Babon Catchment: The MSEC Benchmark Site in Indonesia

(Based on Country Report)

Introduction

The Indonesian population is estimated to reach 270 million in 2025 and this translates to an increase in food demands of about 30%. For rice alone this means a requirement for 17 million tons increase from the current 53 million tons annual consumption. To be self-sufficient in rice (which is politically and socially important), Indonesia must intensify agriculture by implementing at least medium-input rather than low-input technologies (Eswaran, 1998) and protecting the soil from degradation to ensure sustainability. The fact remains that erosion-prone hilly and mountainous areas are being used intensively for agriculture by the rural poor. This results in aggravation of land degradation brought about by soil erosion. The implementation of soil conservation has been accorded low priority among most farmers because most conservation technology options do not promise direct and short-term profits. Moreover, past recommendations for soil conservation have focused on expensive investments which contradict the reality of the rural poor (Garrity and Agus, 1999; Agus *et al.,* 1998). In addition, policy-makers as well as researchers have not successfully developed on-farm technologies that can address the urgent needs of poor farmers and secure upstream as well as downstream natural resources.

Past research related to these problems and other soil constraints to food production focused on biophysical aspects and technical solutions aimed at improvement and generally were designed without regard to the farmers' conditions. Sites were selected without carefully considering the possible geographical extension of the results. Consequently, farmers' adoption, if any, has been low, slow, and oftentimes unsustainable.

Recognition of this failure led to a re-examination of approaches to research on sustainable land management. Participatory catchment management research using an integrated and interdisciplinary approach has evolved and has been adopted by IBSRAM-MSEC in its research network, including the work in Indonesia. The site selected is the Babon catchment in Kaligarang watershed in Semarang, Central Java.

Benchmark Site

The site (model catchment) was selected based on the representativeness of its land use, topography, socioeconomic condition of the region (main watershed), accessibility, and possible collaboration with existing (research) institutions. In addition, the suitability of the site for hydrological monitoring was also set as a criterion.

Preliminary discussion about prospective research sites was conducted jointly by CSAR and IBSRAM scientists. Three general sites were visited and evaluated based on the aforementioned criteria. These were in Pasaman, West Sumatra, Tulang Bawang Watershed in Lampung, Sumatra, and the Kali Garang Watershed in Semarang, Central Java. The advantages and disadvantages of the different sites were evaluated for the final selection. After so much discussion, the Babon catchment at Keiji village in Kali Garang Watershed was finally selected (Figure 1).

While the watershed in Pasaman, West Sumatra was the best choice from the biophysical point of view, it was disqualified because of poor accessibility. The Tulang Bawang Watershed in Lampung also had poor accessibility although it would have been a good link with the International Center for Research in Agroforestry (ICRAF). As earlier mentioned, the Kali Garang Watershed in Central Java was finally selected as the site for MSEC-Indonesia. Institutional links were made with the Assessment Institute of Agricultural Technology (AIAT) in Ungaran, Central Java, and Agri-business Project (P2SUKA) a collaborative project between CSAR and CIRAD. AIAT conducts mostly on-farm agronomic and socioeconomic evaluation of promising technologies and P2SUKA concentrates on meteorological and hydrological aspects of agri-business on meso-catchments of Kaligarang Watershed.

The Babon Catchment was further identified within the Kali Garang Watershed for the more detailed catchment study (Figure 1). The various land uses of Babon microcatchment, including perennial tree crops, annual upland crops, and lowland rice fields (*sawah*) is the strength of this catchment, but the catchment's steep slopes may be an extreme case in northern Java. The site is described as follows:

Province: Central Java

District/subdistrict: Semarang/Ungaran

Village: Keji

Catchment name: Kali Garang (220 km^2)

Sub-catchment (mesocatchment): Babon (139 ha)

Latitude: 07° 20'; S; Longitude: 110° E

Slope: 15–75 %

Babon Catchment is located about 3 km west of Ungaran and about 20 km south of Semarang, the capital of the province (Figure 1). Accessibility to Keji village is relatively easy and the farmers are under the influence of the urban areas. The distribution of the measuring instruments is shown in Figure 2.

Initial survey was conducted in September 1999 to identify the biophysical condition, farming practices, rainfall pattern, and natural resources (soil, water, and vegetation). The socioeconomic survey was conducted to understand the social, cultural, and institutional problems and potentials. A more in-depth farmer profile survey, including mapping of farm ownership, was conducted from July to August
2000. A combination of open ended and semistructured surveys was used. Biophysical site characterization, which includes contour mapping, soil mapping, and
site geological characterization were conducted from December 1999 to April 2000. A digitized map at the scale of 1:5,000 was produced for contour, land use and soil information. Soils were classified according to the Soil Taxonomy Classification (Soil Survey Staff, 1996).

Characteristics of Kaligarang Watershed

The general description of Kaligarang Watershed is adapted from CSAR (1999). The watershed extends from south to north, from the summit of Mount Ungaran (2,050 m asl) to the coastal line of the Java Sea. Kaligarang River empties into the Java Sea through Semarang city, the capital of the province of Central Java. The total area of the watershed is about 220 km^2. Three tributaries contribute to the Kaligarang River. These are Kali Kreyo (west), Kali Kripik (centre) and upper Kaligarang (east). Geographically Kaligarang Watershed can be divided into three areas:

- The highlands, with elevations between 400–2,050 m asl. are the steep slope area of Mount Ungaran, with an ancient volcano dating back to the Pleistocene era. The geological substratum mainly constitutes basaltic lava. Slopes range from 15–40% and become steeper closer to the summit. Drainage patterns (hydrological networks) are composed of concentric narrow valleys formed by rapid flows due to torrential rains. Forest still covers the steepest slopes, but annual food crops and various estate crops (rubber, cloves, and tea) dominate the area with 400–1000 m elevation.
- The Intermediate Plateau, with elevations between 50–400 m asl., corresponds to a hilly region with the geological substratum constituting volcanic breccia, tuff, and sandstone. The hydrological network spread out in three tributaries that pass through winding and narrow valley bottoms. The river beds are overlaid with stones indicating the occurrence of flash floods. The landscape is covered by a mosaic of agroforestry gardens, villages, and rice fields.
- The 10-km wide coastal plain, which used to be swampy alluvial plain, is now widely built up, including fishery and pond areas. The three tributaries merge into Kaligarang River near the border of the coastal plain and the intermediary plateau and the Kaligarang River is canalized from Simongan reservoir to the sea.

Geology and parent materials

Based on a geological map (Magelang-Semarang sheet), at a scale 1: 100,000 (Thaden *et al.,* 1975) the study area belongs to the formation of Central Ungaran lahar (cinders) and volcanic rocks from the Pleistocene-Holocene (Quarternary) age. The lahar and lava consist of andesite and basaltic rocks.

Visual field observation shows that the soil in the study area on the middle volcanic slopes is derived from intermediary tuff, volcanic ash, intermediary volcanic rocks (andesite), and mafic rocks (basalt) while the valley bottom developed from alluvial and colluvial materials resulting from gravitational translocation. Soils derived from the volcanic tuff and ash have a bulk density of 1.0 g cm^{-3}, light colour, and contain volcanic glass (Puslittanak, 1995). The intermediary volcanic rocks (andesite) generated dark coloured soils and a relatively high soil pH (>6.0). Part of the lava and cinders in the form of boulders and rocks protrude on the steep slopes.

The study catchment consists of a middle volcanic slope from the Ungaran volcanic system and valley bottom in the middle of the catchment (CSAR, 1997). The land was formed as a result of Mount Ungaran activity that yielded lava and lahar flows, tuff eruption, and volcanic ash. The volcanic activity also resulted in hill formations stretching from south to north. The secondary process resulted in valley formation between the hills in which Kalisidi River and Babon, Jaru, and Kembloso streams flow.

Land use

Agroforestry (a mix of perennial tree crops and annual food crops) and lowland rice fields (*sawah*) dominate the land use of Kali Garang. Homesteads and industry occupy about 4,500 ha (20%) of the land (Table 1) and the change toward this land use from agricultural purposes has been very rapid. Moreover, homesteads
and industries extend from the steeplands to the city and this has been attributed by local officials as a contributing factor to frequent floods. Despite the rapid development of industry and housing, agriculture will remain an important field of employment, especially because it needs a large labour force. Agricultural commodities diversify from food crops to fruits and animal products as a response to urban demands and more competitive benefits from nonrice commodities. Meanwhile, off-farm employment has become increasingly important.

Biophysical characteristics of Babon catchment

Topography

The study area is located at an elevation between 390–510 m asl. Around 55% of the area is steep to very steep (25–75 % slope) and only a small portion of the valley bottom has plain and undulating slopes (Table 2 and Figure 3). Most of the land, including parts of the upland and the lowland rice fields, has been bench terraced.

Soil

Soils in the area are determined primarily by parent materials, while other soil-forming factors did not really affect the soil type. Soil families and main land uses are given in Table 3. The soil map (Figure 4) consists of 15 land units as listed in Table 4. Grouping of land units was based on soil family, slope classes, and land phases. The presence of an aquic moisture regime and the existence of streams in the catchment enable lowland rice (*sawah*) production.

Socioeconomic setting of Babon catchment

History

Keji, the village where Babon Catchment is located, is a dynamic village in terms of agricultural, social, and economic conditions. A study conducted by Ungaran Assessment Institute of Agricultural Technology (AIAT) (Prasetyo *et al.,* 1997) described the time trend of land uses of Keji village. During the Dutch colonial period, before 1942, the area was dominated by kapok (*Ceiba petandra*), and rubber (*Havea brasiliensis*). In 1942 there was a promotion of castor bean planting for castor oil production. In 1952, probably due to difficulties in processing and marketing, castor was completely removed and the successive plants diversified to coffee (*Coffea robusta*), durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), jackfruit (*Artocarpus integra*) etc.

In 1977, sand mining activities for construction are believed to have diverted water supplies away from agriculture. Chemical fertilizers were introduced in the same year and several farmers planted cloves (*Eugenia aromatica*). In 1979, farmers found that rubber was not profitable and replaced it with durian. In 1979 and 1980, nonagricultural developments were also progressing and these included road pavement and domestic water supply networks using PVC and plastic pipes. A re-greening (afforestation) programme was introduced in 1984. In 1990 house construction was intensified. Two urban-based businessmen obtained certification of land believed to be owned by the government during the Dutch colonial period (one was granted 25 ha land and the other 17 ha), but villagers have farmed the land for generations without a formal certificate. Local farmers then became shareholders on the lands.

In 1992 sand mining was intensified and this believed to have diverted water supplies further from lowland rice fields. In 1996 an irrigation dam was constructed on Babon River, but in only one year, the construction collapsed. Food crop based farming for corn, cassava, and peanut was also common historically.

History suggests that farmers have experimented and selected technologies they consider appropriate. They have shifted and diversified from one commodity to the other. Thus it is imperative in this study to learn from farmers about their experiences and to blend the existing knowledge with scientifically proven technology innovations.

Farming, on average, contributes to less than 50% of family income, but farmers perceive farming as important for food security and as an additional income source. Any soil erosion management to be introduced must have significant production prospects, otherwise it will be unpopular.

Local organizations

At the village level, a farm credit recipient group (KUT Group) has been established. A similar programme in the past tended to form farmer groups but the groups disappeared with the completion of the programme. The potential of a group's role for diffusion of technology between members is still difficult to assess at this stage, but at least the members seem to respond positively to our bottom-up, interdisciplinary approach. Most of the former programmes, according to the farmer group members, came with subsidized inputs or farm credit, but farmers are also hoping to have more technical guidance.

The office of the village head is considered to have an important role in farming as well as in any other development programme because every new programme should be acknowledged and registered by the village head office. A few personnel at the office, such as the Village Secretary appear to be very familiar with the farming programme and farmers' concerns.

There were a number of well-respected key persons in the village. In previous government programmes, however, they were not well identified and thus were not asked for advice. We believe that their direct involvement in the programme, including the MSEC research programme, would smooth our interaction with farmers. Family ties and a communal system was strong among villagers and this means that conservation efforts may be more successful if developed among people having communal ties.

Land tenure and urban influence

The land tenure system in Kali Garang Watershed is variable and this is reflected by the tenure system in Babon microcatchment. The lowland rice fields (0.05–0.25 ha), are cultivated either by owners or shareholders. One farmer can farm on more than one small plot. The same patterns of tenure system and farm size are also found in the upland areas (Setiani *et al.,* 1999), especially on food-crop based upland fields.

Some land owned by landlords or companies based in Semarang city is mainly planted to rambutan. However in 1998, with reform jubilation, villagers claimed land rights to cultivate the tree farm floor with annual crops such as taro (*Colocasia esculenta*) and other shade-tolerant crops. With slopes as steep as 45–75% there is a growing concern among the local government that cultivation of the land may contribute to significant amounts of sedimentation. For Babon microcatchment, the landlords seem to be cooperating with researchers and extension workers to allow management of their land as long as the tree crop yield is not reduced.

With this wide variety of social backgrounds it appears that several approaches will be needed to facilitate farmers to manage their land judiciously.

Employment

The total population of Keji village is 1,812 people and the population density is about 1,000 persons km^{-2}. The proportion of male to female is about 1:1. Most villagers consider themselves as farmers although about one-third of them work off farm (Table 5) from which several families can generate income higher than from on-farm sources (Tables 6 and 7). During the off season many villagers take off-farm employment in construction, sand mining, and trading sectors to complement the on-farm income.

From on-farm sources only about 22% of the villagers can make >Rp.2,000,000 annual income, while off farm, around 40% of the village labour force can expect >Rp.2,000,000 annual income (Table 6). The main reasons for low on-farm income include small farm size, low inherent soil fertility, planting of low value crops, and low-input technology implementation. It seems the opportunity to make higher income is greater from the off-farm than the on-farm sector and this reflects a greater attraction for off-farm than on-farm activities. On average, 36% of family income is earned from off-farm sources (Table 7). This creates a bigger challenge for the agricultural sector to come up with more profitable technology.

Expenditure is mainly (60%) used for food and clothing while investment for agriculture and education is only 5 and 4%, respectively. Interestingly, 18% of expenditure is allocated for social events and 13% for miscellaneous secondary consumption. Thus, agricultural extension will face the challenge of how to educate farmers to reallocate their expenses.

Villagers' mobility

To complement their low income, villagers migrate either seasonally or permanently, voluntarily or through government programmes. Migration can be classified into three categories:

- **Commuting** to Ungaran and the surrounding areas for jobs with garment manufacturers and soft drink industries. This kind of employment generates around Rp.4,800,000 to Rp.9,600,000 annual income and this becomes the main employment for young female villagers. Male villagers take jobs in public transportation, and as labourers and traders as their main off-farm employment and such work can generate annual income as high as Rp. 4,800,000–Rp 18,000,000.
- **Off-season or voluntary migration** – Off-season migration to Jakarta, Semarang, and other cities as traders, or voluntary migration to major cities in Java or to the outer islands of Java as traders and labourers. Such migration is usually done by the heads of households and they visit their family every 2–6 months.
- **Transmigration** to Irian Jaya and Kalimantan. This is the last resort when there is no opportunity to obtain other on-farm or off-farm jobs.

Stakeholders

Several institutions are directly involved in Kaligarang Watershed management as shown in Table 8. This fact opens ample opportunity for MSEC to learn from the successes and failures of ongoing and completed activities. In addition, interaction with existing institutions, to be complementary and not to overlap in the programme, will be among our primary agenda. Furthermore, empowerment of the local community to manage the land, with researchers' (and extension workers') facilitation has been and will continue to be our main approach.

Land use and vegetation

A field survey of land use conducted in April 2000 revealed 10 different land uses in the 139 ha Babon Catchment (Table 9 and Figure 5). Paddy fields stretch along the valley bottom, and various dryland crops, including rambutan (*Nephelium lappaceum*), annual food crops, bushes, nutmeg (*Myristica fragrans*) and intercropping cassava (*Manihot esculenta*) between various perennial crops including coconut (*Cocos nucifera*), sego (*Arena pinnata*), robusta coffee (*Coffea robusta*), durian (*Durio zibethinus*), and banana (*Musa paradisiaca*) are found on the upper and the middle slopes (Figure 6). Tree density under traditional agriculture is sometimes very high (less than 3 m apart). Rambutan orchards and nutmeg farms are owned by a few landlords and the villagers cultivate lowland rice, upland food crops, and various perennial crops. In general the local farmers implement low-input (labour and supplies) agriculture. For annual upland crops, cassava is preferable to peanuts, corn etc., because of low-input requirements. As shown in Table 7, only about 5% of the family expenditure is allocated for agricultural inputs. Since the farmers' main objectives are to minimize inputs and maximize products, it appears that long-term investments such as for soil conservation is unattractive (Setiani *et al.*, 1999) unless low-cost and income-generating techniques are offered.

To overcome low investment and low farming efficiency problems the Provincial Agricultural Service is introducing a pilot project of the communal farming scheme on a 100 ha area. MSEC is waiting for the result of whether larger farm size, managed by the community, will make agriculture more efficient. We foresee, however, that strong and coordinated institutions are the precondition of such communal farming.

Soil fertility and nutrient management

Most farmers perceived soil fertility in the study area as low for land planted to annual food crops. However, due to their inability to purchase complete (NPK) fertilizers and/or high expectation for barnyard manure, only urea and manure are widely used. The use of manure varies depending on availability although some farmers claimed that they may have overused manure. Urea use also varies depending on the farmers' purchasing ability. Some farmers mentioned that they use 50 kg urea 1,250 m^{-2} (400 kg ha^{-1}), a very high rate for lowland rice. Upland food crops, especially cassava, receive no external input. Cassava farming involves only soil tillage and planting using 20 cm long cuttings and the soil is never cultivated until harvest time at nine to 12 months after planting.

Perennial crops such as rambutan (*Nephelium lappaceum*) and nutmeg (*Myristica fragrans*), are mostly under the control of landlords, and the interviewed farmers (mostly shareholders) did not explain the management of the tree crops very well. Tree monocropping is usually found on farms of large (>5 ha) landholdings. Local farmers with small (<1 ha) farm size tend to have complex agroforestry systems with a combination of perennial as well as annual crops. Fruit trees of the smallholder farms are planted from planting materials of variable quality while the city dwellers with large landholdings use grafted seedlings and plant the trees at regular plant spacing.

Soil degradation problems and management

The most commonly recognized erosion is gully erosion and landslides. Farmers are not really concerned about sheet erosion and even if it occurs, they believed that it does not cause a significant decline in soil fertility. Farmers perceive that bench terraces they had constructed almost perfectly control soil erosion and save nutrients from translocation by water. Yield decline over time, for example of cassava, is believed to result from nutrient removal with harvest.

Bench terraces (forward sloping) were constructed in the late seventies and early eighties as part of the national re-greening programme. Terrace raisers and lips are mostly devoid of erosion protecting vegetation. A typical practice in this location as well as anywhere else in Java is that farmers cut thin layers of terrace raisers

during land preparation and they believe that natural vegetation grown on terrace raisers harbours many plant pests, especially rats.

Water problem and management

For the lowland rice fields, water is available for two to three rice crops per year. Only occasionally when the dry spell is extremely dry, such as in 1997, does water availability become a problem. A dam was constructed by the Ministry of Public Works on Babon stream a few years ago, but it collapsed during the first rainy season after the construction. Farmers believed that if the dam had been functional, the chance to have three rice crops per year would have been much higher. For the uplands, water availability is not considered to be a major problem by most farmers.

Re-greening activities

Re-greening is a national scale conservation programme conducted on farmers' land. Bench terracing and perennial tree planting have been promoted as the main conservation measures in the re-greening programme. Tree crops, mainly the so-called multipurpose tree species, MPTS (including *Leucaena leucocephala, Switenia mahagony,* and *Albizia falcata*) are promoted by distribution of seedlings, free of charge. The trees planted two to three years ago sometime are very closely spaced (even less than 2 x 2 m) and they compete with annual food crops which most farmers depend on for their subsistence needs.

Table 1. Land use type and area in Kaligarang Watershed.

Land use	**Area (ha)**
Irrigated lowland rice fields	6,000
Agroforestry garden	7,500
Forest and estate crops	3,500
Homesteads and industries	4,500
Miscellaneous	500
Total	**22,000**

Source: CSAR (1999).

Table 2. Slope classes of the Babon Catchment.

Symbol	**Slope class**	**Area**	
	%	**ha**	**%**
A	0–3	6.8	5
B	3–8	26.9	19
C	8–15	2.9	2
D	15–25	23.6	17
E	25–45	40.8	30
F	45–75	34.1	24
G	>75	3.7	3
Total		139	100

Table 3. Soil family and dominant land use for Babon Catchment.

Soil family	**Main land use/vegetation**
Fine, mixed, isohyperthermic, Aeric Epiaquepts	Lowland rice, 2 crops per year
Fine, mixed, isohyperthermic, Typic Endoaquepts	Lowland rice, 3 crops per year
Fine, mixed, isohyperthermic, Andic Eutrudepts	Upland, mixed crops of cassava with coffee (Coffea robusta), coconut (*Cocos nucivera*), durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), and peanuts (*Arachis hypogaea*).
Fine, mixed, isohyperthermic, Aquic Eutrudepts	Lowland rice (*Oryza sativa*) or root crops, corn (*Zea mays*), or peanuts.
Fine, mixed, isohyperthermic, Humic Eutrudepts	Nutmeg (*Myristica fragrans*)
Fine, mixed, isohyperthermic, Andic Dystrudepts	Rambutan (*Nephelium lappaceum*), cassava (*Manihot esculenta*), *Imperata cylindrica*, and American gooseberry (*Melastoma malabatricum*)

Table 4. Land units of the Babon Catchment.

No.	Soil Family	Slope %	Phase: Terrace height m	Phase: Surface Condition	Area ha	Area %
1	Fine, mixed isohyperthermic, Aeric Epiaquepts	2–8	0.5–1.0	-	16.15	11.6
2	Complex: Fine, mixed isohyperthermic, Aeric Epiaquepts Fine, mixed isohyperthermic, Aquic Eutrudepts	25–45	1.0–2.0	-	2.00	1.4
3	Fine, mixed isohyperthermic, Typic Endoaquepts	0–2	<0.25	-	6.35	4.6
4	Fine, mixed isohyperthermic, Aquic Eutrudepts	2–8	0.25–0.5	-	4.75	3.4
5	Fine, mixed isohyperthermic, Andic Eutrudepts	0–2	<0.25	Gravelly	0.45	0.3
6	Fine, mixed isohyperthermic, Andic Eutrudepts	2–8	0.25–0.5	-	6.05	4.4
7	Fine, mixed isohyperthermic, Andic Eutrudepts	8–15	0.25–0.5	Eroded	2.90	2.1
8	Fine, mixed isohyperthermic, Andic Eutrudepts	15–25	-	-	23.60	17.0
9	Fine, mixed isohyperthermic, Andic Eutrudepts	25–45	-	-	26.10	18.8
10	Fine, mixed isohyperthermic, Andic Eutrudepts	45–75	-	-	29.25	21.1
11	Fine, mixed isohyperthermic, Andic Eutrudepts	45–75	1.0-2.0	Eroded	1.30	0.9
12	Fine, mixed isohyperthermic, Andic Eutrudepts	45–75	1.0-2.0	Stony	1.65	1.2
13	Fine, mixed isohyperthermic, Humic Eutrudepts	25–45	-	-	3.05	2.2
14	Complex: Fine, mixed isohyperthermic, Humic Eutrudepts Fine, mixed isohyperthermic, Andic Eutrudepts	45–75	-	-	1.90	1.4
15	Fine loamy, mixed, isohyperthermic, Andic Dystrudepts	25–45	-	-	9.65	6.9
x	Bank	>75	-	-	3.70	2.7
	Total				138.85	100

Table 5. Population distribution of Keji village by sex and income sources.

Description	Number of persons
Total population	1,812
- Male	918
- Female	894
Number of households	405
Source of income	
• Farmers (owners)	
• Farm labourers/shareholders	310 persons
• Cattle husbandry	62 persons
• Poultry	72 persons
• Off-farm	89 persons
	116 persons

Source: Setiani (unpublished data).

Table 6. Income sources, annual income distribution (Rupiah) and percentage of labour force earning each class of income in Keji village.

Income source and class	Percentage of labour force earning income
On-farm	
➢ 100,000–500,000	33.4
➢ 500,000–1000,000	22.2
➢ 1000,000–2000,000	22.2
➢ 2000,000	22.2
Off-farm	
➢ 100,000–500,000	20.0
➢ 500,000–1000,000	00.0
➢ 1000,000–2000,000	40.0
➢ 2000,000	40.0

Source: Cahyati Setiani (unpublished).

US$1.00 = Rp. 8,000

Table 7. Annual income sources and expenditures of Keji households.

Income		Expenditure	
Source	**Amount, Rp (%)**	**Allocation**	**Amount, Rp (%)**
Annual crops	894,120 (30)	Education	114,496 (4)
Perennial crops	476,864 (16)	Foods, clothing	1,717,440 (60)
Animal husbandry /poultry	536,472 (18)	Agricultural inputs	143,120 (5)
Off-farm	1,072,944 (36)	Social	515,232 (18)
		Miscellaneous	372,112 (13)
Total	**2,980,400 (100)**	**Total**	**2,862,400 (100)**

33US$1 = Rp. 8000

Table 8. Stakeholders and watershed management activities in Kaligarang Watershed.

Institution	Activity
1. Central Java Regional Planning Board, BAPPEDA in collaboration with Gajahmada University, Yogyakarta	• Developed management plan for the watershed (completed)
2. Afforestation and Soil Conservation Service, Dinas PKT	Regreening and conservation activities (terracing, absorption or water retardation wells, tree planting) since 1984
3. Regional Board of Environmental Impact Management, BAPEDALDA	• Various natural resource management programs • Agroclimatic data dissemination
4. District-level Agricultural (food crop, animal husbandry, and estate crops) services.	Promotion of agricultural management for higher productivity and income.
5. Assessment Institute of Agricultural Technology, Ungaran	Assessment and adaptation of site specific agricultural technology
6. Ministry of Public (Civil) Works	Development of irrigation networks, domestic water supplies, roads.
7. P2SUKA (CSAR-CIRAD collaboration on development of Agribusiness farming system)	Watershed-scale research on agro-climate, hydrology, and agribusiness on three tributaries of Kaligarang Watershed and in Sumatra and Kalimantan.
8. MSEC (AARD-IBSRAM collaboration)	Conducting watershed-scale, integrated research on soil management for erosion mitigation and community welfare.

Table 9. Land use/vegetation of Babon Catchment.

Symbol	Land use / vegetation	Area	
		ha	%
Sw	Lowland rice field (sawah)	34.9	25
Tg	Annual crop (cassava, peanuts)	4.0	3
Tg+Tt	Cassava inter-cropped between various perennial tree crops	4.4	3
Rb	Rambutan (*Nephelium lappaceum*)	66.8	48
Pl	Nutmeg (*Myristica fragrans*)	5.2	4
Bb	Bamboo (*Bambusa vulgaris*)	1.2	1
Tt	*Albizia falcata*, coconut (*Cocos nucifera*)	5.0	4
Sm	Shrubs	0.5	0
Sm + Al	Shrubs and *Imperata* grass	9.75	7
Kp+Mj	Coffee (*Coffea robusta*), Gnetum (*Gnetum gnemon*)	3.6	2
X	Cliff	3.7	3
	Total	139	100

Figure 1. Hydrological and meteorological instrument placement within Babon catchment

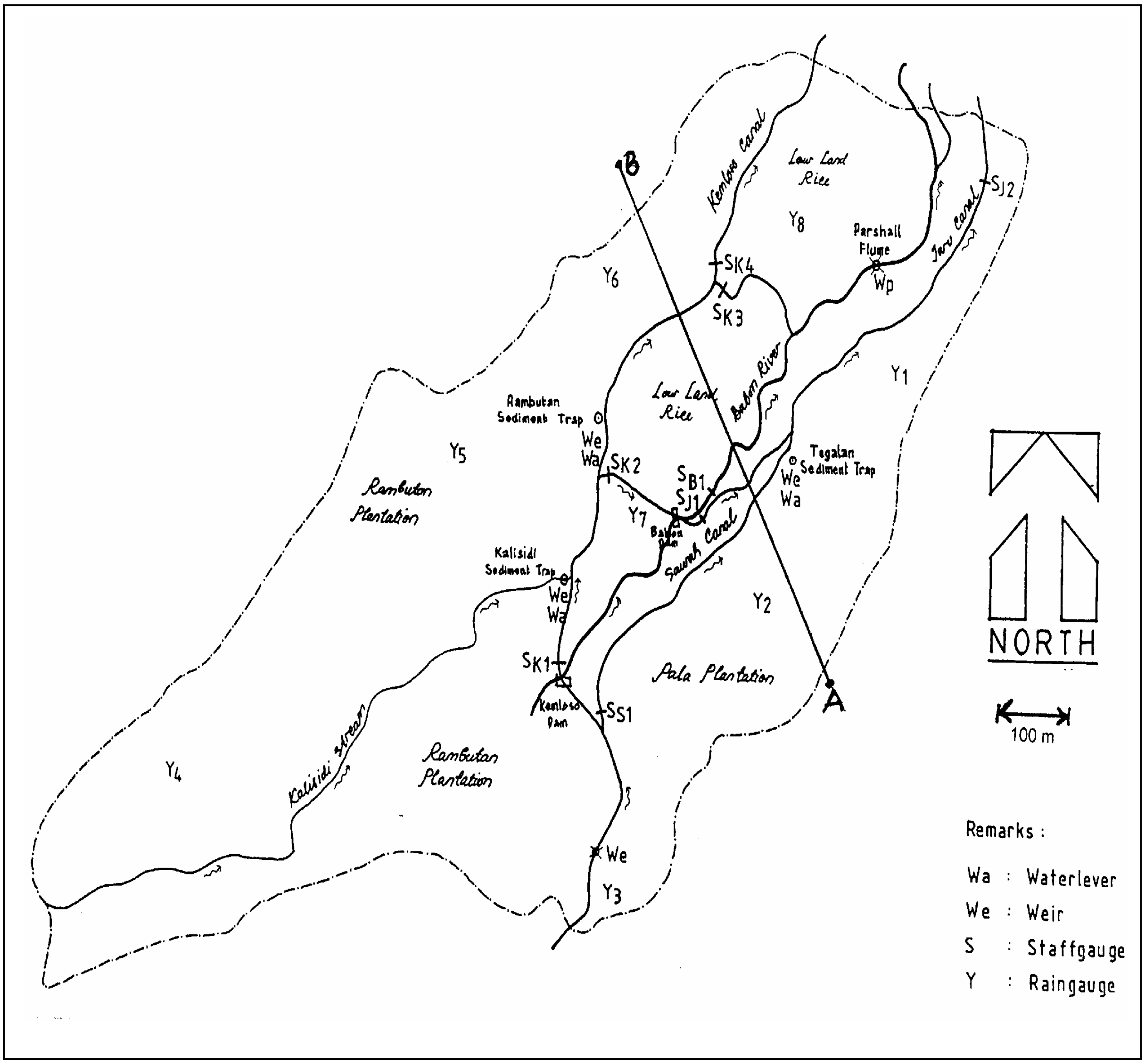


Figure 2. Hydrological and meteorological instrument placement within Babon catchment

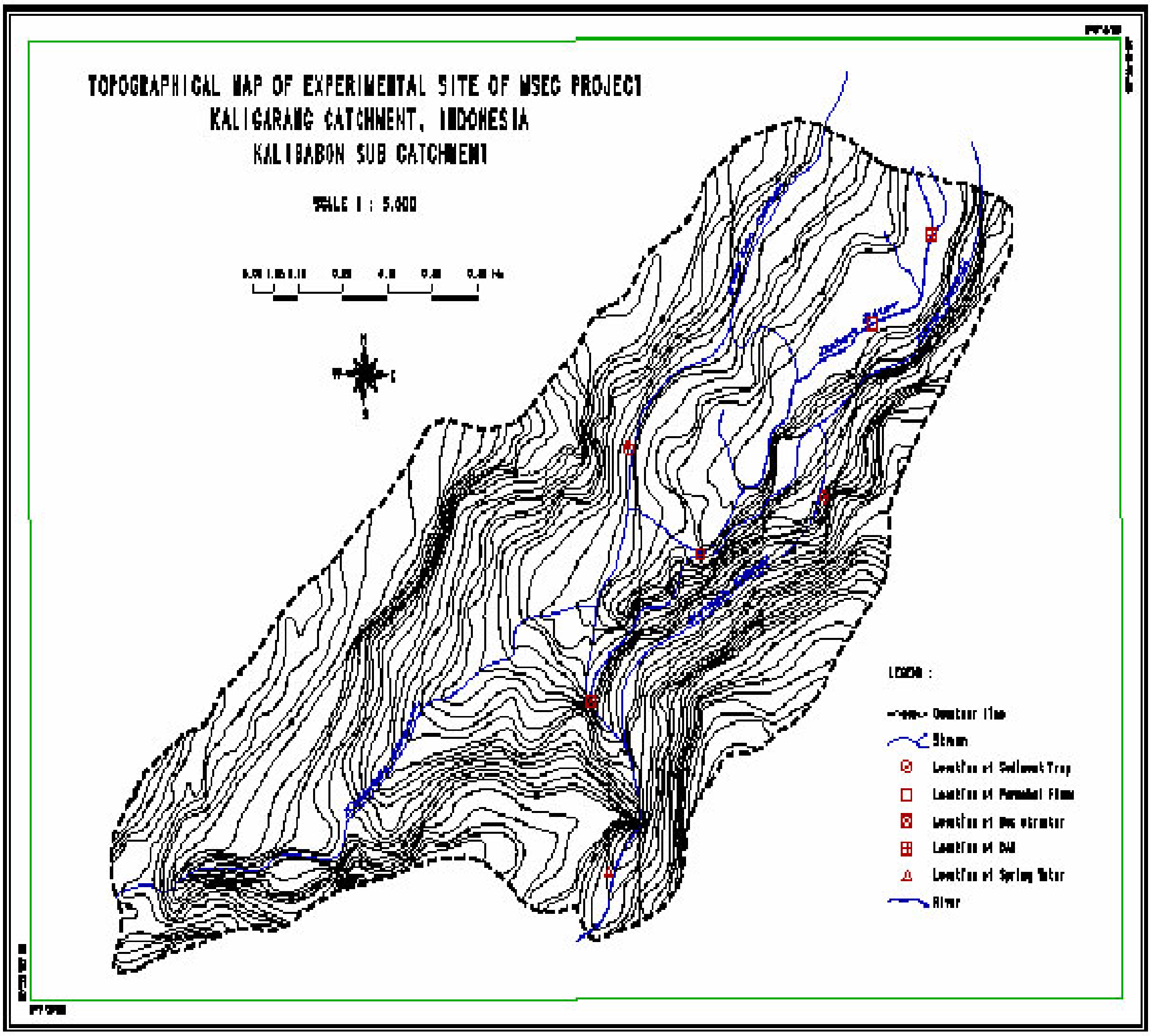


Figure 3. Topographic map of Babon catchment

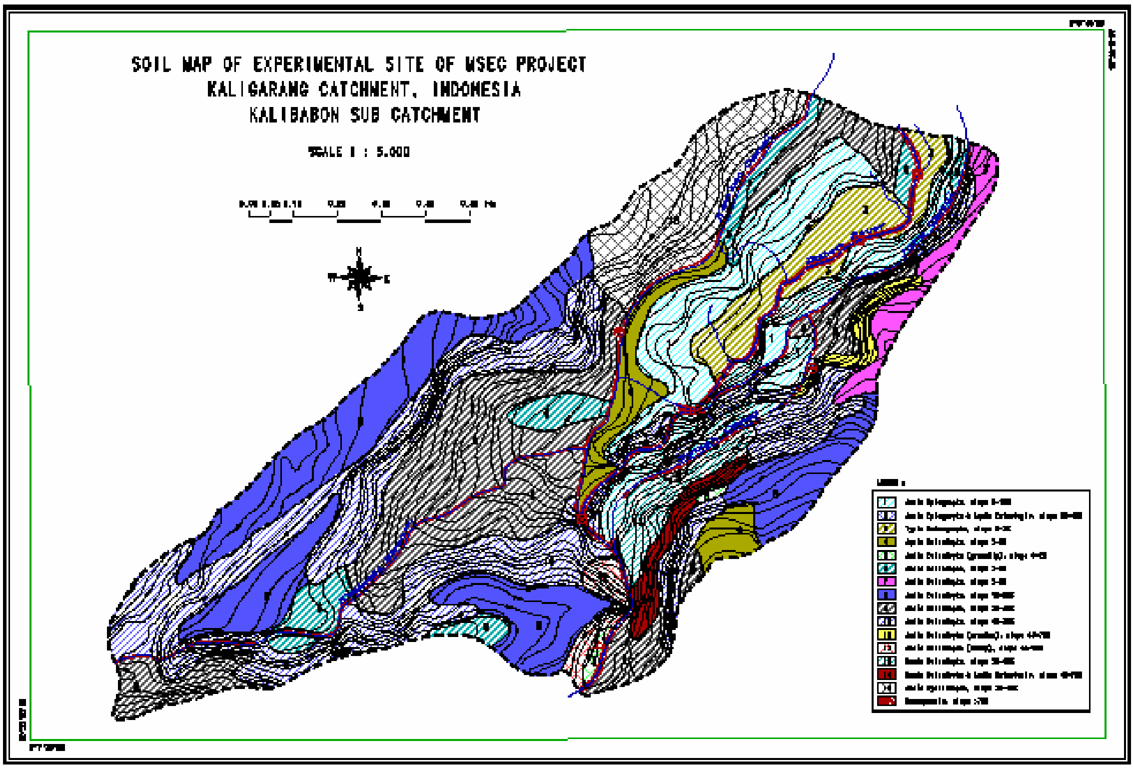


Figure 4. Soil map of Babon catchment

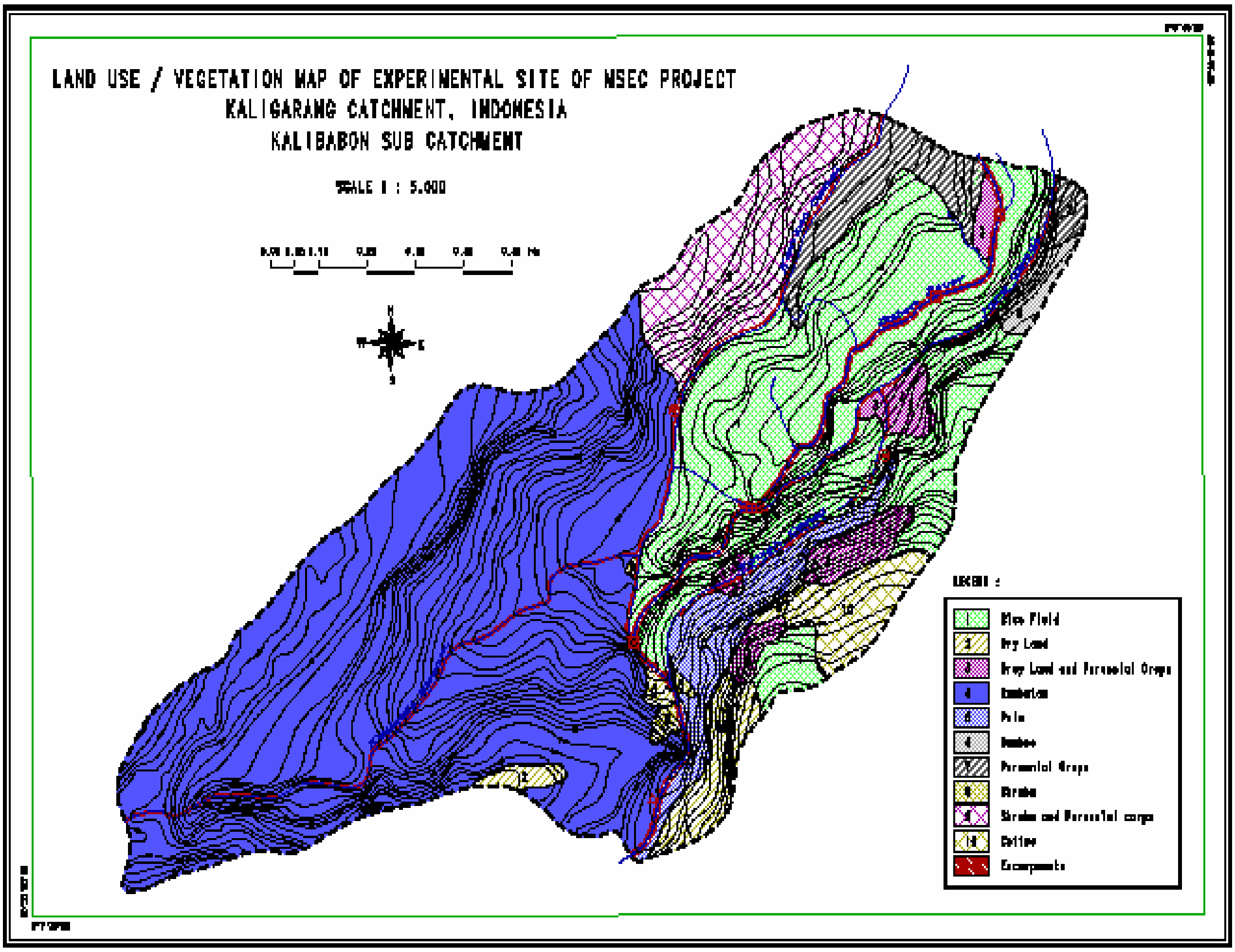
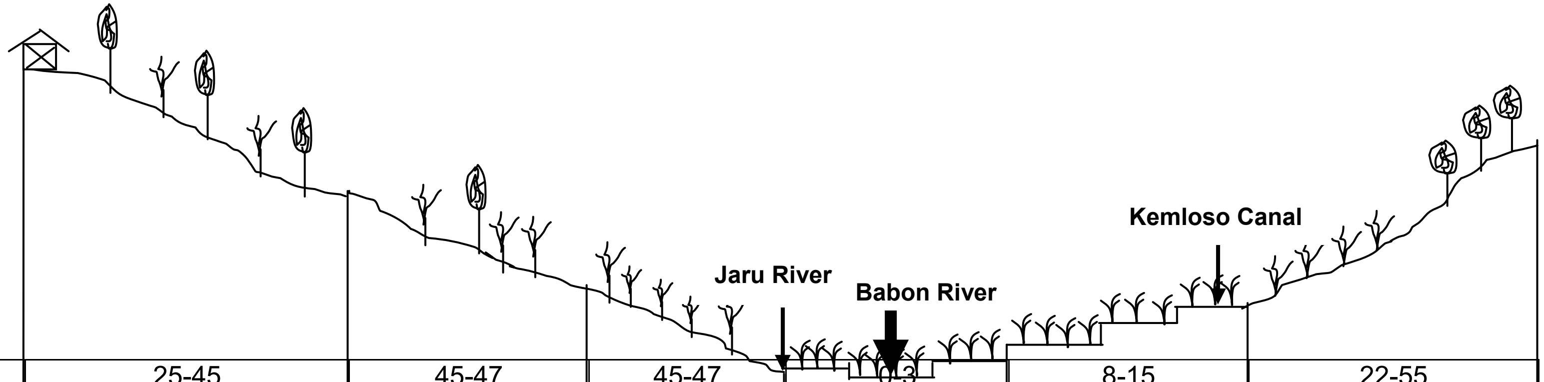


Figure 5. Land use/vegetation map of Babon catchment



Slope (%)	25-45	45-47	45-47	0-3	8-15	22-55
Stoniness (%)	5-10	15-20	15-20	5-10	0	0
Vegetation	Coffee, coconut, durian, cassava, rambutan	Nutmeg, sago	Coconut, cassava	Rice, 3 crops per year	Rice (1-2 crops per year) + secondary crops	Imperata, *Melastoma spp., rambutan*
Parent materials	Intermediary tuff, Igneous rocks	Intermediary tuff, Igneous rocks	Intermediary tuff, Igneous rocks	Colluvial, alluvial	Intermediary tuff	Intermediary tuff
Soil pH	5.5-6.0	6.0-6.5	5.5-6.0	6.0-7.0	5.5-6.0	4.5-5.5
Soil color	Brown	Dark brown	Brown	dark gray	brown with concretion	reddish brown
Soil texture	Clay-loam	Clay	Clay loam-clay	Clay	Clay	Clay loam-clay
Soil Sub-group (USDA 1996)	Andic Eutropepts	Andic/Typic Humitropepts	Andic Eutropepts	Typic Tropaquepts	Typic Eutropepts	Andic Dystropepts

Figure 6. Southeast-Northwest transect (line A-B in Figure 2) of Babon Catchment