and tax books which were cross referenced to the map, showing the precise location of each farmers land, it was possible to locate precisely each of the plots surveyed. The locations of the plots surveyed were entered daily on this large scale map and colour coding used to distinguish each rice variety. Thus a running-check could be kept on the distribution and rice variety in the plots surveyed. Where it was thought that the number of samples was insufficient, additional efforts were made to obtain more samples from the area.

The survey technique consisted of:

i) Weighing of 5 *ikat* (tied bundles of TVR) or 5 *zak* (bagged NI and HYV), using the beam balance.

ii) Drawing of rice samples from the centre of each ikat or *zak*, and the determination of the moisture content by use of a battery powered moisture meter, marked in 0.2% divisions.

iii) Measurement of the net harvested area (i.e. the total area less the ground used for the bunds *(pematang)* forming boundaries and internal divisions, using the 30 m roll tape: measurements were made to the nearest 0.l m.

iv) Counting the number of *ikat* or *zak* so far harvested; by measuring the area still try be harvested, an estimate was made of the expected yield of the remaining area.

v) Counting the number of persons and sex in the harvest team.

The farmer was asked:

vi) Total amount of fertilizer *(rabuk)* applied and its type (Urea or Triple Superphosphate).

vii) Total amount of pesticides (*obat-obatan*) and the type used (Sevin-85-SP or Diazinon).

viii) To estimate crop losses (relative to the previous season), and the reasons for the loss (insects, rodents, input supply problems).

The leader of the harvest team was asked:

ix) Length of time (estimated) that would be required to complete the harvest and transport the rice to the village.

x) Share that the team received for carrying out the harvest, expressed as a proportion of the total harvest.

The results of measurements and answers were recorded using a prepared data form; the name, address *(ban jar)* of the farmer and the variety of rice were also entered on the card (see Appendix A4.1 for a sample of the data form).

4.3.3

Analytic Methods

The Harvest Survey data was analysed to determine the following: Net yield of edible rice *(beras)* per are (0.01 Ha) (kg/are).

Energetic content of the net yield (MJ/are).

Energetic content of *beras* paid to the harvest team (MJ).

Metabolic energy expended by the harvest team (MJ) .

Energetic ratio of the harvest share to harvest work (MJ).

Net energetic yield to the farmer (MJ).

Number of hours required to harvest 1 kg of *beras* (hrs/kg).

Number of hours required to harvest 1 are (hrs/are).

(Not all of the above results were employed in later analysis).

Conversion factors, determined in the Milling and Hand pounding Surveys (see Tables 4.2 and 4.3) were used to calculate the edible yield of beras (kg/are), for each variety, from the gross yield of *padi* (stalk-rice) and *gabah* (unmilled rice). The value for the energetic content of edible rice (14.772 MJ/kg) was taken from the Nutrition Almanac (1975) and that for the hourly metabolic energy expenditure of harvesting (0.767 MJ/hr) from Edmundson (1976). These values were employed to calculate the energetic content of inputs (harvesting labour) and outputs (edible rice). The factor used to correct for moisture content, unripened seed and included dirt (*hampa*) was taken from standard tables prepared by the Indonesian Government food procurement and distribution agency (BULOG 1979).

The analysis proceeded as follows:

i) The average value of moisture content was determined by averaging the 5 measured values (% W/W).

ii) Average *ikat* or *zak* weight was determined by averaging the 5 measured values (kg).

iii) Total wet weight of the harvest was calculated by multiplying average weight by the number of *ikat* or *zak (*kg*)*.

iv) Weight of wet *gabah* (unmilled rice) was calculated using the varie ty specific conversion factor (kg).

v) Weight of dry *gabah* was calculated using the correction factors determined by BULOG (kg).

vi) Weight of *beras* (edible rice) was determined using the variety specific conversion factor (kg).

vii) Edible energetic content of the *beras* was calculated by multiplying the weight of beras by 14.772 MJ.

viii) Energy accruing to the harvest team was determined by multiplying the energy content of the *beras* by the harvest share (MJ).

ix) Area of the surveyed plot was determined by multiplying measured length and breadth (are).

x) Yield per are of beras was calculated by dividing the weight of dry beras by the area of the plot (Kg/Are).

xi) The number of harvesters and duration of harvest work were multiplied together and then multiplied by 0.767, to calculate the amount of metabolic energy expended in harvesting (MJ).

xii) A Harvest Input-Output Ratio (HER) was determined by dividing the energy content of the harvesters share of *beras* by the metabolic energy expended in harvesting.

xiii) Number of Harvesting hours per area (hrs/are) and hours per kg *beras* were calculated by dividing area and edible yield by harvest duration.

4.3.4

Results

The total area surveyed during the harvest survey was 64.81 ha, this represents 13.1% of the total area irrigated by *Dam Ubud* (496.38 ha). The yield of edible rice (*beras*) and other variables for each of the 7 varieties was calculated using the procedure set out in the preceding section. Mean yield of *beras* varied between 19.48 kg/are (IR-36) and 14. 04 kg/are (Gembira), and the overall mean yield of *beras* for the surveyed area was 17.09 kg/are. Mean yields of *beras*, area surveyed and average plot (*sekut*) size are presented below (Table 4.4).

TABLE 4.4

Harvest Survey Dam Ubud Area: Mean Edible Yield, Surveyed Area and Mean Plot Size.

Variety	N*	Yield (kg/are)		Area Surveyed	Plot Size (are)	
		Mean	S.D.	(are)	Mean	S.D.
IR-36	47	19.48	5.88	1421.0	30.23	15.34
Pe1ita	52	16.46	7.69	1615.2	31.14	15.85
Gembira	19	14.04	8.26	525.0	27.63	9.21
Cicih Beton	31	17.80	5.62	893.1	28.81	13.60
Cicih Kapuk	46	16.76	5.51	1280.8	27.84	12.21
Ketan Gadis	16	18.94	8.16	472.8	29.55	13.66
Ketan Bali	10	15.62	5.77	271.7	27.17	7.91
Overall	**221**	**17.09 (kg/are)**		**64.81 ha**	**29.32 are**	

*N = No. of Samples (See Appendix A4.2 for an analysis of the effect on yields of crop losses).

Mean work durations for each variety were calculated on the basis of weight (hrs/kg *Beras*) and area (hrs/are) for each of the seven varieties of rice. Mean Work Duration to Harvest 1 kg of *Beras* was: (range) 0.22 - 0.37 hrs/kg Beras; Mean duration to Harvest 1 are was: (range) 3.46 - 5.42 hrs/are . Table 4.5 below tabulates Mean Work Durations for each of the seven rice varieties of rice.

TABLE 4.5

Harvest Survey *Dam Ubud* : Mean Work Duration to Harvest 1 kg *Beras* and Harvest 1 Are.

Variety	N*	Work Duration (hrs/kg)		Work Duration (hrs/are)	
		Mean	S.D.	Mean	S.D.
IR-36	47	0.29	0.11	5.42	2.16
Pelita	51	0.31	0.14	4.52	2.34
Gembira	19	0.37	0.14	4.67	1.88
Cicih Beton	30	0.22	0.11	3.46	1.57
Cicih Kapuk	43	0.22	0.10	3.60	1.56
Ketan Gadis	15	0.29	0.09	5.38	1.89
Ketan Bali	10	0.28	0.13	3.83	1.42

*N = No. of Samples

The data collected on fertilizer use is presented below (Table 4.6). Although the data concerns agricultural inputs rather than output, the data was collected at the time of the

Harvest Survey and is thus presented here. The only Fertilizer in use in the survey area was Urea, with a 46.6% Nitrogen content. No pesticide use was reported by the farmers in the survey sample and thus pesticide (insecticide and rodenticide) use is taken to be zero in later calculation of the energetic inputs to rice cultivation in the PRA.

TABLE 4.6

Harvest Survey *Dam Ubud* : Mean Fertilizer Use per Are and Percentage of Sample Farmers using Fertilizer (Urea, N = 46.6%)

Variety	No. Using Fertilizer	Application Rate (kg/Are)	Percentage of Total Sample Farmers
IR-36	44	1.65	93.6%
Pelita	46	0.90	88.5%
Gembira	15	0.64	77.0%
Cicih Beton	7	0.42	22.6%
Cicih Kapuk	12	0.45	26.1%
Ketan Gadis	13	0.74	81.3%
Ketan Bali	3	0.84	30.0%
Survey Mean	**140**	**0.67**	**63.4%**

*N = No. of Samples

4.4

Sawah Labour Inputs

In contrast to the surveys of Harvest yields and processing conversion factors, in which data was obtained by direct measurement, this survey sought the 'informed opinion' of the 19 *Pekaseh Subak* (elected leader/co-ordinator of the *subak*) of the *subak* within the PRA.

Initially it was planned to interview a sample of the farmers who worked sawah within the PRA, either whilst they were at work in the sawah or in their homes. A questionnaire was prepared on the necessary inputs of: human and draft labour, physical materials (seed, fertilizer, pesticides, etc.), for the cultivation of his own land. A range of questions concerning the size, ages, educational levels of the farmer's family, and the consumption of kerosene and firewood in the farmers household, was also included in the questionnaire. This approach proved unworkable for two major reasons: firstly, survey personnel spent an unreasonable amount of time trying to locate sample farmers, at home or in the *sawah*; secondly, when it was possible to locate sample farmers (both those whose harvests had been surveyed, and others encountered at random) the farmers proved unwilling to stop work to answer questions they considered having little relevance for their own welfare. Thus this approach was abandoned in favour of the survey directed towards the 19 *Pekaseh Subak*.

4.4.1

Aim

The aim of this survey was to determine the human and draft labour requirements for each of the work activities involved in the cultivation and harvesting of rice.

4.4.2

Survey Method

Each of the 19 Pekaseh subak were visited in their homes and asked to answer a range of questions concerning: labour inputs, and related production variables (e.g. seed, fertilizer) necessary for rice cultivation in the subak for which they were *Pekaseh*. (See Appendix A4.3 for a copy of the Questionnaire). The most detailed answers were sought on questions relating to labour inputs of specific cultivation operations. On this topic the *Pekaseh Subak* were asked (for an area of 30 Are) : the number of workers, daily duration of work, and the number of workdays required to accomplish 12 operations involved in cultivation, from the preparation of the *sawah* prior to planting to the harvesting of the ripe *padi*.

4.4.3

Analytic Method

The answers given by each of the 19 *Pekaseh* for task-specific labour durations, expressed as man-hours per 30 Are, were calculated by multiplying together number of workers, daily work hours and days required. The results of this computation were tabulated. The total labour requirements for each of the 19 *subak* were calculated by simple addition of task specific labour durations. Work durations for specific operations were added and the mean and standard deviation for each was determined. To obtain the per Are labour requirement the calculated value, for a hypothetical 30 Are plot of sawah, was divided by 30.

4.4.4

Results

The results of the calculation outlined above are presented in Table 4.7 (below). For two of the preplanting operations a rake drawn by two cattle, is used to flatten the newly hoed sawah, for these operations animal labour duration is assumed to be the same as human labour duration, i.e. the time worked by the operator of the draft animals. For clarity in presentation the cultivation operations have been grouped in the following way: (a complete tabulation can be found in Appendix A4.2).

Land Preparation: includes, the cutting down of last seasons remaining rice straw, hoeing the sawah twice by hand, raking the soil flat after hoeing using a cattle-drawn rake.

Cultivation: includes, the cutting and bundling of rice seedlings, transplantation of the seedlings, weeding the sawah twice, bird

watching and pest control.

Harvesting: includes, cutting the ripened rice, the threshing or making of ikat, and the transportation of the rice to the owner’s home.

TABLE 4.7

***Sawah* Cultivation Dam Ubud: Human and Animal Work Durations for Three Stages of Rice Cultivation (Animate Inputs).**

Operation	Duration of Labour (hours/Are)	
	Human	**Animal**
Land Preparation	7.41	2.12
Cultivation	12.1	0
Harvesting	4.40	0
Total	**23.95**	**2.12**

4.5

Energy Analysis of *Sawah* Cultivation

In this section the results of the surveys carried out in the Primary Research Area provide the data for undertaking an Input-Output Energy Analysis of the energy requirements of *sawah* cultivation. The values of inputs and output, given in the previous Sections (4.1 to 4.4) are expressed in terms of energy expended and acquired in rice cultivation. The conversion values used to calculate the energetic value of each input and output have been obtained from a variety of sources, these values, and their sources are presented in Tables 4.8 and 4.9 (below).

TABLE 4.8

Energy Content of Inputs to Rice Cultivation

Item	Energy Content (MJ/Unit)	Source
Human Labour		
Light Work	0.529	Edmundson, 1976
Medium Work	0.767	Edmundson, 1976
Heavy Work	1.392	Edmundson, 1976
Hoeing Sawah	1.133	Edmundson, 1976
Animal Labour	8.0	
Cattle (250Kg		Mach, 1976
Fertilizer		
Urea (46.6% N)	38.9	Leach, 1976
TSP (50% P)	7.0	Leach, 1976
Rice Seed		Leach, 1976
Traditional	14.772	Nutrition Almanac, 1975
High Yielding (IR-36)	29.544	Mach & Nutrition Almanac
Pesticides		
Active Ingredient	105.0	Leach, 1976

TABLE 4.9

Energy and Protein Content of Some Staple Crops Grown in Bali.

Item (Edible Portion)	Energy (MJ/kg)	Protein (g/kg)	Source
Milled Rice (*Beras*)	14.772	70.0	Nutrition Almanac, 1975
Rice Bran (*Wot*)	11.119	120.0	Nutrition Almanac, 1975
Maize (*Jagung*)	15.173	100.0 (dry)	Platt, 1962
Cassava (*Ketela Pohon*)	6.395	7.0 (wet)	Platt, 1962
Sweet Potato (*Ketela Rambut*)	4.765	15.0 (wet)	Platt, 1962
Soybean (*Kedele*)	15.968	350.0(dry)	Platt, 1962
Groundnut (*Kacang Tanah*)	24.202	270.0 (dry)	Platt, 1962
Kidney Bean (*Kacang Hijau*)	14.170	240.0(dry)	Platt, 1962

4.5.1

Sawah Labour Inputs

From field observation of sawah cultivation on the PRA, each of the operations were classified as Light, Medium or Heavy Work, Hoeing being classified separately (Edmundson, 1976). Table 4.10 (below) lists Mean Work Duration of each operation, which multiplied by appropriate rate of energy expenditure (MJ/hour) gives the Human Labour energy required for each operation. Calculations were based on the labour energy required per Are (MJ/Are) addition of the energy expanded for each operation gives the total input of human labour energy per Are per crop. The average hourly rate of energy expenditure (MJ/hour) was calculated by dividing total energy expenditure (MJ/Are) by total work duration (hours/Are).

TABLE 4.10

***Sawah* Cultivation Dam Ubud: Human Labour Energy Expenditure per Crop per Are for Each of 12 Operations.**

Operation	Duration	Rate of Energy Expenditure	Energy/Are
	(Hrs/Are)	(MJ/hr)	(MJ/Are)
Cutting Straw	0.62	0.767	0.476
First Hoeing	2.65	1.392	3.689
Raking	0.53	0.767	0.407
Cleaning Bund	0.51	0.767	0.391
Second Hoeing	2.57	1.392	3.577
Raking	0.53	0.767	0.407
Cutting Seedlings	0.17	0.529	0.090
Transplanting	1.25	0.767	0.959
First Weeding	2.92	0.767	2.240
Second Weeding	2.85	0.767	2.186
Bird watching	4.95	0.529	2.619
Harvesting	4.40	0.767	3.375
Total	**23.95**	**0.852**	**20.416**

Adding together the input energy expended by humans and cattle, on a per are basis, the total metabolic energy expenditure was calculated. This is tabulated in Table 4.11 (below).

TABLE 4.11

***Sawah* Cultivation Dam Ubud: Total Hunan and Animal Energy Expenditure for the Cultivation of 1 Are of Sawah (Animate Energy Input).**

Energy Source	Duration (Hours)	Energy Input (MJ/Are)
Human Labour	23.95	20.41
Animal Labour	2.12	16.96
Total	**23.95**	**37.37**

4.5.2

Energy Ratios

To calculate the Input-Output Energy Ratio (ER) for each variety of rice, the energetic value of edible rice (bergs) output per are was divided by the sum of the energetic values of all inputs per are:

Energy Ratio = Total Energy of Edible Output / Total Energy Value of Inputs

The energetic values used for the calculation of the input and output per are taken from Tables 4.8 and 4.9 (above). The variety specific input weight of fertilizer per are from Table 4.6 (above); input rate of rice seed is taken as 0.25 Kg/are (BULOG, pers. com.); and Human and Draft Labour inputs per are from Table 4.10 (above).

TABLE 4.12

Harvest Survey Dam Ubud : Energy of Inputs and Output per Are and Energy Ratio for 7 Varieties of Rice.

Variety	N*	Total Inputs (MJ)	Edible Output (MJ)	Energy Ratio
IR-36	47	106.27	287.83	2.71
Pelita	52	72.37	243.12	3.36
Gembira	19	62.04	207.33	3.34
Cicih Beton	31	44.94	262.91	5.85
Cicih Kapuk	46	44.97	247.64	5.51
Ketan Gadis	16	64.21	279.82	4.36
Ketan Bali	10	50.37	215.20	4.27

*N = No. of Samples

4.5.3

Effects of Fertilizer Use

An analysis was also made of the seven rice varieties to compare energetic inputs and outputs resulting from the use and non-use of fertilizer (Urea). The results of this analysis are presented in Tables 4.13 and 4.14 (below).

TABLE 4. 13

Harvest Survey Dam Ubud: Energy Input and Output per Are and Energy Ratio for 7 Varieties of Rice (no applied fertilizer).

Variety	N*	Total Inputs (MJ)	Edible Output (MJ)	Energy Ratio
IR-36	3	44.8	300.5	6.71
Pelita	6	41.1	167.9	4.12
Gembira	4	41.1	210.8	5.14
Cicih Beton	24	41.1	269.9	6.57
Cicih Kapuk	34	41.1	249.3	6.07
Ketan Gadis	3	41.1	202.1	4.92
Ketan Bali	7	41.1	216.4	5.28

*N = No. of Samples

TABLE 4.14

Harvest Survey Dam Ubud: Input and Output Energy per Are and Energy Ratio for 7 Varieties of Rice (fertilizer applied).

Variety	N*	Total Inputs (MJ)	Edible Output (MJ)	Energy Ratio
IR-36	44	108.9	287.3	2.64
Pelita	46	75.9	251.5	3.31
Gembira	15	66.1	206.6	3.12
Cicih Beton	7	57.6	240.1	4.17
Cicih Kapuk	12	58.6	241.8	4.13
Ketan Gadis	13	69.7	298.5	4.28
Ketan Bali	3	73.9	211.5	2.86

*N = No. of Samples

CHAPTER 5

DISCUSSION AND ANALYSIS OF METHODS AND RESULTS

5.0

Introduction

In this chapter a discussion of the methods (5.1) and results (5.2) of the surveys carried out to determine the levels of the inputs and outputs for rice cultivation for the 'wet-season' crop (December to June) in the *Dam Ubud* area are presented. This discussion is followed (5.3 below) by an outline of the differences in cultivation practices, inputs and handling between the traditional Balinese rice varieties and the 'High Yielding Varieties' of rice introduced to the Ubud area during the last 10 years.

5.1

Rice Hand pounding and Milling Surveys

These two surveys were undertaken because, at the outset of the study, it was not realised that standard conversion factors, (for the processing of *padi* to *gabah* and processing of *gabah* to *beras*) were available from Indonesian Government sources (Dinas Pertanian and BULOG). Thus these surveys were designed to provide the necessary conversion factors, for calculating the yield of edible rice from data collected during the Harvest Survey. The accuracy of the methods depending on two factors:

i) The accuracy with which the samples were weighed

ii) The number of samples of each variety of rice

5.1.1

Rice Hand pounding Survey

In the Hand pounding Survey the scales used to weigh the samples of path and gabah were graduated in 5 g divisions. The weight of the samples of padi was typically 2 kg, and that of the pounded *gabah* typically 1.5 kg, and the systematic weighing error was 2.5 g. Thus the percentage error in the hand pounding conversion factor (which ways calculated by dividing the processed weight of *gabah* by the weight of unprocessed *padi*) was:

Percentage error in weight of padi samples

0.0025 / 2 = 0.001% (approx.) plus

Percentage error in weight of gabah simples

0.0025 / 1.5 = 0.0020 (approx.)

Percentage error in milling conversion factor = + 0.003%

The range of variation in rice hand pounding yield factors determined from the survey (see Table 4.4) indicated that the determination of local, variety specific, conversion factors for the processing of *padi* to *gabah*, made possible more accurate comparison of the edible yields of traditional rice varieties.

The official conversion factor, 0.765, used universally throughout Indonesia for the calculation of edible yields of rice, is derived from data on hand pounding yields gathered throughout the Indonesian rice-growing areas (Dings Pertanian, Bali, pers. comm.). Necessarily, it lumps together data for many different varieties, hand pounding and measurement methods, and is at best a 'rough average' figure, useful only for determining very approximately the yield of *gabah* resulting from the hand pounding of *padi*.

Comparison of the variety specific hand pounding conversion factors determined in the survey, with the official conversion factor (0.765), reveals the factors determined from the survey were from 14% lower (Ketan Bali) to 12% higher (Ketan Gadis) than the official conversion factor.

5.1.2

Rice Milling Survey

The scales used for weighing the incoming and processed samples of rice (*gabah* and *beras*) in the Milling Survey were graduated in 0.5 kg divisions. The weight of the samples of incoming gabah was typically 25 kg and that of the processed beras typically 16 kg, and the systematic error introduced by the scales was 0.25 kg.

Thus the percentage error in the milling conversion factor (which was calculated by dividing the processed weight of *beras* by the weight of incoming *gabah*) was:

Percentage error in weight of gabah samples

0.25 / 25 = 1% (approx.)

Percentage error in weight of beras samples

0.25 / 16 = 2% (approx.)

Percentage error in the milling conversion factor = 3% (approx.)

In the Milling Survey only for the variety Gembira, in which the number of samples reflects the small number of people processing that variety during the survey period, was the size of the sample unusually small in comparison with the other varieties sampled

The milling conversion factors, presented in Table 4.3, are closely comparable with the yield factors used by the government for calculating milling yields. The factors used by the government, for the calculation of the milling yield of edible rice (*beras*) from gabah are given below in Table 5.1.

TABLE 5.1

Official Government Milling Yield Conversion Factors (*Gabah* to *Beras*).

Variety	*Gabah* to *Beras* Yield Factor
IR-36	0.65
Pelita	0.70
Gembira	0.70
Cicih (all types)	0.70

SOURCE: BULOG, BALI, 1979 (pers. comm.).

For the varieties Pelita to and Gembira the government conversion factors are higher than those calculated from the Milling Survey by 9% and 13% respectively.

The specific source of these differences is unknown, they may however derive from:

i) differences in the type of milling machinery used;

ii) the weighing of samples; and/or

iii) differences in yield resulting from the moisture content of the gabah being processed.

5.1.3

Harvest Survey

The general aim of the survey method was to obtain relatively accurate data on rice yields per unit area. Whilst the methodology for this study was in the planning stages, the methods employed by the Government Agricultural Service (Dinas Pertanian) and Irrigation Service (P.U. Dinas Pengairan) were established in conversations with officials and consultants working for these organisations. The methods they used are outlined below for comparison with the methods described in 4.3.2 above.

The Agricultural Service employs the following method:

i) During the harvest period within each sample area, (for example the area of sawah irrigated by Dam Ubud, 491 ha), from 2 to 5 samples of each of the types of rice (IR-36, Nationally Improved and Traditional), depending on the proportion of each type cultivated within the area, are obtained.

ii) For each of the sample plots an area of 6.25 m^2 (2.5 m x 2.5 m) is selected and measured using a tape measure.

iii) The rice from this plot is harvested and weighed using a 30 kg beam balance marked in 0.5 kg divisions (as *padi* or *gabah* depending on the variety of rice), no moisture content measurement is made.

iv) The weight of rice is standardised to a moisture content of 14%, from an assumed field-moisture content of 25%, to correct for moisture loss during drying.

v) The estimated weight of dry rice is then multiplied by 1600 to obtain the yield per Ha (6.25 m^2 x 1600 = 10,000 m^2 = 1.0 ha).

vi) This value is then used to estimate the total yield of rice from the sample area, and these are combined with results from other sample areas to give an estimate of the total yield of all rice varieties for that season, and the island as a whole.

The method used by the Irrigation Service is similar, except that the moisture content of the harvested rice is measured.

Sources of Error in Method Used by the Government Agricultural Service.

A plot size of 30 Are is assumed for the purpose of making a comparison between the method described above and that used in this study (see 4.3.2).

i) In a plot of this size (30 Are) 6.25 m^2 represents approximately 1/500 (0.002) of the area under cultivation. Thus errors of as little as ± 0.5 kg made during the weighing would result in errors of ± 240 kg for a plot of 30 Are (0.5 x 480 = 240), or ± 8 kg on a per Are basis. The calculated per Are yield of rice in this study was typically 18 kg, ± 6Are, (Table 4.4), and thus potential errors, of the order of +8Kg/Are, fall outside the typical range of standard deviations (+6Kg/Are) and introduce a variation of approximately ± 400 in the mean yield of rice per Are.

ii) In the method used by the Agricultural Service the unknown variations in moisture content would also be a source of potential error. The range of values of moisture content measured in this study was typically 18 – 27% (w/w). On the basis of correction factors used for converting the wet weight of rice to a standard dry weight (moisture content 14% (w/w) (see Appendix A5.1) the use of a general figure of 25% moisture content could result in an understating of yield per unit area by up to 10%.

iii) In the method used by the Agricultural Service the other major source of error is the small number of samples taken for each variety and per sampling division (per unit area of sawah). In this study, with from 47 to 77 samples taken for each type of rice, variations in mean yield per Are were from ± 30% to ± 59% of the mean for the varieties of rice sampled; and one sample was taken for approximately every 2 ha of sawah within the Primary Research Area. The method used by the Agricultural Service, taking from 2 to 5 samples of each type of rice and a possible maximum (given three types of rice within the sample division of Dam Ubud) of 15 samples, that is approximately one for every 33 ha of *sawah*.

iv) The final point in comparing these two methods is that the sample drawn by a survey worker from the Agricultural Service is open to unknown bias depending upon the condition of the rice crop in the relatively small area, relative to the average area cultivated by one farmer, from which the sample is drawn. In this study, (in which the average weight of five *ikat* or *zak* is multiplied by the total number of *ikat* or *zak*, to determine the total weight of rice harvested) only small variations (typically ± 50 of the mean weight of an *ikat* or *zak*) were recorded. However, the degree of variation in losses to insects or rodents, which affected the total number of *ikat* or *zak*, was very high within many of the plots sampled, and thus the drawing of a small sample in these cases would have led to large errors in the total weight of the harvest.

The potential for errors arising from:

i) inaccuracies in measurement;

ii) an insufficient number of samples; and

iii) surveyor bias.

have been eliminated or reduced to a minimum in the present study. Variations in the calculated mean yield of rice per Are for each of the varieties included in this study are considered to represent real differences in the yields obtained by the farmers, cultivating each rice variety, in the Primary Research Area. Therefore, taking these points into consideration, the methodology used in this study for the collection of data during the Harvest Survey, is considered likely to be superior in accuracy to the methods used by the Government Agricultural and Irrigation Services.

5.1.4

Sawah Labour Inputs Survey

The Survey Methods which relied upon the 'informed opinions' of the 19 *Pekaseh Subak* of the *Dam Ubud* area, was selected due to time constraints of the study. A more direct method attempted during the study was abandoned due to the time taken to accumulate samples. No estimate can be made of the accuracy of the data presented (4.4.4 above). Thus the data on the Animate Energy inputs to rice cultivation must be regarded as approximations only. In Chapter 6 the data obtained in this study for the labour requirements of *sawah* cultivation are compared with those obtained in other studies of rice cultivation in Bali.

Except for labour requirements of harvesting, which were also measured during the Harvest Survey (see Table 4.5), no comparable data are available. For this category of labour input, mean values obtained in both survey are in good agreement. Sawah Labour Inputs Survey 4.4 hours per Are; Harvest Survey 4.5 hours per Are. The labour requirements of hand pounding padi to obtain *gabah* were not measured during the Rice Hand pounding Survey, thus the omission of post-harvest labour requirements for the traditional rice varieties is understated by an unknown amount. However, from conversations with farmers, who reported that it took 2 women 2 hours to render 30 kg of padi to gabah (energy expenditure approximately 0.1 MJ/kg *padi* or 0.2 MJ/kg *Beras*) this omission has little effect on the total energy inputs so required for traditional rice varieties.

5.2

Discussion of Results

5.2.1

Introduction

The general aim of the surveys carried out in the Primary Research Area was to provide a body of data allowing the comparison of High Yielding Varieties (HYV) of rice with the Balinese Traditional Varieties (TVR) of rice. Two criteria are relevant in making comparison of the results obtained in this study:

i) The per unit area yield of edible rice, i.e. kg/Are

ii) The ratio of energy inputs to outputs, i.e. Energy Ratio (ER)

Seven varieties of rice were sampled (IR-36, Pelita, Gembira, Cicih Beton, Cicih Kapuk, Ketan Gadis and Ketan Bali). Two of these varieties, Ketan Gadis and Ketan Bali are glutinous varieties used for making rice confectioneries and they are not used for everyday consumption. These varieties are grown on small areas in almost every *subak* in Bali, and do not constitute a major proportion of the total rice planted or harvested. For this reason they have been excluded from the following discussion.

The results show that in terms of yield per Are, one HYV (IR-36) was marginally superior to the best of the TVR (Cicih Beton) (see 4.3.4 above); in terms of Energy Ratios, those of the HYV's were significantly lower than those of the TVR's, due to the greater inputs of energy used in cultivation (see Table 4.12 above).

5.2.1

Yields

The initial basis of comparison between the different rice varieties is the size of the yield of edible rice (*beras*) per Are (see Table 4.4). Taking the most modern of the introduced rice varieties (HYV), IR-36 (19.48 kg/Are) and comparing the yield with the highest-yielding of the Traditional rice grown for day-to-day consumption, Cicih Beton (17.80 kg/Are) revealed only a marginal difference in the mean yields. The mean yields of the Nationally Improved Variety, Pelita, was lower than the mean yields of IR-36 and Cicih Beton and very slightly higher than that of Cicih Kapuk. Mean yield of the Nationally Improved Variety Gembira was the lowest of all the varieties surveyed (including Ketan Gadis and Ketan Bali).

Factors Affecting Yields

For all of the samples collected within the survey area no major clustering of one rice variety in relation to the other varieties was evident. Thus variations in soil type, amount of insulation and drainage were considered to be minor factors in explaining the size and variation in yields. There were no reports of insufficient irrigation water from any of the farmers or *pekaseh*. Only one farmer in the survey reported serious difficulties in obtaining necessary inputs. However, from more general information obtained in discussions with farmers and others, short-tern shortages of IR-36 seed, fertilizer, insecticides and application equipment were reported.

It should be noted that variations (standard deviation) in yield per Are, within each of the rice varieties sampled, ranged from 32% - 59% of mean yield, and thus the mean yield per Are for each rice variety falls within the range variation of all of the other varieties of rice surveyed (see Table 4.4).

The range of variation in plot area between each of the rice varieties sampled (27.17 - 31.14 Are) is lower than the variation (standard deviation) within each variety included in the sample, and thus any bias, resulting from factors associated with the size of area cultivated, can be discounted.

High Yielding Varieties (IR-36)

This HYV became available in the survey area in 1974, and with the exception of Pelita and Gembira, replaced all other HYV's (IR-26, IR-30, IR-34), previously cultivated in the Dam Ubud area. Farmers cultivating this variety reported very low losses to insects, and moderate, though unspecified, losses to rodents. The mean yield of farmers reporting less than 5% losses (66% of the sample), was 21.40 kg/Are, only 0.92 kg higher than the whole sample mean, therefore crop losses were a minor influence on individual and mean yields per Are (see Appendix A4.2).

The rate per Are of yield must therefore be due to the attributes of the variety, higher yield per unit area being one of the genetic characteristics selected for during the breeding program at IRRI (IRRI, 1977).

Nationally Improved Varieties (Pelita and Gembira)

These two varieties became available in the survey area in 1969/70, and were the result of breeding research undertaken at the Central Research Institute for Agriculture in Bogor (Hargrove, 1978). The lower yields of Pelita (16.46 kg/Are) and Gembira (14.04 kg/Are; (Table 4.4) were attributed by farmers to infestations by, and losses to, Brown Plant Hoppers, which reportedly attacked these varieties more severely than IR-36 or traditional varieties. The mean yields for farmers reporting less than 5% losses, (42% of the sample), was 21.41 kg/Are, 4.9 kg/Are higher than the whole sample mean, thus losses reduced average yields to 77% of that achieved by farmers with no losses. The relatively high yields achieved by farmers reporting less than 5% losses indicated that the yield potential of this variety is greatly reduced by susceptibility to insect attack. Only 23% of farmers cultivating Gembira reported less than 5% losses, and the mean yield of these farmers, 22.42 kg/Are, was 8.4 kg/Are higher than the whole sample mean, these losses reduced the mean yield to 63% of that achieved by farmers reporting less than 5% losses.

It is apparent that the losses caused by insects, in particular the Brown Plant Hopper, were largely responsible for the low mean yields of these two varieties. In the planting season immediately following this survey the Agricultural Extension Worker (for the Dam Ubud area) reported that the planting of these varieties had almost ceased, and that farmers were planting IR-36 and Cicih Beton in preference to these varieties.

Traditional Varieties (Cicih Beton and Cicih Kapuk)

As far as can be discovered these varieties may have been introduced by the Japanese (during World War II) in about 1942, though whether the current variety is the result of breeding experiments carried out in Bali, by Japanese agricultural scientists, is not known. Of the two Cicih Beton achieved a higher mean yield (17.80 kg/Are) than Cicih Kapuk (16.76 kg/Are); 70% of the farmers cultivating Cicih Beton reported losses of less than 5%, compared with 67% of the farmers cultivating Cicih Kapuk. For Cicih Beton the difference in mean yields, between, farmers reporting losses of less than 5%, and the whole sample mean was 2.25 kg/Are, a reduction of 11%; for Cicih Kapuk the difference was 1.62 kg/Are, a reduction of 10%. Farmers reported that Cicih Beton appeared to have a higher level of resistance to attacks by insects than Cicih Kapuk, and thus was the preferred traditional variety.

Summary

If the comparison of mean yields per Are is restricted to the most modern of the introduced varieties (IR-36) and the highest yielding of the traditional varieties (Cicih Beton) the difference in the mean yields was only 9% (1.68 kg/Are) ; and if a comparison is made between these varieties for those farmers reporting less than 5% losses the difference is reduced to 6% (1.35 kg/Are). In the section on Energy Ratios, which follows, discussion will be restricted to these two varieties, as representatives of the High Yielding and Traditional Varieties of rice, and will focus on the differences in inputs used in the cultivation of IR-36 and Cicih Beton.

5.2.2

Energy Ratios

Introduction

Another basis of comparison between the different rice varieties is that of Energy Ratio (ER). The ER is the ratio of total energy inputs to outputs: inputs include the energy content of seed, land preparation, cultivation, fertilization, harvesting and processing; and energy output is the energy content of edible rice produced. The value of ER's, in instances where crop yie ld per unit area are similar, lies in their ability to quantify the variations in energy inputs required for different cultivation technologies.

A clear division is apparent between the Energy Ratios calculated for the HYV's (IR-36, Pelita and Gembira) and the Traditional Varieties (Cicih Beton, Cicih Kapuk, Ketan Gadis and Ketan Bali) (see Table 4.12 above). Whilst the HYV's all have ER's lower than 1:3.5, the Traditional Varieties have ER's of 1:5.25 or higher. The greatest of these differences is between Cicih Beton (ER = 1:5.85) and IR-36 (ER = 1:2.71). The 9% increase in mean edible energy output of IR-36 (287.8 MJ/Are), the most modern of the HYV' s compared with that of Cicih Beton (262.91 MJ/Are), highest yielding of the traditional varieties, depended upon a 136% increase in energy inputs. This study found the largest variation in the energy content of inputs resulted form the application of nitrogenous fertilizer (see Appendix A4.4).

Factors Affecting Energy Ratios

There were four possible factors which affected the Energy Ratios for each of the rice varieties sampled in this study. These were the energy content of seed, cultivation and processing labour (human and draft), fertilizer applied per Area and edible yield of rice per Are. For all of the varieties surveyed the energy value of human and draft labour inputs were similar (see Table 4.7),

Although the energy content of IR-36 seed was calcula ted to be twice that of other seed stock, seed energy constituted only 7% and 9% of the total energy inputs to IR-36 and Cicih Beton respectively. These two factors, labour inputs and seed, were considered to be of minor significance in analysing differences in Energy Ratios.

The energy content of fertilizer accounted for 58% of total energy inputs to IR-36, whilst only constituting 9% of the total energy inputs to Cicih Beton. The difference in the energy content of mean edible output per Are between the two varieties IR-36 and Cicih Beton, although quite high absolutely (24.9 MJ), was only 9% in relative terms. Thus the factor for which there was most variation was the energy content of fertilizer applied.

The Effect on Energy Ratios of Fertilizer Use

Only 23% of the farmers sampled cultivating Cicih Beton report using fertilizer, compared with 94% of the sample of farmers cultivating IR-36. Thus a comparison of the effects of fertilizer use on Energy Ratios can be made between these two varieties on four criteria:

i) between the whole sample of both varieties.

ii) between those cultivating Cicih Beton and not using fertilizer, and the whole sample for IR-36.

iii) between those cultivating Cicih Beton using fertilizer and the whole sample for IR-36.

iv) between those cultivating Cicih Beton who used fertilizer and those who did not use fertilizer.

i) Comparison between the whole of both samples

The mean rate of fertilizer application for IR-36 was 1.58 kg/Are (61.5 MJ/Are), and for Cicih Beton was 0.l0 kg/Are (3.9 MJ/Are). This difference in use rates accounted for 94% (57.8 MJ) of the variation in energy inputs to these two varieties. The mean (edible) energy output for IR-36 was 287.8 MJ/Are, 9% higher than that for Cicih Beton (262.9 MJ/Are). The ER for Cicih Beton was 1:5.85, 216% higher than that for IR-36 at 1:2.71.

ii) Comparison between Cicih Beton (no fertilizer) and IR-36 (whole sample)

Of the samples of farmers cultivating Cicih Beton, 77% used no fertilizer (labour inputs constituted 91% of total energy inputs); fertilizer use for IR-36 was the same as in (i) above. Fertilizer use for IR-36 accounted for 88% of the difference between these samples in energy inputs. The edible energy output of Cicih Beton was 269.9 MJ/Are, 94% of the edible energy output for IR-36. The ER for Cicih Beton was 1:6.57, 242% higher than that for IR-36. The mean output of edible energy for this sample of Cicih Beton was 3% higher than that of the whole sample of Cicih Beton; and the ER 12% higher than for the whole sample of Cicih Beton.

iii) Comparison of--Cicih Beton (fertilizer) and IR-36 (whole sample)

The 23% of farmers using fertilizer in cultivating Cicih Beton applied fertilizer at a mean rate of 0.42 kg/Are (16.4 MJ/Are), and the energy content of fertilizer accounted for 29% of total energy inputs; fertilizer use for IR-36 was the same as in (i) above. The differences in fertilizer use (1.06 kg/Are) accounted for 85% of the variation in total energy inputs. The mean yield of Cicih Beton was 9% lower than for the whole sample; output of edible energy was 240.1 MJ/Are, 83% of that for IR-36. The ER for Cicih Beton was 1:4.17; 154% higher than that of IR-36; 63% of that for those farmers cultivating Cicih Beton who did not apply fertilizer; and 71% for the whole sample of Cicih Beton.

iv) Comparison of Cicih Beton (no fertilizer and fertilizer)

Fertilizer for Cicih Beton was as in (ii) and (iii) above, and accounts for all of the variation in input energy (29% or 16.5 MJ). The mean edible energy output of those farmers not using fertilizer was (29.8 MJ), 12% higher than for those farmers using fertilizer. The ER of those farmers not using fertilizer was 1:6.57, 58% higher than that of farmers using fertilizer 1:4.17.

To facilitate comparison of the differences in input and output energy and energy ratios, comparisons (ii), (iii) and (iv) above are presented below in three matrices (Table 5.2). The entries in the rows and columns of the matrices are the factor by which the sample within each boundary (e.g. Cicih Beton: fertilizer and no fertilizer) differs from the example on which comparison is based, thus permitting comparisons to be made between any pair of boundaries for each variable (Input Energy, Output Energy and Energy Ratio).

TABLE 5.2

Energy Inputs, Energy Outputs and Energy Ratio for IR-36 and Cicih Beton

INPUTS	Cicih Beton (no fertilizer)	Cicih Beton (fertilizer)	IR-36 (whole sample)
Cicih Beton (no fertilizer)	1.00	1.40	2.59
Cicih Beton (fertilizer)	0.71	1.00	1.85
IR-36 (whole sample)	0.39	0.54	1.00
OUTPUT	Cicih Beton (no fertilizer)	Cicih Beton (fertilizer)	IR-36 (whole sample)
Cicih Beton (no fertilizer)	1.00	1.12	0.94
Cicih Beton (fertilizer)	0.89	1.00	0.83
IR-36 (whole sample)	1.07	1.20	1.00
ENERGY RATIOS	Cicih Beton (no fertilizer)	Cicih Beton (fertilizer)	IR-36 (whole sample)
Cicih Beton (no fertilizer)	1.00	1.58	2.42
Cicih Beton (fertilizer)	0.63	1.00	1.54
IR-36 (whole sample)	0.41	0.65	1.00

Summary

An interesting result is that the edible energy output, of Cicih Beton cultivated without use of fertilizer, was 12% higher than that achieved for the sample of farmers using fertilizer and the ER 58% higher. The only evidence obtained that offered some explanation of this result was indirect: farmers reported that the fee demanded for hoeing sawah that had fertilizer applied during the previous cropping season, was higher than for that to which no fertilizer had been applied. The reason given by farmers for the higher cost was that the work effort required to turn over and breakup soil, after fertilizer application, was greater. This indicates that the application of nitrogenous fertilizer may be leading to changes in soil structure, affecting the yield capacity of the rice cultivated in them.

The inputs of fertilizer and seed, necessary for the cultivation of the HYV's (particularly IR-36) must all be imported to the local area. These imports come, in the main, from Java, where factories for the production of inorganic fertilizers (primarily urea) have been established over the last 10 years. Prior to the introduction of the HYV's, (Pelita being the earliest introduced to the Ubud area) all the inputs necessary for the cultivation of rice came from within the area. The farmers of the area were dependant upon their own skills to make available sufficient nutrients for maintaining the fertility o their rice fields. This was achieved in two ways: by entrapping the nutrients and minerals carried down to the fields in the irrigation water; and, by the application of green manures harvested from the vegetation growing within the area.

Assuming that the ER, calculated for the sample of farmers cultivating Cicih Beton without using inorganic fertilizer, is representative of the ER's for rice cultivation, prior to the introduction of HYV's and the widespread availability of inorganic fertilizers, this analysis indicated that the 6% increase in per Are output of edible energy achieved by the variety IR-36 has required a 259% increase in energy inputs compared with traditional rice cultivation practises. To obtain the same quantity of edible output energy, IR-36 required 2.42 times more energy than was necessary traditionally, the largest portion of this additional energy input (88%) deriving from the use of organic fertilizers.

5.3

MAJOR DIFFERENCES BETWEEN HIGH-YIELDING VARIETIES AND TRADITIONAL VARIETIES OF RICE.

ITEM	HIGH YIELDING VARIETIES	TRADITIONAL VARIETIES
SEED	Developed from earlier HYV seed in the Philippines, requires special facilities for seed multiplication, testing, packaging and distribution.	Seed for the next seasons crop is selected from current season's crop by farmers; receives extra attention in drying and storage.
GENETIC QUALITIES	Results of special breeding and backcrossing program; selected for high yield response to nitrogen fertilizers; shorter time from germination to maturity; resistance to a range of common insect pests, fungi and viruses; short, thick stems less susceptible to lodging; acceptable grain quality.	Long, relatively thin stems; moderate response to fertilizer; low to moderate resistance to insect, fungi and viruses; relatively higher resistance to water shortages; preferred taste characteristics; susceptible to lodging (falling prior to harvest) at moderate to high rates of fertilizer application.
GERMINATION	Carried out in wet bags, or may be direct seeded into rice field; responds well to basal application of Urea and/or TSP (Triple Superphosphate).	Heads of seed are placed on the top of the soil in specially prepared seed beds; good response to basal application of Urea or TSP; less affected by weed growth in seed beds.
FERTILIZER	Requires application of nitrogenous fertilizer at the rate of 150 to 200 kg/ha to achieve yield potential, may also require TSP; organic fertilizer, green and animal manure still used.	Yields well with sufficient application of green and animal. manures; good response to law to moderate (50 to 100 kg/ha) application of urea; severe lodging results from over application, due to elongation of stems during vegetative growth.
HARVESTING	Plant stems cut in bundles low to the ground with a sickle; grain threshed in the field; low to moderate losses due to shattering of grain panicle prior to or during harvesting; in some areas introduction of *'tebasan'* system, i.e. preharvest sale of crop to contractor.	Only top 20 to 30 cm of stem harvested, each head harvested individually with small knife; grain on stem made into bundles (*ikat*) for transportation and storage; no reports of *'tebasan'* system for these varieties.
GRAIN DRYING	Loose grain (*gabah*) spread on dry, flat surfaces, e.g. concrete slab for sun drying prior to storage and/or milling.	Ikat of grain stood on end and spread open for sun drying prior to storage and/or hand pounding to render *gabah* from *padi.*

ITEM	HIGH YIELDING VARIETIES	TRADITIONAL VARIETIES
HANDPOUNDING	Not necessary to obtain *gabah*, and the husk of the *gabah* is too thick, and tightly attached to the endosperm to make hand pounding of *gabah* to *beras* feasible; reportedly like rubber (*karet*) to pound.	Used to separate the stalk from the grain, and, prior to the introduction of mechanical rice mills, used to render *beras* from the *gabah* carried out by women in small groups who work to a rhythm whilst pounding.
MILLING	Requires the establishment of mechanical rice mills, drying and storage facilities; overmilling results in lower yield and complete loss of inner bran layer, with consequent reduction in nutritional quality; milling yield slightly lower than TVR.	Traditionally by hand pounding, at present almost all milled in mechanical rice mills; slightly higher milling yield than HYV.
STORAGE	Poor storage qualities with losses of up to an estimated 20% reported, long term (longer than one year) results in higher losses and deterioration of grain quality.	Good storage qualities, with nil or law losses during storage, reportedly 5 to 10 years without deterioration of grain quality when stored in ikat.
TASTE	Regarded by the population as being tasteless, or very bland, and having poor qualities of intergrain adherence that are necessary for the 'balling' of rice with the fingers prior to eating.	Most varieties, if not overmilled, have a nutty flavour, and the taste, texture and ease in eating are preferred to those of introduced rice varieties.
FINANCIAL	The need to purchase special seed and fertilizer means that credit extension facilities must be provided; may increase rural debt burden due to crop failures and inability to repay loans and thus receive credit for the coming season.	Traditional forms of credit within the *subak* and the *banjar* are used interchangeably to acquire credit for low level of extra local inputs or payment for hired labour; many transactions carried out on a barter basis with other farmers or other members of the farmer's extended family group.
INFORMATION	Introduction requires the training and employment of extension workers to inform farmers of necessity to apply fertilizer and the differences in harvesting characteristics.	Passed on from one generation to the next, religious mythology contains didactic tales relating to the manner in which the farmers should relate to their rice and the ceremonies which are necessary for crop protection and giving thanks for a successful harvest.

CHAPTER 6

RICE CULTIVATION: COMPARATIVE ENERGY ANALYSIS

6.0

Introduction

The results of the present study, described and analysed in the previous Chapters were drawn from research limited spatially and temporally. The detailed study was carried out in an area irrigated by Dam Ubud, only one of the many in Bali; measurements were made in only 19 of the approximately 1,300 subak in Bali; and the total area covered by the study (about 500 ha) represented only approximately 0.5% of the total area of sawah in Bali (±100,000 ha). Temporally, the study was limited to one cropping season, the 1978-79 wet season; and, additionally, lack of manpower restricted the number of variables that could be studied in detail.

The spatial and temporal limitations of the present study therefore restrict the legitimacy of making general statements, about the effects on agricultural energy flaws of the new cultivation technologies used for the HMV's of rice. To reduce these limitations, and set the present study in a broader framework, relevant data from four contemporary studies of rice cultivation in different areas of Bali, and two earlier agroeconomic investigations, have been used to make comparative energy analyses. The results are presented in this Chapter. Finally, the method of Energy Analysis is then used to calculate an Energy Ratio for contemporary (1978) Balinese rice production.

The present study concentrated on intensive sampling of those variables chosen for study, and on establishing close working relationships with the farmers and pekaseh subak in the study area. This intensive study allowed detailed comparisons to be made between the varieties of rice cultivated in the area, and allowed a preliminary exploration to be made of some of the more obvious ecological processes occurring in and near the sawah.

6.1

Spatial Generalisation of Results

Both before and during the period in which the present study was undertaken, a series of other studies were made, to determine the range of economic benefits that might be reasonably expected from improvements in irrigation, and extending the cultivation of HYV's of rice. These studies were commissioned by the Government of Indonesia, and undertaken by overseas consultants, usually working in cooperation with the Bali Department of Public 1,Iorks Irrigation Service (Perkerjaan Umum, Dinas Pengairan). These studies have focused on the effects on rice yields (and total production) of making available additional irrigation water during the mid-year dry season (May-October).

Three studies, prepared by overseas consultants, contain sufficient data on physical inputs and outputs of rice cultivation to permit the undertaking of energy analyses: these are "Permanent Weirs in Bali" (Bali Design Team, 1978) (Appendix A6.1(A) and (B)); "Bali

Irrigation Study Final Report" (Asian Development Bank, 1978) (Appendix A6.2 (A) to (C)); and "Tukad Saba Study: Annex 1 (Agriculture and Economics)" (Appendix A6.3 (A) and (B)) ; (Sir M. MacDonald & Partners, 1976). In addition a study, undertaken by P.U. Pengairan, "Kumpulan Beberapa Data Pertanian" (1978) (Appendix A6.4 (A) to (I)) (translation: "Compilation of Various Agricultural Data"), provides an overview of inputs and outputs used in the cultivation of staple crops (including rice) in Bali.

6.1.1

A Comment on Methods

Whilst the methods by which the information contained in these reports is not the main topic under consideration here, some brief comments on their reliability seems appropriate. At the outset it should be noted that, the methods used for data collection varied considerably between studies. Data on crop inputs and outputs in "Permanent Weirs in Bali" (BDT, 1978) was all collected in interviews with the *pekaseh* of the subak in the study area, and the report comments that much of the data is "suspect, particularly that regarding the yields of rice obtained" (p.19). The data presented in the "Bali Irrigation Study Final Report" (ADB, 1978) was also collected by an interview technique, however in this study 103 farmers in the study areas were interviewed using pretested questionnaires to ascertain the levels of cropping inputs and outputs. All of the information on crop inputs and outputs in "Tukad Sabah Study" (SMP, 1976) was abstracted from other studies conducted in Northern Bali and East Java, and the yield projections made in the study were based on rice yields obtained from experimental trials in North Bali. None of these studies directly measured the areas of the farms or yields of rice on which their later calculations were based.

The data presented in "Kumpulan Beberapa Data Pertanian" (PUP, 1978) is based on staple-crop production data collected by Dinas Pertanian (Agriculture Department), (for reservations on methods used by Dinas Pertanian, see.5.2 above) and the report contains no other details on the methods used.

The Energy Analyses which follow must be regarded as indicative only of the trends resulting from changes in rice cultivation technology in Bali. They have been included here as they provide 'extensive' data on these trends, whilst the present study is 'intensive' and localised in nature. However, each of these 'extensive' reports presents a wealth of more general information, and commentary, on almost every aspect of agriculture in Bali, and in this respect alone, they are valuable contributions to the stock of general knowledge about the island.

(In the passages that follow, the abbreviations used above (e.g. ADB, 1978) are used for purposes of identifying each of the studies).

The input and output data abstracted from each of these reports has been analysed, using the values for the energy content of inputs and outputs given in Tables 4.8 and 4.9 (above). The details of each of the calculations are presented, in a format similar to that used by Leach (1975), in Appendices A6.1 to A6.4. It should be noted that the value used for the human metabolic energy expenditure for *sawah* cultivation is based on the unweighted average hourly rate, determined in the *sawah* Labour Inputs Survey (Table 4.10) and multiplied by 8 times, to give a value for an 8-hour work day (i.e. 0.852 MJ/hour x 8 hours = 6.8 MJ/man-day); and for the cultivation of dry-land crops a lower rate has been used, based on Edmundson (1976): rate for medium work (Table 4.8) and an 8-hour work day (i.e. 0.767 MJ/hr x 8 hours = 6.14 MJ/man-day).

6.1.2

Human and Draft Labour Inputs

In all these studies the authors make the point that labour requirements vary little between wet and dry season rice crops. The lowest figure for human labour inputs is 131 man-days/ha

(ADB, 1978); and the highest 326 man-days/ha (PUP, 1978). Energy expenditure ranges from 893.4 MJ/Ha to 2224.7 MJ/Ha. The greatest difference reported between HMV's and Traditional Varieties is 9 man-days/ha; the higher figure being for the HYV's (PUP, 1978 and BDT, 1978). Thus all but one of these studies found that human labour requirements were lower than for that found in the present study (299.4 man-days or 2 , 041 MJ/Ha), and indicate that labour requirements for HYV's and Traditional Varieties are substantially the same.

The figures on draft labour requirements fall into two groups, two studies (BDT, 1978 and SMP, 1976) quote the figures of 7 animal-days/ha (± 290 MJ/ha), and the other two approximately twice that figure (17 animal-days or ± 680 MJ/ha), (ADB, 1978 and PUP, 1978). The draft labour requirement found in the present study was (42.4 animal-days or 1,696 MJ/ha) more than twice that of the ADB (1978) study. This difference may result from confusion in the tabulation of draft labour requirement, as in all of the reports, it is unclear whether durations of work quoted are for a pair of animals on a per day basis, or for the total animal-days required.

6.1.3

Fertilizer Inputs

Considerable differences exist in the reported amount of fertilizer used for HYV's (IR-36 in the main) and Traditional Varieties. The figures for Urea fertilizer use on HYV's range from 100 kg/ha (BDT, 1978) to 200 kg/ha (ADB, 1978) (3,890 to 8, 0911 MJ/ha). In all the studies inputs of Urea fertilizer for the HYV's represented 52 to 72% (mean 62%) of total energy inputs to HYV cultivation. The data given in these studies for inputs of Urea are in good agreement with the input level found in the present study for IR-36 of 6,418.5 MJ, 61% of total energy inputs. In addition all of the studies reported applications of Triple Superphosphate for HYV's of 10 to 35 kg/ha (70 to 245 MJ/ha), which represented a small percentage of total energy inputs (1 to 3%); whilst the present study found no use of this type of fertilizer.

Only two of the studies reported on cultivation inputs for the traditional varieties, one of the studies (BDT, 1978) reported inputs of 50 kg/ha (1,945 MJ/ha) of Urea fertilizer, whilst the other study (PUP, 1978) reported no use of inorganic fertilizer; when used, it accounted for 38% of total energy inputs. In the present study fertilizer inputs to traditional varieties accounted for 36% (Cicih Beton) to 39% (Cicih Kapuk) of total energy inputs. Thus the application rates calculated for the present study are in good agreement with those obtained in the BDT (1978) survey.

6.1.4

Rice Yields

In one of the studies (ADB, 1978) yields are given for both the wet and dry season crops of HYV (IR-36) in three areas of Bali (see Appendix A6.2 (A) to (C)). In two of the areas the wet season yield is reported to be higher than that for the dry season. In North Bali the increase is 13%, and in South Central Bali 21%. In the third area (South West Bali) surveyed by this study the dry season yield is reportedly higher by 35%. To reduce as much as possible seasonal effects on yields, the discussion below is restricted to a comparison of wet season yields.

As the rice yield reported in SMP (1976) for North Bali is based on the yield obtained from an experimental trial plot, it is not included in this comparison. The highest wet season yield of HYV reported in the other studies is 2,228 kg/ka (32,912 MJ/ha) (PUP, 1978); and the lowest 1,231 kg/ha (18,184 MJ/ha) (ADB, 1978). Thus the mean wet season yield for IR-36 found in the present study, 1,948 kg/ha (28,783 MJ/ha), falls within the range of yields reported in the surveys under consideration.

The yields for traditional varieties of rice reported ranged from 1,120 kg/ha (16,545 MJ/ha) (BDT, 1978) to 1, 664 kg/ha (24,581 MJ/ha) (PUP, 1978). Somewhat lower than the mean yield for Cicih Beton (1,780 kg/ha or 26,291 MJ/ha) in the present study and spanning the mean yield calculated for Cicih Kapuk (1,592 kg/ha or 23,517 MJ/ha). Thus the yields for the traditional varieties reported in other studies are in reasonable agreement with those found in this study.

6.1.5

Energy Ratios

Turning now to the Energy Ratios (ER) calculated for the studies being compared, and again excluding the study of North Bali (SMP, 1976). The ER's for the HYV's range from 1:3.24 (EDT, 1978 and PUP, 1978) to 1:1.89 (ADB, 1978). The ER calculated for IR-36 in the present study was 1:2.17, and thus fell approximately midway between those calculated for all the other studies.

ER's calculated for the traditional varieties were 1:6.90 (PUP, 1978) and 1:3.25 to 2.94 (BDT, 1978), positioning the ER's for the present study, for Cicih Beton (1:5.85) and Cicih Kapuk (1:5.85) within the range of values calculated for the other two studies.

To simplify comparison of the range of energy inputs, outputs and ERs for these studies, the values calculated for the wet season crops are presented below in tabular form (Tables 6.1 and 6.2). Apart from the range of comparisons, to which attention has been drawn, it can be seen that the clear division in ER's between the HYV's and Traditional Varieties, commented on in Chapter 5 (5.2 above) is confirmed by the analysis of data drawn from other studies.

TABLE 6.1

HYV's: Calculated Total Input and Output Energy, Energy Ratio and Location for 6 Surveys.

Location	Input (GJ/ha)	Output (GJ/ha)	ER	Source
S. Central Bali	6.97 - 8.57	22.56	3.24 - 2.63	BDT, 1978
S.W. Bali	9.64	18.18	2.55	ADB, 1978
North Bali	11.20	24.40	1.93	ADB, 1978
S. Central Bali	11.10	26.12	1.95	ADB, 1978
All Bali	10.16	32.91	3.24	ADB, 1978
Dam Ubud	10.63	28.78	2.71	Present Study
Mean	9.95 -10.22	25.49	2.60 - 2.50	
Mean (excl. Dam Ubud)	3.81 -10.13	24.83	2.58 - 2.46	

TABLE 6.2

Traditional Varieties: Calculated Total Input and Output Energy, Energy Ratio and Location for 3 -Surveys.

Location	Input (GJ/ha)	Output (GJ/ha)	ER	Source
Central Bali	5.09 - 5.62	16.55	13.25 - 2.94	BDT, 1978
All Bail	3.56	24.58	6.90	PUP, 1978
Dam Ubud				
Cicih Beton	4.49	26.29	5.85	Present Study
Cicih Kapuk	4.50	24.76	5.50	Present Study
Mean	4.41 – 4.54	23.05	5.38 – 5.30	

6.2

Temporal Generalisation of Results

Two other studies of rice cultivation in Bali have been used to establish (indicative) Energy Ratios for cultivation of traditional rice varieties, prior to the use of inorganic fertilizers. The earlier of these two studies "Landbouw in de Afdeeling Zuid-Bali" (Bakker, 1934), was undertaken by the Dutch colonial authorities, in order to determine the level of rice yields in South Bali for land taxation. The second of the studies, "Monografi Pulau Bali" (Raka, 1955), is a more general overview of the islands population, geography, agriculture and trade, for the period from 1936 to 1954.

The work by Bakker presents data-of the area of *sawah* in South Bali (Kabupaten Tabanan, Badung, Gianyar, Klungkung and Karangasem) and the per hectare yields of padi for the year 1934. In none of the areas surveyed did the farmers make use of inorganic fertilizer, soil fertility being maintained by the traditional methods described in Chapter 3 (3.1.4). In the book by Raka the area of *sawah* and rice yield per hectare (by Kabupaten) are given for the whole of Bali. Additionally he notes, that traditional soil fertilization techniques, which are described in detail, were still the norm for rice cultivation in Bali.

Both of these studies are based on agricultural statistics compiled by government departments. The data on yields per hectare are based on the methods described in Chapter 5 (5.1.3), except that the area of the sample plots (25 m^2) used to establish per hectare yields is four times that currently in use.

The energy analyses of their data is based upon the energy content values given in Table 4.8 and 4.9 (above), and the values for the energy content inputs of human and draft labour are those determined in the present study (see Table 4.11 above); these values concur with those calculated from data in other studies, (see Section (6.2). In the energy analyses of both these studies the input energy for cultivation is the same as that determined for the traditional varieties of rice to which no fertilizer has been applied, grown in the *Dam Ubud* area (3, 737 MJ/ha) . The details of these analyses may be found in Appendix A6.5(A) and (B).

6.2.1

Yields and Energy Ratios

The yields per hectare in both these studies are very similar, 2,231 kg/ha (Bakker) and 2,280 kg/ha (Raka), and both are considerably higher than those determined for Cicih Beton (1,827 kg/ka) and Cicih Kapuk (1,688 kg/ha) grown without the use of inorganic fertilizer, in the present study (see Appendix A4.4 (D) and (E). If, however, they are compared with yields, of those farmers reporting less than 5% losses, (only 16% of whom used fertilizer) the differences are smaller, Cicih Beton (2,005 kg/ha) and Cicih Kapuk (1,838 kg/ha) (see Appendix A4.2 (D) and (E). In making such a comparison it should be born in mind that a high proportion of current crop losses are due to insect pests that were not present when the studies by Bakker and Raka were made, e.g. the Brown Plant-Hopper.

Due to the higher yields reported in the two studies the ER's were consequently higher than those determined in the present study. The ER for rice cultivation in South Bali was 1:7.36, and that for the whole island for 1948 1:7.53. Those determined in the present were 1:6.57 (Cicih Beton) and l:6.07 (Cicih Kapuk). It should also be noted that the ER obtained for traditional rice grown without inorganic fertilizer inputs, calculated from the P.U. Pengairan (1978) report, was 1:6.90, in good agreement with the ER's calculated for 1934 and 1938, despite the extra energy input of pesticide for contemporary cultivation (see Table 6.2).

Thus the ER's determined in the present study are in good agreement with those calculated for the cultivation of rice using traditional methods, and prior to the introduction of inorganic fertilizer.

6.3

Contemporary Rice Production

To complete the range of comparative Energy Analyses of rice production for the whole of Bali, an indicative Energy Analysis was made for the year 1978. Due to the aggregation of production data it was not possible to determine the relative contributions by to total production made by the traditional varieties of rice. However, it is known that of the total area planted during 1978 (176,549 ha) approximately 2/3 was planted with HYV's, mainly IR-36 (BULOG, 1979).

The main results of all the comparative analyses presented in this Chapter are presented in tabular form in Table 6.1 below. This analysis shows that the trend to lower ER's, resulting from the application of nitrogenous fertilizers, was maintained in an aggregated analysis of current Balinese rice production. The ER for Balinese rice production in 1978 was found to be 1:3.17, approximately half that for Traditional cultivation, and that inputs of urea fertilizer accounted for approximately 50% of total energy inputs. The details of this analysis can be found in Appendix A6.6(A) and (B). Despite the large increase in energy inputs due to fertilizer use, the increase in the per hectare yield of edible rice, compared with 1934 yields, has been marginal, having increased by only approximately 100 kg/ha during the last 45 years.

CHAPTER 7

CONCLUSIONS AND POLICY RECOMMENDATIONS

7.0

Introduction

Given the limited land area available for food production in Bali, an expanding population, two methods have been available for increasing the total production of the main food staple rice. These are: (i) increasing the number of rice crops per year that can be cultivated; and (ii) increasing the yield of rice harvested from each hectare of sawah cultivated. Both these methods have been used in Bali.

i) Increases in the number of rice crops has been achieved by improvements in irrigation, which, since the 1950's, have made possible the double-cropping of rice on an additional 53,000 ha. Since 1974, the area of sawah double cropped has increased by approximately 13%, and this increase has been responsible for most of the 13% increase in total rice production achieved during this period.

ii) The efforts to increase per hectare yield have met with only marginal success. Between 1974 and 1978 the average yield of edible rice has increased by only approximately 2% from 2,276 kg/ha to 2,114 kg/ha, and when cured with the average yield of 2,280 kg/ha achieved 45 years ago, the improvement is insignificant. However, the efforts to increase per hectare yields has resulted in a reduction in the Energy Ratio of Balinese rice production from approximately 1:7 to 1:3. This fall in Energy Ratio has resulted from the introduction of the High Yielding Varieties of rice, and the use of energy intensive nitrogenous fertilizer, necessary for cultivation of these varieties.

In this study Energy Analysis was used to compare the quantities of energy inputs and outputs for each of the rice varieties cultivated in the Dam Ubud area of Bali. The analysis of results showed that the Energy Ratio calculated for the High Yielding Varieties of rice were approximately half that of the Energy Ratios calculated for the Traditional rice varieties. More detailed analysis of the results showed that the reduction in Energy Ratio was due to the use of energy-intensive nitrogenous fertilizer.

In order to extend the applicability of the results of the detailed research, an Energy Analysis based on published material, of contemporary rice production in other areas of Bali was undertaken. The analysis showed that the Energy Ratios for rice cultivation in the Dam Ubud area were representative of the differences in Energy Ratios between High Yielding and Traditional Varieties of rice in Bali. An analysis of data for rice production in Bali for the years 1934 and 1948, showed that the Energy Ratios for the cultivation of Traditional Varieties, without use of nitrogenous fertilizer, in the Dam Ubud area, was similar to historical Energy Ratios.

7.1

Conclusions

Three conclusions can be drawn from the present study:

i) That total rice production has increased owing to improvements in the irrigation system which have made possible expansion of the area which can be double-cropped.

ii) That attempts to increase total rice production through cultivation of the range of currently available High Yielding Varieties of rice has been only marginally successful.

iii) That due to the use of the nitrogenous fertilizer required for the cultivation of the High Yielding Varieties of rice, the energetic efficiency of Balinese rice production has been approximately halved.

7.2

Policy Recommendations

In the light of the foregoing conclusions the following suggestions for Balinese agricultural policy are offered:

1. That a rice breeding program, that aims at the development of rice varieties with the following general characteristics, be initiated:

    i) Relatively higher yields, without dependence on energy intensive inorganic fertilizer.

    ii) High genetic resistance to common pests and diseases.

    iii) Maturation periods similar to those of the current High-Yielding Varieties.

    The aim of such a program would be to develop rice varieties whose macronutrient requirements could be met by intensive applications of green manures and composts, eliminating the need to apply, and hence manufacture and/or import, energy intensive nitrogenous fertilizers. The increased cropping intensity made possible by shorter maturation periods would allow the cultivation of five to six crops every two years, thus increasing total annual production from a fairly fixed amount of sawah. The susceptibility of intensive monocultures to devastation by insect and disease plagues necessitates the incorporation of genetic resistance to the known and potential predators.

2. The initiation. of a field research and extension programme whose aim was t,-, identify those species of plants, and the most effective methods for supplementing soil fertility and improving soil structure from the use of intensive use of:

    i) Aquatic, sawah dwelling, nitrogen fixing plants, e.g. Azzola pinnata.

    ii) Green manures and composts made from plants grown on unirrigated land adjacent to the sawah.

    iii) Collection and composting of urban vegetable and organic wastes that would otherwise be thrown into watercourses passing through these population centres.

    Research in Bali by the Dutch during the 1930's showed that it was possible to increase yields of Traditional rice varieties by 328 to 620 kg/ha by the intensive application of green manures and composts of vegetation groom on unirrigated land

(Moll, 1941). Contemporary experiments conducted in China confirm these results, and have also shown that such applications have beneficial effects on soil structure (FAD, 1977). Thus, the development of insect resistant varieties, with shorter maturation periods, not dependant upon the use of nitrogenous fertilizer, could be complemented by the intensive organic fertilization, necessary for maintaining soil fertility when double or triple-cropping is practised.

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APPENDICES

POPULATION OF BALI - 1976 - ANALYSED BY SEX AND KABUPATEN

KABUPATEN	POPULATION			CHILDREN (~15)			DESA			NO PERSONS PER.		
	MALE	FEMALE	TOTAL	MALE	FEMALE	TOTAL	NO	KM ^{2}	H'HOLD	DESA	KM ^{2}	H'HOLD
BULELENG	219,265	234,891	454,156	101,108	105,576	206,684	145	1,050	77,757	3,132	432.5	5.8
JEMBRANA	95,715	95,785	191,600	43,933	43,241	87,174	49	311	36,903	3,908	615.8	5.2
TABANAN	175,352	180,944	356,296	67,871	68,537	1136,408	99	1,083	62,744	3,599	329.0	5.7
BADUNG	222,116	221,672	443,788	92,917	92,027	:.84,944	51	498	74,842	8,702	891.1	5.9
GIANYAR	148,829	150,648	299,477	62,536	60,308	122,844	51	368	55,120	5,872	813.8	5.4
KLUNGKUNG	71,457	75,313	146,770	32,078	32,971	65,049	56	315	26,039	2,621	465.9	5.6
BANGLI	78,613	76,719	155,332	33,825	33,388	67,213	69	453	28,410	2,251	342.9	5.5
KARANGASEM	143,361	150,024	293,385	60,665	61,937	122,602	44	804	56,591	6.668	364.9	5.2
TOTAL	**1,154,708**	**1,185,996**	**2,340,704**	**494,933**	**497,985**	**1992,918**	**564**	**5,561**	**418,406**	**4,150**	**420.9**	**5.6**

SOURCE: "POPULATION OF OUTER JAVA: RESULTS OF POPULATION REGISTRATION 1976" (BIRO PUSAT STATISTIK JAKARTA 1976)

BALI POPULATION - SEPTEMBER 1976 - BY KABUPATEN AND URBAN/RURAL.

KABUPATEN	**NO. OF DESA**			**NO. OF HOUSEHOLDERS**			**POPULATION**				**PERSONS/ H'HOLD**		
	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL	% OF TOTAL	URBAN	RURAL	% OF POP URBAN
BANGLI	2	67	69	2,123	25,817	27,940	12,016	139,730	151,746	6.5	5.66	5.41	7.9
JEMBRANA	4	45	49	2,898	32,702	35,600	14,958	173,225	188,183	8.1	5.16	5.30	7.9
KLUNGKUNG	5	51	56	2,176	23,410	25,586	13,511	134,260	147,771	6.4	6.21	5.74	9.1
BULELENG	15	130	145	7,955	78,370	86,325	45,582	414,036	459,618	19.8	5.73	5.28	9.9
GIANYAR	2	49	51	1,760	52,734	54,494	9,808	283,683	293,491	12.7	5.57	5.38	3.3
BADUNG	4	47	49	16,674	55,874	72,548	106,228	331,116	437,344	18.9	6.37	5.93	24.3
TABANAN	3	96	102	3,061	59,186	62,247	18,005	332,781	350,786	15.1	5.88	5.62	5.1
KARANGASEM	2	42	44	3,015	52,048	55,063	16,458	271,431	287,889	12.4	5.46	5.22	5.7
TOTAL	**37**	**527**	**564**	**39,662**	**380,141**	**419,803**	**236,566**	**2,080,262**	**2,316,828**	**100**	**5.96**	**5.47**	**10.2**

SOURCE:"FACILITAS SOSIAL DESA: 1976" BIRO POS--AT STATISTIK, JAKARTA 69.

BALI: POPULATION (ESTIMATED) 1971 - 1978

REGENCIES	1971	1972	1973	1974	1975	1976	1977	1978
BULELENG	403,237	409,070	409,785	422,334	429,364	446,347	454,671,	458,350
JEMBERANA	172,006	171,712	173,453	173,196	178,935	188,20	189,923	191,588
TABANAN	328,056	339,925	348,672	339,649	343,448	350,169	352,460	350,468
BADUNG	400,283	407,565	408,076	414,102	427,709	436,157	439,097	443,101
GIANYAR	271,576	281,412	277,402	287,649	288,899	294,328	298,512	297,358
BANGLI	138,327	143,328	144,902	146,500	149,047	152,661	153,846	144,119
KLUNGKUNG	139,307	138,481	139,765	137,584	142,096	144,237	140,243	154,444
KARANGASEM	267,299	267,305	272,054	273,174	274,867	288,340	293,969	300,446
TOTAL	**2,120,091**	**2,158,798**	**2,174,109**	**2,194,188**	**2,234,265**	**2,300,446**	**2,322,721**	**2,339,874**

SOURCE: KANI'OR SENSUS DAN STATISTIK, BALI (1979)

BALI: BALI POPULATION AND AGRICULTURE - SUMMARY 1920 - 1954.

	POPULATION	NO	DENSITY/KM ^{2}		POPULATION	NO	DENSITY/KM ^{2}
BALI	1920	947,233		GIANYAR	1930	164,422	453
	1930	1,101,393	198		1950	221,490	602
	1950	1,484,043	264		1954	211,792	576
	1954	1,519,041	270		1961	232,600	632
					1971	271,600	738

SOURCE: BALI: STUDIES IN LIFE THOUGHT, AND RITUAL VAN HOEVE, THE HAGUE, 1960.

APPENDIX A1-1

BALI POPULATION BY KABUPATEN - 1920 AND 1930

REGENCY	**POPULATION**			**DENSITY**
(KABUPATEN)	MALE	FEMALE	TOTAL	PER/KM [2]
TABANAN	87,367	89,799	177,166	210.11
BADUNG-	96,397	96,595	192;992	377.78
GIANYAR	81,628	82,794	164,422	453.20
KLUNGKUNG	77,599	80,427	158,026	188.71
KARANGASEM	93,750	97,138	190,888	226.06
JEMBRANA	23,917	23,344	47,261	56.53
BULELENG	82,910	87,728	170,638	126.67
TOTALS: (1930)	543,568	557,825	1,101,393	
TOTALS: (1920)	467,460	479,773	1 947,233	

FARM WORKERS/100 WORKERS 1930

	MALE	FEMALE	TOTAL
SINGARAJA	71.92	27.22	69.98
S. BALI*	91.92	37.07	82.24

*South Bali Includes: Kabupaten Tabanan, Badung, Gianyar, Klungkung, Karangasem & Bangli.

TOWN POPULATION 1920 & 1930

	YEAR	MALE	FEMALE	TOTAL
SINGARAJA	1920	5,142	5,294	10,436
	1930	6,056	6.289	12,345
DEN PASAR	1920	4,359	4,142	8,501
	1930	8,148	8,221	16,639

POPULATION INCREASE 1920 TO 1930 (%)

KABUPATEN	**MALE**	**FEMALE**	**TOTAL**
JEMBRANA			
BULELENG	19.52	19.98	19.75
TABANAN			
BADUNG	12.00	10.71	11.35
GIANYAR	15.51	15.57	15.54
KLUNGKUNG	17.54	16.71	17.12
KARANGASEM	14.01	14.89	14.46

SOURCE: \'VOLKSTELLING, 1930, DEEL V"

BALI POPULATION - 1930 - BY KECAMATEN.

CAMAT	POP'N	CAMAT	POP'N	CAMAT	POP'N
TABANAN		**GIANYAR:**		**BANGLI**:*	
KEDIRI	28,334	BIAHBATU	24,634	BANGLI	18,213
KRAMBATAN	20,609	GIANYAR	40,519	KINTAMANI	22,221
MARGA	35,065	UBUD	43,251	SUSUT	18,062
PENEBEL	26,909	PAYANGAN	13,310	TEMBUKU	15,744
SELEMADEG	42,709	PELIATAN	21,955	**KARANGASEM** :	
TABANAN	23,540	TEGALLATANG	20,753	ABANG	29,461
BADUNG:		**KLUNGKUNG**:*		BEBANDEM	22,597
ABIANSEMAL	45,875	BANDJARANGKAN	19,809	KARANGASEM	35,668
DEN PASAR	25,413	DAWAN	17,268	KUBU	22,780
KESIMN	35,659	KLUNGKUNG	20,240	MANGGIS	25,807
KUTA	38,813	NUSA PENIDA	26,469	RENDANG	17,018
MENGWI	47,232			SELAT	23,857
				SIDEMAN	13,700

* In 1930 Bangli was included with Klungkung for administration. SOURCE: "VOLKSTELLING, 1930, DEEL V"

POPULATION AND LANDUSE - GIANYAR POPULATION (1930)

NAME OF KACAMATEN	POPULATION
GIANYAR	40,519
BLAHBATU	24,634
UBUD	43,251
PAYANGAN	13,310
PELITAN	21,955
TEGALLANG	20,753
TOTAL	164,422

1918 (EST)	120,553
1920 (CENSUS)	141,422
1930 (CENSUS)	164,422
1937 (CALC)	164,439

POP DENSITY	Pers/km^2
BALI	250
GIANYAR	453
Kec. BLAHBATU AND GIANYAR	666

LANDUSE (1934)

SAWAH	15,790 ha	AVE/KK. = 48 ARE	APPROX: 11,000 LANDHOLDERS
TEGALAN	14,567 ha	AVE/KK = 45 ARE	

SAWAH: CLASS AND PRODUCTIVITY GIANYAR 1937

CLASS	AREA	% AREA	PRODUCTIVITY (kg/ha)
1	631	4.2%	4,500 – 5,500
2	4,694	31.3%	3,900 – 4,500
3	5,874	39.1%	3,500 – 3,900
4	2,785	18.6%	3,100 – 3,300
5	992	6.6%	2,700 – 2,700
6	35	0.2%	2,000 – 2,000
	15,011		

SOURCE: VA14 DER KAADEN, W..F. "NOTA VAN TOELIGHTINGEN" (GIANYAR, 1937)

MAIN RIVERS: AYUNG, OOS, PETANU ,PEKERISAN, SANGSANG AND MELANGIT

APPENDIX A1.12

POPULATION - KECAMATAN UBUD - MARCH 1978.

DESA	0-4 YRS		5-14 YRS		15-24 YRS		25 + YRS		TOTAL		GRAND TOTAL	K K	PERS/ FAM.	AREA KM²	POP/DENS PERS/Km²
	M	F	M	F	M	F	M	F	M	F					
UBUD	891	512	702	510	1055	1014	1040	1013	3688	3049	6,737	1119	6.02	4.06	1659
PETULU	406	254	306	245	442	536	430	433	1584	1468	3,052	592	5.16	3.84	795
PELIATAN	620	517	610	520	834	831	725	776	2790	2645	5,435+[2]	790	6.88	3.91	1390
MAS	943	921	936	925	924	963	905	921	3708	3730	7,438	1179	6.31	6.47	1150
LODTUNDUH	345	330	658	606	368	422	997	974	2368	2332	4,700	832	5.65	7.08	664
KEDENATAN	1046	969	1042	970	1409	1414	1204	1213	4703	4569	9,272+[5]	1758	5.27	9.10	1019
SINGAKERTA	669	681	649	670	1044	1047	1013	920	3375	3318	6,693	1185	5.65	7.40	905
TOTALS	**4,920**	**4,184**	**4,903**	**4,446**	**6,076**	**6,227**	**6,314**	**6,250**	**22,216**	**21,111**	**43,327**	**7461**	**5.85**	**42.16**	**1083**
									-				ave		ave
													0.605	S.D.	348

SOURCE: KANTOR CAMAT UBUD, 1979 (PERS COMM)

LANDUSE IN BALI - 1973

KABUPATEN	VILLAGE (No)	SAWAH X l	SAWAH X 2	CROPPED DRY LAND	FRUIT	COCO-NUTS	COFFEE	SWAMP	UNUSE-ABLE	ALANG-ALANG	FOREST	OTHER	TOTAL ha
BULELFNG	1,611	7,465.	6,321	33,292	4,378	7.9	22,067	647	3,300	-	44,840	249	132,080
JUSRANA	1,470	5,160	3,101	1,986	-	25.1	2,734	825	143	-	43,929	99	84,180
TABAVAN	4,576	12,806	11,923	17,839	-	14.8	12,579	373	-	-	9,285	895	85,150
BADUNG	7,010	15,533	4,844	10,760	-	5,587	1,893	1,116	2,704	-	960	3,843	54,250
GIANYAR	6,150	6,76'1	10,247	6,935	-	5.3	-	-	111	-	-	1,195	36,800
BANCLI	1,452	355	2,863	34,831	-	35	3,015	1,548	3,007	-	4,987	-	52,080
KLUNGKUNG	1,594	1,260	3,740	17,863	-	2,232	-	208	3,936	348	90	229	31,500
KARANGASEN	1,617	5,114	2,537	47,338	463	1,231	-	-	16,960	-	8,689	2,141	86,090
TOTAL	**25,480**	**54,460**	**45,576**	**170,844**	**4,841**	**9,138.1**	**42,288**	**4,717**	**30,050**	**348**	**112,780**	**8,651**	**562,130**
%	3.64	9.69	8.11	30.4	0.86	1.63	7.52	0.84	5.35	0.06	20.07	1.54	100

SOURCE: DIREKTORAT AGRARIA, PROPERTY BALI, 1974, JNPUBLISHED

SAWAH & TEGALAN OWNERSHIP IN MID 1930's

NAME OF KABUPATEN	YEAR	SAWAH AREA (ha)	LAND-OWNERS No.	AVE. HOLD (Are)	TEGALAN AREA (ha)	LAND OWNERS No.	AVE. HOLD (Are)	GABAH PRDDUCED (kg)	1934 ave/ha	GABAH/ FARMER (KG/YR)
TABANAN	1933	23,530	38,334	61	44,622	41,132	108	79,870,800	3,394.4	2,083.6
BADUNG	1934	18,005	39,761	45	19,486	37,798	52	79,067,700	4,391,,4	1,988.6
GIANYAR	1935	15,003	31,274	48	13,751	30,795	45	58,752,000	3,916.0	1,878.6
KLUNGKUNG	1935	7,537	18,274	41	32,427	23,553	138	33,501,700	4,445..0	1,833.3
KARANGASEM	1927	7,786	17,295	45 dl	47,901	24,718	194	24,755,050	3,179,,4	1,431.3
TOTAL	**-**	**71,861**	**144,938**	**48**	**158,187**	**157,996**	**105**	**275,956,250**	**3,840.1**	**1,904.0**

SOURCE: "LANDBOU IN DER AFDEELING ZUID-BALI", BAKER, J.B. (1934).

AVE. HOUSEHOLD OWNERSHIP: SAWAH 40 ARE; TEGALAN 87 ARE; GABAH/YR 1,540 KG.

GIANYAR (1934)	ha	HARVESTING INTENSITIES (1934)
TOTAL SAWAH:	15,826	GIANYAR: PADI 93.7%; PALAWIJA 31.4%; TOTAL 123.1%
PADI:	14,823	S. BALI (AVE): PADI 103.4%; PALAWIJA 19.6%; TOTAL 123%
PALAWIJI:	4,976	GIANYAR (1930-34): PADI 89.8%; PALAWIJA 28.2%; TOTAL 113%
TOTAL HARVESTED:	19,799	= 125.1% OF SAWAH AREA

APPENDIX A1.10

GIANYAR LANDUSE - 1976

KECAMATAN	TOTAL AREA (km^2)	SAWAH (km^2)	TANAH KERING/ TEGAL ($km^{2)}$)	PEKARANG-AN (km^2)	GOVT. RESERVES (km^2)	DESA No.	BANJAR No.	POPULATION No.	POPULATION Pers/km^2
GIANYAR	50.164	30.832,66	6,286.69	3.045	-	12	92	57,861	1153.4
BLAHBATU	39.490	23.861	7,265.2	8.363	-	7	60	41,249	1044.5
SOKAWATI	54.735	32.109	10,571	12.060	-	8	90	54,127	988.9
UBUD	42.164	22.643	14,462	5,058	-	7	71	42,335	1004.1
PAYANGAN	75.496	17.218	44,010	4.256	10.010	6	55	32,646	432.4
TEGALLALANG	97.668	20.889	36,700	34.257	5.820	7	62	32,506	332.8
TAMPAKSIRING	42.419	15.493	12,094	13.920	0.910	4	63	31,975	753.8
TOTAL	**402.136**	**163.042**	**141,392**	**80.961**	**16.740**	**51**	**493**	**293,699**	**730.3**
					1974			**272,033**	**676.5**
					1975			**284,522**	**707.5**

SOURCE: "GIANYAR ANGKERAN TH. 1976" KANTOR SENSUS AND STATISTIK GIANYAR 1977

PRODUCTION OF STAPLE CROPS AND HARVEST AREAS - BALI 1974-78

EDIBLE YIELD (Tm)	BEANS	MAIZE	CASSAVA	SWEET POTATO	GROUND-NUT	SOYBEAN	KIDNEY BEAN
1974	365,380	70,671	300,997	144,463	7,612	9,397	544
1975	301,810	41,667	169,806	124,454	6,467	12,518	520
1976	315,093	50,995	254,291	132,780	6,943	7,784	565
1977	376,240	64,178	243,737	156,014	13,136	12,390	1,190
1978	412,122	86,026	272,719	158,553	9,414	11,557	1,958

BASED ON: LAPORAN STATISTIK PERTAN IAN TANANAM PANGAN (SERIES DATA PELITA II), DINAS PERTANIAN, BALI, 1979

AREA PLANTED - STAPLE CROPS (Ha)

AREA (ha)	WET RICE	DRY RICE	MAIZE	CASSAVA	SWEET POTATO	GROUND-NUT	SOYBEAN	KIDNEY BEAN	TOTAL
1974	155,832	14,194	43,810	25,409	17,329	9,462	14,650	1,615	282,301
1975	151,840	10,738	39,048	25,129	18,066	6,264	12,805	2,455	266,345
1976	148,224	7,998	36,560	_-7,031	18,915	8,100	9,608	3,333	249,967
1977	150,977	10,505	59,301	22,741	15,498	10,994	11,183	2,128	283,327
1978	176,594	8,634	67,753	35,621	20,581	15,626	11,959	2,867	339,635

SOURCE: "LAPORAN STATISTIK PERTANIAN TANAMM PANGAN", (SEES DATA PELITA II), DINAS PERTANIAN, BALI, 1979.

BALI: STAPLE CROPS

EDIBLE ENERGY PRODUCTION (PJ x 10^3) 1974-78

CROP	BEANS	MAIZE	CASSAVA	SWEET POTATO	GROUNDNUT	SOYBEAN	KIDNEY BEAN	TOTALS	YIELD	CHANGE FACTOR (Comp. To Prev. Year)
PJ/Tm	**14.714**	**15.173**	**6.395**	**4.765**	**15.968**	**24.202**	**14.170**	**PJ x 10^3**	**GJ/Ha**	
1974	5,397.39	1,072.3	1,924.9	668.4	184.2	149.8	7.71	9,424.70	33.385	-
1975	4,458.34	632.2	1,085.9	593.0	156.5	199.9	7.37	7,133.21	26.782	X 0.848
1976	4,654.55	773.7	1,626.2	632.7	168.0	124.3	8.01	7,987.46	31.954	X 1.160
1977	5,557.82	973.8	1,558.7	743.4	317.9	197.8	16.86	9,366.28	33.058	X 1.149
1978	6,087.87	1,305.3	1,744.0	755.5	227.8	184.5	27.75	10,332.72	30.423	X 0.965

BALI: STAPLE CROPS

EDIBLE PROTEIN PRDDUCTION (Tm) 1974-78

	BEANS	MAIZE	CASSAVA	POTATO	GROUNDNUT	SOYBEAN	KIDNEY BEAN	TOTALS	YIELD KG/Ha	CHANGE FACTOR (Comp. To Prev. Year
1974	25,576.6	7,067.1	2,106.9	2,166.9	2,055.2	3,288.9	130.56	42,392.16	150.17	
1975	21,126.7	4,166.7	1,188.6	1,866.8	1,746.1	4,381.3	124.80	34,601.00	129.91	X 0.816
1976	22,056.5	5,099.5	1,780.0	1,991.7	1,874.6	2,724.4	135.60	35,662.30	142.67	X 1.098
1977	26,336.8	6,417.8	1,706.2	2,34:0.2	3,546.7	4,336.5	285.60	44,969.8	158.72	X 1.112
1978	28,848.5	8.602.6	1,909.0	2,3"18.3	2,541.8	4,045.0	469.92	48,795.12	143.67	X 0.905

SOURCE: "LAPORAN STATISTIK PETANIAN TANAMAN PANGAN, BALI, PELITA II, 1974-79". DINAS PERTANIAN, DEN PASAR, 1979.

YIELDS OF STAPLE CROPS - BALI 1974-78

EDIBLE YIELD (tm/ha)	BERAS (SAWAH)	BERAS (DRY)	MAIZE	CASSAVA	SWEET POTATO	GRDUNDNUT	SOYBEANS	KIDNEY BEAN
1974	2.276	0.726	1.613	11.846	8.336	0.804	0.641	0.337
1975	1.918	1.050	1.067	6.757	6.889	1.032	0.978	0.212
1976	2.038	0.796	1.395	14.931	7.020	0.857	0.810	0.170
1977	2.456	0.514	1.082	6.843	10.067	1.195	1.108	0.559
1978	2.314	0.398	1.270	7.656	7.704	0.602	0.966	0.683

SOURCE: "LAPORAN STATISTIK PERTANIAN TANAMAN PANGAN, (SERIRS DATA, PELITA II), DINAS PERTANIAN, BALI, 1979

APPENDIX A1.11(A)

PRODUCTION OF STAPLE CROPS - GIANYAR 1974-78

YEAR	BERAS (SAWAH)	BERAS (DRY)	BERAS (TOTAL)	MAIZE	CASSAVA	SWEET POTATO	GROUND-NUT	SOYBEAN
1974	71,508	1,362	72,871	3,677	31,526	59,188	186	-
1975	69,023	1,464	70,487	1,943	15,801	36,906	174	86
1976	51,444	821	52,265	3,216	13,585	55,199	74	148
1977	71,152	1,022	72,174	5,052	15,118	65,705	193	32
1978	71,846	1,056	71,952	3,868	29,137	69,928	221	33

AREA PLANTED OF STAPLE CROPS - GIANYAR 1974-78

CROP (ha)	SAWAH	DRY RICE	MAIZE	CASSAVA	SWEET POTATO	GROUND-NUT	SOYBEAN	TOTAL
1974	30,504	1,750	2,100	917	4,370	377	-	40,018
1975	28,265	1,750	1,950	1,195	4,474	277	60	37,971
1976	24,961	1,326	1,980	1,272	6,193	250	436	34,418
1977	29,155	1,425	2,330	1,079	4,791	274	90	39,144
1978	30,205	1,525	2,025	1,540	6,470	199	82	42,046

*BOTH (BASED ON: LAPORAN STATISTIK PERTANIAN TANAMAN PANGAN (SERIES DATA PELITA II), DINAS PERTANIAN, BALI, 1979.

APPENDIX A1.11(B)

YIELDS OF STAPLE CROPS (Tm/ha)- GIANYAR 1974-78

YEAR	WET RICE	DRY RICE	MAIZE	CASSAVA	SWEET POTATO	GROUND-NUT	SOYBEAN
1974	2.344	0.778	1.751	34.379	13.544	0.493	-
1975	2.442	0.837	0.996	13.223	8.249	0.628	1.433
1976	2.061	0.619	1.624	10.680	8.913	0.296	0.339
1977	2.440	0.717	2.168	14.011	13.714	0.704	0.356
1978	2.379	0.692	1.910	18.920	10.808	1.1.11	0.402

SOURCE: (BASED ON: LAPORAN STATISTIK PERTANIAN TANAMAN PANGAN (SERIES DATA PELITA II), DINAS PERTANIAN, BALI, 1979.

AREAS IN BALI USING RICE CULTIVATION INTENSIFICATION PROGRAMME (BIMAS-INMAS) 1968-79

AREA WITH BIMAS/INMAS (1968-1978) ha

REPILITA I (ha)		REPELITA II (ha)	
1968/69	8,189	1973/74	57,910
1969	7,018	1974	53,179
1969/70	18,888	1974/75	63,691
1970	10,870	1975	43,845
1970/71	26,930	1975/76	63,955
1971	13,857	1976	46,033
1971/72	36,671	1976/77	70,133
1972	25,788	1977	56,331
1972/73	57,040	1977/78	71,688
1973	34,749	1978	63,609

NOTES - LINEAR RERESSION (LEAST SQ. METH)

WET SEASON: 1968/69 - 1977/78

$a,^* = 7600.8$, $a^* = 7,256.1$, $r^2 = 0.92$

PROJECT WET SEASON: 1978/79 = 87,418 ha

$Y_w = 7,256.1\ x + 7,600.8$

DRY SEASON: 1969 – 1978

$a_o^* = 165.1$, $a^* = 6,429.9$, $r^2 = 0.92$

PROJECT DRY SEASON: 1979 = 70,894 ha

$Y_D = 6,429.9\ x + 165.1$

GROWTH RATES: 1968 - 1978

WET SEASON: + 875%

DRY SEASON: + 906%

SOURCE: "URAIAN SINGKAT PELAKSANAAN USSAHA INTENSIFIKASI DI BALI", (SOKACA, I.G. (1979)). DINAS PERTANIAN, INTERNAL MEMO, UNPUBLISHED.

BIMAS 1975-79, DESA UBUD

M.T.	VARIETIES PLANTED	BIMAS BARU	BIMAS BIMAA	TOTAL (HA)
1975/76	LOCAL	609.54	387.75	997.29
1976	LOCAL	727.295	244.65	971.95
1976/77	PELITA, IR-5, IR-8	656.00	569.00	1252.0
1977	PELITA, IR-5, IR-8	698.625	290.050	988.68
1977/78	IR-26, IR-28, IR-30	819.875	136.00	955.88
1978	IR-32, IR-36, IR-38 (?)	303.275	76.375	379.65
1978/79	IR-36	449.375	127.75	577.13

SOURCE: KANTOR PERTANIAN, KECHMATAN UBUD, 1979 (PERS COMM).

APPENDIX A4.1

ENGLISH TRANSLATION OF DATA CODING FORM USED FOR THE HARVEST SURVEY

(Questions marked '*' indicate direct measurement or counting of variable).

1. Variety of Rice
2. Name of Subak/Tempek
3. Name of Farmer
4. Name of Banjar (village)
5. Tax and Plot number

6.* Moisture content reading (% W/W) - 5 Ikat or Zak

7.* Weight (kg) - 5 Ikat or Zak

7A.* Total number of Ikat or Zak

8. Weight of Fertilizer applied (kg)
9. Weight/Volume Pesticide used (kg/Ltr)
10. Other Rice Varieties Grown
11. Names of Insects/Pests causing damage to crop

12.* Number of Males and Female Workers in Harvest 'beam

13.* Total Workers in Harvest Team

14. Source of Harvest Team (Seka/Labourers/Family)
15. Number of hours worked to complete Harvest

16.* Length (m) and Breadth (m) of sample plot

17. Was the sample plot: owned/rented/share-cropped/harvest shared
18. Farmer’s opinion of Area of sample plot
19. Percentage of loss due to Insects/Pests
20. If Harvest was shared what was the basis of division
21. Date of Harvest
22. What share of the Harvest did the Harvest team receive

(Section in lower-right was used for calculation of Edible Yield, Yield/Are; See Section 4.3.3)

APPENDIX A4.2 (A)

ENGLISH TRANSLATION OF SURVEY QUESTIONNAIRE FOR SAWAH LABOUR INPUTS SURVEY

1 Name of Subak

2 Name of Pekaseh

3 How many workers and for how long do they work each cropping season for a farm of 30 Are area (No. worke

- A Cutting Rice Straw (from last season)
- B First Hoeing
- C First Raking
- D Trimming Grass on Sawah Bunds
- E Second Hoeing
- F Second Raking
- G Pulling Seedlings
- H Planting Seedlings

4
- I First weeding
- J Second Weeding
- K Spraying Insecticide
- L Applying Fertilizer
- M Bird scaring
- N Harvesting/Threshing

5 What is the Work Schedule after Planting:

- A How many days after Transplanting is the water changed?
- B How many days before the Rice is first Fertilized?
- C How many days is the Rice Field drained before Fertilizing?
- D How old (days) is the rice at the Second Fertilizer Application?
- E How old (days) is the rice at the Third Fertilizer Application?
- F How old is the rice before the Second Weeding?
- G After Harvesting how many days before work (hoeing) begins?

6. In what year were new varieties of rice introduced in this Subak and what variety was introduced?

7. In what year was IR-36 introduced and what area was planted in the first year (season) ?

8. In which year did this Subak enter Bimas/Inmas and until which year?

9. What was the area planted to the following varieties during the last season (1978) ? (Cicih, Ketan, Gembira, Pelita, IR-36).

10. What was the area planted to the following varieties during the current season (1978/79)?

(Cicih, Ketan, Gembira, Pelita, IR-36).

11. What percentage of the harvest was lost in the season (1978) for each of the varieties? (Cicih, Ketan, Gembira, Pelita, IR-36).

12. How much fertilizer was applied for an area of 30 Are to each of the varieties? (Cicih, Ketan, Gembira, Pelita, IR-36).

APPENDIX A4.22 (B)
DAM UBUD AREA - LABOUR INPUT SURVEY, 1979

	Cutting Rice Straw	First Hoeing	First Raking	Trimming Grass	Second Hoeing	Second Raking	Pulling Seedlings	Planting Seedlings	First weeding	Second Weeding	Spraying Insecticide	Applying Fertilizer	Bird scaring	Harvesting/ Threshing	**Total**
PACUNG	16	72	16	16	128	16	6	40	32	32	6	6	120	150	**656**
JUNGJUNGAN	30	128	16	16	128	16	5	45	128	128	12	6	160	140	**968**
TAMAN	20	128	16	16	96	16	5	32	100	100	12	12	150	140	**843**
TITIBUAH	40	128	16	16	32	16	5	32	96	96	12	12	160	120	**781**
BINGINAMBE	20	48	16	16	80	16	5	40	96	96	6	6	120	120	**685**
BABAKAN	20	48	16	16	40	16	5	35	96	96	12	12	160	140	**712**
LEGUNG	16	72	16	16	12	16	6	40	32	32	6	6	120	150	**656**
LANDAU	10	96	16	5	48	16	5	40	96	96	6	6	60	140	**740**
JATI	10	4	16	16	8	16	5	32	96	96	6 ,	6	160	120	**675**
SAKTI	36	120	16	16	120	16	5	(40)	100	100	5	5	150	126	**(855)**
BUNGKUAN	20	80	16	16	40	16	5	40	96	96	12	12	160	120	**729**
JUWUKMANIS	20	64	16	16	40	16	5	35	80	80	12	12	160	140	**696**
SEMUJAN	27	100	16	16	96	16	5	(40)	96	96	12	12	160	120	**(812)**
SUKANAYAH	10	49	16	16	64	16	4	40	96	96	6	6	120	120	**659**
TEMPEK	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**TOTAL**
GENE N	16	90	16	16	80	16	5	40	96	96	6	6	160	120	**763**
MUNA	10	64	16	16	90	16	5	32	90	90	6	6	160	140	**741**
PADANGTEGAL	10	48	16	16	72	16	5	40	60	20	6	6	160	140	**615**
LATENG	8	48	16	16	96	16	5	32	80	80	12	12	160	120	**763**
NYUHKUNING	16	80	16	16	40	16	4	40	96	96	12	12	120	140	**724**
AVERAGES	18.7	79.5	16.0	15.4	77.2	16.0	5.0	37.6	87.5	85.4	8.79	8.79	148.4	131.9	**718.6**
S.D. s	9.1	29.8	-	2.52	33.6	-	0.47	4.0	23.2	27.3	3.14	3.14	17.1	1.42	**83.51**
RANGE HI	40	128	-	16	128	-	6	40	128	128	12	12	160	160	
RANGE LO	8	48	-	5	32	-	4	32	32	20	5	5	120	120	
Ave./Are (Man-hr)	0.62	2.65	0.53	0.51	2.57	0.53	0.17	1.25	2.92	2.85	0.29	4.95	4.40	23.95	**23.95**

*ITEMS IN COLUMNS REFER TO THE OPERATIONS INVOLVED IN SAWAH CULTIVATION, REFERRED TO IN TABLE 4.10 EXCLUDING ITEMS 11 & l2 WHICH ARE PESTICIDE APPLICATION (11) AND FERTILIZER APPLICATION (12).

APPENDIX: A4.2 (A)

HARVEST SURVEY DAM UBUD: IR-36 - EFFECTS OF CROP LOSSES - STATISTICAL ANALYSIS

ITEM (AND UNITS)	N	AVE.	S. D.	<= 5% LOSSES			<= 10% LOSSES			< =15% LOSSES		
AREA (SEKUT) (ARE)	47	30.23	15.34	31	28.89	13.74	40	30.78	15.83	44	30.76	15.38
FERTILIZER: AVE/ARE (KG/ARE)	47	1.58	1.03	31	1.63	1.10	40	1.63	1.07	44	1.63	1.04
YIELD: BERAS (KG/ARE)	47	19.48	5.88	31	21.40	5.41	40	21.01	5.20	44	20.35	5.44
WORK I/P: (HRS/KG BERAS)	47	0.29	0.11	31	0.26	0.11	40	0.27	0.11	44	0.28	0.11
WORK I/P: (HRS/ARE)	47	5.42	2.16	31	5.58	2.24	40	5.60	2.17	44	3.52	2.17
TOTAL BERAS (KG)	47	27,687.8		31	19,165.8		40	26,035.6		44	27,541.7	
TOTAL AREA (ARE)	47	1,421.0		31	895.6		40	1,239.2		44	1,353.4 -	
TOTAL FERTILIZER (KG)	44	2,242.0		30	1,484.9		38	1,957.2		42	2,147.2	

APPENDIX: A4.2 (B)

HARVEST SURVEY DAM UBUD: GEMBIRA - EFFECTS OF CROP LOSSES - STATISTICAL ANALYSIS

ITEM (AND UNITS)	N	AVE.	S.D.	<= 5% LOSSES			<= 10% LOSSES			<=25% LOSSES			<= 50% LOSSES		
AREA SEKUT (ARE)	19	27.63	9.21	5	23.28	3.78	9	27.00	8.91	13	26.65	10.66	16	27.40	9.88
FERTILIZER: AVE/ARE (KG/ARE)	19	0.54	0.35	5	0.72	0.29	9	0.56	0.33	13	0.49	0.35	115	0.51	0.37
YIELD: BERAS (KG/ARE)	19	14.04	8.26	5	22.42	8.31	9	21.14	7.18	13	18.87	7.68	115	16.92	8.05
WORK I/P: HRS/KG BERAS	19	0.37	0.14	5	0.23	0.03	9	0.26	0.07	13	0.32	0.13	16	0.37	0.15
WORK I/P: HRS/ARE	19	4.67	1.88	5	4.93	1.73	9	5.40	2.20	13	5.09	1.88	16	4.99	1:72
TOTAL BERAS (KG)	19	7,368.40		5	13,046.1		9	46,228.3		13	84,958.1		16	118,701.2	
TOTAL AREA (ARE)	19	525.0		5	116.4		9	243.0		13	346.4		16	438.4	
TOTAL FERTILIZER (KG)	15	283.1		5	33.47		8	1,229.6		10	2,220.4		12	3,603.7	

APPENDIX A4.2 (C)

HARVEST SURVEY DAM UBUD:PELITA - EFFECTS OF CROP LOSSES - STATISTICAL ANALYSIS

ITEM (AND UNITS)	N	AVE.	S.D.	<= 5'8 LASSES			<= 10% LOSSES			<= 25% LOSSES			<= 50% LOSSES		
AREA (SEKUT) (ARE)	52	31.14	15.85	22	33.0	15.9	29	32.6	18.4	35	32.1	17.7	42	31.9	16.6
ESTIMATED LOSS (%)	52	23.50	28.65	22	0.23	1.07	29	2.59	4.35	35	6.00	8.64	4:1	11.95	16.69
FERTILIZER: AVE/ARE (KG/ARE)	52	0.81	0.53	22	0.85	0.39	29	0.88	0.38	35	0.84	0.42	Q	0.87	0.39
YIET D: BERHS (KG/ARE)	52	16.42	7.69	22	21.41	5.45	29	20.64	5.25	35	20.49	5.04	42	19.19	5.92
WORK I/P: (HRS/KG BERAS)	51	0.31	0.14		0.27	0.08	29	0.28	0.08	34	0.28	0.08	40	0.29	0.08
WORK I/P: (HRS/ARE)	51	4.52	2.34	22	5.61	2.28	29	5.51	2.18	34	5.52	2.02	40.	5.30	1.96
TOTAL BERAS	52	26,583.4			15,543.7			19,513.1			23,020.5			25,710.7	
TOTAL AREA (ARE)	52	1,615.21		22	(45%) 726.0		29	(59%) 945.4		35	(70%) 1,123.5			(83%) 1,339.8	
TOTAL FERTILIZER (KG)	46	1,300.5			617.1			832.0			943.7			1,165.6	

APPENDIX A4.2(D)

HARVEST SURVEY DAM UBUD:CICIH HETON : EFFECTS OF CF0P LOSSES - STATISTICAL ANALYSIS

ITEM (AND UNITS)	N	AVE.	S.D.	<= 5% LOSSES			<= 25% LOSSES		
AREA (ARE)	31	28.81	13.60	24	30.29	14.63	30	29.02	13.78
AVE. FERILIZER (KG)	31	2.87	6.11	-	-	-	-	-	
FERTILIZER: AVE/ARE (KG/ARE)	31	0.10	0.27	24	0.05	0.13	30	0.11	0.28
YIELD: BERAS (KG/ARE)	31	17.80	5.62	24	20.05	5.77	30	19.16	5.55
WORK I/P: (HRS/KG BERAS)	30	0.22	0.11	23	0.17	0.06	29	0.20	0.08
WORK I/P: (HRS/ARE)	30	3.46	1.57	23	3.33	1.14	29	3.68	1.34
TOTAL BERAS (KG)	31	15,895.0		24	14,576.4		30	16,684.9	
TOTAL AREA (ARE)	31	893.1		24	727.0		30	870.7	
TOTAL FERTILIZER (KG)	7	89.0		4	37.6		6	95.2	

APPENDIX A4.2(E)

HARVEST SURVEY DAM UBUD: CICIH KAPUK - EFFECTS OFCROP LOSSES - STATISTICAL ANALYSIS

ITEM (AND UNITS)	N	AVE.	S.D.	<=5% LOSSES			<=10% LOSSES		
AREA SEKUT (ARE)	46	27.84	12.21	32	28.01	10.95	33	28.78	13.08
FERTILIZER: AVE/ARE (KG/ARE)	46	0.10	0.29	32	0.08	0.17	39	0.10	0.27
YIELD: BERAS (KG/ARE)	46	16.76	6.06	32	18.38	4.85	37	17.50	5.50
WORK I/P: (HRS/KG BERAS)	43	0.22	0.10	29	0.19	0.07	35	0.22	0.10
WORK I/P (HRS/ARE)	43	3.60	1.56	30	3.51	1.23	36	3.89	1.68
TOTAL BERAS (KG)	46	21,471.1		32	16,470.4		39	19,745.2	
TOTAL AREA (ARE)	4 6	1,280.8		33	896.3		3 9	1,098.8	
TCTAL FERTILIZER (KG)	12	128.5		7	70.5		8	118.7	

APPENDIX A4.4 (A)

DAM UBUD: IR-36 ENERGY ANALYSIS - EFFECTS OF FERTILIZER APPLICATION

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	1,421.0	60.70	1,360.3
YIELD BERAS (KG/ARE)	19.48	20.34	19.45
TOTAL BERAS (KG)	27,687.8	1,234.6	26,453.2
FERTILIZER (MJ/ARE)	61.46	0.0	64.19
FERTILIZER (MJ)	87,213.8 58%	0.0	87,213.8 59%
LABOUR (MJ)	53,102.8 35%	2,268.4 83%	50,834.4 34%
SEED (MJ)	10,495.5 7%	448.3 17%	10,047.2 7%
TOTAL INPUTS (MJ)	151,012.1	2,716.7	148,095.4
TOTAL OUTPUT (MJ)	409,004.2	18,237.5	390,766.7
ENERGY RATIO	2.71	6.71	2.64
INPUTS/ARE (MJ/ARE)	106.27	44.76	108.9
OUTPUT/ARE (MJ/ARE)	287.83	300.5	287.3
SAMPLE SIZE	47	3	44
AVE. SIKUT (ARE)	30.23	20.23	30.92
FERTILIZER (KG/ARE)	1.58	0.0	1.65
FERTILIZER (KG)	2,242.0	0.0	2,242.0

APPENDIX A4.4 (B)

DAM UBUD: PELITA ENERGY ANALYSIS – EFFECTS OF FERTILIZER APPLICATION

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	1,615.2	162.91	1,452.3
YIELD BERAS (KG/ARE)	16.46	11.37	17.03
TOTAL BERAS (KG)	26,583.4	1,851.5	24,731.9
FERTILIZER (MJ/ARE)	31.51	0.0	35.01
FERTILIZER (MJ)	50,589.5 43%	0.0	50,589.5 46%
LABOUR (MJ) 20.0% +5.9%	60,360.0 52%	6,087.6 91%	54,272.5 49%
SEED (MJ) 3.9%	5,964.9 5%	601.6 9%	5,363.3 5%
TOTAL INPUTS (MJ)	116,896.4	6,689.2	110,225.3
TOTAL OUTPUT (MJ)	392,690.0	27,350.4	365,339.6
ENERGY RATIO	3.3E	4.12	3.31
INPUTS/ARE (MJ/ARE)	72.37	41.06	75.90
OUTPUT/ARE (MJ/ARE)	243.12	167.89	251.56
SAMPLE SIZE	52	6	46
AVE. SIKUT (ARE)	30.14	27.15	31.57
FERTILIZER (KG/ARE)	0.81	0.0	0.90
TOTAL FERTILIZER	1,300.5	0.0	1,300.5

APPENDIX A4.4(C)

DAM UBUD: GEMBIRA ENERGY ANALYSIS - EFFECTS OF FETILIZER APPLICATION

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	525.0	85.61	439.4
YIELD: BERAS (KG/ARE)	14.04	14.27	13.99
TCTAL BERAS (KG)	7,368.4	1,221.9	6,146.5
FERTILIZER W/ARE)	21.01	0.0	24.90
FERTILIZER (W)	11,012.6 34%	0.0	11,012.6 38%
LABOUR (MJ)	19,619.3 60%	3,199.3 91%	16,420.4 57%
SEED W)	1,938.9 6%	316.2 9%	1,622.7 5%
TOTAL INPUTS W)	32,570.8	3,515.5	29,055.7
TOTAL OUTPUT (MJ)	108,846.0	18,049.9	90,796.1
ENERGY RATIO	3.34	5.14	3.12
INPUTS/ARE (MJ/ARE)	62.04	41.06	66.13
OUTPUT/ARE (MJ/ARE)	207.33	210.84	206.64
SAMPLE SIZE	19	4	15
AVE SIKUT (ARE)	27.63	21.40	29.29
FERTILIZER/ARE (KG/ARE)	0.54	0.0	0.64
TOTAL FERTILIZER	283.1	0.0	283.1

APPENDIX A4.4(D)

DAM UBUD: CICIH BETON ENERGY ANALYSIS - EFFECTS OF FERTILIZER

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	893.1	683.1	210.0
YIELD BERAS (KG/ARE)	17.80	18.27	16.26
TOTAL BERAS (KG)	15,895.0	12,481.1	3,413.9
FERTILIZER (MJ/ARE)	3.89	0.0	16.34
FERTLIZER (MJ)	3,462.1 9%	0.0 -	3,462.1 29%
LABOUR (MJ)	33,375.2 83%	25,527.5 91%	7,847.7 65%
SEED (MJ)	3,298.2 8%	2,522.7 9%	775.5 6%
TOTAL INPUTS (MJ)	40,135.5	28,050.2	12,085.3
TOTAL OUTPUT (MJ)	234,800.9	184,370.8	50,430.1
ENERGY RATIO	5.85	6.57	4.17
INPUTS/ARE (MJ/ARE)	44.94	41.06	57.55
OUTPUT/ARE (MJ/ARE)	262.91	269.90	240.10
SAMPLE SIZE	31	24	7
AVE. SIKUT (ARE)	28.81	28.46	30.00
FERTILIZER (KG/ARE)	0.10	0.0	0.42 .
TOTAL FERTILIZER (KG)	89.0	0.0	89.0

APPENDIX A4.4(E)

DAM UBUD: CICIH KAPUK ENERGY ANALYSIS - EFFECTS OF FERTILIZER APPLICATION

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	1,280.8	995.1	285.7
YIELD BERAS (KG/ARE)	16.76	16.88	16.37
TOTAL BERAS (KG)	21,471.1	16,794.1	4,677.0
FERTILIZER (MJ/ARE)	3.89	0.0	17.51
FERTILIZER (MJ)	4,998.7 8%	0.0	4,998.7 30%
LABOUR (MJ)	50,315.0 83%	37,183 91%	10,676.6 64%
SEED W)	4,972.3 9%	3,674.9 9%	1,055.1 6%
TOTAL INPUTS (MJ)	60,286.0	40,858.9	16,730.4
TOTAL OU'T'PUT (MJ)	317,171.1	248.082.5	69,088.6
ENERGY RATIO		6.07	4.13
INPUTS/ARE (MJ/ARE)	47.07	41.06	58.56
OUTPUT/ARE (MJ/ARE)	247.64	249.31	241.82
SAMPLE SIZE	46	34	12
AVE. SIKUT (ARE)	27.84	29.27	23.81
FERTILIZER/ARE (KG/ARE)	0.10	0.0	0.45
TOTAL FERTILIZER (KG)	128.5	0.0	128.5

APPENDIX A4.4(F)

DAM UBUD: KETAN GADIS ENERGY ANALYSIS - EFFECTS OF FERTILIZER APPLICATION

ITEM	OVERALL		NO FERTILIZER		FERTILIZER	
TOTAL AREA (ARE)	472.8		91.50		381.3	
YIELD BERAS (KG/ARE)	18.94		14.25		20.03	
TOTAL BERAS (KG)	8,956.0		1,251.7		7,704.3	
FERTILIZER (MJ/ARE)	22.95		0.0		28.79	
FERTILIZER (MJ)	10,942.6	36%	0.0		10,942.6	41%
LABOUR (MJ)	17,668.5	58%	3,419.4	91%	14,249.2	54%
SEED (MJ)	1,746.1	6%	337.9	9%	1,408.1	5%
TOTAL INPUTS (MJ)	30,357.2		3,757.3		26,599.9	
TOTAL OUTPUT (MJ)	132,298.0		18,490.1		113,807.9	
ENEMY RATIO	4.36		4.92		4.28	
INPUTS/ARE (MJ/ARE)	64.21		41.06		69.76	
OUTPUT/ARE (MJ/ARE)	279.82		202.1		298.5	
SAMPLE SIZE (N)	16		3		13	
AVE. SIKUT (ARE)	29.55		30.50		29.33	
FERTILIZER (KG/ARE)	0.59		0.0		0.74	
TOTAL FERTILIZER (KG)	281.3		0.0		281.3	

APPENDIX A4.4 (G)

DAM UBUD: KETTAN BALI ENERGY ANALYSIS - STS OF F'IMILIZER APPLICATION

ITEM	OVERALL	NO FERTILIZER	FERTILIZER
TOTAL AREA (ARE)	271.7	194.7	77.0
YIELD BERAS (KG/ARE)	15.62	15.25	16.48
TOTAL BERAS (KG)	3,958.2	2,855.9	1,102.3
FERTILIZER (MJ/ARE)	8.56	0.0	32.68
FERTILIZER (MJ)	2,528.5 18%	0.0	2,528.5 44%
LABOUR (MJ)	10,153.4 74%	7,275.9 91%	2,877.5 51%
SEED (MJ)	1,003.4 8%	719.0 9%	284.4 5%
TOTAL INPUTS (MJ)	13,685.3	7,994.9	5,690.4
TOTAL OUTPUT (MJ)	58,470.5	42,187.4	16,283.2
ENERGY RATIO	4.27	5.28	2.86
INPUTS/ARE (MJ/ARE)	50.37	41.06	73.90
OUTPUT/ARE (MJ/ARE)	215.20	216.68	211.47
SAMPLE SIZE	10	7	3
AVE. SIKUT (ARE)	27.17	27.81	25.67
FERTILIZER (KG/ARE)	0.22	0.0	0.84
TOTAL FERTILIZER (KG)	65	0.0	65

APPENDIX A6.1(A)

Energy Analysis based on Data from "Permanent Weirs in Bali" (Bali Design Team, 1978)

HYV Rice, Kabupaten Tabanan (South Central Bali*) Wet Season 1977-78 (MJ/Ha Crop)

INPUTS			
Human Labour	238 days @ 6.82 MJ/day		1,623.2
Draft Labour	7.3 days @ 40 MJ/day		292.0
Fertilizer Urea	100 to 125 kg @ 38.9 MJ/kg		3,890.0 - 4,862.5
Fertilizer TSP	10 to	25 kg @ 7 MJ/kg	70.0 - 175.0
Seed	30 kg	@ 29.54 MJ/kg	886.3
Pesticide	2 to 7 Ltr	@ 105 MJ/Ltr	210.0 - 735.0
		Total Inputs	**6,971.5 - 8,574.5**
OUTPUT			
Edible Rice	1,527 kg	@ 14.77 MJ/kg	22,564.2
(Beras)		Energy Ratio	1:3.24 - 2.63
		Energy/Protein	65.22 - 80.2 MJ/kg

*Coastal Legion (below 200m)

APPENDIX A6. 1(B)

Energy Analysis based on Data from "Permanent Weirs in Bali" (Bali Design Team, 1978)

Traditional Rice, Kabupaten Tabanan (Central Bali*) Wet Season 1977-18 (MJ/Ha Crop).

INPUTS		
Hunan Labour	247 days @ 6.82 MJ/day	1,684.5
Draft Labour	6.6 days @ 40 MJ/day	264.0
Fertilizer Urea	50 kg @ 38.9 MJ/kg	1,945.0
Seed	60 kg @ 14.77 MJ/kg	886.3
Pesticide	3 to 8 Ltr @ 105 MJ/Ltr	315.0 - 840.0
	Total Inputs	5,094.8 - 5,619.8
OUTPUT		
Edible Rice	1,120 kg @ 14.77 MJ/kg	16,544.6
(Beras)	Energy Ratio	1:3.25 - 2.94
	Energy/Protein	64.98 - 71.68

*South Central Hilly Region (+400m)

APPENDIX A6. 2 (A)

Energy Analysis based on Data from "Bali Irrigation Study Final Report" (Asian Development Bank, 1978)

HYV Rice, Kabupaten Jembrana (South West Bali) Dry and Wet Seasons 1976-77 W/Ha Crop) .

INPUTS (Same for wet and dry seasons)		
Human Labour 131 days	@ 6.82 KJ/day	893.4
Draft Labour 17 days	@ 40 MJ/day	680.0
Fertilizer Urea 156 kg	@ 38.9 MJ/kg	6,068.4
Fertilizer TSP 35 kg	@ 7 MJ/kg	245.0
Seed 40 kg	@ 29.54 MJ/kg	1,181.6
Pesticide 5.4 Ltr	@ 105 MJ/Ltr	567.0
	Total Inputs	9,635.4
OUTPUT		
I Edible Rice 1,231 kg	@ 14.77 MJ/kg	18,184.3
(Beras)	Energy Ratio	1:1:89
	Energy/Protein	111.82KJ/kg
1,6.66 kg	@ 14.77 MJ/kg	24,610.2
	Energy Ratio	1:2.55
(Dry Season)	Energy/Protein	82.62K7.kg

APPENDIX A6.2(B)

HYV Rice, Kabupaten Buleleng (North Bali) Dry and Wet Seasons 1976-77 (MJ/ha Crop) .

INPUTS (Same for wet and dry seasons)			
Human Labour	131 days	@ 6.82 MJ/day	893.4
Draft Labour	17 days	@ 40 MJ/day	680.0
Fertilizer Urea	208 kg	@ 38.9 MJ/kg	8,091.2
Fertilizer TSP	25 kg	@ 7 MJ/kg	175.0
Seed	40 kg	@ 29.54 MJ/kg	1,181.6
Pesticide	1.7 Ltr	@ 105 MJ/Ltr	179.6
		Total Inputs	11,200.8
OUTPUT			
Edible Rice	1,652 kg	@ 14.77 MJ/kg	24,403.3
(Beras)		Energy Ratio	1:2.18
	(wet Season)	Energy/Protein	96.86 MJ/kg
	1,462 kg	@ 14.77 MJ/kg	21,596.7
		Energy Ratio	1:1.93
(Dry Season)		Energy/Protein	109.45 MJ/kg

APPENDIX A6.2(C) HYV Rice, Kabupaten Tabanan (South Central Bali) Dry and Wet Seasons 1976-77 (MJ/ha Crop).

INPUTS (Same for wet and dry seasons)			
Human Labour	131 days	@ 6.82 MJ/day	893.4
Draft Labour	17 days	@ 40 MJ/day	680.0
Fertilizer Urea	200 kg	@ 38.9 MJ/kg	7,780.0
Fertilizer TSP	50 kg	@ 7 MJ/kg	350.0
Seed	40 kg	@ 29.54 MJ/kg	1,186.6
Pesticide	2 Ltr	@ 105 MJ/kg	210.0
		Total Inputs	11,095.0
OUTPUT			
Edible Rice	1,768 kg	@ 14.77 MJ/kg	26,116.9
(Beras)		Energy Ratio	1:2.35
	(Wet Season)	Energy/Protein	89.65 MJ/kg
	1,462 kg	@ 14.7 MJ/kg	21,596.7
		Energy Ratio	1:1.95
(Dry Season)		Energy Protein	108.41MJ/kg

APPENDIX A6. 3 (A)

Energy Analysis based on Data from "Tukad Sabah Study" (Sir M. MacDonald & Partners)

HYV Rice, Kecamatan Buleleng 1975-76 (North Bali) Wet Season (MJ/ha Crop)

PRESENT INPUTS		
Human Labour 244 days	@ 6.82 MJ/day	1,664.1
Draft Labour 7 days	@ 40 MJ/day	280.0
Fertilizer Urea 100 kg	@ 38.9 kg	3,890.0
Fertilizer TSP 30 kg	@ 7 MJ/kg	210.0
Seed 45 kg	@ 29.54 MJ/kg	1,329.3
Pesticide 1.5 Ltr	@ 105 MJ/Ltr	157.5
	Total Inputs	7,530.9
PRESENT OUTPUT		
Edible Rice 2,600 Kg	@ 14.77 MJ/kg	38,407.2
Beras	Energy Ratio	1:5.10
	Energy/Protein	41.38 MJ/kg

APPENDIX A6.3 (B)

HYV Rice, Kabupaten Buleleng (North Bali), Projected I/O 1985 (MJ/Ha Crop).

PROJECTED 1985 INPUTS		
Human Labour 256 days	@ 6.82 MJ/day	1,745.9
Draft Labour 7 days	@ 40 MJ/day	280.0
Fertilizer Urea 200 kg	@ 38.9 MJ/kg	7,780.0
Fertilizer TSP 50 kg	@ 7 MJ/kg	350.0
Seed 45 kg	@ 29.54 MJ/kg	1,329.3
Pesticide 2 Ltr	@ 105 MJ/kg	210.0
	Total Inputs	11,695.2
PROJECTED 1985 OUTPUT		
Edible Rice 2,860 kg	@ 14.77 MJ/kg	42,247.9
(Beras)	Energy Ratio	1:3.61
	Energy/Protein	58.42 MJ/kg

APPENDIX A6.4 (A)

Energy Analysis based on Data from "Kumpulan Beberapa Data Pertanian" (P.U. Dinas Pengairan, 1978)

HYV Rice (*Padi Sawah*) (MJ/ha crop)

INPUTS			
Human Labour	326.4 days	@ 6.82 MJ/day	2,224.74
Draft Labour	16.9 days	@ 40 MJ/day	676.0
Fertilizer Urea	150 kg	@ 38.9 MJ/kg	5,835.0
Fertilizer TSP.	25 kg	@ 7 MJ/kg	175.0
Seed	35 kg	@ 29.54 MJ/kg	1,034.0
Pesticides	2 Ltr	@ 105 MJ/Ltr	210.0
		Total Inputs	10,157.5
OUTPUT			
Edible Rice	2,228 kg	@ 14.77 MJ/kg	32,912.0
(Beras)		Energy Ratio	1:3.24
		Energy/Protein	65.1 MJ/kg

APPENDIX A6.4 (B)

Traditional Rice (*Padi sawah*) (MJ/Ha Crop)

INPUTS			
Human Labour	317.1 days	@ 6.82 MJ/day	2,161.4
Draft Labour	16.9 days	@ 40 MJ/day	676.0
Seed	35 kg	@ 14..77 MJ/kg	517.0
Pesticide	2 Ltr	@ 105 MJ/Ltr	210.0
		Total Inputs	3,564.4
OUTPUT			
Edible Rice	1,664 kg	@ 14.77 MJ/kg	24,580.6
(Beras)		Energy Ratio	1:6.90
		Energy/Protein	30.60 MJ/kg

APPENDIX A6.4(C)

Dry Land Rice (*Padi Gaga*) (MJ/Ha Crop)

INPUTS			
Human Labour	110 days	@ 6.14 MJ/day	675.0
Draft Labour	15.4 days	@ 40 MJ/day	616.0
Seed	40 kg	@ 14.77 MJ/kg	590.9
		Total Inputs	1,880.9
OUTPUT			
Edible Rice	676 kg	@ 14.77 MJ/kg	9.985.9
(*Beras*)		Energy Ratio	1:5.31
		Energy/Protein	39.75 MJ/kg

APPENDIX A6.4(D)

Maize (*Jagung*) (MJ/ha crop)

INPUTS			
Human Labour	132.5 days	@ 6.14 MJ/day	813.0
Draft Labour	26.1 days	@ 40 MJ/day	1,044.0
Seed	25 kg	@ 15.17 MJ/kg	379.3
Pesticide	3 Ltr	@ 105 MJ/Ltr	315.0
		Total Inputs	2,551.3
OUTPUT			
Dry Corn	1,300 kg	@ 15.17 MJ/kg	19,721.0
Jagung Kering		Energy Ratio	1:7.73
		Energy/Protein	19.67 MJ/kg

APPENDIX A6.40

Sweet Potato (*Ketela Rambut*) (MJ/ha crop)

INPUTS			
Human Labour 62.8 days		@ 6.14MJ/day	385.3
Draft Labour 15.8 days		@ 40 MJ/day	632.0
		Total Inputs	1,017.3
OUTPUT			
Sweet Potato (wet) 8.5 kg		@ 4.77 MJ/kg	40,502.5
Ketela Rambut (*Ubi Basah*)		Energy Ratio	1:39.81
		Energy/Protein	7.98 MJ/kg

APPENDIX A6.4(F)

Cassava (Ketela Pohon/Ubi Kayu) (MJ/Ha Crop)

INPUTS		
Human Labour 118.8 days	@ 6.14 MJ/day	729.0
Draft Labour 17.6 days	@ 40 MJ/day	704.0
	Total Inputs	1,433.0
OUTPUT		
Cassava (wet) 8,600 kg	@ 6.40 MJ/kg	54,997.0
Ketela Pohon (*Ubi Basah*)	Energy Ratio	1:38.38
	Energy/Protein	23.80 MJ/Kg

APPENDIX A6.4(G)

Groundnuts (*Kacang Tanah*) (MJ/Ha Crop)

INPUTS		
Human Labour 155. 1 days	@ 6 .14 MJ/day	951.7
Draft Labour 21.1 days	@ 40 MJ/day	840.0
Seed 150 kg	@ 24.20 MJ/kg	3,630.3
Pesticides 2 Ltr	@ 105 MJ/Ltr	210.0
	Total Inputs	5,632.0
OUTPUT		
Groundnuts (dry) 970 kg	@ 24.20MJ/kg	23,475.9
Kacang Tanah (*biji kering*)	Energy Ratio	1:4.17
	Energy/Protein	21.50 MJ/kg

APPENDIX A6.4(H)

Soybean (Kedele) (MJ/ha crop)

INPUTS		
Human Labour 65.7 days	@ 6.14 MJ/day	403.1
Draft Labour 2.5 days	@ 40 MJ/day	100.0
Seed (Dry Beans) 40 kg	@ 15.97 MJ/kg	638.7
Pesticide 2 Ltr	@ 105 MJ/Ltr	210.0
	Total Inputs	1,351.8
OUTPUT		
Soybean (dry) 773 kg	@ 15.97 MJ/kg	12,343.3
Kedele (*biji kering*)	Energy Ratio	1:9.13
	Energy/Protein	5.00 MJ/kg

APPENDIX A6.4(I)

Kidney Beans (Kacang Hijau) (MJ/ha crop)

INPUTS		
Human Labour 48.2 days	@ 6.14 MJ/days	295.8
Draft Labour 2.5 days	@ 40 MJ/days	100.0
Seed (dry beans) 30 kg	@ 14.17 MJ/kg	425.1
Pesticide 1.5 Ltr	@ 105 MJ/Ltr	157.5
	Total Inputs	978.4
OUTPUT		
Kidney Beans (dry) 280 kg	@ 14.17 MJ/kg	3,967.6
Kacang Hijau (*Biji Kering*)	Energy Ratio	1:4.06
	Energy/Protein	14.56 MJ/kg

APPENDIX A6. 5 (A)

Energy Analysis of Traditional Rice Cultivation in South Bali (1934) Based on data from "Landbouw in de Aftdeeling Zuid-Bali" (Bakker, 1934)

1934 South Bali (Kabupaten Tabanan, Badung, Gianyar, Klungkung, Karangasem)

Total Area of Sawah	71,861Ha (cropping intensity -100% - 1 crop/year)	
Total Production Padi	275,956.3 Tm	Yield 3,840 kg/ha Crop
Total Production Gabah	229,043.7 Tm	Yield 3,187 kg/ha Crop
Total Production Beras	160,330.6 Tm	Yield 2,231 kg/ha Crop
Total Production of Edible Energy	2,368,403.8 MJ	Yield 32.958 MJ/ha

ENERGY ANALYSIS

INPUTS		
Human Labour 299.4 days	@ 6.82 MJ/day	2,041
Draft Labour 42.41 days	@ 40 MJ/day	1,696
Seed 50 kg	@ 4.77 MJ/kg	738
	Total Inputs	4,475
OUTPUT		
Edible Rice 2,231 kg	@ 14.77 MJ/kg	32,958
(Beras)	Energy Ratio	1:7.36
	Energy/Protein	28.66 MJ/kg

APPENDIX A6.5 (B)

Energy Analysis of Traditional Rice Cultivation in Bali Based on Data from "Monografi Pulau Bali" (Raka, 1955)

Total Area of Sawah (1948)	96,433 ha	(South Bali. 76,422 ha)
Island Wide - Cropping intensity 100%: 1 crop/year		
Total Production Padi	378,495.6 Tm	Yield 3,925 kg/ha
Total Production Gabah	314,151.3 Tm	Yield 3,258 kg/ha
Total Production Beras	219,905.9 Tm	Yield 2,280 kg/ha
Total Production of Edible Energy	3,248.451 PJ	Yield 33,686.4 MJ/ha

ENERGY ANALYSIS

INPUTS		
Human Labour 299.4 days	@ 6.82 MJ/day	2,041
Draft Labour 42.41 days	@ 40 MJ/day	1,696
Seed 50 kg	@ 4.77 MJ/kg	738
	Total Inputs	4,475
OUTPUT		
Edible Rice 2,280 kg	@ 14.77 MJ/kg	33,686.4
(Beras)	Energy Ratio	1:7.53
	Energy/Protein	28.04 MJ/kg

APPENDIX A6.6(A)

Total Rice Production, Bali 1978: Summary of Inputs and Outputs

Total Sawah	100,036 ha	(Bulog, 1979)
Total Planted	176,594 ha	(Dinas Pertanian, 1979)
		(76,558 ha Double-Cropped)
Imports of Agricultural Inputs: used in rice production		
Fertilizer Urea	24, 208.8 Tm	(Bulog, 1979)
Fertilizer TSP	785.1 Tm	(Bulog, 1979)
Pesticides (Various)	352.0 Ltr	(P.T. Petani, Bali, pers. comm.)
OUTPUT		
Total production of Edible Rice	408,709 Tm	(Dinas Pertanian, 1979)
		(excl. dryland rice)
Average Yield of Edible Rice	2,314kg/ha	(Beras)
Total Exports of Edible Rice	35,300 Tm	(Bulog, 1979)

APPENDIX A6.6 (B)

Indicative Energy Analysis of Rice Production, Bali, 1978

INPUTS		
Hunan Labour 299.4 days	@ 6.82 MJ/day	2,041
Draft Labour 44.4 days	@ 40 MJ/day	1,696
Fertilizer Urea 137 kg	@ 38.9 MJ/kg	5,333
Fertilizer TSP 4.5 kg	@ 7 MJ/kg	31
Seed (HYV) 50 kg	@ 29.54 MJ/kg	1,477
Pesticides (various) 2 Ltr	@ 105 MJ/Ltr	210
	Total Inputs	10,788
OUTPUT		
Edible Rice 2,314 kg		34,182
(Beras)	Energy Ratio	1:3.17
	Energy/Protein	66.03 MJ/kg

SOURCE: HUMAN AND DRAFT LABOUR, SEED TABLES 4.8, 4.9, 4.12 FERTILIZER, PESTICIDES AND EDIBLE RICE APPENDIX A 6.5(A)