AN INFORMATION SUPPORT SYSTEM FOR IDENTIFYING FARMING SYSTEM PART II: A CASE STUDY OF SLEMAN REGENCY, YOGYAKARTA PROVINCE

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ABSTRACT

The second part of the study is to validate the developed information system in a selected farming area. For the primary data, a farm survey is conducted in Sleman Regency, Yogyakarta Province. The sixty (60) household farms in 6 (six) districts are investigated which were grouped into animal-based and tractor-based farms.

Based on the farm survey, the results described that the total annual water surplus in the study area is 792 mm that reached from November to April and water deficit is 355 mm from May to October. There is also surplus situation of number of animal-drawn and local equipment for land preparation in each district, but deficiency in number of power tiller and it's matching tillage equipment. The sensitivity analysis indicated those yield and crop price are the most significant factor in determining the net return of the crop production system.

Keywords: Information support system, farming system, water balance, sensitivity analysis

INTRODUCTION

Yogyakarta is one of Indonesian Provinces that lies in the middle of Java. Administratively, the land area of Yogyakarta Province is about 3,185 km^2, which consists of the regencies of Kulon Progo, Bantul, Gunung Kidul, Sleman and Yogyakarta Municipality.

Agroecologically, this region can be divided into two zones; (a) irrigated/rain-fed wetland, and (b) high-altitude zone. While, demographically, in Yogyakarta Province about 29.82% of economically active population engaged in agriculture and more than 50% of population are living in rural area. Number of population is approximately 3.3 million people, and the man-land ratio was 1,025 inhabitants per km^2 (Anon., 2000a).

The objectives of this part are to validate and verify the developed system (Sutiarso, 2002) in the real case of farming system. Moreover, the system is also used to evaluate the characteristic of the farming system in the selected area and then give recommendations to its further development.

METHODOLOGY

Selection of the Study Area

To obtain a proper information on farm conditions and validate the developed information system for identifying the farming system, a case study approach was implemented in the selected area, which was based on one of the agroecological zone where categorized in Yogyakarta Province. The selected area is located in Sleman Regency and this site is situated in Yogyakarta Province representing the irrigated/rain-fed wetland zone. The farm survey was conducted from April to June, 2001 in six districts as part of this regency. Farms were categorized into two groups i.e. (a) power tiller-based farm where mainly farmers used a power tiller as power source in land preparation and (b) animal-based farm where they used animal as major power source, so that each farm group were represented in three districts.

Data Collection

A total of 60 selected farms were surveyed. These farms were stratified into two categories based on type of power used, of which 30 farms (power tiller-based) were taken from Minggir, Moyudan and Sleman District and 30 farms (animal-based) were taken from Prambanan, Ngaglik and Kalasan District. The main part of the study was based on primary data that was collected by direct field interviews of farmers using a structured questionnaire. Information likes physical environment, climate, location and other related aspects of the study area were collected from relevant government offices at province, regency, and districts also sub district level. The sources for secondary data were the central bureau of statistics and other official records. Secondary data was needed: (a) to support primary data for giving proper information of the study area, (b) to be used to compare between condition of the selected area and the district and regency levels, especially in Yogyakarta Province. The distribution of farmer households surveyed in the selected area is presented in **Table 1**.

Table 1. Distribution of farmer households to be surveyed

Regency	District	Sub District	Number of Respondent
Sleman – A (Power tiller-based farm)	1. Minggir	a. Sendangsari	2
		b. Sendangrejo	2
		c. Sendangarum	3
		d. Sendangmulyo	3
	2. Moyudan	a. Sumberarum	3
		b. Sumberagung	3
		c. Sumberrahayu	2
		d. Sumbersari	2
	3. Sleman	a. Triharjo	3
		b. Pandowoharjo	2
		c. Caturharjo	2
		d. Tridadi	3
Sleman – B (Animal-based farm)	1. Prambanan	a. Bokoharjo	3
		b. Sambirejo	2
		c. Madurejo	3
		d. Sumberharjo	2
	2. Ngaglik	a. Minomartani	2
		b. Sinduharjo	3
		c. Sardonoharjo	2
		d. Donoharjo	3
	3. Kalasan	a. Tirtomartani	2
		b. Purwomartani	3
		c. Tamanmartani	3
		d. Selomartani	2
	Total		**60**

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RESULTS AND DISCUSSION

General Information of the Selected Area

1. Inventory of farming system

Land utilization in Sleman Regency could be categorized into two types, i.e.; wetland and dryland. Moreover, wetland can be divided as irrigated and rain-fed areas. The dryland is utilized for many purposes like house compound, pond and garden. The irrigation facilities, and the primary and secondary canals, are completely controlled by the government, while tertiary distribution is managed by the villagers.

Full-technically irrigated land in Sleman Regency was about 11,341 ha, with planting intensity of 2 to 3 times per year (Anon., 2000b). There were 174 power tillers (hand tractors) with an average rated power of 6 kW that served approximately 24,291 ha of mostly paddy fields. The working capacity for land preparation either plowing or harrowing was about 7 to 10 h/ha. The majority of the power tillers in the area were available for rent at average hiring rate of about Rp. 250,000/ha for land preparation. The two highest numbers of hand tractors were 42 and 37 units, in the western districts of Minggir and Moyudan, respectively. They preferred using hand tractor (power tiller) than animal power based tillage operation due to some benefits, e.g.: (a) to increase work productivity, (b) to improve tillage quality, (c) to save field operation time, and (d) to decrease yield loss factor due to delay of land preparation. Thus, in fact, increased agricultural production in these districts during the past years was due to increased use of power tillers as a power source for land preparation, better farm water management and use of high yielding varieties.

Agricultural equipment used in Sleman Regency was dominated by hand tools like hand hoe, sickle and hand pushed seeder ("tugal"). Most of the agricultural operations are still done by manual equipment except land preparation. There were only 106 water pumps available to irrigate during dry season. The capacity of these pumps varied between 1700 and 2850 l/h. The number of throw-in type power threshers was 47 with an average capacity of 775 kg/h.

2. Cropping pattern

In irrigated and rain-fed areas, the dominant cropping system practiced by the farmers was rice followed by maize, especially in the first and second planting season. It can be seen that crops were grown in all planting seasons (**Figure 1**).

However, in the third season, rice area decreased resulting in 26.73% and 8.15% of total irrigated and rain-fed area planted, respectively. The average area of maize increased from 2.3% to 43% of total area. This was related to a pattern of the average monthly rainfall, which had the highest distribution from November to April. Besides rice and maize, soybean, peanut, cassava and mungbean were also planted in the third planting season. The cropping intensity in the study area was 103% for the first and second seasons, which decreased to 91% in the third season. This was due to variation in water availability from both irrigation canal and rainfall. The planted areas for rice on power tiller-based and animal-based farms were about 0.54 ha and 0.29 ha per respondent, respectively. The rice varieties mostly planted were IR-36 (3.34%), IR-64 super (60%), Cisadane (31.67%) and local (4.9%). The average rice yields were about 5,566 kg/ha for power tiller-based farms and 4,398 kg/ha for animal-based farms.

On power tiller-based farms, the average planted area for maize was 0.76 ha per respondent with an average yield of 2,743 kg/ha, while on animal-based farms, planted area was 0.32 ha with an average yield of 2,191 kg/ha. Furthermore, the farmers mostly used three varieties of maize, i.e.; Hybrid (76.92%), Arjuna (3.85%) and local (19.23%). Planted areas of soybean per farmer in both power tiller and animal-based farms were about 0.26 ha. Soybean varieties that they mostly used were local (33.33%) and Wilis (66.7%) with an average yield of 1,256 kg/ha in both areas. Similarly, peanut was planted on an average area of 0.89 ha on power tiller-based farms and 0.19 ha per respondent on animal-based farms. All farmers used a local peanut variety.

3. Farm management practices

Animal and tractor power were used for land preparation only (plowing and harrowing), while for post land preparing operations, manual power was used. In the power tiller-based farms, the percentages of power tiller used were about 68.58%, 23.95%, 1.85% and 11.54% for wetland rice, maize, soybean and peanuts, respectively. On the other hand, the percentages of animal power used were 94.44%, 10.19%, 5.66% and 0% for the same crops, respectively.

4. Details of inputs

The inputs consisted of seed, fertilizer and pesticide. Based on field interviews, the use of fertilizer and pesticide were nearly the same for all crops. The average seed rates used were 44, 25, 33 and 45 kg/ha for rice, maize, soybean and peanuts, respectively. The total cost of seed used varied from Rp. 75,000/ha to Rp. 110,000/ha. Generally, seed rate used in both areas was nearly the same, except for peanuts. Its seed use on power tiller-based farms was 21 kg/ha, while on animal-based farms, it was 62 kg/ha. This was due to the peanut variety planted and the condition of power tiller-based farm is better than the other area.

The average rates of fertilizer were 211 kg/ha, 95 kg/ha, 72 kg/ha and 75 kg/ha for urea, TSP, KCl and ZA, respectively, for almost all crops. The total cost of fertilizer varied from Rp. 325,000/ha to Rp. 510,000/ha. The common pesticides and insecticides used were Furadan, Diazinon and Thiodan. In the study area, the average rates were 3.10 kg/ha, 0.51 kg/ha and 0.35 kg/ha for Furadan, Diazinon and Thiodan, respectively. The total cost of pesticides was about Rp. 104,875/ha.

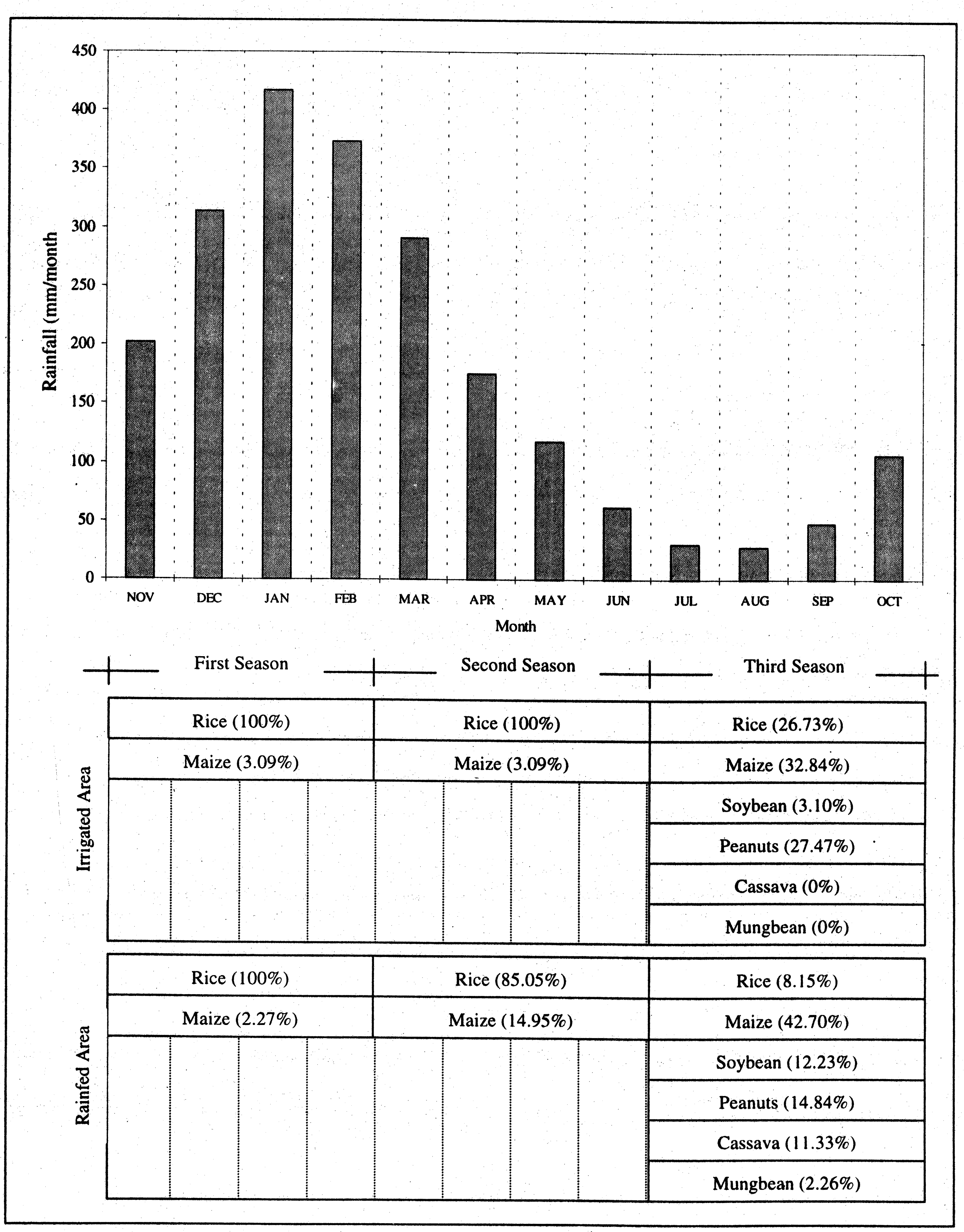

Fig. 1. The cropping pattern and monthly rainfall in the study area

Results of the Developed Information System

1. Water balance

A simple water balance model (inflows and outflows) was adopted for modeling water balance in the field. The monthly results of this model are illustrated in **Figure 2.** The monthly rainfall had the highest intensity during November to April (175 mm in April and 417 mm in January). During May to October, monthly rainfall intensity decreased and the lowest intensity was about 28 mm in August. This situation affected the farming system, especially in rain-fed area. Farmers started to grow the secondary crops such as maize, soybean, peanuts and cassava, anticipating the water availability. Finally, the water balance model in this study is expected to be used as guidance for managing the farm water requirement.

The results show that the values of monthly Potential Evapotranspiration (PET) are nearly uniform ranging from 129 mm to 176 mm, which was due to the tropical location. The fluctuation of average monthly air temperature was also uniform (range from 27°C to 28°C). However, the low value of PET occurred during continuous rainfall and cloudy conditions. The Actual Evapotranspiration (AET) values ranged from 48 mm to 176 mm, which was different from PE, because, when the rainfall rate was higher than the PE rate, all water losses due to evaporation were taken from the rainfall. So in this situation AE was similar to PE. When the rainfall rate was lower than the PE, all water loss was not due to evaporation (insufficient condition). A part was taken as water storage. In this situation, AE rate could not reach the PE, or in other words AE was less than PE.

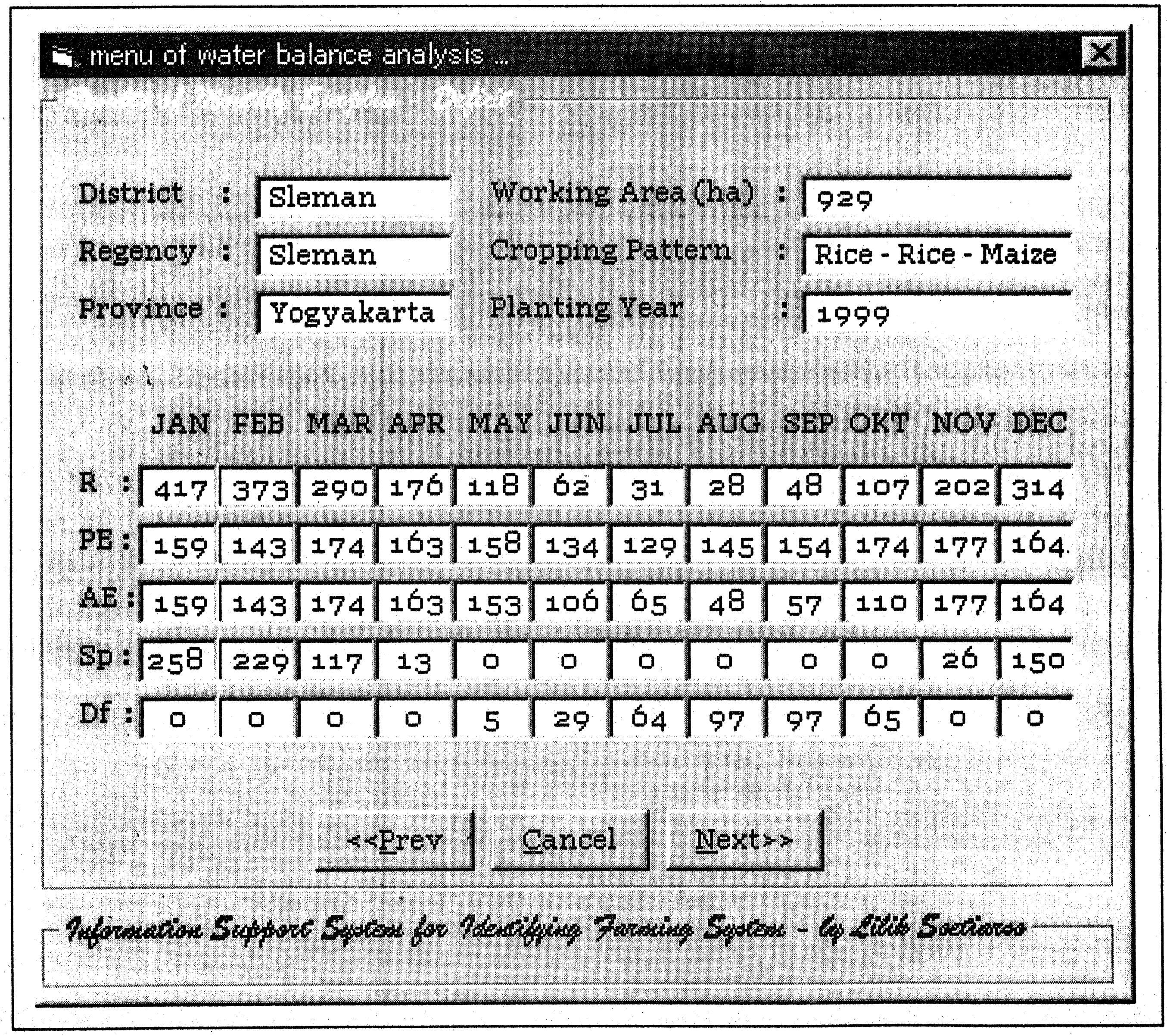

Fig. 2. Displayed result of the monthly surplus – deficit water balance

2. Agricultural power and equipment selection

The primary survey showed that almost all farms are either animal-based or power tiller- based. The energy requirement, field efficiency, and coefficient of traction and transmission for plowing and harrowing varied with the type of implement. **Table 2** gives the values of these parameters. The yield loss factor for different crops due to delay of land preparation was 0.6 to 0.7 kg/ha/day (Butani, 1992). In order to optimize use of agricultural machinery, the size and amount of power source and equipment should match the power required. The annual use and operating costs of the power units and equipment also need to be considered in selecting equipment. Such decisions are critical because of the high proportion of total costs attribute to machinery and the infrequency and irrevocability of such decisions. A procedure was designed to obtain optimum power required and to select matching implements. Some parameters to be considered in this procedure were crop area, crop price, yield loss factor, labor cost and working hours. This system was grouped into two sub-systems, i.e.; animal-based and power tiller-based power. The power rates of animal and hand tractor in land preparation were 8 animal-days/ha and 2 unit-days/ha, respectively.

Table 2. Parameters related to field operations performed using animal and tractor

OPERATION	E (kWh/ha)	EF	TC
A. Plowing		0.81	0.75
a. Moldboard	34.10		
b. Rotary	25.80		
c. Local	20.20		
B. Harrowing		0.74	0.60
a. Rotary	25.80		
b. Local	10.25		

Note :
E : Energy required for field operation (Hunt, 1983)
EF : Field efficiency for field operation (Hunt, 1983)
TC : Tractive and transmission coef. for field operation (Kepner et al., 1980)

a. Animal-based power

The main animal power source used in the study area was cattle (cow). The study showed that the numbers of animals required were 246, 381, 591 and 442 heads for Sleman, Prambanan, Ngaglik and Kalasan Districts, respectively. The number of selected matching implement, both wooden local plow (working width - 20 cm) and wooden comb harrow (working width - 150 cm) were 123, 190, 295 and 221 units in the same districts, respectively. The cattle are used in these four districts, with an average power of 0.4 kW/animal. According to 2000 statistical data on animal population (Sleman Regency), the number of cattle recorded were 1522, 3521, 1853 and 1937 heads in Sleman, Prambanan, Ngaglik and Kalasan District, respectively, while the populations of buffalo in the same districts were 415, 78, 164 and 100 heads, respectively. From these data, cattle are more popular than buffalo and its population was sufficient and available to serve power demand for animal-drawn implement in land preparation. So, it can be concluded that the required power and matching equipment in the animal-based farms was sufficient in the study area.

b. Power tiller-based power

Similarly, the computer program calculated the optimum power tiller required and matching implements in the study area. The commonly used tractor and its implement in the study area are power tiller (6 kW) and for plowing, moldboard (working width - 25 cm) or rotary plow (working width - 80 cm), while for rotary harrow (working width - 80 cm) and comb harrow (working width - 75 cm).

The study showed that the optimum numbers of hand tractors required were 69, 69, 47 and 13 units in Minggir, Moyudan, Sleman and Ngaglik Districts, respectively. The numbers of moldboards required were 35, 47, 13 units for Moyudan, Sleman and Ngaglik Districts, while the number of rotary plow required were 69 and 35 units for Minggir and Moyudan Districts. On the basis of these numbers, in Moyudan District, farmers used two types of plowing implements, i.e.; moldboard plow and rotary plow equally. Considering a supply-demand model, it was concluded that the numbers of power tillers and matching implements were insufficient to serve required power demand in the study area. In fact, to overcome this problem and to reduce time losses for field operations, farmers usually use animal power for land preparation or they rent a hand tractor from another area. A displayed running program of the agricultural power and equipment selection menu can be seen in Figure 8 of the first part (Sutiarso, 2002).

3. Output of sensitivity analysis

This analysis was designed in terms of cost and return. The return components mainly consisted of yield and crop price, while cost components simply consisted of input materials (seed, fertilizer and pesticides), labor and power used. The initial yields of rice, maize, soybean and peanuts were 5,164 kg/ha, 2,583 kg/ha, 1,255 kg/ha and 2,050 kg/ha, respectively. In scenario-2, it was assumed that yield of these crops decreased by 5% from initial values. The amount of net return was decreased by about 9%, 9%, 7% and 14% for rice, maize, soybean and peanut, respectively, in both tractor-based and animal-based areas.

CONCLUSIONS

The farming system in Sleman Regency is wetland rice-based. The secondary crops grown were maize, soybean and peanut. The selected area was dominated by animal-based and power tiller-based power sources for farm operations. The animal-based farm represented a rain-fed area and the other represented an irrigated area. Average land holdings by individual farmer were about 0.33 ha, which was one of the major constraints for using the bigger farm machinery. The cropping pattern profile was determined by climate, topography, water supply, farming tradition and socio-economic factors. The water availability was characterized by surplus condition from November to April and deficit condition from May to October. These conditions were strongly affected by the cropping pattern both in its time and crop kind, particularly in the animal-based farm (rain-fed area). The optimum power and equipment required on animal powered farms was lower than the animal and implements available. However, the number of power tillers required was higher than the available power tillers. The sensitivity analysis indicated that yields and price of crop are the most significant factors that influence the agricultural production system in terms of the cost-return.

The developed information support system was validated by using surveyed-based data in the selected region, i.e. Sleman Region, Jogjakarta Province. There are some suggestions to develop the information system further:

1. In order to improve the utility of the information system particularly in water balance analysis, it should be added that some alternate methods for calculating the potential evapotranspiration such as Modified Penman , Blaney-Criddle or Christiansen Method may be used. So the users have alternate models to obtain the result that properly meet their location characteristics.
2. Rainfall and soil characteristics should be considered as database for determining the optimum number of power tillers required. Operationally these factors closely related to each other, particularly an available and required time for land preparation.
3. Crop database should be enlarged by adding information related to other common crops such as cassava and mungbean.

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