CROP-LIVESTOCK SYSTEMS RESEARCH IN ASIA: DESIGN AND TESTING OFR

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Introduction

Evolving research methodology

In the Asian Rice Farming Systems Network (ARFSN), it was convenient to initially "ride" on the Cropping Systems Research (CSR) methodology. Such methodology evolution started with multiple cropping in early 60's. In 1974, this became multiple cropping, then cropping systems in 1979 at which time then Asian Cropping Systems Network was formed. The methodology has since developed thru consultation and interaction among collaborating scientists from national programs in the network. It consists of site selection, site description, design, testing, preproduction evaluation, and production program. A consensus to adapt the CSR into FSR was reached in the Crop-Livestock Research Workshop among network scientists at IRRI in April, 1983.

From cropping systems to farming systems

This shift from cropping systems research (CSR) towards FSR is to be done following the CSR method, either in an existing research site and intercropping livestock as an additional farm component to be investigated. Other animals and enterprises may be considered later and as the situation may warrant. In China, for instance, swine is the livestock being considered in a predominantly grains cropping systems. This step by step move, instead of considering everything in the system all at once, was deliberately done to (a) facilitate interdisciplinary effort, and (b) focus on more direct crop-livestock interdependence, e.g., use of fibrous crop residues as livestock feed, recycling animal manure for fertilizer, and utilizing animal draft power.

Smallholder farms in Asia

Importance of livestock

If India and China were included, Asia would account for roughly half the world population of 5 B. Correspondingly, 30% of 1.2 B cattle are found in Asia (Table 1.). Buffaloes are 97% of the 131 M, 29% of 1.12 B sheep and 80% of the 454 M goats.

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Table 1. Distribution of Domestic Ruminants (1000 head)[a]

Area	Cattle	Buffaloes	Sheep	Goats
World	1,213,731	131,146	1,116,449	454,667
Asia	369,432	127,636	325,085	365,171
China	64,130	30,080	120,880	80,448
India	182,408	61,296	4,108	71,644
Indonesia	6,482	2,321	3,611	8,051
Japan	4,136	-	11	80
Philippines	1,983	3,037	31	1,450
Thailand	4,963	5,583	62	31
Africa	169,527	2,380	182,091	146,125
Australia	26,321	1	135,706	-
Europe	134,411	457	134,309	11,599
North and Central America	176,306	8	21,786	11,207
South America	231,751	315	197,863	18,582
USA	110,961	-	12,513	1,400
USSR	115,900	350	143,599	5,824
Developed	424,582	807	524,490	24,410
Developing	789,149	130,340	591,959	430,257
Developing, %	65	99	53	95

[a] Modified from FAO (1981) by Loosli and McDowell 1985.

Farm landholdings also continue to dwindle as they are shared by an increasing population and no rapid reduction in the proportion of farm families. So-called landless farmers, who may own some livestock and serve as hired laborers in farm work, further lower the average. In Burma, average farmers may cultivate up to 5 ha, about 4 ha in Thailand, less than 2 ha in Philippines and Indonesia, about 0.5 ha in China. The situation in China is also rapidly changing as the government implements the responsibility system. The new system basically retains the farm commune but allows farm families to cultivate a piece of land on their own.

Design consideration of on-farm trials

In designing on-farm trials that seek to improve livestock enterprise(s) of small farms, two consideration are important:

1. Integrated crop and livestock enterprises
   In Asia and most of the developing countries, client farms of FSR are generally small (<1 up to 5 ha) and highly integrated. Seldom would such farmers pursue a mono-enterprise specialization. Even if he attempts to do so, his limited land and capital resources force him to maximize use of such resources and to spread risk among crops and enterprises whenever possible. Furthermore, farmers who specialize like in vegetable growing, pig, or poultry raising, may end up in the semi-commercial to commercial scale; way out of FSR efforts.

2. Ruminant, especially large animals as entry point
   To gain experience in the conduct of FSR, it was also deemed wise to start with two interacting farm enterprises: crop and large ruminant. Later, when the methodology and interdisciplinary work relationships are more clear, other components of the farm may be included, like fish, pig, chickens, ducks, silkworm, etc.
   It is also accepted that crop and livestock interaction are more defined for the ruminants. They are more interdependent with the crops in terms of utilizing crops residues. The non-ruminants may consume some grains and brans but not the fibrous residues; they can also be fed with purchased feed.

Crop-livestock FSR

Expanding the cropping systems methodology

At the 1983 Crop-livestock workshop, it was agreed to conduct on-farm research initially in a site in five countries. Participants felt prepared to start in China, Sri Lanka, Indonesia, Thailand, and Philippines.

Design of activities was conceived along the following scheme (Fig. 1).

DESIGN ACTIVITIES

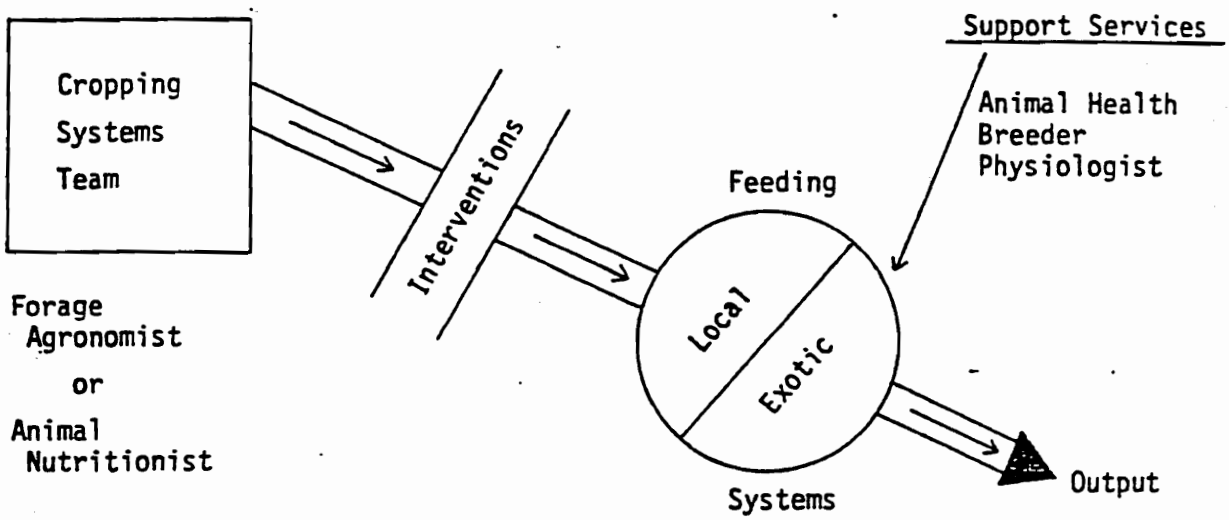

Fig. 1. Design of crop-livestock research

The cropping systems team adds a forage agronomist or animal nutritionist to review the cropping systems site. They then design a set of experiemnts to meet the needs of the animal feeding system. Other scientists are also involved in order to more fully understand the system. For instance, animal health problems may be assessed so that confounding effect on feeding may be accounted for.

Pre-project experience

At that time too, enough optimism was expressed as follows:

1. Some simple techniques have been used successfully elsewhere
2. Starting with few sites with livestock would make possible fielding a larger team with more evaluation capabilities.

3. Cropping systems evaluation techniques should be useful, e.g., forages or crop by-products.
4. In sites where increased feed supply is a treatment, farmers' comments on effect on animals and adoption rate will be effective if somewhat crude evaluation tool.
5. On site researchers are fairly experienced to cope with more complex data analysis.

Problem areas

In addition, problem areas were identified not only to caution research work but also to serve as methodological issues to be resolved with time. These were:

1. Ex ante analysis needed to screen technology interventions
2. Time frame for crop-livestock research much longer than for crops
3. Value of crop by-products subjective and may lead to complex budgeting problems
4. Oversimplified model evaluation may lead to inaccurate decisions
5. Cropping systems evaluation techniques may not apply to crop-livestock systems
6. Farmers may keep livestock to meet objectives other than that for crops that combined analyses may produce dubious procedures
7. On site staff relatively young with little experience to prevent complicated evaluation procedures
8. Family and animal relationships are important but no accepted analytical procedure may be available
9. Social benefits and sustainability of production must be considered but with few acceptable evaluation techniques.

Research methodology review in Year 3

On the third year of implementation, Crop-livestock researchers again held a workshop in Khon Kaen, Thailand last July, 1986. Critical evaluation of the research methodology emphasized the following points:

1. Identification of farmers; goals need to be improved so more appropriate interventions can be designed. e.g., proceeds from cattle sales paetly finances crop inputs
2. Farmers' participation at all stages of FSR is important. Some ways of eliciting their participation include use of maps to identify plots. Presenting the results of initial site description to them is also useful. Then, after identifying possible interventions, researchers

should again consult the farmers. Other activities to involve farmers include field visits to station, field day, farmers' training, etc.

3. To overcome the problem of maintaining treatments throughout the experimental period, the "before and after" approach was suggested. This is in contrast to the conventional comparison between treatments. Ways of evaluating the technology include persistence, acceptability and spillover.
4. Difficulty in measuring interactions. This could be avoided by identifying them in site description, e.g., crop yield and feed availability.
5. Input from statisticians in guiding FSR researchers is encouraged. However, this could not be at the sacrifice of the objective of the trial and farmer involvement.

On-going crop-livestock systems projects

Sta. Barbara, Pangasinan

In the Philippine research system, partitioning of research activities is guided by the Philippine Council for Agriculture and Resources Research and Development (PCARRD) into program, project, and study. The study is the basic unit of activity; and several subject studies in a discipline or related disciplines make up a project. Two projects or more that interrelated make up a program.

In the Philippines crop-livestock systems research project, studies are being simultaneously pursued in the following:

On-station

1. Feed technology; determination of feeding value of crop residues, by-products, and forages.
2. Pesticide residues in rice and other crops and in animals.
3. Systems analyses and simulation.

On-farm

1. Integrated crop-livestock systems
   a. Cattle fattening
   b. Water buffalo breeding (cow-calf)
   c. Backyard forages
   d. Rice and dual-purpose crops (grain + fodder)
2. Crop component
   a. Rice and dual-purpose crops (grain + fodder)
   b. Crop component technology
      1) Variety trials: rice, mung, cowpea, etc.
      2) Fertilizer trials, agronomic practices.
3. Animal health
4. Sociology and role of women
5. Pesticide residues
6. Economic analyses

One project coordinator and eight subject matter or study leaders manage the different activities, supported by four field research assistants and two research aids. Farm labor is hired as the need arises, like in obtaining and processing crop cut samples.

A research study leader may conduct both on-station and on-farm activities under one study: as in the case of the worker on pesticide residues. The project economist coordinates with the systems analyst as the latter organizes data for simulation purposes.

Project Location

The project is being conducted in 2 barangays (villages) of Sta. Barbara town, Pangasinan province, some 262 km north of Manila. Barangay Malanay represents the irrigated lowland while barangay Carosucan, rainfed lowland.

Rainfall peaks in August and starts in May or early June, then ends in late September thru October. Soil is clay loam to sandy loam with pH 6.7-7.9.

Rainfed Lowland Site

Barangay Carosucan is 6 km from town and is a rainfed area with about 142 ha; 56% of which are lowland and 44% upland. An irrigation system was built several years back but it has been inoperational due to serious siltation and lack of water. Average landholding is 1.6 ha per household.

A rice monocrop predominates, and average rice yield is 2.7 t/ha. Depending on the amount of rainfall that follows after harvest in November, some farmers may plant tomatoes, mung, peanuts, etc., but most field are left fallow.

Cattle and buffalo holdings average 1.4 per farm; or a stocking rate of 1 mature animal unit/ha (1 A.U./ha).

Farmer operators are 48 years old on the average; and a household has 5 members, 3 of whom regularly work on the farm.

Irrigated Lowland Site

Barangay Malanay consists of 118 ha, with 205 households. It has 35% land fully irrigated, 29% partially irrigated, 17% upland, and 19% rainfed. Average landholding is 1.3 ha per household.

Two rice crops are grown in the fully irrigated areas and average rice yield is 3.1 t/ha. Uplands and partially irrigated areas are planted to rice, peanut, corn, cowpea, string beans, tomatoes, etc.

Cattle and buffalo holdings average 1.1/household, and 0.92 A.U./ha stocking rate.

Farmer operators are also 48 years old on the average, households have 7 members, 4 of whom work on the farm.

Livestock Component

1. Animal Production

Farmer cooperators from each barangay were selected based on criteria from a benchmark survey of the two sites, as well as the farmer's willingness to collaborate with the research. In Malanay 20 farmers were involved, while in Carosucan, 18 farmers (Table 2.). Assignment to respective treatments was based on size of landholding and involvement in animal raising. Farmers with less than the number of animals required in the treatment group were provided with fattening cattle, on a "paiwi" sharing[3] system. This was to equalize animal holdings within treatment.

Interventions or technology package in livestock management include daily feeding with 2 kg Luecaena or other legume forages, provision of urea-molasses-mineral blocks, establishment of improved forages in lots and animal health care. Utilization of fibrous crop residues, especially rice straw, was recorded and related with actual farm grain and residue output.

The animals of the farmers were weighed during the start of the experiment, and every 1 1/2 months thereafter.

Table 2. Experimental treatments, crop-livestock

	Treatments	No. of Cooperators	Farm Area ha	Livestock (No. of Draft + Fattener)
Barangay Malanay (Irrigated)				
I	+ Technology	6	0.5 - 2	1 + 1
II	+ Technology	5	2.1 - 3.5	1 + 2
III	Control	4	0.5 - 2	1 + 1
IV	Control	4	2.1 - 3.5	1 + 2
Barangay Carosucan (Rainfed)				
I	+ Technology	4	0.5 - 1	1 + 0
II	+ Technology	5	1.1 - 2	1 + 1
III	Control	5	0.5 - 1	1 + 0
IV	Control	5	1.1 - 2	1 + 1

*Technology = package of interventions; a) daily Luecaena or legume feeding, b) salt + urea + molasses + mineral supplement, c) improved fodder supply thru legume crop residues and forage in homelots, and 4) animal health care.

Cattle liveweight gains

After 300 days feeding period, liveweight gains of cattle, apparently do not reflect differences due to farm size or interventions (Table 3.). This is especially so in Carosucan, wherein animals gained the least (0.1 kg/day). In Malanay, overall performance of animals was more uniform than in Carosucan. Control animals (Treatment III and IV) were however gaining as much if not more weight than in the intervention groups (I and II). Animals consist of those owned by farmers and contributed by the project; and were not all fed to start at the same time. Disposal of Malanay project animals was completed in October, 1985.

Table 3. Liveweight gains of fattening cattle

	Treatment	No. of Animals	Live weight		
			Initial	Final	ADG*
Malanay	I	7	279	335	0.20
	II	3	280	335	0.21
	III	3	250	303	0.22
	IV	2	293	341	0.23
Carosucan	I	4	214	272	0.18
	II	7	238	284	0.16
	III	3	174	244	0.22
	IV	5	226	278	0.17

*Average Daily Gain; 300 days feeding period.

Year round feed profile

One day each month, feeds offered to cattle were measured. Results of this feeding profile is summarized for the whole year, and average daily feed offered to cattle were (kg as fed):

Rice straw	5.6
Weeds	7.4
Leucaena leaves	0.4
Corn stover	0.1
Rice bran	0.2
Salt	0.01
Total	13.8

When the above values were transformed into dry matter (DM), daily crude protein (CP) and total digestible nutrients (TDN) were 0.38 and 3.17 kg, per animal, respectively (Table 4.). Protein was apparently deficient, compared to a daily requirement of 0.53 kg. Fig. 2 shows the monthly profile of feed offered.

Furthermore, the feed intake from free grazing and tethering was apparently marginal, to explain the low liveweight gains of animals. No estimates were made on feed consumed from grazing and tethering. No nutrient requirements were also added for draft use of the animals.

Table 4. Estimated crude protein and total digestible nutrients, Malanay feed offered (kg DM)

Feed	DM	CP	TDN
Rice straw	4.2	.16	1.97
Weeds	1.85	.18	1.00
Leucaena leaves	0.11	.02	0.06
Corn stover	0.08	-	-
Rice bran	0.20	.02	0.14
Total	6.44	0.38	3.17

Crop Component

1. Cropping Pattern Testing

The irrigated/upland test site in Malanay

The existing farmers pattern of planting two rice crops a year is already intensive enough, however a 70 day turnaround time between rice exist where the fields are left fallow.

Crop cut samples of the first rice crop showed about 92% of the farms planted to high yielding varieties and the rest to local cultivars. The prominent HYV's planted were the following with mean t/ha grain yield: IR42, 4.91; IR36, 3.12; IR32, 3.83; and IR54, 3.09. The farmers' local variety obtained a similar yield to IR42 (4.05 t/ha). Fresh fodder yield after harvest showed that the farmers' variety yielded highest (15.50 t/ha) followed by IR32 (15.47), IR36 (13.31). IR42 (11.42) and IR54 (11.09).

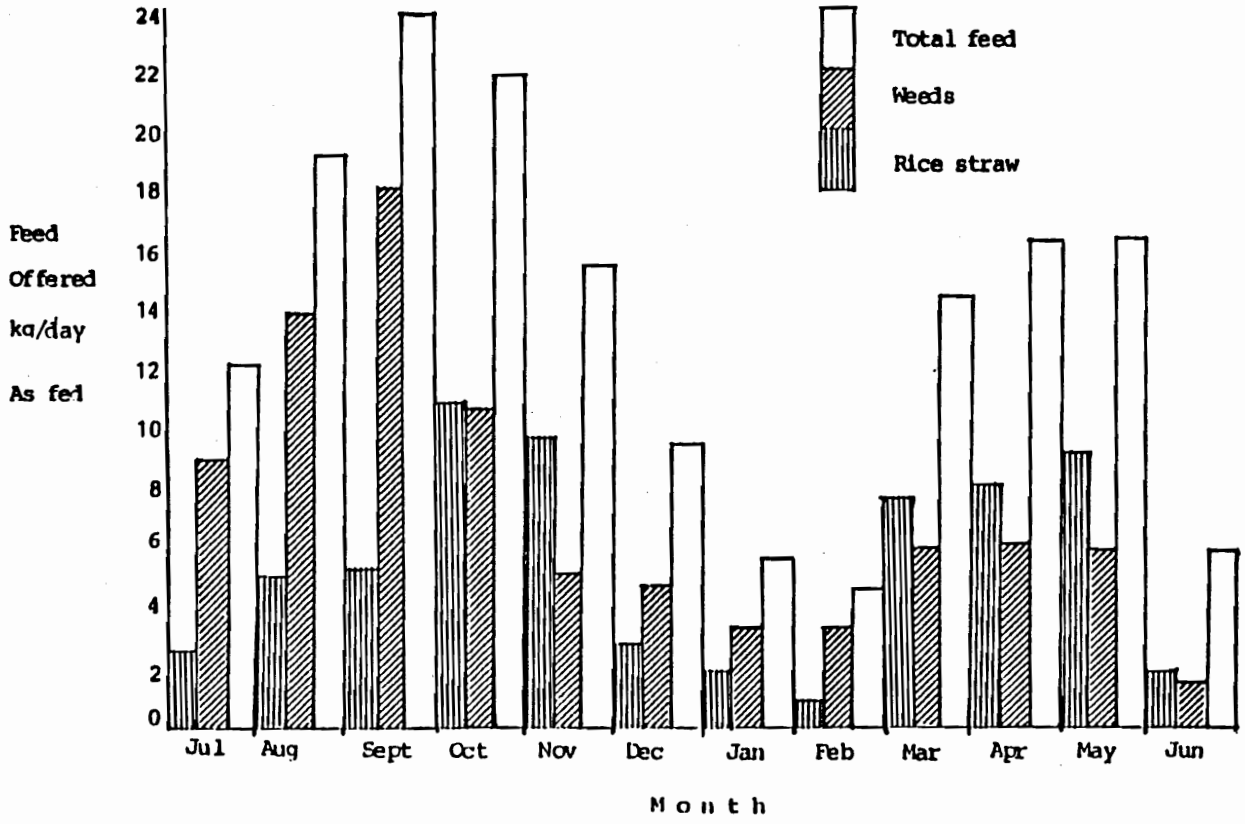

Fig. 2. Av daily feed offered to Cattle, Malanay

The rainfed test site in Carosucan

At the rainfed test site, cropping pattern trials are conducted to intensify the only rice crop the farmers are growing. Fitting in upland crops (mostly legumes) to take advantage of the residual soil moisture is the main thrust. The research team at the site further classified the rainfed site under two categories (which will be their basis to conduct cropping pattern trials). One is a medium light soil but drought-prone and the other is a heavy soil poorly-drained and flood-prone. These two distinct soil textural types cover at least 40 and 60 percent of the site area respectively and majority of the rice areas in the province of Pangasinan. Farmers themselves recognize the importance of these two land types by planting early maturing HYV's (IR36) in lighter soils where water stress is expected to occur but taller and late maturing varieties (IR42, IR48 and Local) under heavier soils where flooding occurs at a time when early HVY's are at their reproductive stage and will be fully submerged if planted under flood-prone areas.

In lighter soils, transplanted early maturing rice (IR36) followed by mungbean, and cowpea was compared to rice alone which was the farmers' traditional pattern. Surprisingly, after the experimental pattern second crop establishment in zero tillage, 55% of the livestock cooperators followed mungbean and cowpea establishment under full tillage and using the local cultivars.

Grain yield in rice showed that the experiemental pattern obtained and advantage of 7 and 51 percent compared to F1 and F2 farmers while only a 2 and 6 percent advantage in terms of fresh fodder yield respectively. Likewise, for mungbean and cowpea a grain yield advantage of 22% and 55% was obtained by the experimental plots compared to F2 farmers with a fodder yield potential of 3.37 and 1.75 t/ha. No fodder yield measurement were obtained from F2 farmers. Results of the two crop system showed that TPR-MG and TPR-CP in the experimental pattern over that of the F1 farmers can be accounted to an additional mungbean or cowpea yield, while that in the F2 farmers can be attributed to the higher cost in weed control and fertilizer use (60-0-0 vs 73-0-0 for experimental and farmers practice respectively) in rice and higher yields obtained by the high yielding upland crops after rice.

Khon Kaen, Thailand

Background

The main objective was to develop a methodology on farming systems research in integration of crop and livestock enterprises of the small farmers. The research also sought to encourage collaborative research in farming systems approach. The parameters applied in measuring the tests become the specific objectives of the project i.e. cropping patterns suitable to animal production, farm by-products utilization, alternative technologies performance, farm resources efficiency and identification of constraints.

Project Components/Implementing Coordination

A. Coordination (FSRI/DOA)
   1. Appointment of committees
   2. Monthly and quarterly meetings
   3. Financial administration
   4. Progress report
   5. Annual Wprkshop

B. Crop Component (FSRI/DOA)
   1. Preliminary survey and farmers selection
   2. Soil sampling and analyses
   3. Site description
   4. Planting, care and monitoring
   5. Evaluation, analysis

C. Animal Component (DOLD)
   1. Survey of public pasture
   2. Animal live-weighing
   3. Crop residue chemical analysis
   4. Backyard forage crops monitoring
   5. Crop-animal by-products monitoring
   6. Animal Health

D. Socio-Economic Component
   1. Baseline survey (OAE)
   2. Farm-book recording and monitoring
   3. Economic analysis of cropping patterns testings (OAE)
   4. Rural Rapid Appraisal (KKU)
   5. Evaluation of technology impact (KKU)

Methodology

Strategy

The strategy is based on the Asian Cropping Systems Methodology agreed upon in a conference held in 1983 which followes site selection, site description, design, testing multi-location testing and so on.

Design

After the preliminary survey, the cooperative farmers were selcted and classified into three patterns, according th their enterprises, mode of cultivated areas and farm income, namely:

- animal-based
- crop/animal-based, and
- crop-based farming pattern

All components of research are carried out superimposedly upon the three farming patterns and interrelationship is studied.

Cropping Pattern and Health

Based on the existing and typical topography of northeastern region, the cropping patterns are laid out into three types of land, i.e. upland, upper-paddy and lowr-paddy.

Animal Growth and Health

Artificial insemination was introduced to the farmers to produce half-bred dairy cows of local American Brahman grade and Holstein Fresian and marketed to Dairy Promotion Organization. The male offspring are beef production and local buffaloes are also taken into consideration for monitoring.

Liveweight of animals from each cooperator farmers are recorded along with their feeding patterns. The changes in number of animals and relative reasons are being monitored. Backyard forage crops yield and crop residues along with utilization of farm yard manure are recorded and anlyzed chemically. Veterinary services are given to the cooperator farmers as well as non-cooperators.

Socio-Economics Component

A base line survey was carried out to describe the existing system quantitatively. Farm records are kept to study the whole farm activities of the cooperator farmers and a nearby village. Cost and return analyses of the cropping pattern testing is also done.

Two surveys using rural rapid appraisal techniques were conducted to identify some social constraints and attitude of the farmers in aspect of farm residues utilization.

Results in Year 1

1. Cropping Patterns

Table 4 shows yield and economic return of tested patterns in two of land types. Only cropping pattern: peanut-green corn gives positive return under upper paddy condition. Low crop yields in all

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patterns were due to long drought (887 mm. of annual rainfall) and insect pests damage up to some extent. Moreover, the variable costs, particularly the insecticides and labour were considerably high. A crop like green corn was found to provide residue for animals of about 11.2-19.7 t/ha.

2. Animal Growth and Health

Growth rate (g/head/day) of cattle decreased from October to November onwards where the forage become inadequate. The period coincided with rice harvesting when farmers had less time to take care of their animals/ The animals were then grazed freely in the paddy field after harvesting and there were plenty of fresh rice straw resulting in increase in weight during January to February. The weights again decreased during March to April. This may be due to shortage of feeds again or it is the time of planting field crops like cassava and kenaf where farmers take less care of the animals.

Batumarta, Indonesia

Farming Profile in Batumarta Research Site

Batumarta transmigration project I covering eleven settlement units with 4,50- households, was a specially designed transmigration settlement. It was gradually settled within 6 year period from 1976 to 1981. This project was financed by IBRD Loan; each family recieves 5 ha land instead of 2 ha, the first project with rubber tree component, massive research efforts on food crops pattern, climate, cattle development, soil conservation, Imparata cylindrica (alang-alang) contril, socio-economic monitoring, and reestablishment of perennial crops.

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Dry Season Component Technology Testing

Some component technology experiments were conducted during the dry season 1985 both on crops and livestock components. These are:

Livestock-Forage

1. Adaptation trial on several legume fodder crops
2. Study on the combination of grass (Setaria) and legume fodder crops for animal feeding.

Initial Site Description

Resources

The 5 ha land holding was intended for homeyard (0.25), grazing (0.25) food crop land (0.75 ha), food crop land II (1.75), rubber (1) and reserved (1) for perennials. In reality it consists of 4 parcels of (0.25 + 0.75) ha, 2 ha, 1 ha of rubber and 1 ha reserved for rubber.

Animal power

This was expected to be supplied by the project. An adult cattle for each household should be repaid with one 6-9 month old calf. The first group of cattle were distributed in 1978. So far about 199 of household in the oldest unit has had a cattle while the later settlement unist such as unit VI , only 30% of households have cattle. The provision of draft cattle for transmigrant has been planned because experience shows that farmers face difficulties to cultivate all the allocated landholding.

Perennial crops

These consist of coffee, coconut, clove, kapok, rubber and fruit trees such as citrus, mango, cashew nut, banana and rambutan. About half of the total coffee population i.e. 90,000 trees were planted in unit III, the rest are found in Unit V, VI and XI . Coconut are more evenly distributed mostly in Unit II-VII. Unit III is also ranked first for clove trees followed by Unit IV and VI. Rubber trees for unit I up to VI has been able to be tapped for about few months to about 1.5 years. So far only a small portion of perennial crops are on bearing stage.

Income

Transmigrants generate their income by implementing several economic activities to meet their need for food as well as for cash. Food crop farming is the most dominant economic activity. Other activities are tree crop, animal husbandry, off farm and non farm job.

Food crop farming

It started in houseyard parcel and develop in later years to other plots. The cultivated area increase with increasing years settlement and availability of family labor as follows:

Arrival year	Household size	Labor force	Actual farm labor	Cultivated area
1976-1978	5.4	3.44	2.62	1.43
1979-1981	5.0	3.31	2.01	1.13

Perennial crops other than rubber

These could only supply small cash income between Rp 144,000 and Rp 56,000, - per year. Since 1983 there were a few settlement units where rubber parcel could be tapped already and gave net cash income between Rp 30,000 and Rp 40,000 per month. The availability of constant cash inflow every two weeks was a great help for farmers' daily life.

Planning for the crop/livestock systems research

Objectives

The main objective of the crop/livestock systems research is to improve the economic well-being of the transmigrant farmers by improving the animal and crop production systems. The primary focus will be on the various systems. The primary focus will be on the various components of these systems such as animal feed and health, varietal improvement and soil fertility and management.

The second objective of the research will be to develop strategies for increasing the cultivated area on land allocated for each transmigrant family. The third and perhaps most important objective is to develop a strategy by which these subsystems may be fitted together into profitable and manageable units recognizing that, initially at least, there will be capital and labor constraints.

Research approach

Socio economic studies

I. Compilation of standard data for ex ante analysis for each agricultural commodity that may be used in farm systems, it may consist of input-output analysis from initially up to maximum production.

II. Market studies of each commodity (locally and internationally) to get an idea of market potential of crop.

III. Baseline study of existing system

IV. Socioeconomic monitoring of existing farm systems over time to get a better idea of farm practices and constraints for:
   a. Planning purposes
   b. Evaluation of introduced technologies ever time
      Rationale: Baseline survey data becomes obsolete and must be modified.

Biological Research

I. Food Crops
   A. Component studies
      - Varietal improvement
      - Soil fertility and management
   B. Cropping systems
      - Fine tuning but basically O.K.

II. Perennial Crops
   A. Component studies
      - Methods of increasing perennial crops (other than rubber) plantation with capital and labor constraints,
      - Basic technology from Industrial/Estate Crop Research Institute

B. Systems Research
- To be done and basically consider as means for land stability and cash income

III. Livestock
A. Component studies
- Animal feed
- Animal health

B. Systems
- To be done but will basically consider:
  * Large ruminants as power source.
  * Goats and sheep as source of supplementary income
  * Chickens as source of supplementary income.

IV. Mixed Crops/Livestock Systems Research

FS - A Existing systems, but without livestock
Approach: Monitor

FS - B Existing systems, and with livestock
Approach: Monitor

FS - C Existing system Gradually Improved
Approach:
a. Improve management (subsidized credit available for livestock)
b. Gradually increase perennial crops
c. Keep within farmers capital and labor constraints

DS - D Improved systems with Intensification
Approach:
a. Improve management
b. Increase perennial crops
c. Assume government intervention for capital and labor constraints

Footnotes and Acknowledgments

1/ Crop-Livestock Systems Research Project Coordinator and Assoc. Professor, Institute of Animal Science, UPLB, Laguna, Philippines; Senior Research Fellow, Rice Farming Systems Program, IRRI Los Baños, Philippines; and Head, Rice Farming Systems Program, IRRI Los Baños, Philippines, and Coordinator, Asian Rice Farming Systems Network, respectively.

2/ With special acknowledgment to the ARFSN collaborators in FSR and crop-livestock research.

3/ Pa-iwi - Traditional livestock rearing-sharing scheme whereby lender provides animal to caretaker. Incremental profit is split 50:50 upon sale, and initial animal value to lender.

References

Crop-livestock workshop proceedings. 1983. Asian Rice Farming Systems Network, IRRI Los Banos, Philippines.

Loosli, J. K. and L.R. McDowell. 1985. The role of ruminants in warm climates. pp. 1-19. In L.R. McDowell (ed.) Nutrition of grazing ruminants in warm climates. Academic Press, Inc. Orlando, F2.

Proceedings, Crop-livestock systems research workshop. in press. Asian Rice Farming Systems Network, IRRI Los Banos. Philippines.