Lokale ecologische kennis van bodem- en waterfuncties bij boeren in Sumberjaya, Sumatra, Indonesië.

Farmers' local ecological knowledge of soil and watershed functions in Sumberjaya, Sumatra, Indonesia

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Scriptie voorgelegd aan de Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen voor het behalen van de graad van Bio-Ingenieur in de Landbouwkunde.

Academiejaar: 2003-2004

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Annexes

Annex 1: More detailed review of the history of the Sumberjaya watershed

The Sumberjaya area has a long history of human use, as indicated by megalithic remains and Chinese ceramics resulting from long distance trade relations. However, population densities were low until about the year 1900. In the end of the 19th century the Semendonese, coming from South Sumatra province, were the first ones to migrate into the Sumberjaya watershed. They settled in the Western part, founded Sukajara, the oldest village in Sumberjaya and claimed the land, before migrating further southwards since the 1920's. In the beginning of the 20th century, the so-called jungle coffee (kopi rimba) system was practised. It consisted in clearing the underbrush and cutting some of the trees, followed by planting coffee under the forest canopy. The coffee trees were not pruned and grew up to 8 meters; hence branches had to be bent over for harvesting the coffee cherries (Verbist *et al.*, 2002).

Later, the so-called *ladang berpindah* system or shifting cultivation was practised on the slopes in Sumberjaya. After clearing and burning the forest, upland rice was sown and simultaneously coffee was planted. In the second year, annual crops like maize and tubers were grown, while in the third year the coffee plants started to give a small harvest. The fourth year usually gave a bumper harvest, but from then on, yields decreased continuously. During the regeneration fallow of 7 to 30 years, the secondary forest could recover. Every third year the farmer opened a new part of the forest to start the ladang cycle (Ultee, 1949).

In 1935 Huitema describes the coffee cultivation: "The population in Way Tenong [now known as the sub-district Sumberjaya] is still very scarce. Besides the old forest on the slopes of the surrounding mountains and the vast secondary forests, one can find coffee gardens in all stages of development. The local population sees the soil as very fertile and suitable for coffee cultivation. The fact that large-scaled exploitation has not taken place yet is because of the isolated location of this sub-district. The opening of new roads in 1918 and 1925 in the western part gave boost to the cultivation of Robusta coffee."

The governmental transmigration programs of the BRN (Biro Rekonstruksi Nasional) caused settling of Sundanese independence war veterans in Sumberjaya in the early 1950s, and also triggered spontaneous migration from Java and Bali and of earlier transmigrants (Charras, M and M. Pain, 1993), attracted by the good soils (Benoit, 1999). The Javanese and Sundanese migrants converted the natural valley bottoms to paddy rice fields, and introduced the techniques of irrigated rice cultivation. Construction of the road between Simpang Sari and Bukit Kemuning in the early fifties removed the constraint of limited food security based on local rice production as a better market connection did not only allow for increased exports

of coffee and wood, but also for imports of rice (Suyanto, 2000). This drop in transport costs and also the high coffee prices encouraged the Javanese and Sundanese to deforest slopes and to practice the so-called Semendo or ladang system. (Sumberjaya literally means 'source of wealth'). This massive deforestation led to the current conflict between the state guardians of the protection forest and the farmers (Verbist, 2001).

Shifting cultivation was still practised until recently, until the intense immigration of mainly Sundanese and Javanese farmers had caused the population density to become too high to permit long fallows. As a result, the Semendonese farmers were forced to leave the area and continue shifting cultivation in less densely populated forest zones or to abandon their traditional cultivation system and adapt more permanent and intensive agricultural methods as introduced by the same immigrants. Currently, shifting cultivation is not practised anymore in the Sumberjaya area. However, to clear new land for more intensive and permanent fields, the farmers still apply the slash-and-burn methodology.

This transmigration and the resultant increasing population were the major driving forces for drastic land use changes in the hilly area of Sumberjaya the last few decades. In the early 1970s, most of the area was still under forest cover, with some upland area under shifting cultivation of crops and vegetables and some paddy rice in the lower valleys. In the following years forest and upland fields were converted to infertile grasslands (because the fallow cycle of shifting cultivation became too short for regeneration of the forest) and coffee plantations, with an establishment of monoculture plantation, which were later, from the second half of the eighties, converted to mixed plantations (Syam *et al.*, 1997). Because of the enormous immigration in the 1980s (the population doubled in only ten years) triggered by the high coffee world market prices, all shifting cultivation fields and grasslands have been converted to a more productive use. Because of the massive dieback of cloves in the early 1980's, which until then made up most of the upper stratum in many coffee gardens, a lot of sun coffee appeared in those days (Verbist *et al.*, 2002). In 1987 ten thousand coffee planters from the slopes of the Sekincau volcano in West Sumberjaya hired a private company from Jakarta to enlarge the access road to their villages. With the coffee boom, it was profitable for the farmers to make this big investment of about 250 kg of coffee per household themselves (Mougeot, 1990). The consequent decrease of transport costs made that even larger forest areas of the Sekincau volcano alongside the borders of the Bukit Barisan Selatan National Park were cleared to be converted to coffee, which triggered reaction from the Forestry Department (Verbist at al., 2002).

The last ten years the immigration balanced the emigration so the population growth is almost zero (Tandean, 2000). Recent field interviews revealed that since the late nineties, many young families migrate further north (up to Bengkulu), where there is still forest and land available (Verbist *et al.*, 2002).

The rapid conversion of forest to coffee gardens after 1978 triggered commotion among foresters. There is an old widespread perception that local people would be unable to manage forests in a sustainable way (Huitema, 1935; Junius, 1933; Kusworo, 2000; Elmhirst, 1996).

The Department of Forestry stepped up its efforts to remove people from the vast areas (75% of the nation's territory) that are officially classified as State Forest Land (Li, 2000). Sumberjaya is the source of some major watersheds in Lampung province and that is why forest protection schemes such as forest zone designation, settlers eviction and reforestation have been implemented. Since 1970, zones have been delineated as State Forest according to the areas classified as 'Boschwezen' by the Dutch administration in the 1930s, although villagers claim that previous governmental officials have officially transferred some parts of the land to them. The protection forest zones, installed under the Forest land Use Plan TGHK (Tata Guna Hutan Kesepakatan) in 1990, seem to be merely a restoration of the maps of the Dutch and unilaterally revoke decisions and decrees from earlier Indonesian authorities concerning land use and land use rights (Verbist, 2000).

Up to now, the precise location of the boundary of the forest zone remains unclear, being depicted differently on various official maps. Anyway, the farmers' proposition to have the right to manage lands within the forest zones has been completely ignored. Any kind of occupation of the protection forest zone was formally forbidden (Kusworo, 2000). The fact that the 'new' boundaries of the State Forest Land were taken so large criminalised a large part of the local population, which caused conflicts and probably even promoted further deforestation.

Since the mid-1970s, some areas of cleared land have been reforested or intended to be reforested and since the late 1980s, the provincial government started to evict settlers, destroying their coffee gardens and houses located in the protection forest zone. This Translok (Transmigrasi Lokal) Program aimed at a better distribution of Lampung's population and to reforest Protection Forest areas and critical watersheds. Thousands of households were evicted; a part of them was transmigrated to North Lampung while the rest had to leave on their own. Also people from villages founded by the BRN (and thus by the government) were forced by the local authorities to move (Verbist *et al.*, 2002).

In mid 1994, the construction of the World Bank funded Way Besai HEPP (hydroelectric power plant) Project started, and to support this project the Forestry Department would enforce boundaries of State Forest land together with a reforestation throughout the entire water catchment area. Other watersheds such as the Way Rarem and Way Umpu were also affected for reasons of conservation of irrigation networks downstream (Kusworo, 2000). This led to a second wave of evictions and demolition in the villages located in the protection forest zone. Because of the large protest and objections of the villagers, asking the status of their land to be officially clarified, the destruction of coffee farms and houses has been halted since 1996. The relation between local communities and forestry officers was at its lowest point, and a clear land ownership status still has not been obtained. The regulations did not achieve their objectives as all coffee gardens destroyed and reforested are being reopened massively since mid 1998. Due to the 'Reformasi' movement following the economic and monetary crisis, the weakening of the centralised power diminished the enforcement capacity of the Forestry officials. This, together with high coffee prices, caused that natural forest clearing reached a new peak from 1998 to 2000 (Kusworo, 2000). This second coffee boom in 1997 increased the farmers' income so they could invest in transport means as motorcycles in order to deliver the coffee straight to the trader and get a better price (Verbist *et al.*, 2002).

Responding to international criticism, NGO campaigns and the threatened disruption of timber exports, the Minister has acknowledged that forest-dwelling communities which have customary conservation practices and local capacities for collective organisation and discipline may be able to play a role in forest management. The Department has therefore conceded the issue of knowledge, but rejected the discourse that grants to forest dwellers traditional and enduring rights for the land currently under Forestry control. Those who are permitted to remain on land officially classified as State Forest Land must do so on terms defined by the Forest Department (Li; 2000).

The Forestry Department started realising that their hard approach did not work and participates now in the negotiation support system for Community Forestry Management Schemes. Villagers hope that some part of their territory can be reclassified as private land and local communities hope to get formal recognition to manage their coffee farms in forest land through HKm (Hutan Kemasyarakatan: community forestry) certificates. Contracts and agreements between the Forestry Department and farmer groups could be used as tool to control how farmers use forest land. One of the constraints is that there are no clear criteria or guidelines on how farmers should manage this forest land, which creates a very confusing

situation for the local community. Some farmers organised themselves in ‘pre-HKm’ groups to fulfil the prerequisites (such as map, management plan and group legalisation), and to co-ordinate the procedure of application in order to get formal right to manage State Forest Land (Kusworo, 2000). By now (August 2002), temporary permits have already been given to 2 farmer groups in Gunung Terang village. Twelve other groups have applied and are in negotiation.

Deforestation still continues. Only on the crests, ridges and very steep slopes there is still forest left, where it would hardly interfere with watershed functions. Paradoxically, it seems that there are more trees in the coffee gardens on the private land than in the State Forest Land (Verbist, 2001).

Annex 2: Current farming in Sumberjaya

Coffee gardens (kebun kopi) are the dominant land use in the entire Sumber Jaya region. The types of gardens vary from monoculture to mixed agroforestry. The cultivation of these gardens is intensified by coffee rejuvenation and diversification with other components such as annual crops, short-term perennials and timber or fruit trees. Application of organic and chemical fertilisers and of pesticides, and conservation practices such as ridging, pitting and terracing of slopes are commonly used. Average coffee yield is around 1.5 ton per hectare (Kusworo, 2000).

Quite some families have both irrigated rice fields (sawah) and coffee gardens (kebun kopi), which provides them the ideal combination of cash and food commodities. In their home gardens (pekarangan), families plant vegetables, spices and medicinal plants for local consumption, and some raise goats and chickens. Many households also have fishponds for production for the local market (Kusworo, 2000).

Coffee farms are the main factor used by local farmers to classify families into poor, medium and better off. Poor farmers are landless farmers without permanent houses. Medium families are smallholder farmers that own less than 2 ha, have semi-permanent houses and can only afford inputs through loans. Families that are considered better off own more than 2 ha, have a permanent house and vehicle(s), can pay external labour and are able to buy inputs. Some farmers are organised in co-operative groups, often evolving to HKm (community forestry) groups (Kusworo, 2000).

On the world market, Lampung coffee is known for its medium to low quality, which reduces the low market prices even more. Within Lampung, the sub-district of Sumberjaya is known for its low coffee quality, mainly caused by factors at farm level. Labour is insufficient during the harvest season, which causes the farmers to harvest by strip picking, whereby all the cherries from a branch are collected without consideration of the degree of maturity. Green picked cherries dry more slowly, tend to blacken and produce a less tasteful coffee after roasting. Often up to 80-90% of the cherries are picked green. Coffee is dried directly on the ground or on mats, so it gets wet every time it rains. The hulling also happens on the farm, which induces a further quality loss by creating a lot of broken beans. Merchants tend to homogenise the coffee, which results in poor quality coffee, because the current price structure gives a better price for a larger quantity hence more intensive treatment to upgrade the quality is not profitable. The farmers will not invest in producing coffee of better quality

because they know that they will not get a better price for it. The absence of a price system based on quality inhibits the production of good coffee.

The government promoted the planting of Arabica coffee in one village in the eighties in an attempt to improve the quality, but villagers started to uproot this coffee since they get the same price per kg as for Robusta coffee while the yields per ha are much lower. An attractive price coupled to high quality coffee is what stimulates complex coffee agroforests in Latin America, but the current price structure in the south of Sumatra only stimulates mass production at the expense of quality. Rewarding quality production could increase both farmer income and agro-biodiversity as in Latin America; however, this can only be achieved by removing the current negative market incentives (Verbist *et al.*, 2002).

Annex 3: Coffee farming typology

Agroforestry can be defined as a dynamic, ecologically based, natural resources management system that, through the integration of trees in farmland and rangeland, diversifies and sustains production for increased social economic and environmental benefits (Leakey, 1996, 1997).

The coffee gardens in Sumberjaya can be classified according to three criteria: vegetation structure complexity, management intensity and security of land tenure (Budidarsono *et al.*, 2000). The vegetation structure complexity varies between the extremes of simple monoculture and mixed agroforest coffee. Three types of management can be distinguished. The traditional pioneer system as applied by the Semendo is some kind of shifting cultivation technique without external inputs. Migrants in old coffee gardens mostly practise the semi-intensive system with low external inputs. The intensive system on the other hand is characterised by intensive measures to increase the productivity per unit of land. Two determining forms of land tenure have been observed: coffee gardens on private land (tanah marga) and coffee gardens on state forest land (hutan kawasan) (Budidarsono *et al.*, 2000).

Based on information from Chapman (2001), Verbist *et al.* (2002) and own field experience, a more pragmatic classification can be made, which does not account for every variant within the continuous range between simple monoculture sun coffee and complex multistrata gardens that can be seen in Sumberjaya, but has been proven to be useful in the field. This classification distinguishes five garden types, as there are pioneer coffee, monoculture sun coffee, coffee with simple shade, coffee pepper gardens and complex multistrata polyculture gardens.

Pioneer coffee refutes to recently established gardens on converted forest or scrubland. These young plantations are clean weeded and lack well-developed earth constructions for soil conservation. Shade trees are absent or recently planted and still too small to fulfil their any role of significance. Sometimes annual ground crops such as peanuts, chilli and tomatoes are planted between the coffee rows to have some yields while the coffee is still unproductive. In all cases pioneer coffee can easily be identified by the presence of large patches of bare soil. The method of establishing these permanent coffee gardens has a lot in common with the previously practised ‘ladang’ shifting cultivation system. This young coffee evolves to a sun coffee system or a simple or complex shade garden.

Monoculture sun coffee plantations are characterised by the absence of shade trees. These gardens are intensively managed and highly productive but also require quite some

input of agrochemicals. If these inputs are not given, the soil is rapidly exhausted resulting in a shorter coffee life cycle.

Simple shade coffee gardens possess scattered shade trees of less than three different species forming a thin and irregular overstorey. The most common shade tree species found in these gardens are *Erythrina spp.* (dadap), *Glyricidia sepium* (kayu hujan) and sometimes *Leucaena glauca* (lamtoro) or *Albizzia falcata* (sengon laut), often with pruned canopies. Vertical structural diversity is still rather poor.

Coffee pepper gardens can be recognised by alternate rows of coffee trees and pepper vines. The same shade tree species as found in simple shade gardens are used here as trellis for the pepper crops, especially *Glyricidia* seems to be preferred, which makes the upper canopy of shade trees more complete. Fruit tree components can be present, but are most often found clustered or along the garden boundary.

The multistrata polyculture coffee gardens can be called true coffee agroforests, consisting of coffee planted under shade tree species as in more simple gardens but often of a bigger size, and mixed with a variety of beneficial plants as fruit trees, nuts, vegetables, medicinal plants, etc. Weeding is done regularly, coffee trees are often pruned and topped, but not in all cases and the soil is sometimes fertilised with organic manure or now and then with chemical fertiliser. It occurs often as home garden nearby settlements and supplies the households with more diversified products and services, functioning as a buffer when coffee prices are depressed.

A recent survey in Sumberjaya showed that the multistrata system is dominated by *Erythrina* with additions of fruit trees as *Durio zybethinus* (durian), *Nepthelium lappaceum* (rambutan), *Mangifera indica* (mango), *Artocarpus heterophyllus* (jack fruit), *Psidium guayave* (guava), *Persea americana* (avocado), *Syzigium grandis* (jambu), *Musa paradisaica* (banana), *Theobroma cacao* (cocoa) and other species as bamboo, *Borassus flabellifer* (sugar palm), *Aleurites molucana* (kemiri or candlenut), *Ceiba pentandra* (kapok), *Parkia speciosa* (petai or stink bean), *Gnetum gnemon*, *Syzyium aromaticum* (clove), *Cinnamonum zeylanicum* (kayu manis or cinnamon), etc (Liswanti, 1999). Strikingly, Holle already recommended a lot of these species in 1863 for coffee gardens of which the production is declining and for which the need for renewal is high.

A profitability assessment carried out by ICRAF has revealed that the coffee farming systems in Sumber Jaya are financially and economically profitable. This is one of the main reasons why there has been so much spontaneous migration towards Sumberjaya. It is interesting to note that in the complex agroforest system where only medium levels of

external inputs are applied, the return to land is slightly higher due to higher revenues from other commodities (Budidarsono *et al.*, 2000).

Annex IV: Topic lists used as basis for interviews

All these topic lists were originally composed in Indonesian language. Here you can find the summarised versions in English.

Topic list for interviews with farmers

Background data:

- name, ethnic group, educational level
- Since when are you in Sumberjaya, where did you come from, with whom, and since when did you start cultivating?
- What kind of fields do you have, size of fields, land tenure situation?
- Is farming profitable or not, which problems do you face and how can you solve them?

Landscape approach

- how steep is your field?
- water availability?
- ideal landscape positions for coffee and paddy rice cultivation?

Soil:

- what kind of soil do you have?
- which kind of soils are most suitable for coffee or paddy rice and why?

Water:

- what is the function of water and from where do you obtain water?
- is the water quality/quantity the same as before? Why (not)?
- During which time of the year is the water quality lower? Why?

Erosion:

- what is erosion? Did you already see soil being washed away?
- What causes this? What is the effect?
- How to prevent erosion under different field conditions?
- Do you weed in your fields? How? Can some weeding techniques increase erosion? Why?
- Are there other trees in your garden? Why?
- What are the best locations for coffee gardens, paddy fields, shrubs, and forest, regarding the river?

Forest:

- what is the function of the forest?
- Is there still forest left in the neighbourhood? Why don't people clear it?

Topic list for interviews with farmers: revised version after first series of interviews

Background data:

- name, ethnic group, location of farm, land tenure situation, land size, type of field
- Since when are you in Sumberjaya, when did you start cultivating?

Landscape:

- Which kind of slope is best for coffee/ paddy rice: flat, steep? Why?
- How does the slope influence erosion, landslides, river turbidity, production?

Soil:

- Soils of which colour are most (un)suitable for coffee/paddy rice? Why?
- Which other soil properties are beneficial? Why?

Water:

- What is water used for and where do you get it from?
- How is river water quality and quantity: when it rains compared to dry spells, now compared to earlier times? Why?
- How to solve these problems? Where can you get clean water?
- Where does river water turbidity come from? Is turbid water good or to irrigate paddy fields with? And what about water coming from the coffee gardens? Are furrows needed?
- How is the turbidity of the water coming from paddy fields and entering the river?
- During floods, how is the water turbidity? What happens when this water enters the paddy fields? Why?
- How to prevent turbid runoff water from entering into the river? When shrubs, grasses or trees are planted on the riverside, what happens to the runoff water flowing to the river?

Erosion:

- Does erosion take place in coffee gardens with steep slopes?
- What are the effects? How to prevent it?

Forest:

- What are the forest functions?
- What happens when the forest cover is removed?
- Is it good/bad to have forest or shrubs between river and coffee gardens?

- When the forest on steep slopes has to be converted to coffee gardens or paddy fields, how to prevent too much erosion from taking place?

Shade trees:

- What is it function? Why and how?
- Which species are best? Why?
- What happens when no shade trees are planted?
- Why are there coffee gardens without shade trees?

Terrace:

- What is it function? Why and how? Advantages/ disadvantages?
- When do you need to construct terraces?
- Why are there coffee gardens without terraces?

Weeding:

- What is it function? Why and how? Advantages/ disadvantages?
- What happens when you don't weed?

Topic list for interviews with non-farming village people

Background data: name, ethnic group, location, and profession. The rest of the topic list is comparable to the second farmer topic list, starting with general issues of water quality and quantity, forest functions, and later focussing more on agricultural aspects.

Topic list for interviews with extension officers

Background data: name, employer, function and education. The rest of the topic list is completely the same as the second farmer topic list.

Topic list for interviews with Forestry officials

Background data: name, employer, function and education. The rest of the topic list is comparable to the second farmer topic list, starting with general issues of forest functions and water problems, and later focussing more on agricultural aspects.

Topic list for interviews with directors of the Hydroelectric Power Plant

Background data: name, employer, function and education. The rest of the topic list is comparable to the second farmer topic list, starting with general water issues, and later focussing more on aspects concerning forests and agricultural activities.

Annex V: List of all interviewed persons

Table 1 contains data of the farmers consulted through in-depth interviews. Table 2 contains similar data for the farmers that participated in the validation test. Information on other interviewed stakeholders can be found in Table 3

Name of farmer	Ethnicity[1]	Location[2]	Position[3]	Fields[4]	Interview date
Pak Cik Udi, Pak Basrun	Se	WP	u	k + s	August 14, 2002
Pak Burhanudin	Su	WP	d	S	August 19, 2002
Pak Emed	Su	WP	m	k + s	August 19, 2002
Pak Sapari	Ja	WP	d + u	k + s + sa	August 19, 2002
Pak Komer	Su	WP	u	k + s	August 22, 2002
Pak Aki Ili	Su	WP	d + m + u	k + s	August 23, 2002
Pak Aruman	Su	WP	d	k + s	August 23, 2002
Pak Karma	Su	WP	d	S	August 24, 2002
Pak Jamiun	Su	WP	d	s + sa	August 25, 2002
Pak Sapari	Ja	WP	d + u	k + s + sa	August 25, 2002
Pak Emed, Pak Usep	Su	WP	m	k + s	August 26, 2002
Pak Oyin	Su	WP	m	K	August 26, 2002
Pak Sodikin	Su	WP	m	K	August 26, 2002
Pak Cik Udi	Se	WP	u	K	August 29, 2002
Pak Darmawan and wife	Se	WP	u	K	August 29, 2002
Pak Aceng, Pak Tukadi	Su + Ja	WP	u	k + s	August 30, 2002
Pak Soleh, Pak Tugiman	Su + Ja	WP	u	K	August 30, 2002
Pak Tugiman	Ja	WP	u	K	August 30, 2002
Pak Yahyan	Ja	WP	u	k + sa	August 30, 2002
Pak Dadang	Su	WP	d	k + s	September 5, 2002
Pak Haudin	Se	WP	d	K	September 8, 2002
Pak Kanta	Su	WR	u	K	September 11, 2002
Pak Kasimun	Ja	WR	m	k + s + sa	September 11, 2002
Pak Saifudin	Su	WR	m	k + s	September 11, 2002
Pak Usup	Se	WR	m	k + s + sa	September 11, 2002
Pak Wardiyana	Se	WR	u	K	September 11, 2002
Pak Yahman	Ja	WR	m	k + s + sa	September 11, 2002
Pak Atang, Pak Sanap	Su	WR	d	S	September 12, 2002
Pak Royani	Su	WR	d	K	September 12, 2002
Pak Saudi	Ja	WR	d	K + sa	September 12, 2002

Table 1: farmers for in-depth interviews

[1] Legend ethnicity: Ja is Javanese; Se is Semendonese; and Su is Sundanese.
[2] Legend location: WP is Way Petai watershed and WR is Way Ringkih watershed
[3] Legend position: d is downstream; m is midstream; and u is upstream
[4] Legend fields: k is coffee garden; s is paddy field; and sa is vegetable field

Name of farmer	Ethicity	Location	Position	Fields
Pak Mamad Suhendra	Su	WP	U	K + S
Pak Yahnu	Se	WP	D	K
Pak Akoh	Su	WP	D	K + S
Pak Baridi	Ja	WP	M	K
Pak Ocad	Su	WP	D + M	K + S
Pak Memed	Su	WP	D	K + S
Ibu Sumi	Su	WP	D + U	K + S
Pak Burhan	Su	WP	M	K
Pak Toil	Ja	WP	U	K
Pak Umid	Su	WP	U	K
Pak Tarsum	Su	WR	U	K + S
Pak Yayan + Pak Mul	Ja	WR	U	K + S
Pak Sastro + Pak Yuyun	Ja	WR	U	K
Pak Kasijo	Ja	WR	M	K + S + Sa
Pak Parno	Ja	WR	M	K + S + Sa
Pak Kurdi	Su	WR	M	K + S
Pak Suganda	Su	WR	D + M + U	K + Sa
Pak Sutiono	Ja	WR	M	K + S + Sa
Pak Surta	Su	WR	D	K + S
Pak Adun	Su	WR	D	K + S
Pak Paryoto	Ja	WK	D	K + Sa
Pak Triman	Ja	WK	M	K + Sa
Pak Surip	Ja	WK	M	K
Pak Sartani	Se	WK	M	K
Pak Sarpendi	Se	WK	U	K + Sa
Mbah Bungkus	Ja	WK	U	K
Pak Gimin	Ja	WK	U	K + Sa
Pak Cik Nawi	Se	WK	D	K

Table 2: Farmers interviewed for validation test

Stakeholder	Name	Profession	Location	Ethnicity
Villager	Pak dan Bu Osi	Photographer	Simpang Sari	Su
Villager	Pak Margani	School teacher	Simpang Sari	Se
Extension officer	Pak Yedi Rohyadi	Local extension coordinator	Simpang Sari	
Forestry service	Pak Hartawan	Head of Forestry service	Sukapura	
HEPP official	Pak Sugeng	Director of operation	HEPP	

Table 3: Other interviewed stakeholders

Annex VI: Test questionnaire: statements, results and interpretation

This Annex contains the translation of all test statements, together with tables of the answers of the farmers. Farmers had the possibility to agree with the statement (potentially only under more specified conditions), to disagree completely, or to admit ignorance of that particular aspect[5]. Be aware that half of the test statements are opposite to the Knowledge Base (KB) statements. The names and data of the different farmers can be found in Annex V. Explanations for the non-validation of 6 of the 68 statements can be found in Annex XVII, whereas potential knowledge differences between subgroups of farmers are investigated in Annex XVIII.

Shade trees

1. The roots and leaf litter of shade trees in coffee gardens cannot enhance rainwater infiltration
2. hence the water flows directly downslope
3. and a lot of soil is washed away.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
2	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
3	**TS**	TS	TS	TS	TS	TS	TS	S	S	TS	TS	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
1	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
2	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
3	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 100%, 100%, respectively 92.86%.

4. The shade tree protects the coffee crop and the soil from sun heat during the dry season
5. hence the coffee leaves are green
6. and the soil isn't dry and hard.

[5] Farmers had three choices: S: "Setujuh: I agree"; TS: "Tidak setujuh: I don't agree"; TT: "Tidak Tahu: I don't know".

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
5	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
6	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
4	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
5	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
6	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 100%, 100%, respectively 100%.

Weeding

7. Weeds in a sloping coffee garden cannot retain soil during rain showers
8. hence soil is washed away by the water
9. and the coffee growth and production are reduced.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**TS**	TS	TS	TS	TS	S	TS	S	S	TS	TS	TS	TS	TS	TS	TS
8	**TS**	TS	TS	TS	TS	S	TS	S	S	TS	TS	TS	TS	TS	TS	TS
9	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
7	TS	TS	TS	TS	TS	TS	TS	S[6]	TS	TS	TS	TS	TS	TS
8	TS	TS	TS	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS
9	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 85.71%, 85.71%, respectively 100%.

10. Weeding by hoeing causes the soil to be soft
11. hence coffee grows well.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	**S**	S	S	S	S	S	S	S	S	TS	S	S	S	S	S	TS

11	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
10	**S**	S	TS	S	S	S	S	S	S	S	S	S	S	S
11	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 89.29%, respectively 100%.

12. Removing weeds in the coffee garden by spraying pesticides does not cause the soil to become hard
13. but coffee hair roots can die
14. and the coffee production declines.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12	**TS**	TS	TS	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS	TS	TS
13	**S**	TS	S	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	S	S	S
14	**S**	S	S	S	S	TS	S	TS	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
12	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
13	**S**	TS	TS	S	S	TS	S	S	TS	TS	S	TS	S	TS
14	**S**	S	S	TS	TS	S	S	S	TS	S	S	S	S	S

Validation of the KB statements: 96.43%, 35.71%, respectively 82.14%.

15. Forking the soil of a steep coffee garden renders the soil soft
16. hence a lot of soil is washed away by the rains during the wet season
17. but during the dry season forking can render the soil dry

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
16	**TS**	S	TS	S	TS	S	S	TS	TS	S	S	TS	S	S	TS	S
17	**S**	S	S	TS	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
15	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

16	**TS**	TS	TS	TS	TS	S	TS	S	TS	S	TS	S	TS	TS
17	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 100%, 53.57%, respectively 96.43%.

18. During the rainy season, clean-weeding can increase erosion in sloping coffee gardens
19. hence the soil looses fertility.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18	**S**	S	TS	TS	S	S	S	TS	TS	S	S	S	S	S	S	S
19	**S**	S	TS	TS	S	S	S	TS	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
18	**S**	S	S	S	S	S	TS	S	S	S	S	S	S	S
19	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 82.14%, respectively 89.29%.

Terraces

20. It is better to terrace a coffee garden on a steep slope
21. hence when it rains, the rainwater doesn’t flow directly downslope but stops on the terraces
22. hence you don’t immediately run out of soil and organic matter

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
20	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
21	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
22	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
20	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
21	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
22	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 100%, 100%, respectively 100%.

23. When it rains, still a lot of runoff takes place from coffee gardens that are terraced or planted with shade trees
24. and the runoff water isn't any clearer compared to coffee gardens without terraces and shade trees.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
23	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS
24	**TS**	TS	TS	TS	TS	TS	TS	S	S	TS	TS	TS	S	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
23	**TS**	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS	TS	TS
24	**TS**	S	TS	S	TS	S	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 96.43%, respectively 78.57%.

Infiltration pits

25. For coffee gardens on sloping or flat fields, it is better to make infiltration pits
26. in order to collect organic matter in the hole
27. hence the soil becomes more fertiles.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
25	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
26	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
27	**S**	TS	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
25	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
26	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
27	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 100%, 100%, respectively 96.43%.

28. For a coffee garden on a steep slope, infiltration pits cannot store the runoff water
29. hence the soil and organic matter are lost soon.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
28	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
29	**TS**	TS	TS	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
28	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
29	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 100%, respectively 96.43%.

Furrows

30. For a steep coffee garden with furrows, the runoff water will enter the furrows
31. and won't flow directly downslope
32. but the water still takes along quite some mud
33. and remains turbid

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
30	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
31	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
32	**TS**	TS	TS	S	S	TS	TS	TS	TS	S	TS	TS	TS	S	S	TS
33	**TS**	TS	TS	TS	S	TS	TS	S	TS	S	S	TS	S	S	S	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
30	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
31	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
32	**TS**	TS	TS	TS	S	S	S	S	TS	TS	TS	S	TS	TS
33	**TS**	TS	TS	S	S	S	S	S	S	TS	TS	S	TS	TS

Validation of the KB statements: 100%, 100%, 64.29% respectively 50%.

Forest

34. Where the forest is cleared to install coffee gardens, bare soils are predominant
35. hence raindrops fall directly on the soil.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
34	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S
35	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
34	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
35	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 96.43%, respectively 96.43%.

36. When the forest is cleared, the rainwater directly flows downslope
37. and consequently causes big floods
38. but the water remains clear
39. and return quickly to its normal level.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
36	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S
37	**S**	S	TT	S	S	S	S	TS	S	S	S	S	S	S	S	S
38	**TS**	TS	TT	TS	TS	TS	TS	S	TS	TS	TS	TS	TS	TS	TS	TS
39	**S**	S	TT	S	S	S	S	TS	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
36	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
37	**S**	S	S	S	S	S	S	S	S	TS	S	S	S	S
38	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
39	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 96.43%, 89.29%, 92.86%, respectively 92.86%.

40. Before the forests were opened to cultivate coffee, the river water was clearer,
41. but during the rainy season, a lot of floods took place as well
42. and during the dry season, the rivers did have a lack of water.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
40	**S**	S	TT	S	S	TS	S	S	S	S	S	S	S	S	S	S

41	**TS**	TS	TT	S	TS	S	TS	S	TS	TS	TS	TS	TS	TS	TS	TS
42	**TS**	TS	TT	TS	TS	S	S	S	S	TS	TS	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
40	**S**	TS	S	S	S	S	S	S	S	S	TS	S	S	S
41	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
42	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 85.71%, 85.71%, respectively 82.14%.

43. The forest on the mountains functions to protect the water springs.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
43	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
43	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 96.43%.

45.

46.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
44	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S
45	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S
46	**S**	S	TT	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
44	**S**	S	S	S	S	S	S	S	S	S	TS	S	S	S
45	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
46	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 92.86%, 96.43%, respectively 96.43%.

Paddy rice fields

47. The runoff water coming from a coffee garden during a rain shower is turbid when it enters a paddy field
48. because it contains organic matter
49. hence it can fertilise the paddy field.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
47	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
48	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
49	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
47	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
48	**S**	S	S	S	S	TS	TS	S	S	S	S	S	S	S
49	**S**	S	S	S	S	TS	TS	S	S	S	S	S	S	S

Validation of the KB statements: 100%, 92.86%, respectively 92.86%.

50. During havy rains, not all runoff water from the coffee gardens may enter in the paddy fields
51. because it can damage the rice plants and the water can wash away the paddy soil
52. hence a furrow leading to the river should be made in between coffee garden and paddy field.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
50	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
51	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
52	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	TS	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
50	**S**	S	S	S	S	S	S	S	S	TS	S	S	S	S
51	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
52	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 96.43%, 100%, respectively 96.43%.

53. For a paddy field with rice plants, the water leaving the paddy field is turbid when it rains.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
53	**S**	S	TS	S	S	S	TS	TS	TS	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
53	**S**	S	S	S	TS	S	S	S	TS	S	TS	S	S	S

Validation of the KB statements: 75.00%.

54. The water leaving a paddy field that is being hoed is not turbid when entering the river.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
54	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
54	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 100%.

55. When turbid river water is used for irrigation of the paddy field, a lot of dirt remains on the paddy field
56. hence the paddy field becomes more fertile
57. and the water is less turbid when it leaves the paddy field again.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
55	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
56	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
57	**S**	S	TT	TS	S	S	TS	S	TS	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
55	**S**	S	S	S	S	S	TS	S	S	S	S	S	S	S
56	**S**	S	S	S	S	S	TS	S	S	S	S	S	S	S
57	**S**	S	S	TS	S	S	TS	S	S	S	S	S	S	TS

Validation of the KB statements: 96.43%, 96.43%, respectively 75%.

Flooding

58. Water that floods a paddy field can damage the paddy field and the rice plants.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
58	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
58	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S

Validation of the KB statements: 100%.

59. Turbid flood water that enters a paddy field can fertilise the paddy field
60. because dirt stays behind in the paddy field.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
59	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
60	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
59	**S**	S	S	S	S	S	TS	S	S	S	S	S	S	S
60	**S**	S	S	S	S	S	TS	S	S	S	S	S	S	S

Validation of the KB statements: 96.43%, respectively 96.43%.

61. Big floods don’t cause riverbank erosion and landslides to take place
62. besides when shrubs or big trees are planted on the riversides.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
61	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
62	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28

61	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
62	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statements: 100%, respectively 100%.

Shrubs and bushes

63. Shrubs and bushes as riparian vegetation cannot filter turbid runoff water coming from the coffee gardens.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
63	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	S	TS	TS	S	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
63	**TS**	TS	TS	TS	TS	S	S	TS	TS	TS	TS	TS	TS	TS

Validation of the KB statement: 85.71%.

Water quality

64. The river water is turbid when it rains
65. because the rainwater brings along earth from the coffee gardens
66. but you can still use the water to drink and wash.

	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
64	**S**	S	S	TS	S	S	S	S	S	S	S	S	S	S	S	S
65	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
66	**TS**	TS	TS	S	TS	TS	TS	TS	TS	TS	S	TS	TS	TS	TS	TS

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
64	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
65	**S**	S	S	S	S	S	S	S	S	S	S	S	S	S
66	**TS**	TS	TS	TS	TS	TS	TS	TS	TS	TS	S	TS	TS	TS

Validation of the KB statements: 96.43%, 100%, respectively 89.29%.

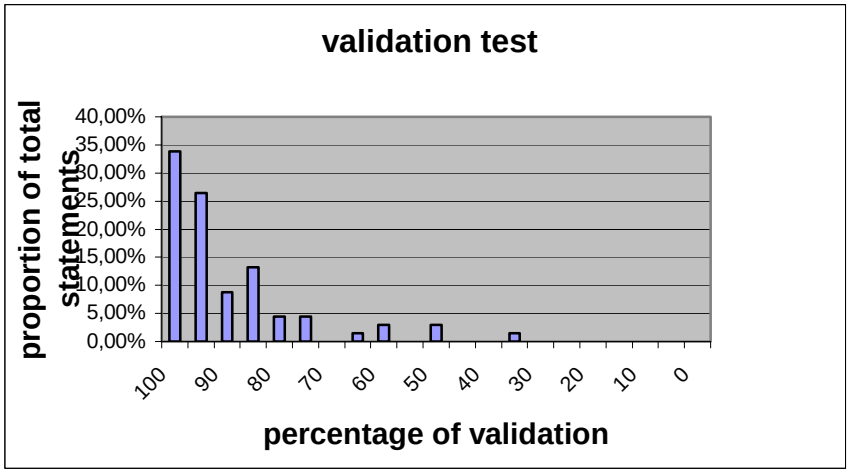
67. Pesticide residues from coffee gardens and paddy rice fields can end up in the river when it rains
68. and can poison the fish in the fishponds.

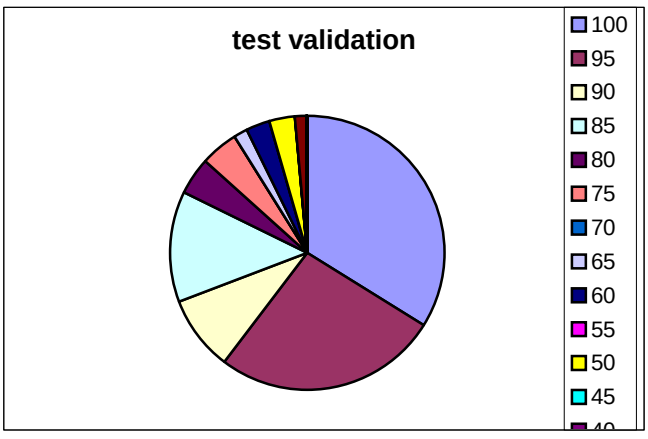
	KB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
67	**S**	S	TS	TS	S	S	S	TS	TS	S	S	S	S	S	TS	S
68	**S**	S	TS	S[1]	S	S	S	TS	TS	S	TS	S	S	S	TS	S

	KB	16	17	18	19	20	21	22	23	24	25	26	27	28
67	**S**	S	S	S	TS	TS	S	S	S	TS	S	TS	TS	S
68	**S**	S	S	S	TS	TS	S	TS	S	TS	S	S	S	S

Validation of the KB statements: 64.29%, respectively 67.86%.

The following two graphs reflect the percentage of validation for the total of the 68 statements.





Annex VII: Formal Statements of the Knowledge Base

Forest clearing

- an increase in amount of felling of forest tree causes a decrease in cover of forest if the reforestation of land action is no
- land_use_change forest kebun causes a decrease in cover of forest
- an increase in amount of clearing of forest causes a decrease in cover of forest

- a decrease in availability of land causes an increase in amount of land_use_change forest kebun if the land slope is in the range flat to too_steep
- the need of land_use_change field forest is high if the field slope is too_steep

Fertility of cleared soils

- clearing of forest causes the organic_matter_content of soil is high
- burning of forest causes the organic_matter_content of soil is high
- land_use_change forest field causes the organic_matter_content of soil is high
- land_use_change forest field causes the fertility of soil is high
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- the fertility of soil is high causes the need of application of fertiliser is low if land_use_change forest kebun and burning of land

- the soil location is near_forest causes the soil fertility is good if weeding of soil and the application of fertiliser action is no
- the fertility of soil_near_forest is same_as soil_near_village if the clearing of land moment is same and the cultivation of soil method is same

- an increase in fertility of soil causes an increase in production of plant
- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- an increase in fertility of soil causes an increase in suitability_for_coffee of soil
- an increase in organic_matter_content of soil causes an increase in rate of growth of coffee
- an increase in fertility of soil causes an increase in production of coffee
- the suitability_for_coffee of soil is high causes the production of coffee is high

- land_use_change forest field causes the fertility of soil is high if the time moment is less_than_three_years_later
- land_use_change forest field causes the fertility of soil is high if the time moment is less_than_three_years_later and the land slope is steep
- land_use_change forest field causes the fertility of soil is high if the time duration is long and the land slope is flat
- an increase in duration of cultivation of kebun causes a decrease in fertility of soil if the application of fertiliser action is no
- an increase in duration of cultivation of sawah causes a decrease in fertility of soil if the application of fertiliser action is no and the application of harvest_residue action is yes

- the fertility of soil is low causes the coffee leaf colour is yellow if the application of fertiliser action is no
- the fertility of soil is low causes dying of coffee twig if the application of fertiliser action is no
- a decrease in fertility of soil causes a decrease in rate of growth of coffee
- a decrease in suitability_for_coffee of soil causes a decrease in size of coffee bean if the application of fertiliser action is no
- a decrease in suitability_for_coffee of soil causes a decrease in production of coffee if the application of fertiliser action is no

- a decrease in fertility of soil causes the soil colour is reddish
- a decrease in fertility of soil causes the soil colour is yellowish
- a decrease in organic_matter_content of soil causes the soil colour is yellow if the application of fertiliser action is no
- a decrease in fertility of soil causes an increase in need of application of fertiliser

Forest functions

- an increase in cover of forest causes an increase in presence of tree

- an increase in cover of forest causes a decrease in impact_on_soil of rainfall
- the tree presence is no causes the impact_on_soil of rainfall is high
- an increase in amount of leaf_litter causes a decrease in impact_on_soil of rainfall

- a decrease in impact_on_soil of rainfall causes a decrease in amount of erosion of soil
- the impact_on_soil of rainfall is high causes the landslide occurence is possible if the tree presence is no
- an increase in impact_on_soil of rainfall causes an increase in turbidity of water
- a decrease in impact_on_soil of rainfall causes a decrease in speed of runoff of rain_water

- an increase in presence of tree causes an increase in amount of root
- an increase in amount of tree causes an increase in amount of leaf_litter

- a decrease in amount of leaf_litter causes a decrease in cover of soil
- the soil cover is absent causes cracking of soil if the time season is dry
- a decrease in cover of forest causes a decrease in humidity of soil if the time season is dry
- an increase in cover of soil causes an increase in humidity of soil if the weather humidity is dry
- an increase in amount of leaf_litter causes an increase in humidity of soil if the weather humidity is dry
- a decrease in amount of leaf_litter causes an increase in rate of drying of soil if the weather humidity is dry
- an increase in cover of forest causes an increase in amount of retention of water
- an increase in amount of leaf_litter causes an increase in amount of retention of water
- an increase in amount of root causes an increase in amount of retention of water
- a decrease in cover of forest causes a decrease in availability of water if the time season is dry
- an increase in amount of retention of water causes an increase in availability of water if the time season is dry
- clearing of land causes a decrease in availability of water if the time season is dry

- an increase in amount of leaf_litter causes an increase in organic_matter_content of soil
- decomposition of leaf_litter causes an increase in organic_matter_content of soil
- an increase in amount of leaf_litter causes an increase in amount of retention of water
- an increase in amount of retention of water causes an increase in rate of decomposition of leaf_litter
- an increase in rate of decomposition of leaf_litter causes an increase in fertility of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil

- an increase in cover of forest causes an increase in amount of infiltration of rain_water
- an increase in amount of leaf_litter causes an increase in amount of infiltration of rain_water
- an increase in amount of root causes an increase in amount of infiltration of rain_water
- an increase in amount of infiltration of rain_water causes a decrease in amount of runoff of rain_water
- an increase in amount of infiltration of rain_water causes a decrease in speed of runoff of rain_water
- infiltration of rain_water causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low

- an increase in amount of retention of water causes an increase in amount of retention of soil
- an increase in amount of retention of water causes a decrease in amount of erosion of soil if the land slope is steep
- a decrease in cover of forest causes an increase in amount of erosion of soil
- a decrease in amount of leaf_litter causes an increase in amount of erosion of soil if rainfall
- an increase in cover of forest causes a decrease in turbidity of river_water
- land_use_change forest kebun causes an increase in turbidity of water if rainfall and kebun water enter river
- an increase in amount of root causes a decrease in turbidity of water if rainfall and runoff of rain_water and water enter river
- an increase in amount of leaf_litter causes a decrease in turbidity of water if rainfall and runoff of rain_water and water enter river

- a decrease in cover of forest causes an increase in speed of runoff of rain_water
- a decrease in cover of forest causes an increase in amount of runoff of rain_water
- a decrease in cover of mountain causes an increase in amount of runoff of rain_water
- slash_and_burn of land causes an increase in amount of runoff of rain_water
- an increase in amount of leaf_litter causes a decrease in speed of runoff of rain_water
- an increase in amount of leaf_litter causes a decrease in amount of runoff of rain_water
- an increase in amount of root causes a decrease in amount of runoff of rain_water
- an increase in amount of root causes a decrease in speed of runoff of rain_water

- an increase in amount of runoff of rain_water causes an increase in occurence of landslide
- an increase in speed of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy
- an increase in amount of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy

- a decrease in cover of forest causes a decrease in discharge_constancy of river_water

- a decrease in cover of forest causes an increase in speed of runoff of rain_water
- a decrease in cover of forest causes an increase in amount of runoff of rain_water
- an increase in speed of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy
- an increase in amount of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy
- rainfall causes flooding of river if the mountain cover is absent
- a decrease in cover of forest causes an increase in amount of flooding of river if the time season is rainy
- slash_and_burn of land causes an increase in amount of flooding of river
- a decrease in cover of forest causes an increase in turbidity of river_water if flooding of river

- a decrease in cover of forest causes a decrease in duration of flooding of river
- a decrease in cover of forest causes a decrease in duration_before_start of flooding of river if rainfall

- a decrease in cover of forest causes an increase in occurence of drying of river if the time season is dry
- not rainfall causes the drought occurence is yes if the mountain cover is absent

- the forest presence is yes causes the spring condition is protected
- the discharge_of_water of spring is high if the time season is rainy
- the discharge_of_water of spring is low if the time season is dry

- an increase in amount of sawah causes an increase in amount of deviation of river_water
- an increase in amount of deviation of river_water causes a decrease in amount of river_water

- an increase in discharge_constancy of river_water causes an increase in production of plta_dam

- a decrease in cover of forest causes an increase in temperature of air

- an increase in amount of flooding of river causes the need of reforestation of land is high
- the kebun system is like_forest causes a decrease in amount of flooding of river if the kebun location is upstream and the flooding location is downstream

Flooding

Causes of river flooding

- rainfall causes flooding of river if the mountain cover is absent
- the amount of rainfall is high causes flooding of river
- a decrease in cover of forest causes an increase in amount of flooding of river if the time season is rainy
- slash_and_burn of land causes an increase in amount of flooding of river

- a decrease in cover of forest causes a decrease in duration of flooding of river
- the flooding of river duration is short if the land location is upstream and rainfall
- a decrease in cover of forest causes a decrease in duration_before_start of flooding of river if rainfall

- a decrease in cover of forest causes an increase in turbidity of river_water if flooding of river

- rainfall causes an increase in water_level of river
- an increase in amount of infiltration of rain_water causes a decrease in amount of flooding of river if rainfall
- an increase in speed of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy
- an increase in amount of runoff of rain_water causes an increase in amount of flooding of river if the time season is rainy

- flooding of river causes the soil_content of water is high
- an increase in soil_content of water causes an increase in turbidity of water
- flooding of river causes an increase in turbidity of river_water
- the soil_content of water is high causes the water colour is black

- flooding of river causes the organic_matter_content of water is high
- an increase in organic_matter_content of water causes an increase in fertility of water
- an increase in turbidity of water causes an increase in fertility of water
- the fertility of river_water is high if flooding of river
- an increase in fertility of water causes an increase in suitability_for_sawah of water

- the dirt_and_mud_from_village presence is yes causes an increase in turbidity of river_water if flooding of river

- flooding of river causes an increase in depth of river
- the stone location is in_river causes the river depth is not increase
- flooding of river causes an increase in amount of erosion of river bank
- an increase in amount of erosion of river bank causes an increase in width of river

- flooding of river causes an increase in occurrence of landslide if the land location is riversides
- an increase in occurrence of landslide causes an increase in occurrence of change of river path if the landslide location is riversides
- flooding of river causes the change of river path occurrence is possible

Flooding of paddy rice fields

- flooding of sawah causes an increase in amount of displacing of rice
- flooding of sawah causes displacing of rice if the flooding dimension is big
- an increase in amount of displacing of rice causes a decrease in production of rice
- an increase in flow of water causes an increase in amount of displacing of rice if the water location is in_sawah
- flooding of sawah causes a decrease in condition of growth of rice if the rice age is young
- not regulation of irrigation_water causes an increase in flow of water if the irrigation_water location is in_sawah and the time season is rainy

- not regulation of irrigation_water causes an increase in flow of water if the irrigation_water location is in_sawah and the time season is rainy
- a decrease in flow of water causes an increase in stay_in_sawah of water
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil

- flooding of sawah causes an increase in amount of erosion of sawah soil
- an increase in amount of erosion of sawah soil causes an increase in turbidity of river_water if flooding of sawah
- not regulation of irrigation_water causes the amount of erosion of sawah soil is high
- the amount of erosion of sawah soil is high causes destroying of sawah

- a decrease in flow of water causes an increase in stay_in_sawah of water
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil
- flooding of sawah causes an increase in turbidity of sawah water
- an increase in turbidity of water causes an increase in amount of sedimentation of soil if water enter sawah and the sedimentation of soil location is in_sawah
- flooding of sawah causes the river_water location is in_sawah
- the river_water location is in_sawah causes an increase in amount of sedimentation of soil if flooding of sawah
- an increase in amount of sedimentation of soil causes an increase in fertility of sawah soil if the sedimentation of soil location is in_sawah
- flooding of sawah causes an increase in fertility of soil

- flooding of sawah causes an increase in production of rice if the rice age is young
- the rainfall duration is more_than_3hours causes flooding of land if the land location is plta_area and the plta_dam situation is closed and the time season is rainy
- covering_with_soil of rice causes dying of rice

- flooding of sawah causes the sandy_sediment presence is yes
- the sandy_sediment presence is yes causes the sandy_soil presence is yes
- the sandy_sediment presence is yes causes the rice grain content is not empty if the sandy_sediment location is in_sawah
- the fertility of red_soil is low causes the rice grain content is empty
- the rice grain content is empty causes the production of rice is low
- the sandy_sediment presence is yes causes the soil structure is loose
- the sandy_sediment presence is yes causes an increase in suitability_for_sawah of soil
- the organic_matter_content of sandy_sediment is high causes an increase in suitability_for_sawah of soil
- sandy_sediment is_used_as building_material

- flooding of sawah causes an increase in presence of dirt_and_mud_from_village if the sawah location is downstream_of_village
- an increase in presence of dirt_and_mud_from_village causes an increase in fertility of soil if the soil location is in_sawah
- an increase in presence of dirt_and_mud_from_village causes a decrease in need of application fertiliser sawah

- an increase in presence of dirt_and_mud_from_village causes a decrease in production of rice if the time moment is right_before_harvest
- flooding of sawah causes a decrease in production of rice if the time moment is right_before_harvest

- the flooding of sawah duration is short causes an increase in fertility of soil
- the flooding of sawah duration is long causes rotting of rice
- the flooding of sawah duration is long causes dying of rice

Water quality: turbidity, dirt and waste and agrochemicals

- an increase in soil_content of water causes an increase in turbidity of water

- rainfall causes the turbidity of water is high if the kebun slope is steep and runoff of rain_water and water enter river
- and erosion
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_vegetable_garden and vegetable_garden water enter river
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river

- the turbidity of kebun water is low if rainfall and kebun water enter river

- an increase in cover of soil causes a decrease in turbidity of water if the kebun slope is steep and runoff of rain_water
- an increase in amount of root causes a decrease in turbidity of water if rainfall and runoff of rain_water and water enter river
- an increase in amount of leaf_litter causes a decrease in turbidity of water if rainfall and runoff of rain_water and water enter river
- land_use_change forest kebun causes an increase in turbidity of water if rainfall and kebun water enter river
- an increase in impact_on_soil of rainfall causes an increase in turbidity of water
- an increase in amount of dissolving of soil causes an increase in turbidity of water if runoff of rain_water
- an increase in amount of runoff of rain_water causes an increase in turbidity of water
- the water flow is under_soil causes the turbidity of water is low
- a decrease in speed of runoff of rain_water causes a decrease in turbidity of water

- an increase in amount of sedimentation of soil causes a decrease in turbidity of water if the sedimentation of soil location is in_sawah and sawah water enter river
- filtering of rain_water causes a decrease in turbidity of water

- the turbidity of water is low if the soil consistency is hard and runoff of rain_water
- the turbidity of water is high if the soil structure is loose and runoff of rain_water
- the amount of infiltration of rain_water is high if the soil structure is loose
- the amount of runoff of rain_water is low if the soil structure is loose
- the speed of runoff of rain_water is low if the soil structure is loose
- the speed of runoff of rain_water is high if the soil consistency is hard
- the amount of runoff of rain_water is high if the soil consistency is hard
- the amount of infiltration of rain_water is low if the soil consistency is hard

- an increase in cover of forest causes a decrease in turbidity of river_water
- a decrease in cover of forest causes an increase in turbidity of river_water if flooding of river
- an increase in presence of kebun causes an increase in turbidity of river_water if rainfall

- the kebun system is coffee_monoculture causes an increase in turbidity of river_water if rainfall

- the sawah presence is no causes an increase in turbidity of river_water if rainfall

- the planting of tree location is river_sides causes a decrease in turbidity of river_water
- the forest location is river_sides causes the turbidity of river_water is low
- the vegetation type is shrub causes the turbidity of river_water is low if the vegetation location is river_sides and flooding of river

- an increase in amount of erosion of soil causes an increase in turbidity of river_water
- an increase in amount of retention of soil causes a decrease in turbidity of river_water if runoff of rain_water and water enter river

- the turbidity of river_water is high if the time season is rainy
- the turbidity of river_water is low if the time season is dry
- an increase in occurence of rainfall causes an increase in turbidity of river_water

- the turbidity of river_water is low if the time season is rainy and the river size is small

- flooding of river causes an increase in turbidity of river_water
- an increase in amount of erosion of sawah soil causes an increase in turbidity of river_water if flooding of sawah
- the dirt_and_mud_from_village presence is yes causes an increase in turbidity of river_water if flooding of river

- an increase in turbidity of fish_pond water causes an increase in turbidity of river_water if fish_pond water enter river
- an increase in turbidity of sawah water causes an increase in turbidity of river_water if sawah water enter river
- an increase in turbidity of river_water causes an increase in turbidity of sawah water if river_water enter sawah
- making of sawah causes an increase in turbidity of river_water

- the amount of input of turbid_water is high if the river location is downstream and rainfall
- the amount of input of turbid_water is low if the river location is upstream and rainfall
- an increase in amount of input of turbid_water causes an increase in turbidity_duration of river_water if rainfall

Turbid water in paddy fields

- an increase in amount of erosion of soil causes an increase in turbidity of river_water
- an increase in turbidity of river_water causes an increase in turbidity of sawah water if river_water enter sawah
- flooding of sawah causes an increase in turbidity of sawah water

- an increase in turbidity of river_water causes an increase in turbidity of irrigation_water if irrigation of sawah
- the turbidity of irrigation_water is low causes the turbidity of sawah water is low if sawah water enter river

- rainfall causes the need of regulation of irrigation_water is high if irrigation sawah river_water and the turbidity of river_water is high
- not regulation of irrigation_water causes dying of rice if rainfall and irrigation sawah river_water and the turbidity of river_water is high

- an increase in amount of erosion of soil causes an increase in turbidity of sawah water if the erosion of soil location is above_sawah
- the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah
- the rice presence is yes causes the suitability_for_sawah of kebun water is low if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah
- the rice presence is no causes the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah

- rainfall causes the sawah water turbidity is not increase if the hoeing of sawah action is no
- an increase in occurence of rainfall causes an increase in turbidity of sawah water
- the turbidity of sawah water is greater_than river_water if the amount of rainfall is high and sawah water enter river

- the rice presence is yes causes the turbidity of sawah water is low if rainfall and sawah water enter river
- hoeing of sawah causes an increase in turbidity of sawah water if rainfall or irrigation of sawah
- hoeing of sawah causes an increase in turbidity of sawah water

- an increase in stay_in_sawah of water causes a decrease in turbidity of sawah water if runoff of kebun water and kebun water enter sawah and sawah water enter river
- an increase in stay_in_sawah of water causes a decrease in turbidity of sawah water if irrigation of sawah and river_water enter sawah and sawah water enter river

- the suitability_for_sawah of turbid_water is same_as clear_water if irrigation of sawah
- the suitability_for_sawah of clear_water is greater_than turbid_water if irrigation of sawah
- the suitability_for_sawah of turbid_water is greater_than clear_water if irrigation of sawah
- a decrease in turbidity of water causes an increase in rate of growth of plant
- the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah

- an increase in turbidity of water causes an increase in organic_matter_content of water
- an increase in organic_matter_content of water causes an increase in fertility of water
- an increase in amount of erosion of soil causes an increase in organic_matter_content of kebun water if rainfall
- an increase in amount of erosion of soil causes an increase in turbidity of sawah water if the erosion of soil location is above_sawah
- an increase in turbidity of water causes an increase in fertility of water
- erosion of topsoil causes the fertility of kebun water is high
- an increase in fertility of water causes an increase in suitability_for_sawah of water

- an increase in turbidity of water causes an increase in amount of sedimentation of soil if water enter sawah and the sedimentation of soil location is in_sawah
- the river_water location is in_sawah causes an increase in amount of sedimentation of soil if irrigation of sawah
- the kebun water location is in_sawah causes an increase in amount of sedimentation of soil if rainfall and runoff of kebun water and kebun water enter sawah

- an increase in amount of sedimentation of soil causes an increase in fertility of sawah soil if the sedimentation of soil location is in_sawah
- runoff of rain_water causes an increase in fertility of sawah soil if the runoff of rain_water location is in_kebun and kebun water enter sawah and the regulation of water action is yes
- the organic_matter_content of kebun water is high causes an increase in fertility of sawah soil if runoff of kebun water and kebun water enter sawah

- runoff of rain_water causes the sawah soil fertility is not increase if the runoff of rain_water location is in_kebun and kebun water enter sawah

- the river_water content is sandy causes the sandy_sediment presence is in_sawah if river_water enter sawah
- the sandy_sediment presence is yes causes the sandy_soil presence is yes
- the sandy_sediment presence is yes causes the rice grain content is not empty if the sandy_sediment location is in_sawah
- the fertility of red_soil is low causes the rice grain content is empty
- the rice grain content is empty causes the production of rice is low
- the sandy_sediment presence is yes causes the soil structure is loose
- the sandy_sediment presence is yes causes an increase in suitability_for_sawah of soil
- the organic_matter_content of sandy_sediment is high causes an increase in suitability_for_sawah of soil

- the rice presence is yes causes the suitability_for_sawah of kebun water is low if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah
- the rice presence is no causes the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah
- the kebun water location is in_sawah causes covering_with_soil of rice if runoff of rain_water and kebun water enter sawah
- covering_with_soil of rice causes dying of rice

Water quality for consumption

- the turbidity of water is low causes the quality of water is high if the danger_for_consumer of water is low
- a decrease in quality of water causes a decrease in suitability_for_drinking of water
- a decrease in quality of water causes a decrease in suitability_for_cooking of water
- a decrease in quality of water causes a decrease in suitability_for_washing of water
- an increase in turbidity of water causes a decrease in quality of water
- a decrease in turbidity of water causes an increase in suitability_for_drinking of water
- a decrease in turbidity of water causes an increase in suitability_for_washing of water

- the suitability_for_cooking of water is low if the water colour is black
- the water suitability_for_cooking is good if the water colour is yellow
- making of bak causes a decrease in turbidity of water

- the turbidity of river_water is greater_than well_water if the amount of rainfall is high
- the turbidity of spring water is low if the time season is dry
- the turbidity of spring water is low

- the turbidity of spring water is low if the time season is rainy
- not rainfall causes the turbidity of spring water is low if the kebun system is coffee_monoculture

- an increase in presence of dirt_and_mud_from_village causes a decrease in quality of water if the dirt_and_mud_from_village location is in_river and the river location is downstream

- land_use_change forest field causes an increase in herbicide_content of river_water
- rainfall causes the herbicide_content of river_water is high
- an increase in herbicide_content of river_water causes a decrease in suitability_for_drinking of water
- an increase in herbicide_content of river_water causes an increase in herbicide_content of fish_pond water if river_water enter fish_pond
- an increase in herbicide_content of fish_pond water causes an increase in amount of dying of fish

Erosion

Causes of soil erosion

- rainfall causes an increase in amount of erosion of soil if the land slope is steep
- the land slope is too_steep causes the amount of erosion of soil is high if the land location is in_kebun and rainfall

- a decrease in cover of forest causes an increase in amount of erosion of soil
- the vegetation type is shrub causes a decrease in amount of erosion of soil
- an increase in presence of shade_tree causes a decrease in amount of erosion of soil if the shade_tree type is kayu hujan and the kebun slope is steep and the terracing of kebun action is no
- the shade_tree presence is yes causes a decrease in amount of erosion of soil if the kebun slope is steep and the terracing of kebun action is yes
- rainfall causes an increase in amount of erosion of soil if the shade_tree presence is no and the land slope is steep
- a decrease in amount of weed causes an increase in amount of erosion of soil if the kebun slope is steep and rainfall
- the weed presence is yes causes an increase in amount of retention of soil if the time season is rainy and erosion of soil and the kebun slope is steep

- a decrease in impact_on_soil of rainfall causes a decrease in amount of erosion of soil
- an increase in amount of dissolving of soil causes an increase in amount of erosion of soil if rainfall and the kebun slope is steep
- an increase in amount of retention of water causes a decrease in amount of erosion of soil if the land slope is steep
- an increase in amount of leaf_litter causes an increase in amount of infiltration of rainwater
- an increase in amount of root causes an increase in amount of infiltration of rainwater
- infiltration of rainwater causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- an increase in amount of runoff of rainwater causes an increase in amount of erosion of soil if the kebun slope is steep and rainfall
- an increase in amount of retention of soil causes a decrease in amount of erosion of soil

- a decrease in amount of leaf_litter causes a decrease in cover of soil
- a decrease in amount of leaf_litter causes an increase in amount of erosion of soil if rainfall
- the soil cover is absent causes cracking of soil if the time season is dry
- the soil consistency is hard causes cracking of soil if the drought occurrence is yes
- cracking of soil causes an increase in presence of soil_crack
- rainfall causes an increase in amount of erosion of soil if the soil_crack presence is yes and the soil cover is absent and the land slope is not flat

- rainfall causes an increase in amount of erosion of soil if the humidity of soil is low and the shade_tree presence is no
- the humidity of soil is low causes the amount of erosion of soil is high if rainfall
- the red_soil humidity is dry causes the amount of infiltration of rainwater is high

- the amount of infiltration of rainwater is high if the soil structure is loose
- the amount of runoff of rainwater is low if the soil structure is loose
- the speed of runoff of rainwater is low if the soil structure is loose
- the amount of erosion of soil is high if the soil structure is loose and the land slope is steep
- the turbidity of water is high if the soil structure is loose and runoff of rainwater
- the sandy_soil slope is steep causes the amount of erosion of soil is high if rainfall and the sandy_soil texture is sandy
- the amount of erosion of soil is high causes the suitability_for_coffee of sandy_soil is low if the kebun slope is steep

- the soil consistency is hard causes the soil condition is compact
- the amount of infiltration of rainwater is low if the soil consistency is hard
- the speed of runoff of rainwater is high if the soil consistency is hard
- the amount of runoff of rainwater is high if the soil consistency is hard
- the amount of erosion of soil is low if the soil consistency is hard
- the turbidity of water is low if the soil consistency is hard and runoff of rainwater

Effects of soil erosion

- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_vegetable_garden and vegetable_garden water enter river
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river
- an increase in amount of erosion of soil causes an increase in organic_matter_content of kebun water if rainfall
- an increase in organic_matter_content of water causes an increase in fertility of water
- erosion of topsoil causes the fertility of kebun water is high

- an increase in amount of erosion of soil causes an increase in turbidity of river_water
- an increase in amount of erosion of soil causes the river_water colour is yellow if the soil location is in_kebun or the soil location is in_sawah
- the amount of erosion of soil is high causes the river_water content is sandy
- an increase in amount of erosion of soil causes an increase in turbidity of sawah water if the erosion of soil location is above_sawah
- an increase in amount of erosion of soil causes an increase in turbidity of fish_pond water if the soil location is in_kebun and kebun water enter fish_pond

- an increase in amount of erosion of soil causes a decrease in amount of organic_matter if the land slope is steep
- an increase in amount of retention of organic_matter causes an increase in organic_matter_content of soil
- an increase in amount of erosion of soil causes a decrease in organic_matter_content of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- an increase in amount of erosion of soil causes a decrease in fertility of soil if the soil slope is steep
- a decrease in amount of organic_matter causes an increase in need of application of fertiliser
- an increase in fertility of soil causes an increase in production of plant
- an increase in amount of erosion of soil causes a decrease in amount of weed_residue if the kebun slope is steep
- an increase in amount of weed_residue causes an increase in organic_matter_content of soil

- an increase in fertility of soil causes an increase in suitability_for_coffee of soil
- the fertility of soil is low causes the coffee leaf colour is yellow if the application of fertiliser action is no
- the fertility of soil is low causes dying of coffee twig if the application of fertiliser action is no
- a decrease in fertility of soil causes a decrease in rate of growth of coffee
- an increase in organic_matter_content of soil causes an increase in rate of growth of coffee
- a decrease in suitability_for_coffee of soil causes a decrease in size of coffee bean if the application of fertiliser action is no
- an increase in fertility of soil causes an increase in production of coffee
- a decrease in suitability_for_coffee of soil causes a decrease in production of coffee if the application of fertiliser action is no
- the suitability_for_coffee of soil is high causes the production of coffee is high

- land_use_change forest field causes the fertility of soil is high if the time moment is less_than_three_years_later
- land_use_change forest field causes the fertility of soil is high if the time moment is less_than_three_years_later and the land slope is steep
- land_use_change forest field causes the fertility of soil is high if the time duration is long and the land slope is flat

- hoeing of soil causes an increase in fertility of soil if the soil fertility is degraded
- the organic_matter_content of yellow_soil is low causes the need of hoeing of soil is high if the yellow_soil location is in_kebun
- removing of vegetation causes an increase in fertility of soil if the soil fertility is degraded and the vegetation type is grass
- terracing of land causes an increase in fertility of soil if the land slope is steep and the soil fertility is degraded
- planting of shade_tree causes an increase in fertility of soil if the soil fertility is degraded

- an increase in amount of erosion of soil causes a decrease in fertility of soil if the soil location is top_slope
- an increase in amount of erosion of soil causes an increase in fertility of soil if the soil location is foot_slope

- an increase in amount of erosion of soil causes an increase in organic_matter_content of soil if the erosion location is upstream and the soil location is downstream

- the amount of erosion of soil is high causes the suitability_for_coffee of sandy_soil is low if the kebun slope is steep
- the amount of erosion of soil is high causes the suitability_for_coffee of land is low if the land slope is steep

Landslides

- the stability of soil is low causes the landslide occurrence is possible if the land slope is steep and rainfall
- the impact_on_soil of rainfall is high causes the landslide occurrence is possible if the tree presence is no
- an increase in amount of runoff of rain_water causes an increase in occurrence of landslide

- the soil cover is absent causes cracking of soil if the time season is dry
- the soil consistency is hard causes cracking of soil if the drought occurrence is yes
- the drought duration is long causes cracking of soil if the soil location is in_sawah and the time season is dry

- cracking of soil causes the landslide occurrence is possible if the soil location is in_sawah and rainfall

- flooding of river causes an increase in occurrence of landslide if the land location is riversides

- an increase in occurrence of landslide causes an increase in occurrence of change of river path if the landslide location is riversides

- the vegetation type is shrub causes a decrease in occurrence of landslide if the vegetation location is riversides and flooding of river
- the vegetation type is grass causes a decrease in occurrence of landslide if the vegetation location is riversides and flooding of river
- the forest location is riversides causes a decrease in occurrence of landslide
- the planting of bamboo location is riversides causes a decrease in occurrence of landslide if flooding of river
- the planting of tree location is riversides causes a decrease in occurrence of landslide if flooding of river

Cultivation techniques

- rainfall causes an increase in amount of erosion of soil if the land slope is steep
- a decrease in impact_on_soil of rainfall causes a decrease in amount of erosion of soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- an increase in amount of runoff of rainwater causes an increase in amount of erosion of soil if the kebun slope is steep and rainfall
- an increase in amount of dissolving of soil causes an increase in amount of erosion of soil if rainfall and the kebun slope is steep
- an increase in amount of retention of water causes a decrease in amount of erosion of soil if the land slope is steep
- an increase in amount of retention of soil causes a decrease in amount of erosion of soil

- the vegetation type is shrub causes a decrease in amount of erosion of soil
- planting of tree causes a decrease in amount of erosion of soil if the planting of tree location is on_bare_soil
- planting of coffee causes a decrease in amount of erosion of soil if the planting of coffee location is on_bare_soil

- the soil cover is absent causes cracking of soil if the time season is dry
- cracking of soil causes an increase in presence of soil_crack
- rainfall causes an increase in amount of erosion of soil if the soil_crack presence is yes and the soil cover is absent and the land slope is not flat

Terracing

- an increase in slope of kebun causes an increase in need of terracing of kebun
- an increase in slope of sawah causes an increase in need of terracing of sawah
- terracing of land causes a decrease in amount of erosion if the terracing of land location is in_sawah and the land slope is steep

- terracing of land causes the black_soil position is surface if the terracing of land method is good
- the soil colour is black if the organic_matter_content of soil is high
- making of ridge causes a decrease in amount of erosion of soil if the making of ridge location is in_kebun and the kebun slope is steep
- the placing of wood position is perpendicular_to_slope causes terracing of kebun if the kebun slope is steep
- the placing of wood position is perpendicular_to_slope causes an increase in amount of retention of soil if the kebun slope is steep

- terracing of kebun causes a decrease in amount of runoff of rainwater if the kebun slope is steep and rainfall
- an increase in amount of runoff of rainwater causes an increase in occurence of landslide
- terracing of kebun causes a decrease in speed of runoff of rainwater if the kebun slope is steep

- terracing of kebun causes an increase in amount of infiltration of rainwater if the kebun slope is steep
- infiltration of rainwater causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low

- terracing of kebun causes an increase in amount of retention of water if the kebun slope is steep
- an increase in amount of retention of water causes an increase in availability of water if the time season is dry

- terracing of kebun causes an increase in amount of retention of soil if the kebun slope is steep
- an increase in amount of retention of soil causes a decrease in amount of dissolving of soil if runoff of rainwater
- an increase in amount of dissolving of soil causes the coffee root position is surface if the kebun slope is steep

- terracing of kebun causes an increase in amount of retention of fertiliser if the kebun slope is steep
- terracing of kebun causes an increase in amount of retention of leaf_litter if the kebun slope is steep
- terracing of kebun causes an increase in amount of retention of organic_matter if the kebun slope is steep
- an increase in amount of retention of organic_matter causes an increase in organic_matter_content of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- terracing of land causes an increase in fertility of soil if the land slope is steep and the soil fertility is degraded
- terracing of kebun causes an increase in fertility of soil if the kebun slope is steep

- an increase in organic_matter_content of soil causes an increase in rate of growth of coffee
- terracing of kebun causes an increase in rate of growth of coffee if the kebun slope is steep
- the amount of retention of water is high causes the coffee leaf colour is green
- an increase in amount of retention of water causes an increase in rate of growth of coffee

- terracing of kebun causes an increase in ease of walking if the kebun slope is steep

- terracing of kebun causes the need of capital is high
- terracing of kebun causes the need of labour is high
- terracing of kebun causes the need of time is high
- an increase in need of capital causes a decrease in action of farmer
- an increase in need of labour causes a decrease in action of farmer
- an increase in need of time causes a decrease in action of farmer

Furrow

- making of furrow causes a decrease in amount of runoff of rainwater if the land slope is steep and rainwater enter furrow
- making of furrow causes a decrease in speed of runoff of rainwater if the kebun slope is steep
- an increase in amount of runoff of rainwater causes an increase in occurence of landslide
- making of furrow causes a decrease in amount of erosion of soil if the land slope is steep and rainwater enter furrow
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river
- not making of furrow causes the topsoil presence is no if the kebun slope is steep and rainfall
- the topsoil fertility is good
- making of furrow causes an increase in amount of infiltration of rainwater if the kebun slope is steep and the furrow position is perpendicular_to_slope
- infiltration of rainwater causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low

- making of furrow causes an increase in amount of retention of soil if the kebun slope is steep
- making of furrow causes an increase in amount of retention of soil if the terracing of kebun action is yes and the kebun slope is steep and rainfall and runoff of rainwater and water enter furrow
- making of furrow causes an increase in amount of sedimentation of kebun soil if the kebun slope is steep and runoff of rainwater and water enter furrow

- an increase in amount of retention of soil causes a decrease in amount of dissolving of soil if runoff of rain_water
- an increase in amount of dissolving of soil causes the coffee root position is surface if the kebun slope is steep

- making of furrow causes an increase in amount of retention of organic_matter if the kebun slope is steep and the furrow position is perpendicular_to_slope
- an increase in amount of retention of organic_matter causes an increase in organic_matter_content of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- making of furrow causes an increase in fertility of soil if the kebun slope is steep and weed_residue enter furrow
- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- making of furrow causes an increase in rate of growth of coffee if the kebun slope is steep and the furrow position is perpendicular_to_slope

- the time season is rainy causes the need of making of furrow is high if the kebun slope is steep
- an increase in slope of kebun causes an increase in need of making of furrow
- the furrow condition is closed if the time season is dry
- the furrow condition is closed causes heaping furrow soil coffee stem

- the furrow depth is > 50cm causes not coffee root reaching organic_matter

- an increase in presence of furrow causes an increase in turbidity of river_water if the furrow location is in_kebun and flooding of river

Composting holes

- making of lubang causes an increase in rate of decomposition of leaf_litter if the land slope is in the range flat to steep and leaf_litter enter lubang
- an increase in amount of retention of water causes an increase in rate of decomposition of leaf_litter
- an increase in rate of decomposition of leaf_litter causes an increase in fertility of soil
- decomposition of leaf_litter causes an increase in organic_matter_content of soil
- making of lubang causes an increase in rate of decomposition of weed_residue if the kebun slope is in the range flat to steep and weed_residue enter lubang
- an increase in amount of retention of water causes an increase in rate of decomposition of weed_residue
- an increase in rate of decomposition of weed_residue causes an increase in organic_matter_content of soil
- making of lubang causes an increase in fertility of soil if the kebun slope is steep and weed_residue enter lubang
- an increase in organic_matter_content of soil causes an increase in fertility of soil

- making of lubang causes an increase in fertility of soil if leaf_litter enter lubang and weed_residue enter lubang

- making of lubang causes an increase in amount of retention of organic_matter if the lubang location is in_kebun and the kebun slope is steep
- an increase in amount of retention of organic_matter causes an increase in organic_matter_content of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- making of lubang causes an increase in rate of growth of coffee root if the kebun slope is in the range flat to steep

- making of lubang causes an increase in production of coffee if the lubang position is above_coffee_plant and the kebun slope is not_too_steep

- making of lubang causes a decrease in amount of runoff of rain_water if the land slope is steep and rain_water enter lubang
- making of lubang causes a decrease in speed of runoff of rain_water if the land slope is steep and rain_water enter lubang
- an increase in amount of runoff of rain_water causes an increase in occurence of landslide
- making of lubang causes a decrease in amount of erosion of soil if the land slope is steep and rain_water enter lubang
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river

- making of lubang causes an increase in amount of retention of soil if the kebun slope is steep
- making of lubang causes an increase in amount of retention of soil if the terracing of kebun action is yes and the kebun slope is steep and rainfall and runoff of rain_water and water enter lubang
- an increase in amount of retention of soil causes a decrease in amount of dissolving of soil if runoff of rain_water
- an increase in amount of dissolving of soil causes the coffee root position is surface if the kebun slope is steep
- making of lubang causes an increase in amount of retention of water if the lubang location is in_kebun and the kebun slope is steep
- an increase in amount of retention of water causes an increase in availability of water if the time season is dry

- the lubang condition is closed if the time season is dry
- rainfall causes an increase in amount of covering_with_soil of lubang
- an increase in amount of covering_with_soil of lubang causes the lubang condition is closed
- the lubang condition is closed causes the need of digging of lubang is high if the time season is rainy
- the time season is rainy causes the need of making of lubang is high if the kebun slope is steep
- the lubang condition is closed causes heaping lubang soil coffee stem

- making of lubang causes the need of capital is high
- making of lubang causes the need of labour is high
- an increase in need of capital causes a decrease in action of farmer
- an increase in need of labour causes a decrease in action of farmer

The coffee agroforest

- falling of shade_tree leaf causes an increase in amount of leaf_litter
- an increase in presence of shade_tree causes an increase in amount of leaf_litter
- an increase in presence of shade_tree causes an increase in amount of root

- the tree presence is no causes the impact_on_soil of rainfall is high
- an increase in presence of shade_tree leaf causes a decrease in impact_on_soil of rainfall
- a decrease in presence of shade_tree causes an increase in impact_on_soil of rainfall if the shade_tree location is in_kebun

- planting of shade_tree causes an increase in amount of infiltration of rain_water if the planting of shade_tree location is in_kebun
- infiltration of rain_water causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low

- a decrease in presence of shade_tree causes an increase in amount of runoff of rain_water if the kebun slope is steep and rainfall
- an increase in amount of runoff of rain_water causes an increase in occurence of landslide
- an increase in presence of shade_tree causes a decrease in speed of runoff of rain_water if the shade_tree location is in_kebun and the kebun slope is steep and rainfall

- an increase in presence of shade_tree causes a decrease in amount of erosion of soil if the shade_tree type is kayu hujan and the kebun slope is steep and the terracing of kebun action is no
- rainfall causes an increase in amount of erosion of soil if the humidity of soil is low and the shade_tree presence is no
- the shade_tree presence is yes causes a decrease in amount of erosion of soil if the kebun slope is steep and the terracing of kebun action is yes
- rainfall causes an increase in amount of erosion of soil if the shade_tree presence is no and the land slope is steep
- planting of shade_tree causes a decrease in amount of erosion of soil if the shade_tree location is in_kebun and the kebun slope is steep
- the amount of erosion of soil is high if the shade_tree presence is no and the terracing of kebun action is no

- planting of shade_tree causes an increase in amount of retention of soil if the shade_tree location is in_kebun and the kebun slope is steep

- an increase in amount of retention of soil causes a decrease in amount of dissolving of soil if runoff of rain_water
- an increase in amount of dissolving of soil causes the coffee root position is surface if the kebun slope is steep

- planting of shade_tree causes an increase in amount of retention of water if the shade_tree location is in_kebun
- an increase in species_number of shade_tree causes an increase in amount of retention of water if the shade_tree location is in_kebun
- an increase in presence of shade_tree causes an increase in amount of retention of water if the shade_tree root system is not superficial
- an increase in amount of retention of water causes an increase in availability of water if the time season is dry

- planting of shade_tree causes an increase in amount of retention of organic_matter if the shade_tree location is in_kebun and the kebun slope is steep
- an increase in amount of retention of organic_matter causes an increase in organic_matter_content of soil
- an increase in organic_matter_content of soil causes an increase in fertility of soil
- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- an increase in presence of shade_tree causes an increase in fertility of soil
- planting of shade_tree causes an increase in fertility of soil if the soil fertility is degraded

- planting of shade_tree causes an increase in cover of mountain if the shade_tree location is in_kebun
- a decrease in cover of mountain causes an increase in amount of runoff of rain_water
- planting of shade_tree causes a decrease in amount of flooding of river if the shade_tree location is in_kebun and the shade_tree size is big

- an increase in presence of shade_tree causes an increase in amount of shade_tree_product if the shade_tree location is in_kebun
- an increase in amount of shade_tree_product causes a decrease in need of felling of forest tree if the shade_tree location is in_kebun

Protection of coffee plants

- an increase in presence of shade_tree leaf causes a decrease in amount of sunshine if the shade_tree type is dadap
- an increase in presence of shade_tree causes a decrease in amount of sunshine if the shade_tree location is in_kebun

- the shade_tree presence is too_low causes the sunshine amount is too_high if the time season is dry
- the sunshine amount is too_high causes an increase in amount of dying of coffee if the time season is dry
- an increase in amount of sunshine causes an increase in temperature of air
- a decrease in slope of land causes an increase in temperature of topsoil if the amount of sunshine is high
- the shade_tree presence is yes causes the air temperature is not_too_high
- the air temperature is not_too_high causes the rate of growth of coffee is high if the time season is dry
- an increase in temperature of air causes an increase in amount of drying of coffee fruit if the time season is dry

- the time season is coffee_flowering causes an increase in need of sunshine if the sunshine location is in_kebun
- an increase in presence of shade_tree leaf causes an increase in need of pruning of shade_tree if the time season is rainy
- the time season is coffee_flowering causes the pruning of shade_tree action is yes if the shade_tree size is too_big
- an increase in action of pruning of shade_tree causes an increase in amount of sunshine

- the shade_tree presence is too_high causes the sunshine amount is too_low if the shade_tree location is in_kebun
- the sunshine amount is too_low causes a decrease in production of coffee

- the shade_tree presence is yes causes the humidity of subsoil is high if the time season is dry
- the shade_tree presence is no causes the humidity of soil is low if the time season is dry
- the humidity of soil is low causes an increase in occurrence of falling of coffee fruit
- the soil consistency is hard causes an increase in occurrence of falling of coffee fruit if the application of KCl action is no
- the shade_tree presence is no causes the soil consistency is hard if the time season is dry
- the soil consistency is hard causes the coffee leaf colour is yellow if the soil location is in_kebun
- the soil consistency is hard causes the soil condition is compact
- the soil condition is compact causes an increase in amount of dying of coffee

- the shade_tree presence is yes causes an increase in rate of growth of coffee if the shade_tree density is not_too_dense
- an increase in amount of retention of water causes an increase in rate of growth of coffee
- the shade_tree presence is yes causes an increase in strength of coffee

- the shade_tree presence is no causes the coffee leaf colour is yellow if the time season is dry
- the shade_tree presence is no causes the coffee leaf colour is red if the time season is dry
- the shade_tree presence is yes causes the coffee leaf colour is green if the time season is dry
- an increase in presence of shade_tree causes a decrease in occurence of falling of coffee leaf if the time season is dry
- the amount of retention of water is high causes the coffee leaf colour is green

- a decrease in presence of shade_tree causes a decrease in amount of coffee fruit if the shade_tree location is in_kebun
- a decrease in presence of shade_tree causes a decrease in amount of formation of coffee fruit if the time season is dry
- a decrease in amount of formation of coffee fruit causes a decrease in production of coffee

- an increase in presence of shade_tree causes a decrease in occurrence of falling of coffee fruit if the time season is dry

- an increase in presence of shade_tree causes a decrease in occurrence of falling of coffee fruit if the time season is rainy

- the shade_tree presence is yes causes the harvest of coffee moment is later

- the shade_tree amount is too_high causes falling of coffee flower if the shade_tree location is in_kebun
- the shade_tree leaf presence is too_high causes falling of coffee leaf if the time season is rainy
- the shade_tree amount is too_high causes falling of coffee fruit if the shade_tree location is in_kebun and the time season is rainy
- an increase in occurence of falling of coffee fruit causes a decrease in production of coffee

- an increase in presence of shade_tree causes a decrease in rate of growth of weed
- an increase in presence of shade_tree causes a decrease in amount of weed

Shade tree species

- the shade_tree root system is superficial if the shade_tree type is kayu manis
- the suitability_for_coffee of shade_tree is low if shade_tree root attack coffee root
- the shade_tree root system is superficial causes the competition_with_coffee of shade_tree is high if the shade_tree location is in_kebun
- the competition_with_coffee of shade_tree is high causes a decrease in rate of growth of coffee if the shade_tree location is in_kebun
- the competition_with_coffee of dadap_tree root is low if the dadap_tree location is in_kebun

- the suitability_as_shade_tree of dadap_tree is greater_than other_tree if the shade_tree location is in_kebun
- falling of dadap_tree leaf causes the quality of organic_matter is high
- the occurence of dying of dadap_tree is high
- the dadap_tree root type is soft causes the kebun soil structure is loose if the dadap_tree location is in_kebun
- the dadap_tree root type is soft causes the coffee leaf colour is green if the dadap_tree location is in_kebun
- the amount of dadap_tree hair_root is high causes the amount of retention of water is high
- an increase in presence of pepper causes an increase in occurence of dying of dadap_tree if the pepper location is in_kebun and the dadap_tree location is in_kebun

- shade_tree is_used_as trellis_for_pepper if the shade_tree type is kayu hujan

- falling of Kaliandra flower causes dying of coffee flower if the falling of Kaliandra flower location is on_coffee_flower
- the reproduction of Kaliandra is high causes the suitability_as_shade_tree of Kaliandra is low if the Kaliandra location is in_kebun
- the Kaliandra presence is yes causes the disease type is black_fungus if the Kaliandra location is in_kebun

- shade_tree is_used_as land_limit

Weeds

- the rate of growth of weed is high if the time season is rainy
- an increase in presence of shade_tree causes a decrease in rate of growth of weed
- an increase in presence of shade_tree causes a decrease in amount of weed
- planting of Arachis causes a decrease in amount of weed
- planting of Arachis causes the need of weeding of kebun is low

- weeding of field causes a decrease in amount of weed
- not weeding of kebun causes an increase in amount of weed
- a decrease in amount of weed causes a decrease in need of weeding of kebun
- an increase in rate of growth of weed causes an increase in need of weeding of kebun
- a decrease in need of weeding of kebun causes a decrease in need of capital
- an increase in need of capital causes a decrease in action of farmer

- a decrease in amount of weed causes an increase in amount of erosion of soil if the kebun slope is steep and rainfall
- weeding of kebun causes an increase in amount of erosion of soil if rainfall and the kebun slope is steep
- an increase in frequency of weeding of kebun causes an increase in amount of erosion of soil
- weeding of black_soil causes an increase in amount of erosion if the land slope is steep
- the field slope is not_too_steep causes the amount of erosion of soil is low if weeding of field
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river
- the weed presence is yes causes an increase in amount of retention of soil if the time season is rainy and erosion of soil and the kebun slope is steep
- weeding of kebun causes an increase in amount of dissolving of soil if rainfall and the kebun slope is steep
- an increase in amount of dissolving of soil causes the coffee root position is surface if the kebun slope is steep

- an increase in amount of weed causes a decrease in fertility of soil if the weed location is in_kebun
- an increase in amount of weed causes a decrease in amount of coffee fruit if the weed location is under_coffee
- an increase in amount of weed causes an increase in amount of dying of coffee
- an increase in amount of weed causes a decrease in rate of growth of coffee

- an increase in amount of weed causes the coffee leaf colour is yellow
- an increase in amount of weed causes the coffee leaf colour is red
- a decrease in amount of weed causes the coffee leaf colour is green
- weeding of field causes an increase in fertility of soil
- weeding of kebun causes an increase in rate of growth of coffee

- making of weed_strip causes a decrease in amount of erosion of soil if the kebun slope is steep
- making of weed_strip causes the need of weeding of kebun is low
- making of weed_strip causes the coffee production is not decrease

- ring_weeding of kebun causes the coffee production is not decrease
- ring_weeding of kebun causes a decrease in amount of erosion of soil if the kebun slope is steep

- the weed presence is not good causes the need of clean_weeding of kebun is high
- not clean_weeding of kebun causes the weed presence is yes if the time season is rainy
- clean_weeding of kebun causes the coffee leaf colour is green
- clean_weeding of kebun causes the fertility of soil is high
- an increase in frequency of weeding of kebun causes an increase in amount of erosion of soil
- clean_weeding of kebun causes an increase in amount of erosion of soil if the kebun slope is steep and the terracing of kebun action is no
- clean_weeding of kebun causes an increase in amount of erosion of soil if the shade_tree presence is no and rainfall
- the clean_weeding of kebun action is good if the presence of shade_tree is high
- not clean_weeding of kebun causes the soil fertility is not decrease if the time season is rainy
- the weeding of kebun frequency is at_least_five_times_a_year if the weeding of kebun method is good

- hoeing of soil causes a decrease in amount of weed
- application of herbicide causes a decrease in amount of weed
- weeding of kebun causes the weed amount is zero
- application of herbicide causes the weed amount is not_zero if the application of herbicide location is in_kebun

- weeding of kebun causes the soil structure is loose (weeding = hoeing and/or forking)
- hoeing of kebun causes the soil structure is loose
- hoeing of kebun causes the soil consistency is not hard
- forking of kebun soil causes the soil structure is loose
- forking of kebun soil causes the soil consistency is not hard
- weeding of kebun causes the soil structure is loose if the forking of soil action is yes
- weeding of kebun causes the soil consistency is not hard if the forking of soil action is yes
- not forking of kebun soil causes the soil consistency is hard
- cutting of weed causes the soil structure is not loose if the cutting of weed location is in_kebun
- application of herbicide causes the soil consistency is hard if the application of herbicide location is in_kebun
- the application of herbicide frequency is too_high causes the soil consistency is hard if the application of herbicide location is in_kebun

- the amount of infiltration of rain_water is high if the soil structure is loose
- the amount of runoff of rain_water is low if the soil structure is loose
- the speed of runoff of rain_water is low if the soil structure is loose
- the amount of erosion of soil is high if the soil structure is loose and the land slope is steep
- the turbidity of water is high if the soil structure is loose and runoff of rain_water

- the soil consistency is hard causes the soil condition is compact
- the amount of infiltration of rain_water is low if the soil consistency is hard
- the speed of runoff of rain_water is high if the soil consistency is hard
- the amount of runoff of rain_water is high if the soil consistency is hard
- the amount of erosion of soil is low if the soil consistency is hard
- the turbidity of water is low if the soil consistency is hard and runoff of rain_water

- the suitability_for_coffee of red_soil is high if the red_soil structure is loose
- the black_soil structure is loose causes the suitability_for_coffee of black_soil is high
- the soil structure is loose causes the rate of growth of coffee root is high
- the red_soil structure is loose causes the coffee taste is good if the red_soil location is in_kebun
- the red_soil structure is loose causes an increase in size of coffee bean if the red_soil location is in_kebun
- the soil consistency is hard causes an increase in occurence of falling of coffee fruit if the application of KCl action is no
- the soil consistency is hard causes the coffee leaf colour is yellow if the soil location is in_kebun
- the soil condition is compact causes an increase in amount of dying of coffee

- forking of kebun soil causes turning of kebun soil
- weeding of kebun causes not turning of kebun soil (hoeing, cutting,... but not forking!)
- weeding of kebun causes turning of kebun soil (weeding = hoeing and/or forking)

- turning of kebun soil causes an increase in amount of infiltration of rain_water if rainfall
- not turning of kebun soil causes the kebun soil consistency is hard if the time season is dry
- not turning of kebun soil causes the kebun soil consistency is sticky if the time season is rainy

- not turning of kebun soil causes a decrease in production of coffee

- forking of kebun soil causes the humidity of soil is low if the time season is dry
- application of herbicide causes the humidity of soil is low if the application of herbicide location is in_kebun
- rainfall causes an increase in amount of erosion of soil if the humidity of soil is low and the shade_tree presence is no
- the humidity of soil is low causes the amount of erosion of soil is high if rainfall
- the humidity of soil is low causes an increase in occurence of falling of coffee fruit

- hoeing of soil causes displacing of coffee hair_root
- forking of kebun soil causes deplacing of coffee hair_root
- weeding of kebun causes displacing of coffee hair_root (weeding = hoeing and/or forking)
- hoeing of kebun causes an increase in rate of growth of coffee hair_root if hoe contact coffee root
- application of herbicide causes not deplacing of coffee hair_root
- not deplacing of coffee hair_root causes the disease type is fungus
- the disease type is fungus causes the coffee leaf colour is yellow if the disease location is on_hair_root

- application of herbicide causes a decrease in rate of growth of coffee hair_root if herbicide contact coffee root
- application of herbicide causes an increase in amount of dying of coffee hair_root
- an increase in amount of dying of coffee hair_root causes a decrease in rate of growth of coffee

- application of herbicide causes an increase in period of harvest of coffee
- the application of herbicide frequency is too_high causes the coffee leaf colour is yellow
- the application of herbicide frequency is too_high causes an increase in amount of dying of coffee
- an increase in frequency of application of herbicide causes a decrease in fertility of soil if the application of herbicide location is in_kebun

- application of herbicide causes a decrease in production of coffee
- application of herbicide causes the need of forking of kebun soil is high

- forking of kebun soil causes an increase in amount of infiltration of rainwater
- forking of kebun soil causes a decrease in amount of erosion of soil if the kebun slope is steep
- forking of kebun soil causes the erosion of soil amount is not decrease if the kebun slope is too_steep and the shade_tree presence is no
- forking of kebun soil causes an increase in amount of erosion of soil if the kebun slope is steep and the amount of rainfall is high and the terracing of kebun action is no or the coffee age is young
- the need of forking of kebun soil is high if planting of coffee

- an increase in amount of weed_residue causes an increase in organic_matter_content of soil
- the leaving of weed_residue location is on_soil causes an increase in cover of soil if weeding of kebun
- the leaving of weed_residue location is on_soil causes the rate of decomposition of weed_residue is high if weeding of kebun
- an increase in rate of decomposition of weed_residue causes an increase in organic_matter_content of soil
- increase in organic_matter_content of soil causes an increase in fertility of soil

- weeding of kebun causes heaping weed_residue coffee stem if the weeding of kebun method is good and the kebun slope is steep
- heaping weed_residue coffee stem causes an increase in amount of retention of water if rainfall and the kebun slope is steep
- an increase in amount of retention of water causes an increase in rate of decomposition of weed_residue

- making of lubang causes an increase in rate of decomposition of weed_residue if the kebun slope is in the range flat to steep and weed_residue enter lubang
- making of lubang causes an increase in fertility of soil if the kebun slope is steep and weed_residue enter lubang
- making of lubang causes an increase in fertility of soil if leaf_litter enter lubang and weed_residue enter lubang
- making of furrow causes an increase in fertility of soil if the kebun slope is steep and weed_residue enter furrow

Cover crops

- planting of Arachis causes an increase in rate of growth of pepper

- the planting of Arachis location is border if the Arachis location is in_kebun

- planting of Arachis causes an increase in cover of soil
- a decrease in cover of soil causes an increase in amount of runoff of rain_water if the land slope is steep
- planting of Arachis causes a decrease in amount of erosion of soil if the kebun slope is steep
- planting of Arachis causes an increase in amount of retention of soil
- an increase in cover of soil causes a decrease in turbidity of water if the kebun slope is steep and runoff of rain_water
- an increase in cover of soil causes an increase in humidity of soil if the weather humidity is dry
- planting of Arachis causes the erosion of soil amount is not decrease if the kebun slope is steep

- planting of Arachis causes an increase in fertility of soil
- the fertiliser_content of Arachis is high causes an increase in fertility of soil if planting of Arachis

- planting of Arachis causes a decrease in amount of weed
- planting of Arachis causes the need of weeding of kebun is low

- planting of Arachis causes not turning of kebun soil

Landscape elements

- a decrease in cover of forest causes a decrease in discharge_constancy of river_water
- a decrease in cover of forest causes an increase in amount of flooding of river if the time season is rainy
- a decrease in cover of forest causes an increase in turbidity of river_water if flooding of river
- a decrease in cover of forest causes an increase in occurence of drying of river if the time season is dry

- an increase in amount of flooding of river causes the need of reforestation of land is high

- planting of coffee causes a decrease in amount of erosion of soil if the planting of coffee location is on_bare_soil
- planting of tree causes a decrease in amount of erosion of soil if the planting of tree location is on_bare_soil
- the planting of tree location is below_kebun causes filtering of rain_water if runoff of rain_water
- the vegetation type is grass causes filtering of kebun water if runoff of kebun water (alang alang)
- filtering of rain_water causes a decrease in turbidity of water
- filtering of rain_water causes an increase in amount of retention of soil

- the vegetation type is shrub causes an increase in amount of root
- the vegetation type is shrub causes an increase in amount of leaf_litter
- the vegetation type is shrub causes a decrease in amount of erosion of soil
- the vegetation type is shrub causes an increase in amount of retention of soil if runoff of rain_water
- the vegetation type is shrub causes a decrease in amount of runoff of rain_water if the land slope is steep
- the vegetation type is shrub causes a decrease in speed of runoff of rain_water
- the vegetation type is shrub causes the yield amount is zero

Coffee gardens

- the kebun system is like_forest causes a decrease in amount of flooding of river if the kebun location is upstream and the flooding location is downstream
- planting of shade_tree causes a decrease in amount of flooding of river if the shade_tree location is in_kebun and the shade_tree size is big
- the kebun system is coffee_monoculture causes an increase in turbidity of river_water if rainfall
- the shade_tree presence is yes causes a decrease in amount of erosion of soil if the kebun slope is steep and the terracing of kebun action is yes
- rainfall causes an increase in amount of erosion of soil if the shade_tree presence is no and the land slope is steep
- planting of shade_tree causes an increase in amount of infiltration of rain_water if the planting of shade_tree location is in_kebun
- infiltration of rain_water causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low

- terracing of kebun causes an increase in amount of infiltration of rain_water if the kebun slope is steep
- terracing of kebun causes a decrease in amount of runoff of rain_water if the kebun slope is steep and rainfall
- terracing of kebun causes a decrease in speed of runoff of rain_water if the kebun slope is steep
- terracing of kebun causes a decrease in amount of erosion of soil if the kebun slope is steep
- terracing of kebun causes a decrease in turbidity of water if the kebun slope is steep

- making of furrow causes an increase in amount of infiltration of rain_water if the kebun slope is steep and the furrow position is perpendicular_to_slope
- making of lubang causes a decrease in amount of runoff of rain_water if the land slope is steep and rain_water enter lubang
- making of lubang causes a decrease in speed of runoff of rain_water if the land slope is steep and rain_water enter lubang
- making of furrow causes a decrease in amount of runoff of rain_water if the land slope is steep and rain_water enter furrow
- making of furrow causes a decrease in speed of runoff of rain_water if the kebun slope is steep
- making of lubang causes a decrease in amount of erosion of soil if the land slope is steep and rain_water enter lubang
- making of furrow causes a decrease in amount of erosion of soil if the land slope is steep and rain_water enter furrow
- an increase in amount of erosion of soil causes an increase in turbidity of water if the soil location is in_kebun and kebun water enter river

- weeding of kebun causes an increase in amount of erosion of soil if rainfall and the kebun slope is steep
- an increase in frequency of weeding of kebun causes an increase in amount of erosion of soil
- making of weed_strip causes a decrease in amount of erosion of soil if the kebun slope is steep
- ring_weeding of kebun causes a decrease in amount of erosion of soil if the kebun slope is steep

Riparian vegetation

- flooding of river causes an increase in occurence of landslide if the land location is river_sides
- an increase in occurence of landslide causes an increase in occurence of change of river path if the landslide location is river_sides
- flooding of river causes an increase in amount of erosion of river bank

- the forest location is river_sides causes the discharge_constancy of river is high
- the forest location is river_sides causes not flooding of river
- the forest location is river_sides causes a decrease in occurence of landslide
- the forest location is river_sides causes the amount of erosion of soil is low
- the forest location is river_sides causes the turbidity of river_water is low

- the planting of tree location is river_sides causes an increase in amount of retention of water if runoff of rain_water
- the planting of tree location is river_sides causes an increase in amount of infiltration of rain_water if rainfall and runoff of rain_water
- infiltration of rain_water causes the water flow is under_soil
- the water flow is under_soil causes a decrease in amount of erosion of soil if the soil slope is steep
- the water flow is under_soil causes the turbidity of water is low
- the planting of tree location is below_kebun causes filtering of rain_water if runoff of rain_water
- filtering of rain_water causes a decrease in turbidity of water
- filtering of rain_water causes an increase in amount of retention of soil
- the planting of tree location is river_sides causes a decrease in turbidity of water if runoff of rain_water and water enter river
- the planting of tree location is river_sides causes a decrease in turbidity of river_water
- the planting of tree location is river_sides causes an increase in amount of retention of soil if runoff of rain_water
- the planting of tree location is river_sides causes a decrease in occurence of landslide if flooding of river
- the planting of tree location is river_sides causes a decrease in amount of erosion of river bank if flooding of river

- the vegetation type is shrub causes an increase in amount of retention of water if the vegetation location is river_sides and runoff of rain_water
- the vegetation type is shrub causes an increase in amount of infiltration of rain_water if the vegetation location is river_sides and runoff of rain_water
- infiltration of rain_water causes the water flow is under_soil
- the vegetation type is shrub causes filtering of rain_water if the vegetation location is river_sides and runoff of rain_water and water enter river
- the vegetation type is shrub causes an increase in amount of retention of soil if the vegetation location is river_sides and runoff of rain_water
- the vegetation type is shrub causes the turbidity of water is low if the vegetation location is river_sides and runoff of rain_water and water enter river
- the vegetation type is shrub causes the turbidity of water is low if the Kaliandra presence is yes and the vegetation location is river_sides and the land slope is steep and rainfall and water enter river
- the vegetation type is shrub causes the turbidity of river_water is low if the vegetation location is river_sides and flooding of river
- the vegetation type is shrub causes a decrease in occurence of landslide if the vegetation location is river_sides and flooding of river

- the planting of bamboo location is river_sides causes an increase in amount of retention of water if runoff of rain_water
- the planting of bamboo location is river_sides causes an increase in amount of infiltration of rain_water if rainfall and runoff of rain_water
- infiltration of rain_water causes the water flow is under_soil
- the amount of bamboo hair_root is high causes the amount of retention of soil is high
- the planting of bamboo location is river_sides causes a decrease in occurence of landslide if flooding of river
- the planting of bamboo location is river_sides causes a decrease in amount of erosion of river bank if flooding of river

- the vegetation type is grass causes filtering of kebun water if runoff of kebun water
- filtering of rain_water causes a decrease in turbidity of water
- the vegetation type is grass causes an increase in amount of retention of soil if the vegetation location is river_sides and runoff of rain_water
- the vegetation type is grass causes a decrease in occurence of landslide if the vegetation location is river_sides and flooding of river
- the vegetation type is grass causes a decrease in amount of erosion of river bank if the vegetation location is river_sides and flooding of river

Irrigation of paddy field with river water

- irrigation of sawah causes the river_water location is in_sawah
- the river_water location is in_sawah causes an increase in amount of sedimentation of soil if irrigation of sawah
- an increase in turbidity of river_water causes an increase in turbidity of irrigation_water if irrigation of sawah
- an increase in turbidity of river_water causes an increase in turbidity of sawah water if river_water enter sawah
- the river_water content is sandy causes the sandy_sediment presence is in_sawah if river_water enter sawah
- the turbidity of irrigation_water is low causes the turbidity of sawah water is low if sawah water enter river
- an increase in turbidity of water causes an increase in amount of sedimentation of soil if water enter sawah and the sedimentation of soil location is in_sawah
- an increase in turbidity of sawah water causes an increase in turbidity of river_water if sawah water enter river

- the amount of rainfall is high causes not irrigation of sawah if the sawah slope is steep
- rainfall causes the need of regulation of irrigation_water is high if irrigation sawah river_water and the turbidity of river_water is high

- not regulation of irrigation_water causes the irrigation_water amount is too_high if the time season is rainy and flooding of river
- not regulation of irrigation_water causes the amount of erosion of sawah soil is high
- the amount of erosion of sawah soil is high causes destroying of sawah
- an increase in amount of erosion of sawah soil causes an increase in turbidity of river_water
- not regulation of irrigation_water causes dying of rice if rainfall and irrigation sawah river_water and the turbidity of river_water is high
- not regulation of irrigation_water causes the irrigation_water amount is too_low if the time season is dry

- regulation of irrigation_water causes a decrease in flow of water if the irrigation_water location is in_sawah
- regulation of sawah_water_amount causes a decrease in flow of water
- a decrease in flow of water causes an increase in stay_in_sawah of water
- not regulation of irrigation_water causes an increase in flow of water if the irrigation_water location is in_sawah and the time season is rainy
- an increase in flow of water causes an increase in amount of deplacing of rice if the water location is in_sawah
- an increase in amount of deplacing of rice causes a decrease in production of rice

- an increase in stay_in_sawah of water causes a decrease in turbidity of sawah water if irrigation of sawah and river_water enter sawah and sawah water enter river
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil
- an increase in amount of sedimentation of soil causes an increase in fertility of sawah soil if the sedimentation of soil location is in_sawah
- an increase in amount of sedimentation of soil causes a decrease in turbidity of water if the sedimentation of soil location is in_sawah and sawah water enter river
- an increase in turbidity of sawah water causes an increase in turbidity of river_water if sawah water enter river

Runoff water and the paddy fields

- the kebun water location is in_sawah causes an increase in amount of sedimentation of soil if rainfall and runoff of kebun water and kebun water enter sawah
- an increase in amount of sedimentation of soil causes an increase in fertility of sawah soil if the sedimentation of soil location is in_sawah
- an increase in amount of sedimentation of soil causes a decrease in turbidity of water if the sedimentation of soil location is in_sawah and sawah water enter river
- an increase in turbidity of sawah water causes an increase in turbidity of river_water if sawah water enter river

- the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah
- an increase in turbidity of water causes an increase in amount of sedimentation of soil if water enter sawah and the sedimentation of soil location is in_sawah
- the organic_matter_content of kebun water is high causes an increase in fertility of sawah soil if runoff of kebun water and kebun water enter sawah
- runoff of rain_water causes an increase in fertility of sawah soil if the runoff of rain_water location is in_kebun and kebun water enter sawah and the regulation of water action is yes
- the rice presence is no causes the suitability_for_sawah of kebun water is high if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah

- the kebun water location is in_sawah causes covering_with_soil of rice if runoff of rain_water and kebun water enter sawah
- covering_with_soil of rice causes dying of rice
- the rice presence is yes causes the suitability_for_sawah of kebun water is low if runoff of rain_water and the turbidity of kebun water is high and kebun water enter sawah

- an increase in amount of runoff of rain_water causes an increase in amount of deplacing of rice if the runoff of rain_water location is in_kebun and kebun water enter sawah and the regulation of water action is no
- an increase in speed of runoff of rain_water causes an increase in amount of deplacing of rice if the runoff of rain_water location is in_kebun and kebun water enter sawah
- an increase in amount of deplacing of rice causes a decrease in production of rice
- an increase in amount of runoff of rain_water causes an increase in amount of erosion of sawah soil if the runoff of rain_water location is in_kebun and kebun water enter sawah and the regulation of water action is no
- the amount of erosion of sawah soil is high causes destroying of sawah
- an increase in amount of erosion of sawah soil causes an increase in turbidity of river_water

- the making of furrow location is between_kebun_and_sawah causes the regulation of water action is yes if the runoff of rain_water location is in_kebun
- making of furrow causes the kebun water location is not in_sawah if runoff of rain_water and the furrow location is between_kebun_and_sawah
- making of furrow causes the kebun water location is in_river if the furrow location is between_kebun_and_sawah and kebun water enter furrow

- the need of making of furrow is low if the terracing of kebun action is yes and the shade_tree presence is yes and the furrow location is between_kebun_and_sawah
- making of furrow causes an increase in amount of sedimentation of kebun soil if the kebun slope is steep and runoff of rain_water and water enter furrow

- regulation of sawah_water_amount causes a decrease in flow of water
- an increase in flow of water causes an increase in amount of deplacing of rice if the water location is in_sawah
- a decrease in flow of water causes an increase in stay_in_sawah of water
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil
- an increase in stay_in_sawah of water causes a decrease in turbidity of sawah water if runoff of kebun water and kebun water enter sawah and sawah water enter river
- a decrease in amount of sawah water causes a decrease in stay_in_sawah of water if runoff of kebun water and kebun water enter sawah and sawah water enter river
- a decrease in stay_in_sawah of water causes the sawah water turbidity is not decrease if runoff of kebun water and kebun water enter sawah and sawah water enter river

Other relations between paddy fields and water turbidity

- making of sawah causes an increase in turbidity of river_water
- hoeing of sawah causes an increase in turbidity of sawah water if rainfall or irrigation of sawah
- hoeing of sawah causes an increase in turbidity of sawah water
- an increase in turbidity of sawah water causes an increase in turbidity of river_water if sawah water enter river

- the making of furrow location is in_sawah causes the ease of draining of sawah is high
- the humidity of sawah soil is high causes the suitability_for_planting of time is low if the time season is rainy and planting of rice
- the humidity of sawah soil is high causes the need of making of furrow is high if the time season is rainy and planting of rice
- the making of furrow location is in_sawah causes the ease of cultivation of sawah is high
- the making of furrow location is in_sawah causes the flow of sawah water is high
- an increase in flow of sawah water causes a decrease in presence of red_water
- the flow of sawah water is high causes a decrease in presence of mouse

- a decrease in flow of water causes an increase in stay_in_sawah of water
- a decrease in stay_in_sawah of water causes the sawah water turbidity is not decrease if runoff of kebun water and kebun water enter sawah and sawah water enter river
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil

- an increase in flow of water causes an increase in amount of deplacing of rice if the water location is in_sawah
- an increase in amount of deplacing of rice causes a decrease in production of rice

- the rice presence is yes causes the turbidity of sawah water is low if the sawah water presence is yes and rainfall and sawah water enter river
- rainfall causes the sawah water turbidity is not increase if the hoeing of sawah action is no
- the turbidity of sawah water is greater_than river_water if the amount of rainfall is high and sawah water enter river

- a decrease in occurence of rainfall causes a decrease in amount of sawah water
- a decrease in amount of sawah water causes a decrease in stay_in_sawah of water if runoff of kebun water and kebun water enter sawah and sawah water enter river (2way!)
- a decrease in stay_in_sawah of water causes the sawah water turbidity is not decrease if runoff of kebun water and kebun water enter sawah and sawah water enter river
- an increase in stay_in_sawah of water causes an increase in amount of sedimentation of soil

Local soil knowledge

- the cold_soil presence is yes if the temperature of subsoil is low and the temperature of topsoil is high
- the cold_soil presence is yes if the time season is growing_season
- the cold_soil presence is yes if the humidity of topsoil is low and the humidity of subsoil is high
- the cold_soil presence is yes if the amount of retention of water is high
- the cold_soil presence is yes causes the suitability_for_planting of time is high
- the cold_soil presence is yes causes the fertility of soil is high

- the topsoil fertility is good
- the fertility of subsoil is low

Black soils

- the black_soil colour is black
- the darkness of black_soil topsoil is greater_than black_soil subsoil

- the soil colour is black if the organic_matter_content of soil is high
- the organic_matter_content of black_soil is high causes the fertility of black_soil is high
- the organic_matter_content of black_soil is high causes the suitability_for_coffee of black_soil is high
- the fertility of black_soil is high if the black_soil depth is > 25 cm
- terracing of land causes the black_soil position is surface if the terracing of land method is good

- the organic_matter_content of red_soil is high causes the red_soil colour is black
- weeding of black_soil causes an increase in amount of erosion if the land slope is steep
- erosion of black_soil causes the red_soil position is surface
- erosion of black_soil causes the black_soil colour is red if the soil slope is steep
- erosion of black_soil causes the black_soil colour is white if the soil slope is steep
- the black_soil colour is white causes the fertility of soil is very_low if erosion of black_soil

- erosion of black_soil causes the river_water colour is black if the black_soil location is in_forest and the river location is in_forest

- the suitability_for_coffee of black_soil is high
- the suitability_for_coffee of black_soil is greater_than red_soil
- the organic_matter_content of black_soil is high causes the suitability_for_coffee of black_soil is high

- the suitability_for_sawah of black_soil is high
- the black_soil depth is not_too_deep causes the suitability_for_sawah of black_soil is high

- the black_soil structure is loose causes the suitability_for_coffee of black_soil is high
- the suitability_for_coffee of black_soil is high if the black_soil structure is loose and the black_soil texture is sandy
- the suitability_for_coffee of black_soil is high if the black_soil texture is sandy and the black_soil consistency is not soft
- the suitability_for_coffee of black_soil is high if the black_soil texture is sandy
- the suitability_for_coffee of sandy_soil is high if the sandy_soil colour is black
- the black_soil consistency is not sticky causes the suitability_for_coffee of black_soil is high if the black_soil colour is not_too_black
- the black_soil structure is loose causes the suitability_for_sawah of black_soil is high if the black_soil consistency is not sticky
- the suitability_for_sawah of black_soil is high if the black_soil texture is sandy
- the black_soil texture is sandy causes the coffee taste is less_good if the black_soil location is in_kebun
- the black_soil structure is loose causes the rice taste is less_good if the black_soil location is in_sawah
- the soil texture is sandy causes the soil colour is pale

- the black_soil consistency is sticky causes the suitability_for_coffee of black_soil is high if the black_soil consistency is not_too_sticky
- the black_soil consistency is soft causes the suitability_for_sawah of black_soil is high
- the sandy_soil structure is loose causes an increase in ease of hoeing of sandy_soil
- the sandy_soil consistency is not sticky causes an increase in ease of hoeing of sandy_soil
- the ease of hoeing of sandy_soil is high causes the suitability_for_sawah of sandy_soil is high
- the cultivation clayey_soil sawah duration is long causes the application of fertiliser need is normal
- the cultivation sandy_soil sawah duration is long causes the need of application of fertiliser is high
- the suitability_for_sawah of clayey_soil is greater_than sandy_soil

Red soils

- the red_soil colour is red
- the suitability_for_coffee of red_soil is low if the red_soil colour is yellowish
- the suitability_for_coffee of red_soil is low if the red_soil colour is whitish
- the organic_matter_content of red_soil is high causes the red_soil colour is black

- swamp causes the red_soil presence is no
- the content_of_iron of red_soil is high causes the suitability_for_sawah of red_soil is low

- the organic_matter_content of red_soil is low causes the fertility of red_soil is low
- the organic_matter_content of red_soil is high causes the red_soil colour is black
- erosion of black_soil causes the red_soil position is surface
- erosion of black_soil causes the black_soil colour is red if the soil slope is steep
- a decrease in fertility of soil causes the soil colour is reddish
- the fertility of red_soil is low
- the content_of_iron of red_soil is high causes the suitability_for_sawah of red_soil is low

- the fertility of red_soil is low causes the suitability_for_sawah of red_soil is low
- the organic_matter_content of red_soil is low causes the suitability_for_sawah of red_soil is low
- the fertility of red_soil is low causes the rice grain content is empty
- the suitability_for_sawah of red_soil is low causes the production of rice is low if the sawah location is on_red_soil and the amount of application of fertiliser is low
- the fertility of red_soil is low causes the need of application of fertiliser is high if the red_soil location is in_sawah
- a decrease in slope of land causes an increase in suitability_for_sawah of red_soil if irrigation of land and application of fertiliser
- the red_soil suitability_for_sawah is good if the availability of water is high and application of fertiliser
- the red_soil suitability_for_sawah is good if application of fertiliser and application of dolomite

- the organic_matter_content of red_soil is low causes the suitability_for_coffee of red_soil is low
- the fertility of red_soil is low causes the need of application of fertiliser is high if the red_soil location is in_kebun
- the suitability_for_coffee of red_soil is high
- the suitability_for_coffee of black_soil is greater_than red_soil
- the suitability_for_coffee of red_soil is low if the red_soil colour is yellowish
- the suitability_for_coffee of red_soil is low if the red_soil colour is whitish

- the suitability_for_coffee of red_soil is high if the red_soil structure is loose
- the suitability_for_sawah of red_soil is high if the red_soil structure is loose
- the red_soil structure is loose causes the coffee taste is good if the red_soil location is in_kebun
- the red_soil structure is loose causes an increase in size of coffee bean if the red_soil location is in_kebun
- the red_soil structure is loose causes the rice taste is good if the red_soil location is in_sawah
- the red_soil particle_size is big causes an increase in rate of growth of plant if the plant location is on_red_soil

- the red_soil consistency is soft causes the vegetation type is grass if the red_soil location is in_mountain
- application of dolomite causes the red_soil consistency is not hard
- the suitability_for_coffee of red_soil is low if the red_soil consistency is soft_when_wet and the red_soil texture is clayey
- the suitability_for_coffee of red_soil is low if the red_soil consistency is sticky
- the suitability_for_coffee of soil is low if the soil colour is reddish and the soil consistency is soft and the soil consistency is hard_when_dry
- the suitability_for_coffee of red_soil is low if the red_soil consistency is sticky_when_wet and the red_soil consistency is hard_when_dry and the cracking of red_soil condition is dry
- the suitability_for_coffee of red_soil is low causes the need of forking of kebun soil is high
- so if structure is soft, sticky and hard you have to fork a lot!
- application of fertiliser causes the red_soil suitability_for_coffee is good if the red_soil texture is clayey and the red_soil consistency is soft_when_wet
- the red_soil consistency is sticky causes the suitability_for_sawah of red_soil is low
- the sandy_soil structure is loose causes an increase in ease of hoeing of sandy_soil
- the sandy_soil consistency is not sticky causes an increase in ease of hoeing of sandy_soil
- the ease of hoeing of sandy_soil is high causes the suitability_for_sawah of sandy_soil is high

- the suitability_for_fruit_tree of red_soil is high
- the suitability_for_oilpalm of red_soil is high
- the suitability_for_coconut of red_soil is high

Yellow soils

- the yellow_soil colour is yellow
- the fertility of yellow_soil is low
- the organic_matter_content of yellow_soil is low causes the fertility of yellow_soil is low if the yellow_soil colour is brownish
- a decrease in fertility of soil causes the soil colour is yellowish
- not application of fertiliser causes the yellow_soil presence is yes if the soil location is not near_forest and the soil location is near_village
- a decrease in organic_matter_content of soil causes the soil colour is yellow if the application of fertiliser action is no

- the organic_matter_content of yellow_soil is low causes the need of hoeing of soil is high if the yellow_soil location is in_kebun
- the organic_matter_content of yellow_soil is low causes the need of application of fertiliser is high if the yellow_soil location is in_kebun
- application of fertiliser causes the yellow_soil fertility is good if the yellow_soil location is in_kebun

- the fertility of yellow_soil is low causes the suitability_for_sawah of yellow_soil is low if the yellow_soil colour is brownish
- the fertility of yellow_soil is low causes the rice grain content is empty if the yellow_soil colour is brownish
- the fertility of yellow_soil is low causes the need of application of fertiliser is high if the yellow_soil location is in_sawah

Reduced yellow soils

- the yellow_soil presence is yes causes an increase in presence of red_water if the yellow_soil location is in_sawah and the content_of_iron of yellow_soil is high

- the content_of_iron of yellow_soil is high if the yellow_soil location is in_sawah or the yellow_soil location is in_swamp
- the yellow_soil content_of_calcium is too_low if the yellow_soil location is in_sawah
- swamp causes the yellow_soil presence is yes

- the yellow_soil presence is yes causes an increase in presence of red_water if the yellow_soil location is in_sawah and the content_of_iron of yellow_soil is high
- the stone location is under_soil causes the red_water presence is possible
- the tree_trunk location is buried_in_soil causes an increase in presence of red_water if the soil location is in_sawah
- the soil location is near_spring causes the red_water presence is possible
- the spring water location is in_sawah causes the red_water presence is possible

- the yellow_soil presence is yes causes an increase in presence of red_water if the yellow_soil location is in_sawah and the content_of_iron of yellow_soil is high
- the stone location is under_soil causes the red_water presence is possible
- the tree_trunk location is buried_in_soil causes an increase in presence of red_water if the soil location is in_sawah
- the soil location is near_spring causes the red_water presence is possible
- the spring water location is in_sawah causes the red_water presence is possible

- an increase in presence of red_water causes a decrease in fertility of soil if the soil location is in_sawah
- an increase in presence of red_water causes the rice colour is yellow
- an increase in presence of red_water causes a decrease in amount of rice grain
- red_water attack rice if the red_water location is in_sawah
- an increase in presence of red_water causes dying of rice
- an increase in presence of red_water causes a decrease in rate of growth of rice
- an increase in presence of red_water causes a decrease in amount of fish

- an increase in amount of application of dolomite causes a decrease in presence of red_water
- application of dolomite causes neutralisation of iron if the red_water presence is yes
- an increase in amount of application of lime causes a decrease in presence of yellow_soil if the yellow_soil location is in_sawah
- an increase in amount of application of lime causes a decrease in presence of red_water
- an increase in amount of application of manure causes a decrease in presence of red_water

- planting of rice causes the need of draining of sawah is high if the red_water presence is yes
- draining of sawah causes a decrease in presence of red_water
- the sawah condition is dry causes the red_water presence is no
- an increase in flow of sawah water causes a decrease in presence of red_water

White soils

- the white_soil colour is white
- erosion of black_soil causes the black_soil colour is white if the soil slope is steep
- the black_soil colour is white causes the fertility of soil is very_low if erosion of black_soil
- the fertility of white_soil is very_low
- the fertility of white_soil is low causes the need of application of fertiliser is high if the white_soil location is in_sawah
- the suitability_for_coffee of red_soil is low if the red_soil colour is whitish

Deep muddy soils

- the soil location is in_swamp causes the deep_muddy_soil presence is yes

- the ease of draining of deep_muddy_soil is low
- the deep_muddy_soil consistency is unstable causes not rooting of rice
- the deep_muddy_soil consistency is unstable causes the suitability_for_sawah of deep_muddy_soil is low
- the suitability_for_sawah of deep_muddy_soil is high if the rice variety is wild_rice
- the suitability_for_sawah of deep_muddy_soil is low if the rice variety is normal_rice
- the ease of draining of deep_muddy_soil is low causes the suitability_for_vegetables of deep_muddy_soil is low
- the suitability_for_sawah of land is high if the deep_muddy_soil presence is no
- the suitability_for_sawah of dry_soil is greater_than deep_muddy_soil
- draining of swamp causes the water_content of topsoil is low
- the water_content of topsoil is low causes an increase in suitability_for_sawah of swamp if the water_content of subsoil is high

- the rust_content of deep_muddy_soil is high
- the organic_matter_content of deep_muddy_soil is low causes the fertility of deep_muddy_soil is low
- the deep_muddy_soil pH is acid causes the need of application of fertiliser is high
- not draining of sawah causes the sawah soil pH is acid if the time moment is right_before_harvest
- the sawah soil pH is acid causes a decrease in production of rice if the time moment is right_before_harvest

Land not suitable for cultivation

- a decrease in availability of land causes an increase in amount of land_use_change forest kebun if the land slope is in the range flat to too_steep
- the ease of cultivation of land is very_low if the land slope is very_steep
- the need of land_use_change field forest is high if the field slope is too_steep

- degradation of soil causes the need of reforestation of land is high

- the forest presence is yes causes the spring condition is protected

Land suitability for paddy rice cultivation

- the suitability_for_rice of mountain is high if the rice variety is upland_rice and the time season is rainy
- the availability of water is high if the land location is in_dryland_ricefield and the time season is rainy
- the availability of water is low if the land location is in_dryland_ricefield and the time season is dry

- a decrease in availability of water causes a decrease in suitability_for_sawah of land
- the red_soil suitability_for_sawah is good if the availability of water is high and application of fertiliser
- the availability of water is high causes the suitability_for_sawah of land is high if the regulation of water action is possible
- the ease of draining of land is high causes the suitability_for_sawah of land is high if the availability of water is high
- not draining of sawah causes an increase in occurence of disease if the time moment is right_before_harvest
- not draining of sawah causes a decrease in rate of growth of rice if the cultivation of sawah duration is long

- the land slope is steep causes the land suitability_for_sawah is good if the availability of water is high
- a decrease in slope of land causes an increase in suitability_for_sawah of land
- a decrease in slope of land causes an increase in suitability_for_sawah of red_soil if irrigation of land and application of fertiliser
- an increase in risk of erosion causes a decrease in suitability_for_sawah of land
- the land slope is too_steep causes the suitability_for_sawah of land is low
- the suitability_for_sawah of flat_land is greater_than steep_land
- an increase in slope of sawah causes an increase in amount of sawah_dike
- an increase in amount of sawah_dike causes a decrease in size of sawah_compartment
- an increase in slope of sawah causes a decrease in size of sawah_compartment
- a decrease in size of sawah_compartment causes a decrease in suitability_for_sawah of land

- an increase in suitability_for_sawah of land causes a decrease in need of capital if land_use_change land sawah

- the suitability_for_sawah of black_soil is high
- the suitability_for_sawah of red_soil is low
- the suitability_for_sawah of soil is high if the soil colour is not_too_black and the soil colour is not_too_red
- the suitability_for_sawah of sandy_soil is high
- the cultivation clayey_soil sawah duration is long causes the application of fertiliser need is normal
- the cultivation sandy_soil sawah duration is long causes the need of application of fertiliser is high
- the suitability_for_sawah of clayey_soil is greater_than sandy_soil
- the suitability_for_sawah of land is high if the deep_muddy_soil presence is no
- the suitability_for_sawah of dry_soil is greater_than deep_muddy_soil
- the black_soil depth is not_too_deep causes the suitability_for_sawah of black_soil is high

- the organic_matter_content of red_soil is low causes the suitability_for_sawah of red_soil is low
- the content_of_iron of red_soil is high causes the suitability_for_sawah of red_soil is low
- the fertility of red_soil is low causes the need of application of fertiliser is high if the red_soil location is in_sawah
- the fertility of yellow_soil is low causes the need of application of fertiliser is high if the yellow_soil location is in_sawah
- the fertility of red_soil is low causes the suitability_for_sawah of red_soil is low
- the fertility of yellow_soil is low causes the suitability_for_sawah of yellow_soil is low if the yellow_soil colour is brownish
- the red_soil suitability_for_sawah is good if application of fertiliser and application of dolomite
- the red_soil suitability_for_sawah is good if the availability of water is high and application of fertiliser
- the fertility of red_soil is low causes the rice grain content is empty
- the fertility of yellow_soil is low causes the rice grain content is empty if the yellow_soil colour is brownish
- the suitability_for_sawah of red_soil is low causes the production of rice is low if the sawah location is on_red_soil and the amount of application of fertiliser is low

- the sandy_sediment presence is yes causes an increase in suitability_for_sawah of soil
- the organic_matter_content of sandy_sediment is high causes an increase in suitability_for_sawah of soil
- an increase in presence of worm_excrement causes an increase in fertility of sawah

- the black_soil structure is loose causes the suitability_for_sawah of black_soil is high if the black_soil consistency is not sticky
- the suitability_for_sawah of red_soil is high if the red_soil structure is loose
- the red_soil consistency is sticky causes the suitability_for_sawah of red_soil is low
- the suitability_for_sawah of black_soil is high if the black_soil texture is sandy
- the black_soil consistency is soft causes the suitability_for_sawah of black_soil is high
- the sandy_soil consistency is muddy causes the suitability_for_sawah of sandy_soil is high

- the deep_muddy_soil consistency is unstable causes not rooting of rice
- not rooting of rice causes floating of rice
- the deep_muddy_soil consistency is unstable causes the suitability_for_sawah of deep_muddy_soil is low
- the suitability_for_sawah of deep_muddy_soil is high if the rice variety is wild_rice
- the suitability_for_sawah of deep_muddy_soil is low if the rice variety is normal_rice

- the rotation sawah vegetable_garden action is possible if the ease of draining of soil is high and the ease of irrigation of land is high
- the ease of draining of sawah is high causes the land_use_change sawah vegetable_garden occurence is possible
- not rotation sawah vegetable_garden causes a decrease in production of rice
- an increase in duration of cultivation of sawah causes an increase in occurence of disease

- an increase in duration of cultivation of sawah causes an increase in occurence of plague
- the application of manure location is in_vegetable_garden causes an increase in production of rice if land_use_change vegetable_garden sawah

- the suitability_for_vegetables of sandy_soil is very_high
- the humidity of subsoil is high causes the suitability_for_vegetables of sandy_soil is high if the humidity of topsoil is low
- the ease of draining of deep_muddy_soil is low causes the suitability_for_vegetables of deep_muddy_soil is low

Land suitability for coffee cultivation

- the land slope is slightly_sloping causes the suitability_for_coffee of land is high
- the land slope is too_steep causes the suitability_for_coffee of land is low
- the amount of erosion of soil is high causes the suitability_for_coffee of land is low if the land slope is steep
- the suitability_for_coffee of flat_land is same_as steep_land
- the suitability_for_coffee of flat_land is greater_than steep_land
- the suitability_for_coffee of land is high if the land aspect is east and the land slope is slightly_sloping

- the suitability_for_coffee of black_soil is high
- the suitability_for_coffee of black_soil is greater_than red_soil
- the suitability_for_coffee of red_soil is high
- the suitability_for_coffee of red_soil is low if the red_soil colour is yellowish
- the suitability_for_coffee of red_soil is low if the red_soil colour is whitish

- an increase in organic_matter_content of soil causes an increase in suitability_for_coffee of soil
- an increase in fertility of soil causes an increase in suitability_for_coffee of soil
- the organic_matter_content of black_soil is high causes the suitability_for_coffee of black_soil is high
- the organic_matter_content of red_soil is low causes the suitability_for_coffee of red_soil is low
- the fertility of red_soil is low causes the need of application of fertiliser is high if the red_soil location is in_kebun
- the organic_matter_content of yellow_soil is low causes the need of hoeing of soil is high if the yellow_soil location is in_kebun
- the organic_matter_content of yellow_soil is low causes the need of application of fertiliser is high if the yellow_soil location is in_kebun
- application of fertiliser causes the yellow_soil fertility is good if the yellow_soil location is in_kebun
- the suitability_for_coffee of manure is greater_than chemical_fertiliser

- the black_soil structure is loose causes the suitability_for_coffee of black_soil is high
- the suitability_for_coffee of black_soil is high if the black_soil structure is loose and the black_soil texture is sandy
- the suitability_for_coffee of red_soil is high if the red_soil structure is loose
- the red_soil structure is loose causes an increase in size of coffee bean if the red_soil location is in_kebun
- the black_soil consistency is not sticky causes the suitability_for_coffee of black_soil is high if the black_soil colour is not_too_black
- the black_soil consistency is sticky causes the suitability_for_coffee of black_soil is high if the black_soil consistency is not_too_sticky
- the suitability_for_coffee of black_soil is high if the black_soil structure is loose and the black_soil texture is sandy
- the suitability_for_coffee of black_soil is high if the black_soil texture is sandy and the black_soil consistency is not soft
- the suitability_for_coffee of black_soil is high if the black_soil texture is sandy
- the suitability_for_coffee of sandy_soil is high if the sandy_soil colour is black

- the suitability_for_coffee of red_soil is low if the red_soil consistency is soft_when_wet and the red_soil texture is clayey
- the suitability_for_coffee of red_soil is low if the red_soil consistency is sticky
- the suitability_for_coffee of soil is low if the soil colour is reddish and the soil consistency is soft and the soil consistency is hard_when_dry
- application of fertiliser causes the red_soil suitability_for_coffee is good if the red_soil texture is clayey and the red_soil consistency is soft_when_wet
- the suitability_for_coffee of red_soil is low causes the need of forking of kebun soil is high

Suitability for other crops

- the suitability_for_fruit_tree of red_soil is high
- the land suitability_for_fruit_tree is good if the land slope is very_steep
- a decrease in temperature of air causes a decrease in amount of formation of fruit_tree fruit

- the suitability_for_oilpalm of red_soil is high
- the suitability_for_coconut of red_soil is high

- the land location is near_village causes the amount of pig is low
- an increase in amount of pig causes a decrease in suitability_for_maize_banana_cassava of land

Annex VIII: Diagrams of farmer knowledge

With the help of the AKT5 software, flow charts of farmers' knowledge could be made, interlinking the individual statements to a coherent structure. In this Annex, the following diagrams are presented:

1. forest clearing and fertility
2. tree presence effects
3. forest cover effects
4. flooding causes
5. flooding of river effects
6. paddy flooding effects
7. river water turbidity causes
8. water quality
9. erosion causes
10. erosion effects
11. landslide
12. actions that prevent erosion
13. terracing effects
14. furrow in coffee garden effects
15. lubang effects
16. shade tree planting effects
17. shade tree sunshine effects
18. shade tree presence effects
19. weed effects
20. weeding effects
21. herbicide effects
22. *Arachis* effects
23. riverside forest and tree effects
24. riverside belukar effects
25. paddy water regulation effects
26. paddy water turbidity causes
27. red water

Note: some local Indonesian words have been used in the construction of the statements:

- kebun: coffee garden
- sawah: paddy rice field
- bak: basin or vessel
- lubang: infiltration pit or composting hole
- belukar: vegetation of shrubs and bushes

1. Forest clearing and fertility

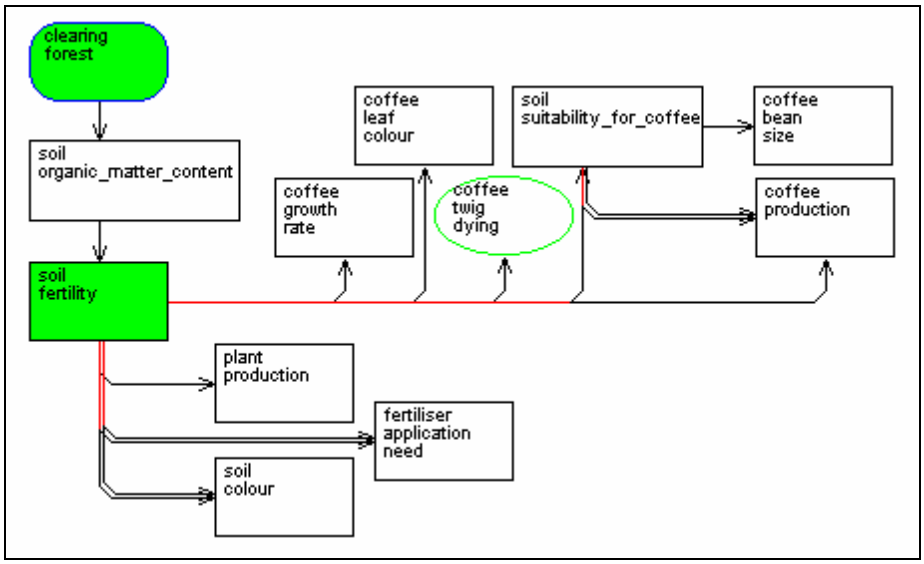


Figure 1: Forest clearing and fertility

2. Tree presence effects

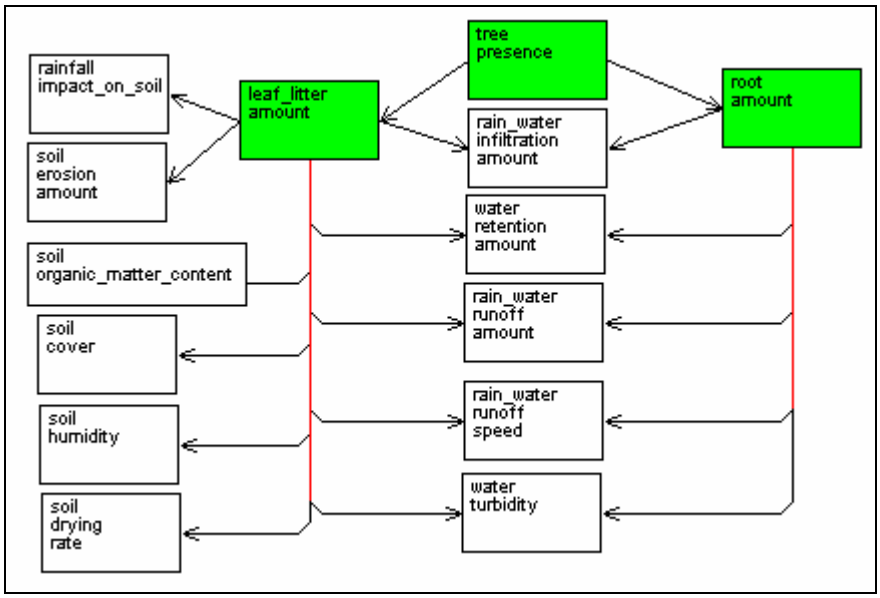


Figure 2: Tree presence effects

3. Forest cover effects

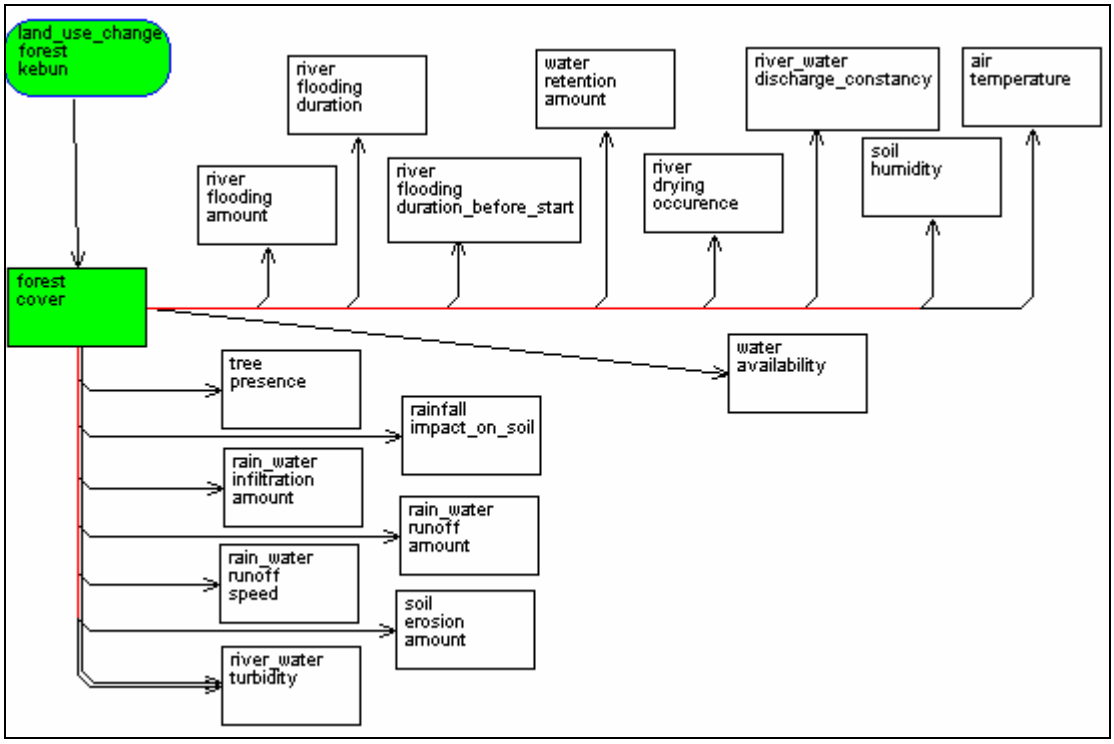


Figure 3: Forest cover effects

4. Flooding causes

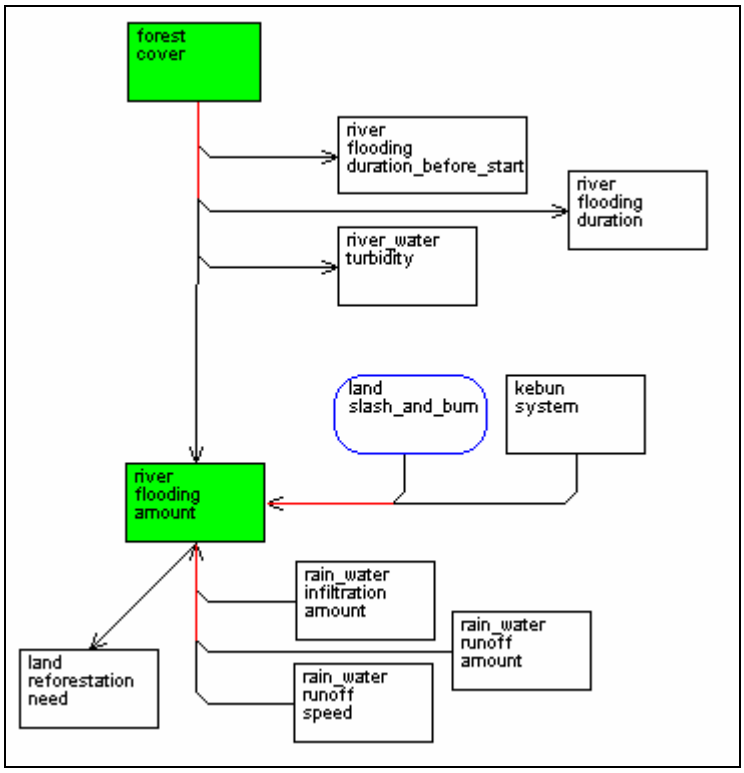


Figure 4: Flooding causes

5. Flooding of river effects

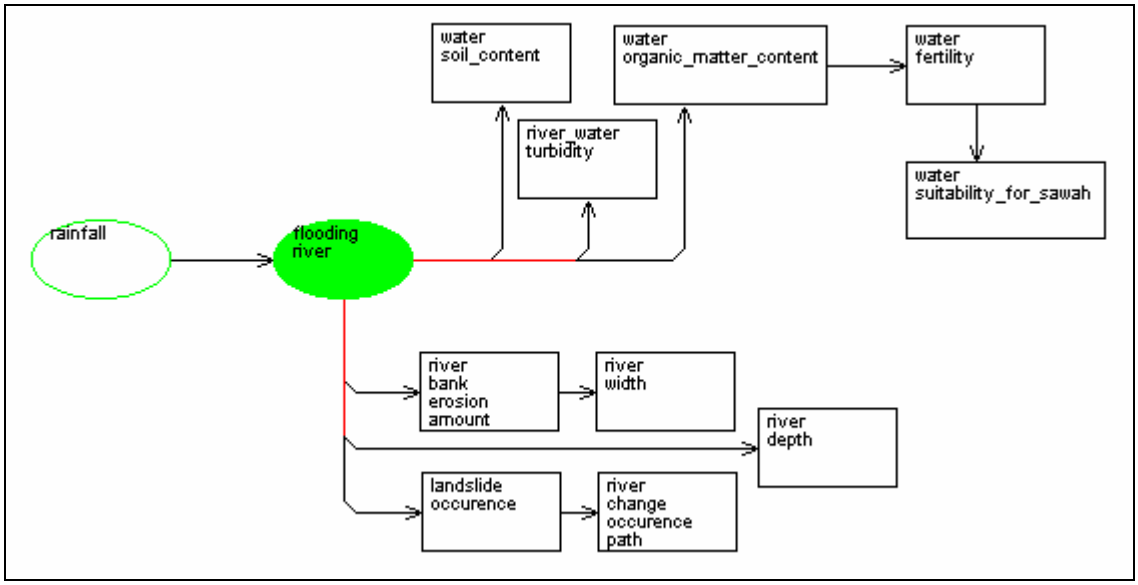


Figure 5: Flooding of river effects

6. Paddy flooding effects

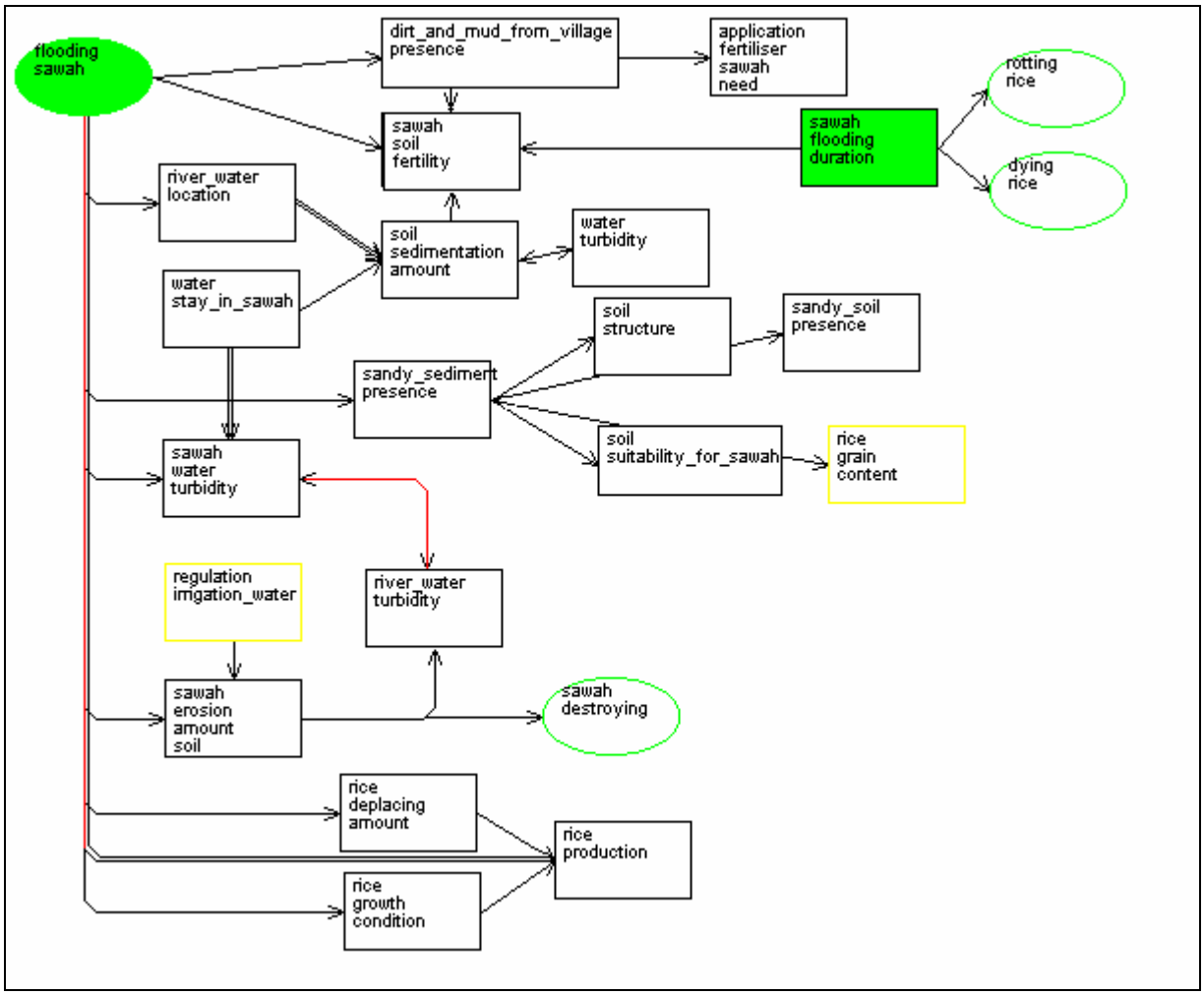


Figure 6: Paddy field flooding effects

7. River water turbidity causes

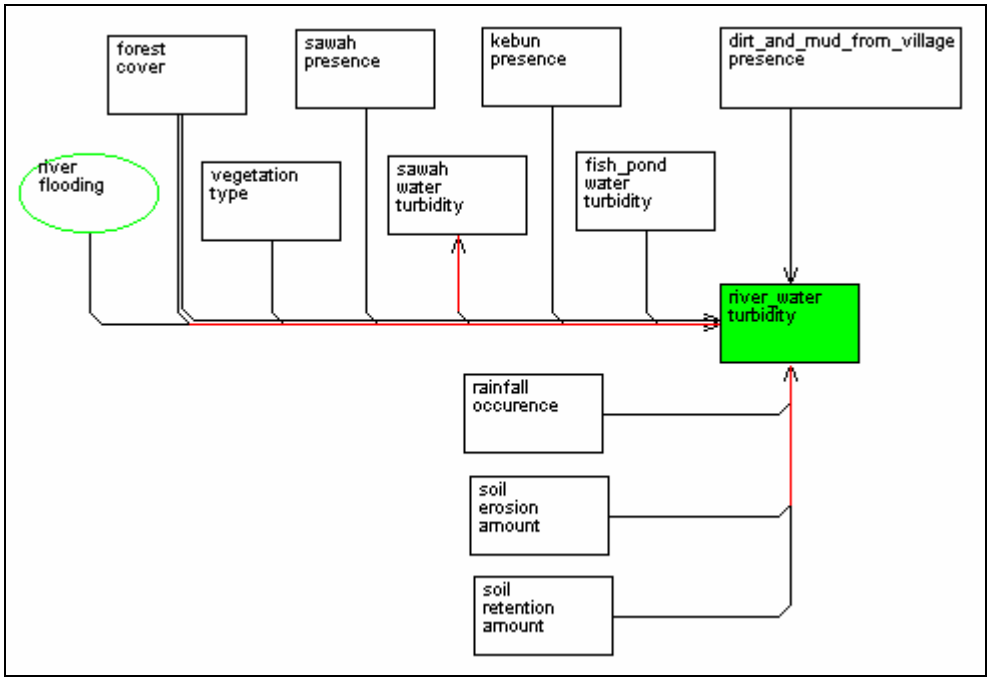


Figure 7: River water turbidity causes

8. Water quality

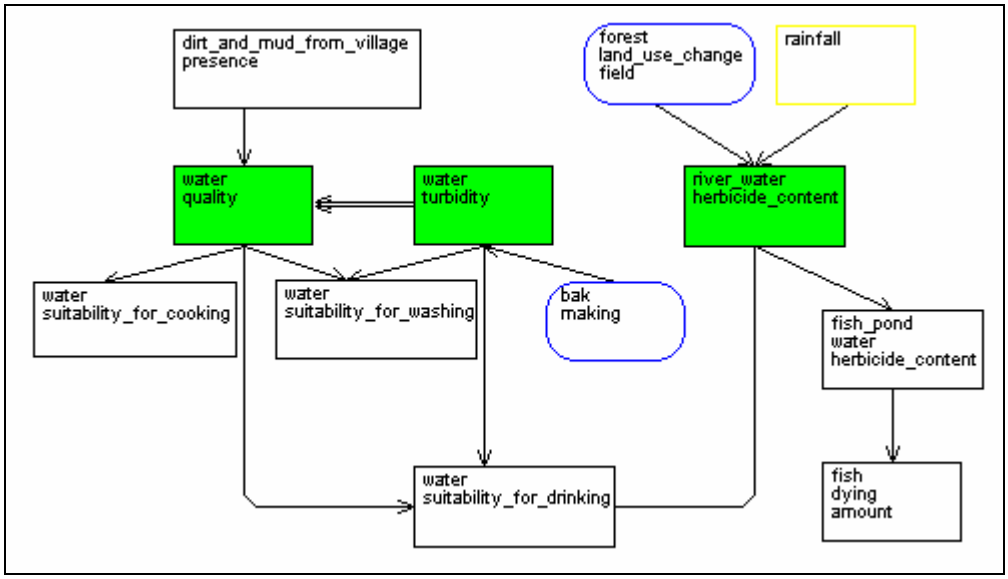


Figure 8: Water quality

9. Erosion causes

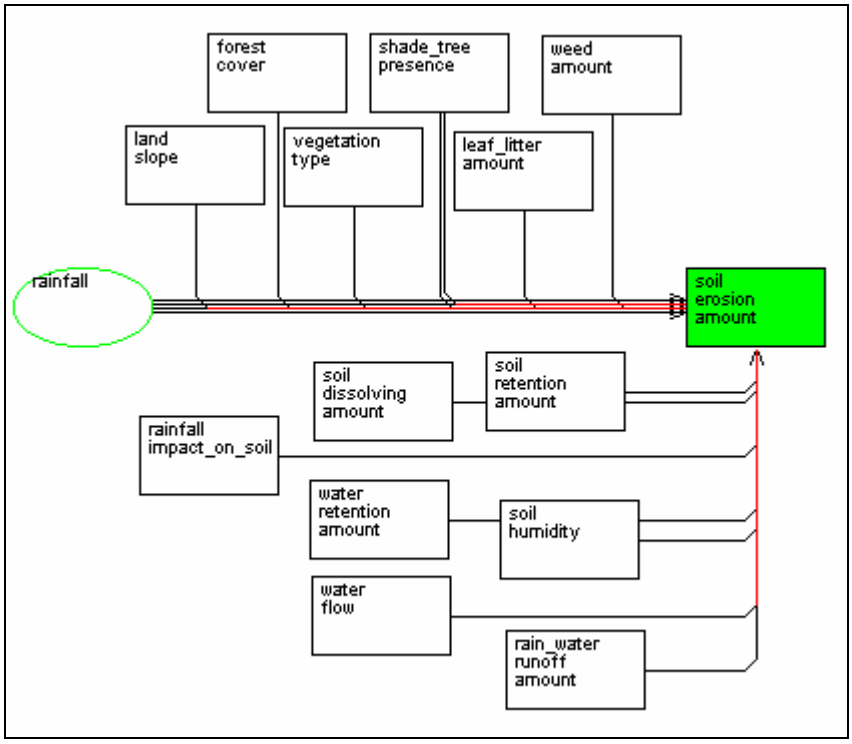


Figure 9: Erosion causes

10. Erosion effects

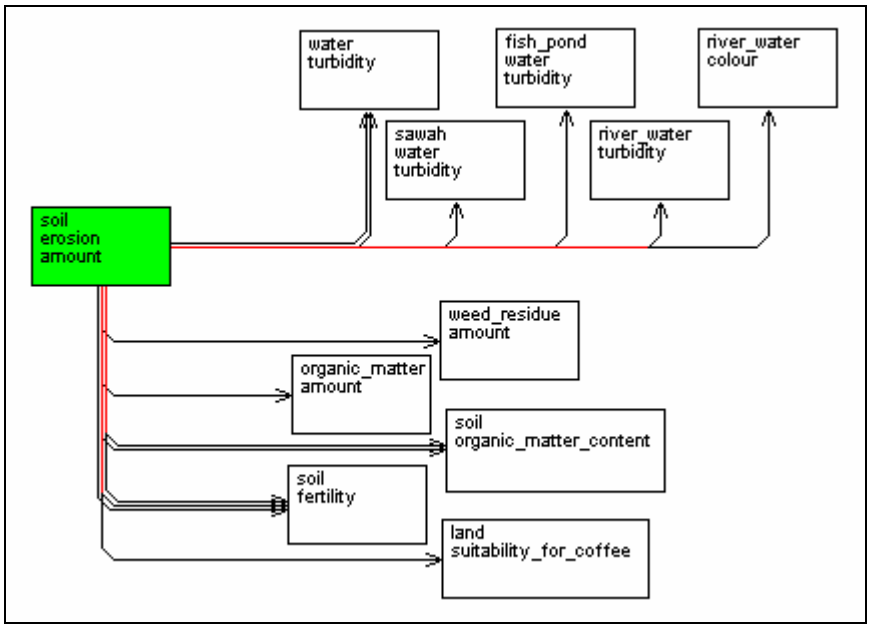


Figure 10: Erosion effects

11. Landslide

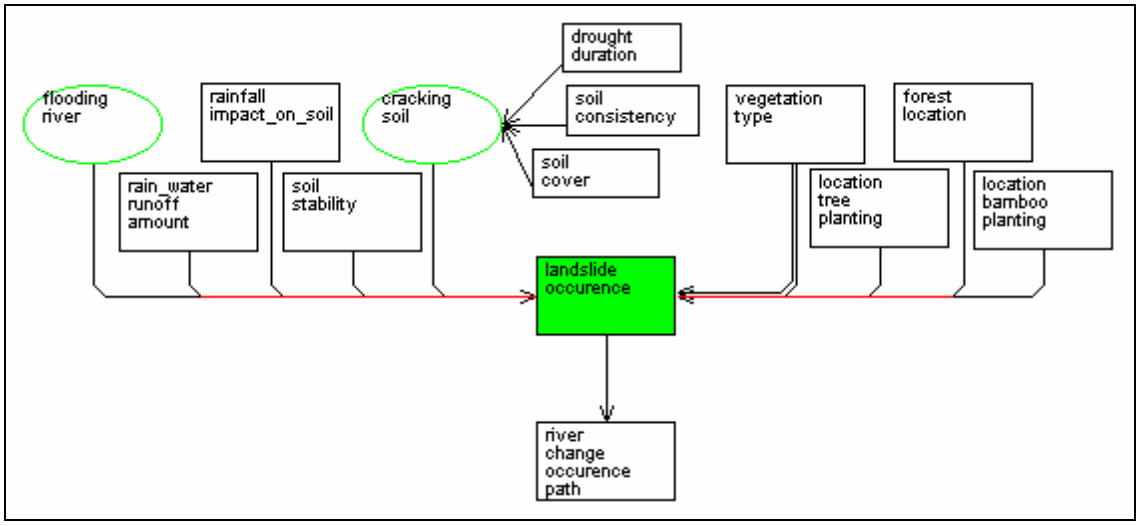


Figure 11: Landslide

12. Actions that prevent erosion

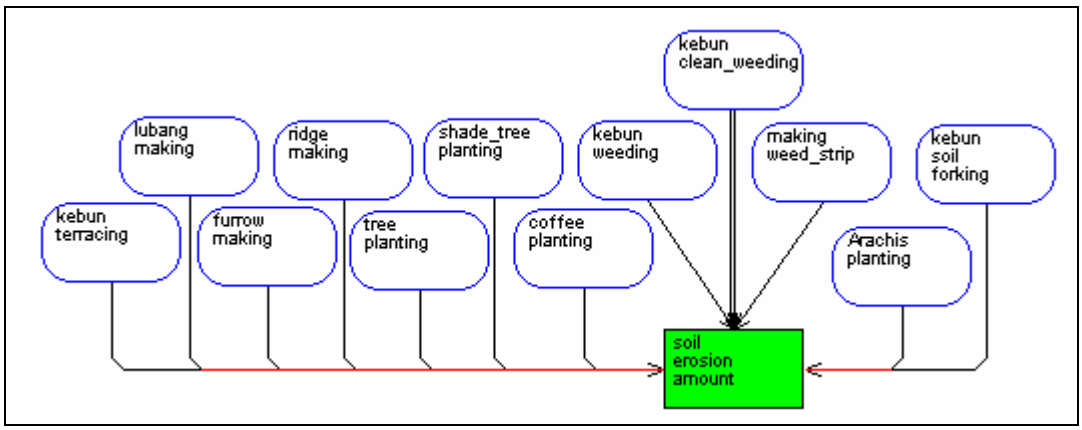


Figure 12: Actions that prevent erosion

13. Terracing effects

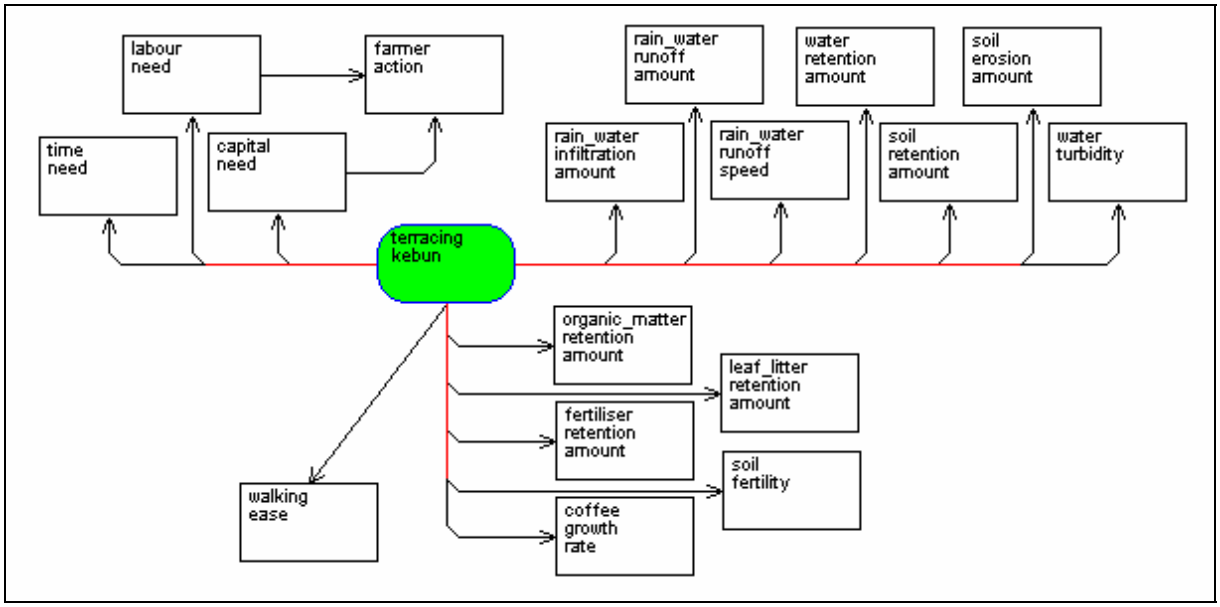


Figure 13: Terracing effects

14. Furrow in coffee garden effects

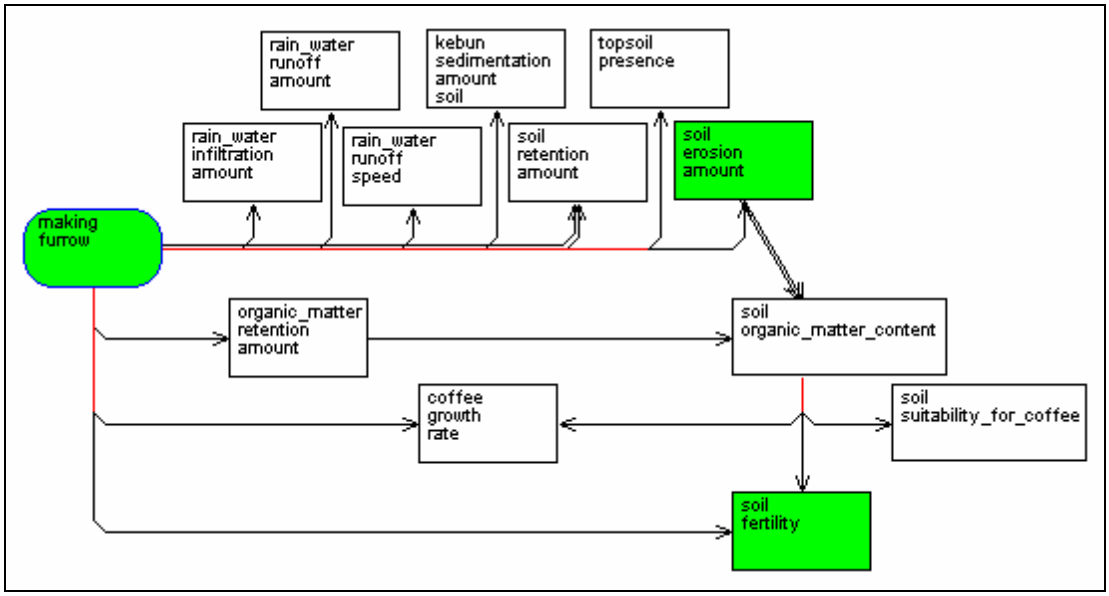


Figure 14: Furrow in coffee garden effects

15. Lubang effects

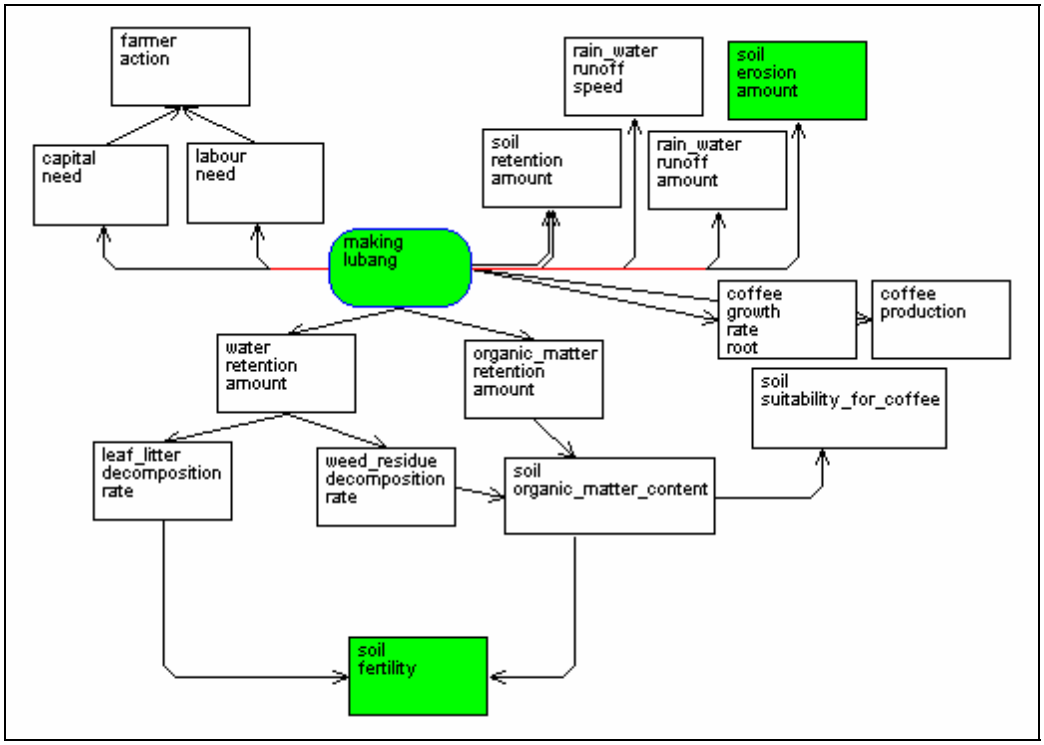


Figure 15: Lubang effects

16. Shade tree planting effects

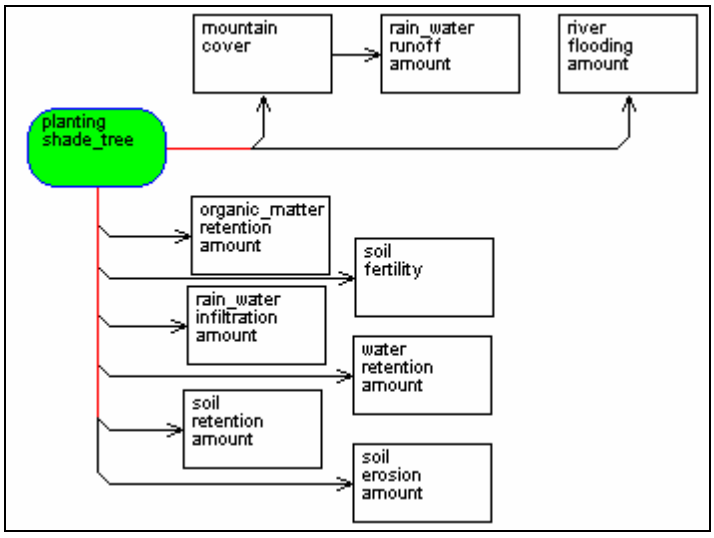


Figure 16: Shade tree planting effects

17. Shade tree sunshine effects

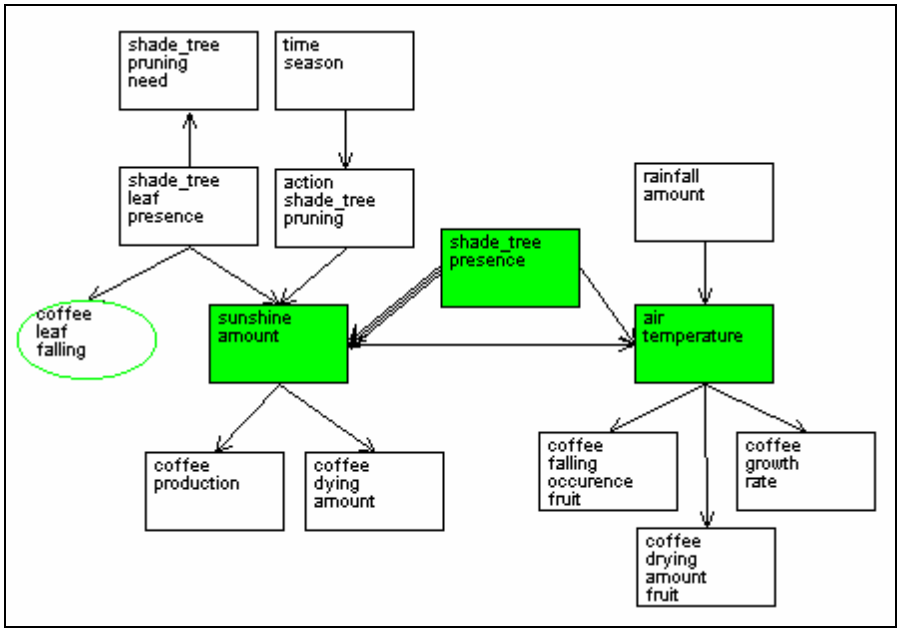


Figure 17: Shade tree sunshine effects

18. Shade tree presence effects

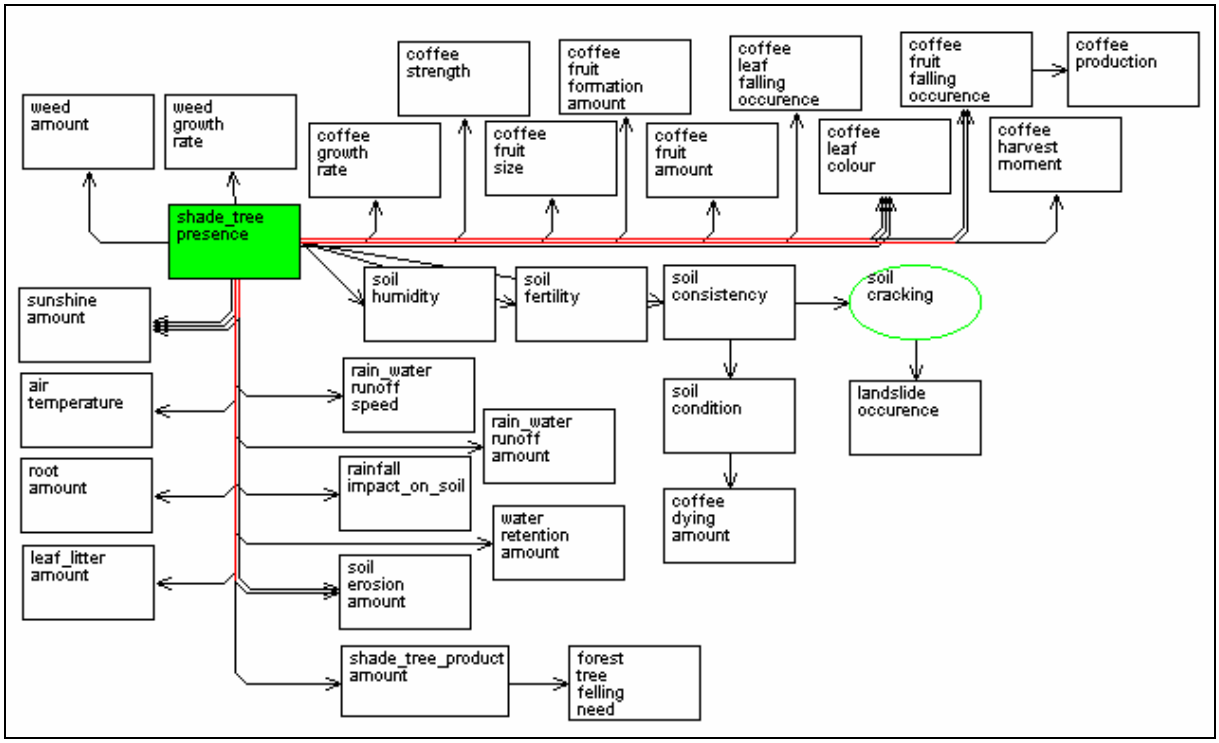


Figure 18: Shade tree presence effects

19. Weed effects

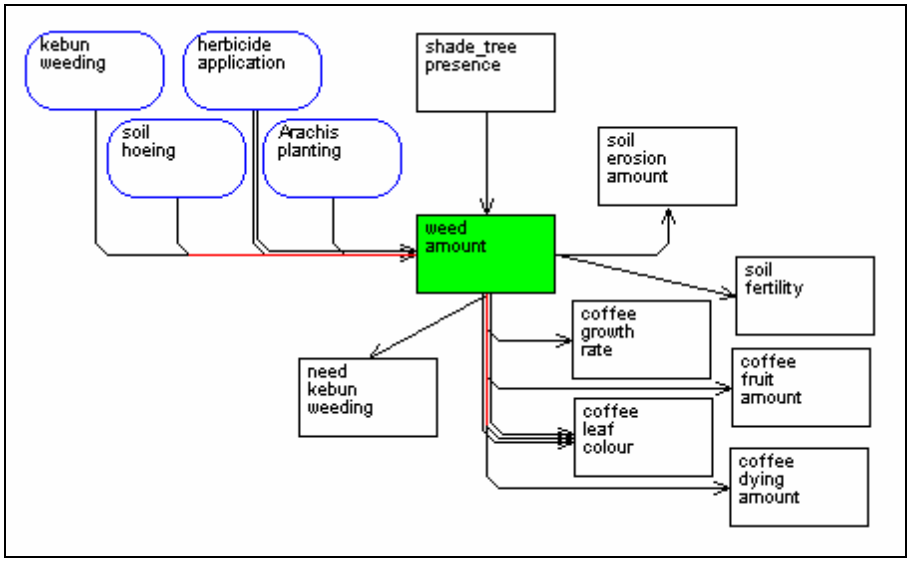


Figure 19: weeding effects

20. Weeding effects

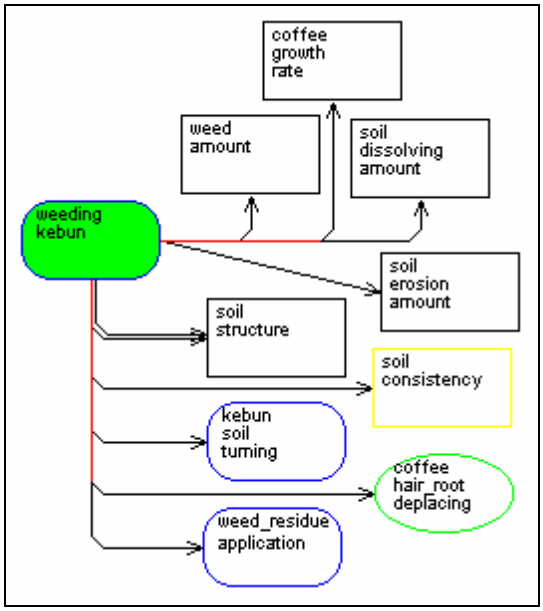


Figure 20: Weeding effects

21. Herbicide effects

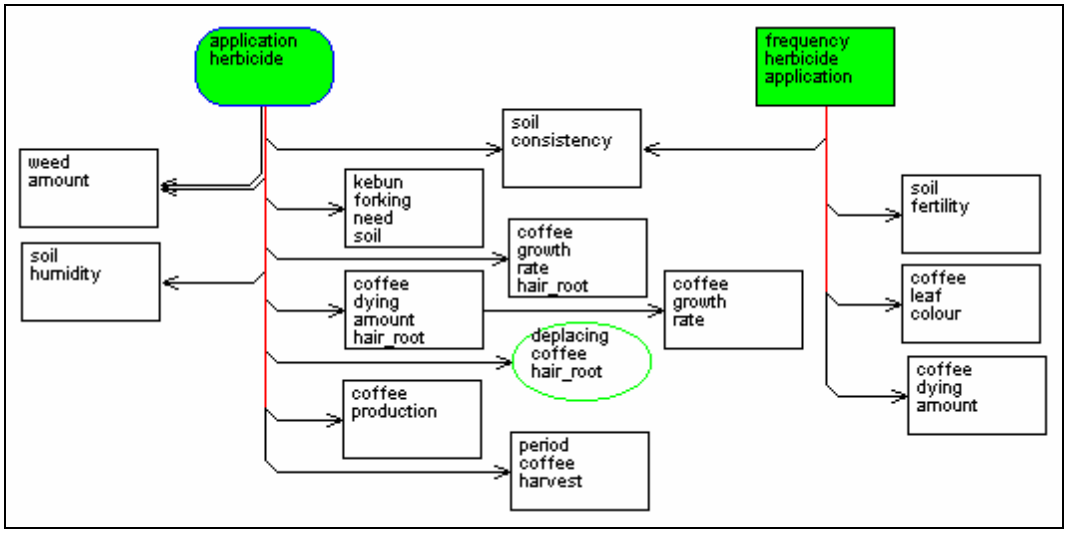


Figure 21: Herbicide effects

22. *Arachis* effects

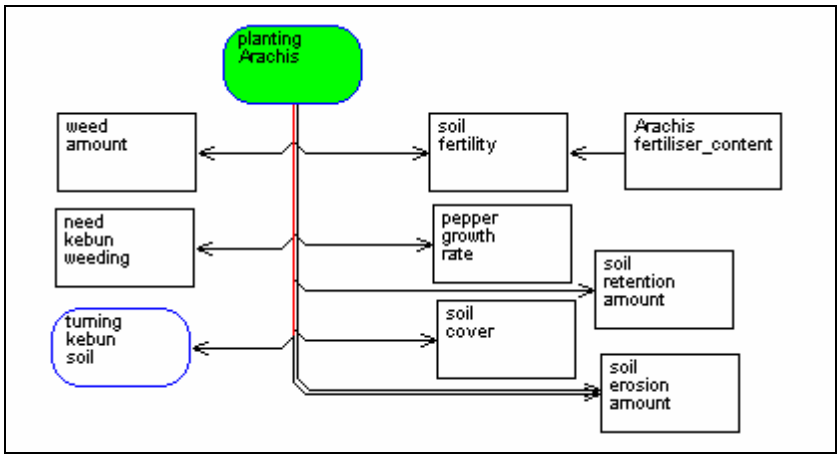


Figure 22: *Arachis* effects

23. Riverside forest and tree effects

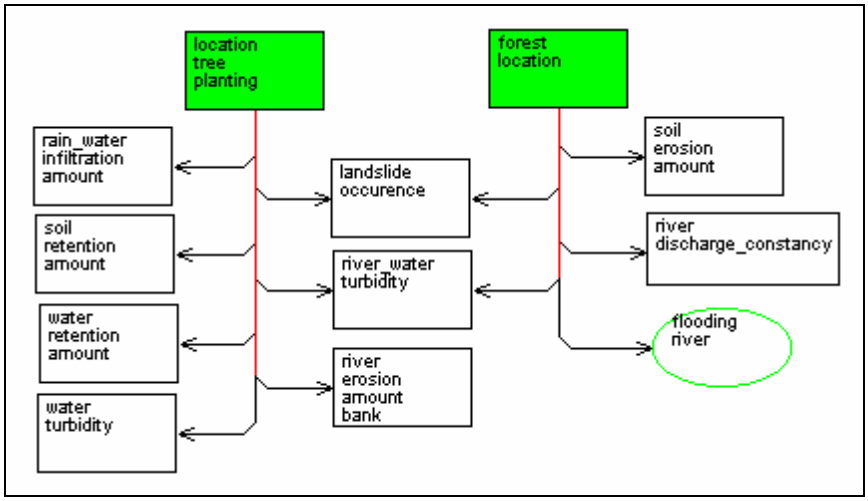


Figure 23: Riverside forest and tree effects

24. Riverside belukar effects

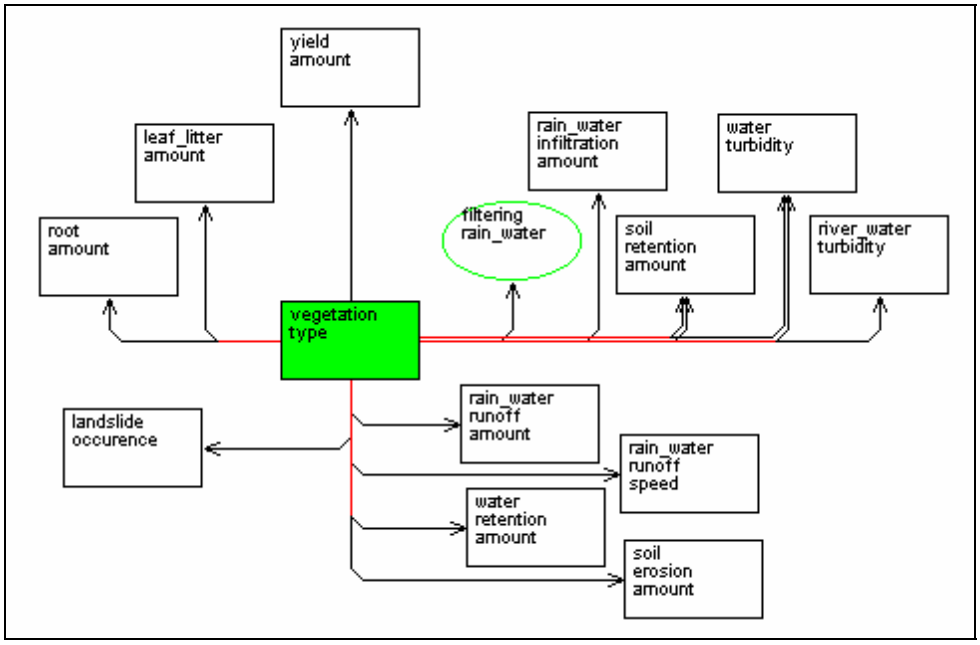


Figure 24: Riverside belukar effects

25. Paddy water regulation effects

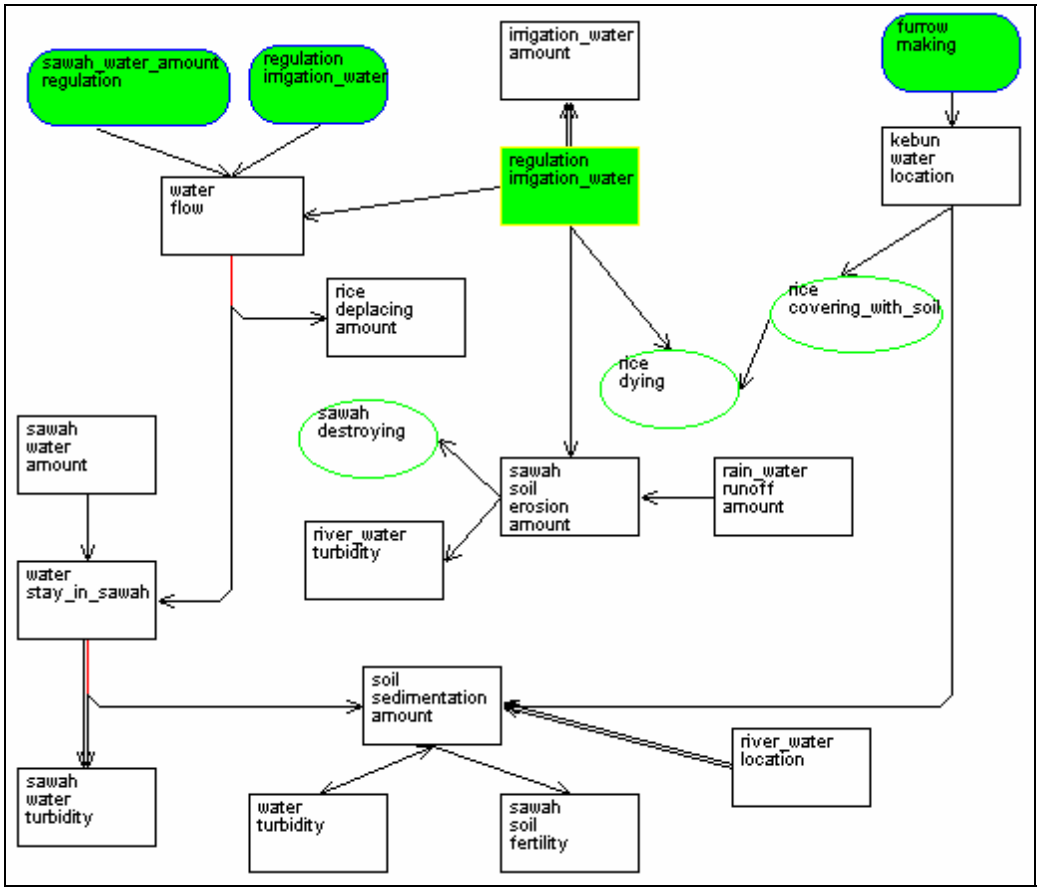


Figure 25: Paddy water regulation effects

26. Paddy water turbidity causes

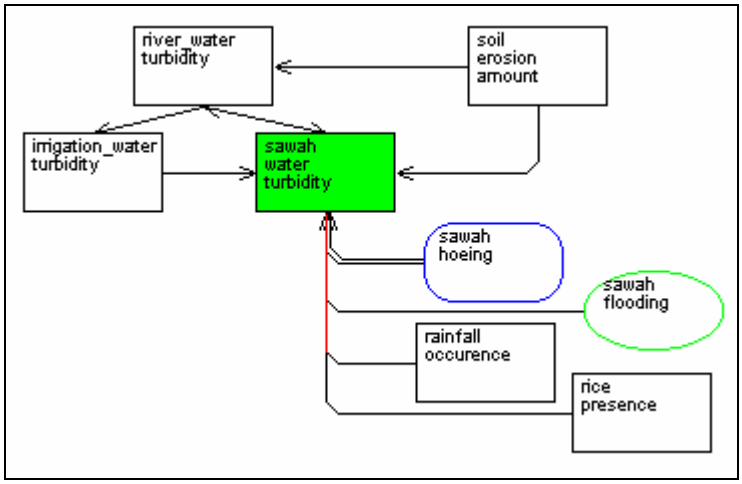


Figure 26: Paddy water turbidity causes

27. Red water

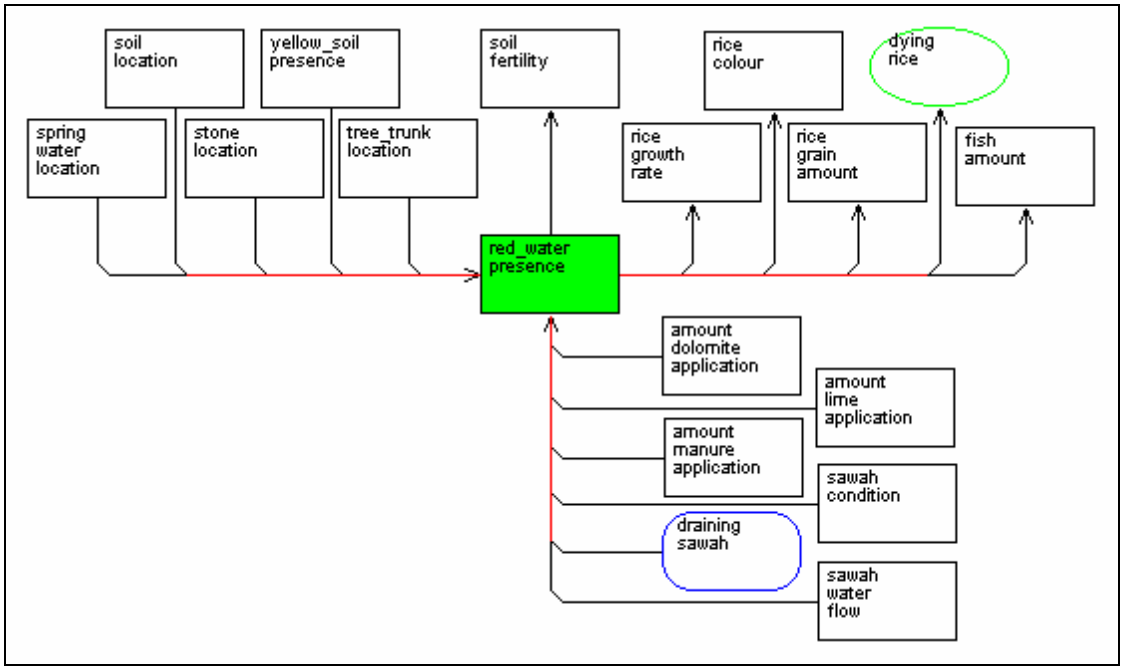


Figure 27: Red water

Annex X: Furrows within a paddy rice field

Sometimes farmer construct furrows in the paddy field itself, for several reasons. First of all, it eases drainage of the paddy field, often needed when rice is planted because then the soil should not be too humid. The paddy field, divided into smaller compartments by the furrows, also becomes easier to cultivate. Another advantage is that the water flows more continuously through the field, which reduces occurrence of soil reduction problems, described by the farmers as reddish or yellowish water (taipere). Faster flow and smaller compartments would also diminish the presence of rodent plagues like mice. On the other hand, the irrigation and runoff water doesn't stay very long in the paddy field because of the higher flow velocity in the furrows, which reduces sedimentation processes and consequently results in a less significant decline of water turbidity by passing through the paddy field.

Annex XI: Cover crops

The last few years, some field experiments with the nitrogen fixing *Arachis pintoi* as soil cover crop in coffee gardens in Sumberjaya have been conducted after it has proven its success in pepper gardens in the region north of Sumberjaya. For the coffee farmers of Sumberjaya, it is still early to draw straightforward conclusions. As only a few farmers are trying out this cover crop, most of the farmers' knowledge probably originates from what they have heard rather than from own experience.

In the pepper gardens, the ring weeding technique is applied to *Arachis* as well, because there is a negative interaction between *Arachis* and the pepper plants. For coffee, it is not clear yet what the result of the interactions between the crops is. One farmer says *Arachis* should be planted alongside the border of the coffee garden where it can function as some sort of filtering strip.

Some farmers do realise that *Arachis*, by covering the soil, can diminish rainwater runoff and hence soil erosion and runoff water turbidity. *Arachis* cannot only retain the soil, but also retains water, increasing soil humidity and water availability for the coffee crop. However, other farmers do not believe the prodigious properties attributed to *Arachis* and do not think that erosion will diminish by planting *Arachis*. Scientific measurements of runoff and soil loss on erosion plots in coffee gardens with and without the cover crop *Paspalum conjugatum sp.*, testify that both runoff and soil loss are drastically reduced by the presence of the cover crop (Afandi *et al.*, 1999, 2002).

Farmers know that *Arachis* can increase the fertility of the soil, they say that *Arachis* 'contains fertiliser', alluding on the nitrogen fixation that takes place in symbiosis with *Rhizobium*. Ankersmit (1940) suggests the planting of Salvia in coffee gardens that are not too shaded, which has prodigious effects if the cover crop is weeded regularly to small strips and used as green manure. In this way the competition with the coffee roots is limited while the soil remains protected.

Farmers say that *Arachis* keeps the soil covered, not giving weeds a lot of chances to grow, so planting of *Arachis* reduces the need for weeding of the coffee garden. One farmer believed that *Arachis* has a negative influence on the coffee growth and yields, since the soil is not being turned over anymore as usually happens when the garden is weeded. This aeration and loosening of the soil is of major importance for the health of the coffee plants. Another farmer mentions that the presence of *Arachis* makes it hard to pick up fallen coffee beans from the soil. Also Holle (1863) and Ankersmit (1940) write that fallen beans have to

be collected carefully to reduce coffee yield losses and to prevent the spreading of plagues as *Stephanoderes hampei* that can seriously reduce future yields.

For coffee, *Arachis* can be useful through its fertilising effect by nitrogen fixation and increase of soil organic matter content, its reducing effect on erosion and on the time needed for weeding.[6] In pepper plantations *Arachis* is also known increase the presence of natural predators of some of the plagues pepper plants suffer from and it stimulates the growth of *Trichoderma* which inhibits the growth of *Phytoptora palmifora* that causes one of the most common diseases on pepper plants (Agus *et al.*, 2002). Other cover crops are not being used although there might be potential beneficial alternatives.

[6] See diagram '*Arachis* effects' in Annex VIII 'Diagrams of farmer knowledge'

Annex XII: Shade tree species

Different tree species are planted as shade tree in the Sumberjaya coffee gardens. Farmers consider type of root system and quality of leaf litter as important shade tree properties.

The root system should not be superficial, as is the case for cinnamon (kayu manis, *Cinnamomum burmanii*) and most fruit trees, because then there is too much competition for water and nutrients between coffee and the shade trees, which retards the coffee growth. Farmers say that the shade tree roots attack the coffee roots. Such species and those with broad root systems are either widely spaced or positioned at the garden boundary to minimise disturbance to coffee. Non-superficial deep root systems, as for *Erythrina spp.* (dadap), *Glyricidia sepium* (kayu hujan) and *Leucaena leucocephala* (lamtoro), are said to be "cold" (dingin) and "soft", whereas roots competing for nutrients and water are considered to be "hot" (panas).

According to scientific literature, shade trees in general should dispose of the following properties: having a big crown with a thin, equally distributed leaf mass, being long-living, not requiring much pruning and having a good natural leaf fall, being easy to reproduce, having roots that anchor the tree firmly, that do not have high nutrient requirements and that don't compete with the crop. Shade trees should also grow fast and produce leaves, be resistant against pruning, drought, diseases and plagues, not bearing thorns, being easy to remove if necessary and if possible, also furnish a usable produce, although the latter is of lower importance than all former properties since the primary function of shade trees is to preserve the well being of the garden (Ruinard, 1951). The tree-root-leaching or 'safety-net' hypothesis states that the deeper roots of trees can capture nutrients from the soil solution, which in cropping systems without trees would be lost by leaching (Young, 1997). This ability of the shade tree root systems to access moisture and nutrients from lower horizons and make these elements available to coffee was acknowledged by farmers in Sumberjaya (Chapman, 2001).

Although *Erythrina* is very sensitive for plagues and diseases, and consequently has a high mortality rate, the farmers still consider it to be the most optimal coffee shade tree. Its roots are not competitive at all and cause the soil to be loose and to retain a lot of water, ensuring the coffee leaves to remain green and healthy. Its light crown provides an optimal shade for the coffee plants. Its leaf litter is rapidly decomposed to organic matter of the highest quality, contributing to high soil fertility. The thick carpet of decomposing leaves found below stands of this tree is regarded as the ideal form of soil protection and

improvement. Because of its high mortality, *Erythrina* would be less suitable as trellis for pepper plants in pepper gardens or mixed coffee pepper gardens.

Glyricidia is considered to be the best trellis for pepper and is also planted quite frequently in coffee gardens although it looses most of its leaves in the dry season and therefore is less suitable to shade coffee. Nevertheless, farmers attribute a lot of good qualities to this common shade tree, as it responds well to pruning, pruned branches can be used as firewood or mulch, its rooting system is deep, has a high water holding capacity, does not compete with the coffee roots, and the leaves are considered as a good composting material (Chapman, 2001).

One farmer opinions that *Leucaena* is less suitable, as its leaves can cause blackening and falling of the coffee cherries, but this contradicts the information collected from other farmers. Farmers generally consider Leucaena as a good shade tree, because it grows fast, allows beneficial sunlight penetration through its small leaves, its regular leaf fall and fast decomposition are good for the soil, it is a deep rooting tree with roots that are water holding, non-competitive with coffee and increasing the water availability. Its branches can be used for firewood (Chapman, 2001).

The properties attributed by the farmers to these most common shade tree species have been confirmed by early experimental scientific knowledge, as reflected by the work of Ruinard (1951).

Calliandra calothyrsus, often planted as tree component in bushes next to the river, is not suitable as shade tree according to the farmers, since the falling of its flowers causes the coffee flowers to die, since it reproduces too fast and since the tree is associated with a black fungal disease.

Besides these typical shade trees, farmers also mention the use of productive trees as fruit trees, timber trees and multipurpose leguminous species in the coffee gardens. Following species have been mentioned: *Durio zybethinus* (durian), *Nepthelium Lappaceum* (rambutan), *Mangifera indica* (mango), *Artocarpus heterophyllus* (jackfruit), *Psidium guayave* (guava), *Persea americana* (avocado), *Syzigium grandis* (jambu), *Musa paradisaica* (banana), *Theobroma cacao* (cocoa) and other species such as bamboo, *Borassus flabellifer* (sugar palm), *Aleurites moluccana* (kemiri or candlenut), *Ceiba pentandra* (kapok), *Parkia speciosa* (petai or stink bean), *Pithecellobium jiringa* (jering or jengkol), *Gnetum gnemon*, *Syzyium aromaticum* (clove), etc.

Thus farmers conclude that shade trees are a necessary component of a sustainable and profitable coffee cultivation systems due to a wide range of positive effects, and they would

become even more important if the yield of their own products could be improved. Several farmers think research about the combination and species of fruit and timber trees suitable as coffee shade trees in the climatic conditions of Sumberjaya can be very useful and can enhance farmers' initiative to plant more shade trees. However, Agus *et al.* (2002) describe that the Sumberjaya area is suitable most fruit species and that the demand for them is bigger than the supply on the local market of Lampung province (although not all have been investigated yet). Through their farmer groups, better information about the market and the prices could be collected so farmers can avoid low prices as often paid by traders. Nevertheless, shade trees require capital and labour in the provision and planting of seedlings (Agus *et al.*, 2002). Some farmers complain about the low accessibility of good and not too expensive seedlings (O'Connor, personal communication, 2002).

However, J. Ruinard (1951) also mentions that in Indonesia, early experiments to use fruit trees and other trees that furnish valuable products as shade trees have failed as those trees mostly do not have the properties good shade trees require and often even harm the crop through competition. The main competitive interactions relevant to agroforestry systems are displacement of crops by the stems of trees, competition for light, competition for water, competition for nutrients and allelopathy or suppression of crops by toxic substances produced by trees (Young, 1997). Nevertheless, fruit, fodder and other products from the trees can compensate economically for the existence of crop yield depression by these trees (Hocking *et al.*, 1997).

Chapman (2001) classifies shade trees in three categories depending on their effect on the coffee understory: coffee beneficial trees, productive coffee neutral trees and coffee negative trees. Coffee beneficial trees have "cold" roots, non-competitive, deep and water holding, that mostly are found to fix nitrogen. Their crown is light and airy or their leaves are small, giving a shade of high quality. Leaves are regularly shed, but are retained during the dry season, they decompose readily and improve soil structure and fertility.

Productive coffee neutral trees are neither considered disruptive or directly beneficial for coffee, they produce fruit, spices or other products usable for household consumption and sale and they still provide shade and soil and water conservation functions.

Coffee negative trees are productive trees specifically grown for timber, fruit or spices. Their economic gains outweigh the negative effect on coffee productivity through their strong, "hot", expansive root systems, high nutrient requirements and poorly decomposing leaves, described as hard (keras) by the farmers. Mostly these trees are planted on the garden boundary.

Annex XIII: Weeding techniques

Removing weeds can happen through a whole range of different techniques such as cutting off the weeds with a long bladed knife or sickle, hoeing with a small hoe (cangkul) and spraying contact or systemic herbicides. All these techniques can be combined with forking the soil. These different methods have different effects on the presence of weeds; on soil structure, consistency and humidity; and on the coffee roots and the coffee crop as a whole. Hoeing the garden causes a complete eradication of the weeds whereas by spraying herbicides or cutting weeds a small portion of the weed population survives.

Weeding techniques can render the soil's consistency either hard or loose, which doesn't only have an influence on the growth of the coffee plants, but also on the erodibility of the soil. Hoeing and forking loosen and aerate the soil, whereas cutting and especially spraying herbicides cause hardening of the soil surface. During the validation test, it became clear that farmers think that the effect of spraying on soil depends a lot on the kind of chemical herbicide used. In this perspective, the cheaper contact herbicides as gramazone (a paraquat herbicide, banned in Europe and North America for suspected carcinogenicity) seem to show off this effect in a most excessive way, whereas systemic herbicides as the more expensive RoundUp (glyphosate) do not have a negative influence on the soil consistency. As already described in the chapter about soil erosion, loose soils are more easily infiltrated by rainwater, and this higher infiltration is counterbalanced by a declined runoff. Nevertheless, these runoff water currents easily carry along the loose soil particles, causing the erosion rate of loose soils and the turbidity of the runoff water to be high. Hard and compact soils are thought to have opposite properties: low infiltration and high runoff, but less erosion because of their hard and firm structure and hence low water turbidity. Loose soils are perceived to be suitable for coffee as the coffee roots grow fast, the coffee beans are big and have a good taste. Hard soils on the other hand enhance falling of the coffee cherries, make the coffee leafs yellowish and can even cause the coffee plants to die. Holle (1863) also writes that the soil has to be loosened from time to time to improve the coffee growth because, according to him, this makes nutrients from the air entering into the soil and this also makes present nutrients more available for the roots.

Another perceived difference between the various techniques is whether they involve turning of the topsoil or not. Some farmers say only forking causes proper turning of the topsoil, while others say that hoeing by itself also turns the soil to a sufficient extent. Turning of the soil causes the rainwater to penetrate into the soil via the induced fissures and cracks,

hereby reducing runoff and erosion processes. According to some farmers, hoeing only moves the upper part of the topsoil, so rainwater is prevented from infiltrating to a greater depth. If the soil is not turned our loosened from time to time, it becomes hard during the dry season and sticky during the wet season, with a consequent decline of coffee yields.

Application of (contact) herbicides not only hardens the soil, but it can also cause the soil to dry out. Forking the garden during the dry season also has a drying effect on the soil. Dry soil is perceived to erode more easily, and also have a negative effect on coffee yields by causing the cherries to fall down. Holle (1863) confirms that too much soil cultivation during the dry season causes the soil too dry out, especially in young gardens with less shade.

The interaction of the weeding technique with the hair roots of the coffee plant is also estimated to be important. Cutting and spraying herbicides evidently do not move the coffee hair roots, while by hoeing or forking these hair roots are displaced and rejuvenated, which stimulates their growth and prevents them from being infected by fungi that have a negative effect on the coffee health. Holle (1863), Ultee (1949) and Ankersmit (1940) on the other hand, advise coffee planters not to hoe too much and too close to the coffee plants as it would damage their root system, whereas forking would be a more appropriate technique to loosen the soil. Chapman (2001) confirms that while hoeing or forking, the main concern of Sumberjaya farmers with flat gardens seems to be disturbing coffee roots close to the stem. Contact herbicides also have a direct negative effect on the health of the coffee roots, especially if the frequency of spraying is high and if spraying is the only applied technique. The coffee hair roots grow slower and die sooner, which decreases the coffee growth rate. This effect is more stringent if the coffee plants are still young. Excessive use of pesticides can also cause a reduction of organic matter content of the soil and to an abundance of bryophytes. Some farmers indicate that the use of systemic herbicides during more than four years on a regular base can lead to dying of the coffee roots and eventually of the whole crop. Too much herbicide can cause the coffee leafs to turn yellow and to fall down, and it would also extend the coffee harvest period. One farmer also says that applying herbicides decreases the soil fertility, because he notices a decline in coffee growth and yields, according to other farmers caused by the hardening and drying of the soil and the negative impact of the herbicide on coffee hair roots.

In general, farmers agree that spraying herbicides decreases the eventual coffee yields. That’s why they think spraying should only happen when there is not enough time and when it is alternated with hoeing or combined with forking, techniques that loosen the soil and stimulate the coffee hair roots. Especially during the rainy season when luxurious weed

growth increases the weeding need and when farmers are occupied by other activities, spraying is a good solution, in spite of its negative side effects.[7]

Farmers are not unanimous about the effects of hoeing and especially forking on soil erosion, because the final result depends on a range of factors. On one hand, runoff and rainwater are enhanced to infiltrate, reducing the soil erosion, but on the other hand the soil is loosened and easily erodes away if the slope is too steep, the rainfall and runoff water is too abundant and no soil conservation techniques as terracing or planting shade trees are applied. Still, forking renders the soil more suitable for coffee cultivation and is a must when young coffee is planted. Earlier local ecological knowledge research in Sumberjaya confirms that farmers know that although infiltration is initially higher, and thus runoff and soil loss are lower, once the forked soil is saturated by heavy rain, the soil loss effects are devastating (Chapman, 2001). In scientific literature, examples of tillage erosion that accounts for the overwhelming amount of soil movement are given, also in the case of hand hoe farming on steep slopes (Turkelboom *et al.*, 1993; Garrity *et al.*, 1995).

[7] See diagram 'herbicide effects' in Annex VIII 'Diagrams of farmer knowledge'

Annex XIV: Weed residues

One of the beneficial side effects of weeding is the presence of weed residues, which can be an important source of organic matter in the coffee garden. The weed residues can be used in three different ways. Sometimes, weed residues are merely left where they are, covering the coffee garden soil, where they decompose and enrich the soil in organic matter. Holle (1863) also describes this as being beneficial for the soil fertility. Other farmers heap the weed residues and pile them against the coffee stems to increase organic matter content where the coffee root density is the highest. This method increases the water retention and hence not only the water availability for the coffee plants but also the decomposition rate of the plant material. Also Holle (1863) and Ankersmit (1940) mention that piling dry grass and weed residues around the coffee stems in the dry season can maintain the soil fresh and humid. Ankersmit (1940) writes that this way, the coffee hair roots will grow into the slowly decaying plant litter, which is a sign that the coffee plants enjoy this fertilisation. He suggests that the same can be done with prunings, to prevent the soil from cracking and the coffee hair roots from being damaged. A last method is to collect the weed residues, often together with leaf litter and other plant material and store it in composting holes or furrows where it will decompose. The resulting organic matter is left in place, spread out on the field or heaped against the coffee stem, all contributing to a higher soil fertility.[8]

[8] See diagram 'weeding effects' in Annex VIII 'Diagrams of farmer knowledge'

Annex XV: Comparison of farmers' knowledge and a scientific model

It appeared interesting to compare the logic of farmers' understanding with the logic of scientific models concerning factors influencing soil erosion, in order to see on which points both structures differ.

The major components in farmers' understanding of erosion process include:

1. Rain
2. standing trees, bamboos and shrubs and their root system
3. ground cover with either leaf litter or live ground vegetation
4. soil – including physical properties and nutrient content

A generalised representation of soil erosion process as understood by farmers is shown in Fig 1.

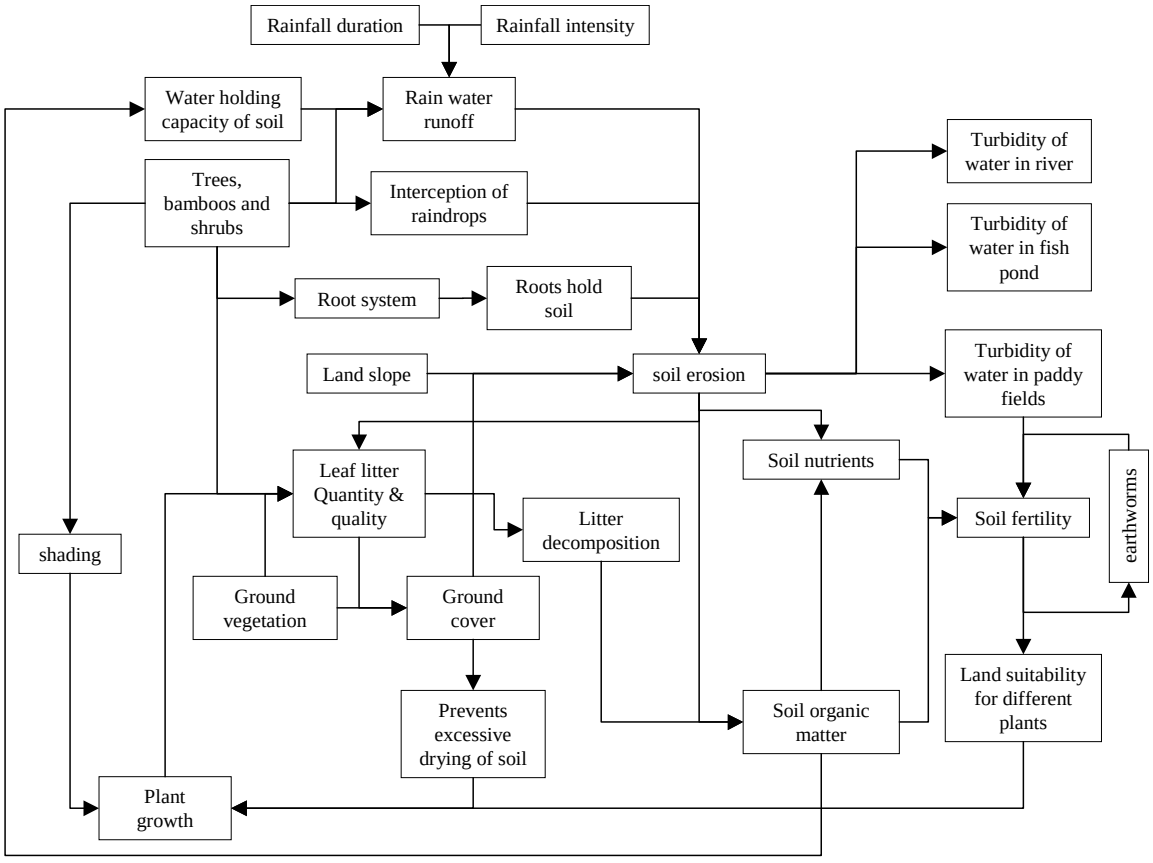


Figure 1: Main components in farmers' understanding of soil erosion process. Arrows show cause-effect relationship between linked nodes.

Rain intensity and duration are considered important in determining the intensity of soil erosion. Trees and other tall vegetation have multiple functions: their crowns that intercept rain drops reduce splash erosion and also cause shading (positive or negative effect depending on density and crop type); the roots (depending on the spread and type) hold soil in place; the stems slow water runoff; and the vegetation provides leaf litter that protects soil from being washed away by rain and also reduces excessive evaporation in dry periods. Decayed leaf litter is an important source of organic matter and plant nutrients for the soil. Presence of earthworms is considered an indicator of good soil and also known to contribute to increasing soil fertility.

Now we look at the computer model WaNuLCAS (Water, Nutrient and Light Capture in Agroforestry System) (Van Noordwijk and Lusiana, 1999) that is able to simulate a range of tree-soil-crop interactions in agroforestry systems. Basic ecological principles and processes, as understood from a scientific perspective, are incorporated in the model using modules such as climate, soil erosion and sedimentation, water and nutrient balance, tree growth and uptake, competition for water and nutrients, root growth, soil organic matter and light capture (Figure 2, Khasanah et al., 2002).

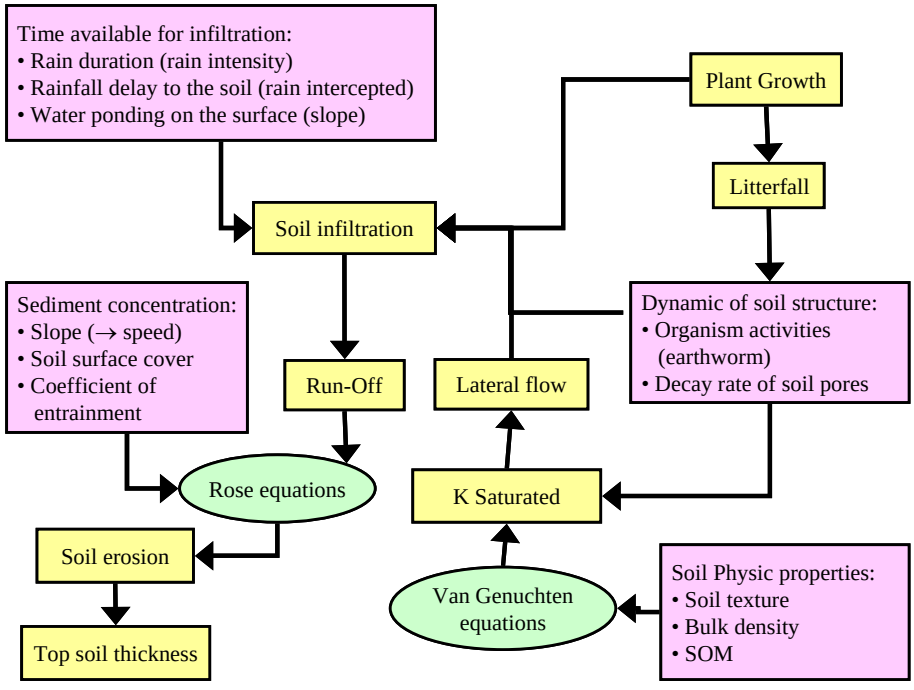


Figure 2. Key factors in the soil erosion component of WaNuLCAS model (Source: Khasanah et al., 2002)

Physical soil properties (texture, bulk density and organic matter content) and soil structure dynamics (biological activity, fed by plant growth through litter fall and root decay) determine the value of K Saturated, conditioning the lateral flow. Rain intensity, plant growth (through consequent interception of rain) and lateral flow influence infiltration, which determines the amount of runoff water. Soil erosion is influenced by the amount of run off water and sediment concentration. The amount of sediment concentration depends on the slope (determining the runoff speed), the soil surface cover (canopy of trees, shrubs, weeds, litter) and the coefficient of entrainment (mainly depending on aggregate stability). Consistent with farmers' understanding, the duration of rain is a factor that determines infiltration thereby influencing amount of runoff.

In the WaNuLCAS model, root decay contributes to soil fertility, but this understanding is missing from farmer knowledge. On the other hand farmers' understanding of two important functions of root networks (1) holding of soil that reduces soil erosion and (2) contribution to soil moisture maintenance and water flow regulation through absorption and later gradual release into soil do not exist in the computer model. This could be a topic for future scientific investigation.

Farmers also emphasised the importance of trees and their leaf litter in breaking the fall of the raindrops, hereby reducing their impact on the soil and decreasing soil erosion. In WaNuLCAS, the amount of water that is intercepted by above ground vegetation cover (tree canopy, shrubs, weeds, litter) has a direct effect on the amount of rain that is falling onto the soil as infiltration water and run off water. The amount of run off water depends on rainfall that exceeds the current infiltration capacity of the soil in the time available for infiltration. The time available for infiltration depends on the duration of the rainfall and rain intensity, the delayed delivery of rainfall to the soil via canopy interception and dripping of leaves, and the rate at which water logging on the surface will actually flow to a neighbouring zone or plot (which depends on the slope). Hence, interception was incorporated in the model as diminishing the amount of rainfall reaching the ground, but impact of rainfall directly increasing soil loss through splash erosion had not been incorporated.

The soil structure dynamics are a consequence of biological activity, mainly represented by earthworm activity, which results from inputs of plant material as leaf litter, prunings and decaying roots. Farmers relate leaf litter and roots directly to infiltration, giving the same results. They also see and value the role of earthworms in soil fertility. Farmers directly link soil physical properties (loose and sandy versus compact and clayey soils) and soil structure dynamics (biological activity: leaf litter and roots) to infiltration, without

making any connection to K saturated or lateral flow as in the model, but with similar outcome.

Understandably, there are differences between local and scientific understanding of soil processes. As most simulation models, WaNuLCAS uses a mathematical approach, while farmers' models are far from any mathematics. Rather simple cause-effect relations are the norm in a local model. WaNuLCAS can predict final output in a quantitative manner based on values used for different input parameters, while farmers' models rely simply on qualitative values such as increase and decrease.

Except for some details, the general logic of the scientific WaNuLCAS model follows the logic of farmers' understanding of erosion processes. Other studies confirm that the role that local people account to water, erosion and sedimentation in landscape formation is remarkably similar to that of Western science; e.g. Niemeijer and Mazzucato (2003) in their study on local knowledge of Gourmantché people in Burkina Faso.

Annex XVI: Land suitability conclusions

Land not suitable for cultivation

Farmers state that too steep a land should remain under forest or should be reforested if already cleared. Already in 1863, Holle writes that too steep slopes should not be cultivated because the good topsoil is too easily washed away. The need for forestation is also high for land that is degraded. These lands should be reclaimed by removing the grasses, hoeing and terracing the land and planting trees. The surroundings of springs should stay under forest cover as well, in order to protect and preserve these natural water sources. As described earlier, farmers think that riparian vegetation can really help in reducing negative effects of deforestation, that is why it might be recommendable not to cultivate the zones closest to the river, but instead plant trees or bamboo, or leave the area for natural vegetation as grasses or shrubs and bushes.

Land suitability for paddy rice cultivation

Only upland rice can be cultivated in the mountains without use of irrigation or other means of control of water availability. In these dry rice fields, the water availability is good during the rainy season but often too low during the dry season. However, most cultivated rice is irrigated paddy rice and this kind of rice requires high water availability. When water is difficult to obtain, paddy rice cultivation is not possible. Hence water availability is the first and most important condition for paddy rice cultivation. Although water can be available, one should also be able to regulate the irrigation of the paddy fields; otherwise the land suitability for paddy rice is not high either. Next to high water availability, it is also desirable for the land to be easy to drain, since not draining of the paddy fields causes an increase in occurrence of diseases and after some years the rice growth starts to decline, having a negative effect on eventual yields.

Even if the slope is steep, the land can be suitable for paddy rice cultivation, as long as water availability is high and bench terraces are constructed. The steeper the slope however, the lower the suitability of the land, because of increased erosion risks, higher installation costs, a high amount of bordering dikes and paddy compartments of a small size which renders the cultivation more difficult. Thus, flat land is most suitable for paddy rice

cultivation, and the suitability decreases with the slope, becoming very low when slopes get very steep.

Flat land, with high water availability, easy to irrigate in a regulated way and easy to drain, is most suitable for paddy rice cultivation and has the lowest installation costs, according to the farmers.

Black soils are perceived to be more suitable for rice cultivation than red soil. Loose and sandy soil is also thought to be very suitable, because easy to hoe, but in the long run, its fertility declines more rapidly than more sticky and clayey soils. Deep muddy soils like swamp soils are unsuitable for any rice but wild floating varieties because conventional rice is not able to root firmly in the unstable muddy soil. Red and yellow soils are less suitable for rice cultivation because they are low in organic matter and have a high iron content. This low fertility inherent to red and yellow soils can cause nutrient deficiency problems, which often come to expression in empty rice grains, slow growth and low yields. Hence the need for fertiliser application and liming of these soils is quite high, but if this is done appropriately yields can also be sufficiently high.

The sandy sediment as deposited by river flooding is very fertile because it contains a lot of organic matter, and it is perceived to increase the land's suitability for paddy rice cultivation. A fertile soil is often characterised by a high biological activity, noticeably by a high presence of earthworms, whose cast is believed to increase soil fertility.

Some farmers defend a rotation of paddy rice and vegetables as a very profitable land use. This rotation is possible wherever the land can easily be irrigated and drained. Farmers say that rice yields decline if rice cultivation is not alternated with other land uses such as vegetable cultivation; also diseases and plagues increasingly occur when rice cultivation is prolonged. The high amounts of manure or other fertilisers applied for vegetable cultivation have a positive effect on rice yields afterwards. Sandy soil would be very suitable for vegetables, certainly when the subsoil remains moist and does not dry out too fast. Soils like deep muddy soils that are hard to drain are not suitable for vegetable cultivation.

Land suitability for coffee cultivation

Flat or slightly sloping land is thought to be most suitable for coffee cultivation. Too steep lands are less suitable because soil losses through erosion can be quite high. Nevertheless, flat lands can have the disadvantage of higher temperatures during the dry season. One farmer mentions that land with aspect to the east is most desirable because then the coffee can

optimally enjoy the morning sun. Ultee (1949) also writes that slightly sloping land is more suitable for coffee production than steep land, because of the high cost of necessary measures to prevent erosion. Holle (1863) mentions that flat terrain and slopes of less than 20 degrees are the easiest to clear and to maintain, and mostly the best earth is found over there. He also mentions that slopes for which the aspect is such that they receive almost no sunshine are less suitable because of less fruit formation and more difficult ripening. Also Ankersmit (1940) mentions that slopes with aspect to the east give better yields than those with aspect to the west because of the beneficial effect of the morning sun.

Dark blackish soils are preferred above soils with red and yellow to white colouring. Coffee plants are said to prefer soils with high organic matter content, which immediately explains the higher suitability and profitability of black soils. Hoeing and applying fertiliser, especially organic manure, is thought to increase suitability of yellow and red soils, low in organic matter.

Coffee also seems to like loose, well-structured and somewhat sandy soils, resulting in higher yields and bigger sized coffee beans. Soft and somewhat clayey soils, sticky in wet conditions but hard and compact when dry, are not appreciated by coffee and coffee farmers, although forking of the soil and application of fertiliser can improve growth conditions.

Thus for coffee it is clear, loose and somewhat sandy soils rich in organic matter are the best soils you can have as a farmer, in spite of their higher erodibility. Scientific literature confirms the insights of the farmers. Holle (1863) writes that most suitable soils are loamy and sandy soils that are rich in humus and have a black or dark brown colour. These soils are found were forests are still present or have just been cleared. Rich sandy and loamy soils, of a darkish red to black colour are suitable as well. Loamy soils are defined as a loose mixture of clay and sand, easy to cultivate. Less suitable or unsuitable are heavy clay soils and poor sandy soils with a light red, yellow or grey colour. Swamp soils are completely unsuitable. Ultee (1949) mentions that coffee is quite selective when it comes to the soil, more than most other crops. Although the pen root can grow more than 1 meter deep, the majority of the hair root mass is situated close to the surface. This implies that the topsoil properties are determinant for the suitability for coffee cultivation, although no impermeable layer may occur on shallow depth. To have a good harvest, coffee plants above all need a soil rich in organic matter, and preservation of this organic matter is of primordial importance for coffee planters. The organic matter will decompose to humus, having a positive influence on soil structure. Coffee needs porous soils and is very sensitive for the right balance between soil air and water content. Thus for coffee organic matter content and physical soil properties are far

more important than chemical soil characteristics. Also Ankersmit (1940) emphasises the importance of the soil organic matter content. If the humus content of the soil decreases, the soil structure can degenerate, causing the soil to crack in dry times and to become sticky and impermeable during heavy rains.

Annex XVII: Explanations for non-validated test statements

The whole test questionnaire and its results can be consulted in Annex VI. As mentioned earlier, 6 out of the 62 statements have not been validated as being part of the core ecological knowledge of the farmers as less than 75% of the informants agreed with them.

The first non-validated statement is about the interaction between herbicide and coffee roots. The strongest opinion – that herbicide can cause the coffee hair roots to die – was verified. The outcome of the test is that, although a majority of farmers did not agree with this statement, herbicide still has an influence on the coffee hair roots, going from slowing down growth, impeding rejuvenation, increasing susceptibility for fungal infections or in extreme cases indeed, after years of continuous spraying, causing part of the coffee hair roots to die.

All farmers agreed that forking the coffee garden causes the soil to be loose, but about the influence of forking of steep gardens on erosion caused by rainfall, the farmers' answers were not consistent. Almost half of them said erosion was to be increased, while others said that infiltration is enhanced and thus erosion is diminished. An explanation for this different knowledge is that the described phenomenon is very context dependent. Indeed, farmers say that rainwater is enhanced to infiltrate in the porous, loose soil if the rainfall is not too intense, the slope is not too steep and especially when terraces are constructed. And of course, during heavy rainstorms the soils become saturated quite soon, causing runoff, which easily sweeps away loose soil particles. Hence the differences in response are not inconsistent because conditions had to be specified more clearly.

A similar explanation could be given for the failure of validation of two statements regarding furrows in coffee gardens as soil conservation technique. Farmers were asked if the water still brought along a lot of mud, and if the water was turbid or not. Some farmers said that less soil was taken along and hence the water appeared less turbid, while others said that still a lot of mud was washed away causing the runoff water to be quite turbid. A possible explanation is embedded in the argumentation of some farmers trying to clarify their opinion. They said that, although the runoff water still erodes the soil of the coffee garden to a certain extent, and hence still contains mud and is turbid, most of this mud is being deposited in the furrows when the runoff water enters these, causing the water in the furrows to loose turbidity. Hence, the tested statement was not clear enough, whether it was the runoff water entering the furrow that was meant, or rather the water flowing through the furrow network to the river.

The fifth and sixth non validated statements dealt with pesticide residues ending up in the river during rainfall, being able to poison fishes in the fishponds. These statements were included because they were mentioned by two of the last interviewed farmers not being verified yet by further interviewing, and because they indicate a water quality problem to which not much attention had been paid to so far. The fact that more than half of the farmers agree with these statements confirms the possible threat agrochemicals impose on river water quality in Sumberjaya.

Annex XVIII: Potential knowledge differences as indicated by test results

The results of the questionnaire have been analysed statistically through detrended correspondence analysis (C.A.) using the computer software CANOCO. Two data matrices have been imported, one with the dependent variables (68 statements * 28 respondents) and the environmental matrix (4 independent variables * 28 respondents). Then an Indirect Ordination has been applied to the data.

This resulted in scores for both the statements and the respondent farmers for 4 axes. To investigate the differences between farmer subgroups, these axes can be plotted, using different labelling for the distinct independent variables (namely ethnic group, watershed, position and type of field). As the resulting eigenvalue for the first axis is more than 3 times higher than for the other 3 axis (more precisely 0.114 versus 0.032, 0.020, and 0.014), it suffices to plot the first axis versus respectively the second, third and fourth one. The scatter plots for the different independent variables follow suit.

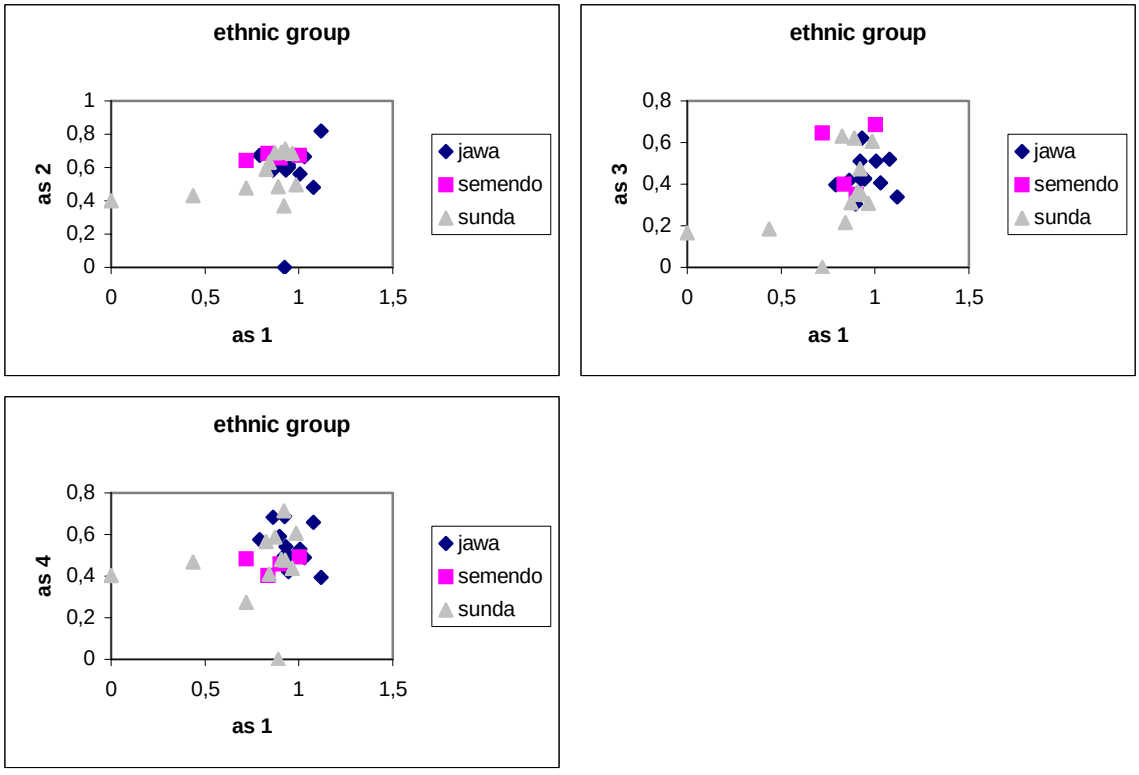


Figure 1: Scatter plots of axis 1 vs. axis 2, 3 and 4 respectively for the independent variable 'ethnic group'

As you can see on the plots, no clear distinctions can be made between different ethnic groups as the average points of the three ethnicities are located very close to each other. This

contrasts with earlier research findings that did claim differences in LEK according to ethnicity. However, these earlier research data were not statistically analysed.

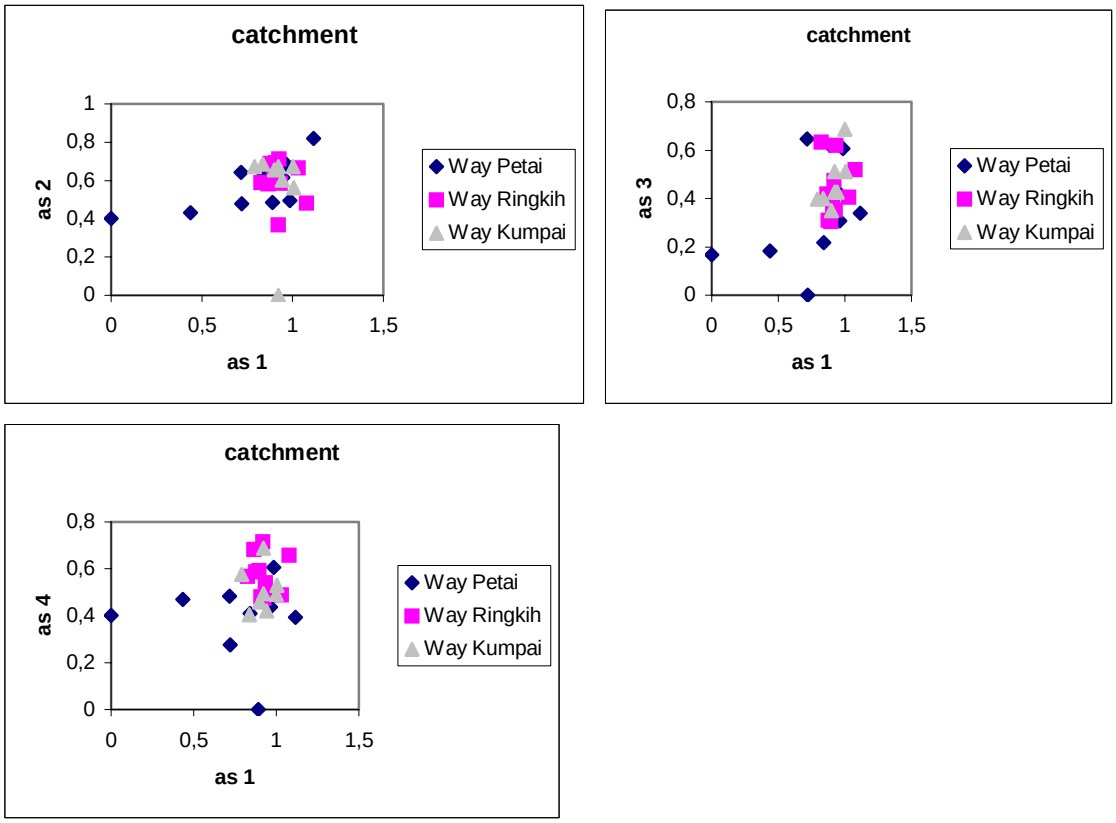
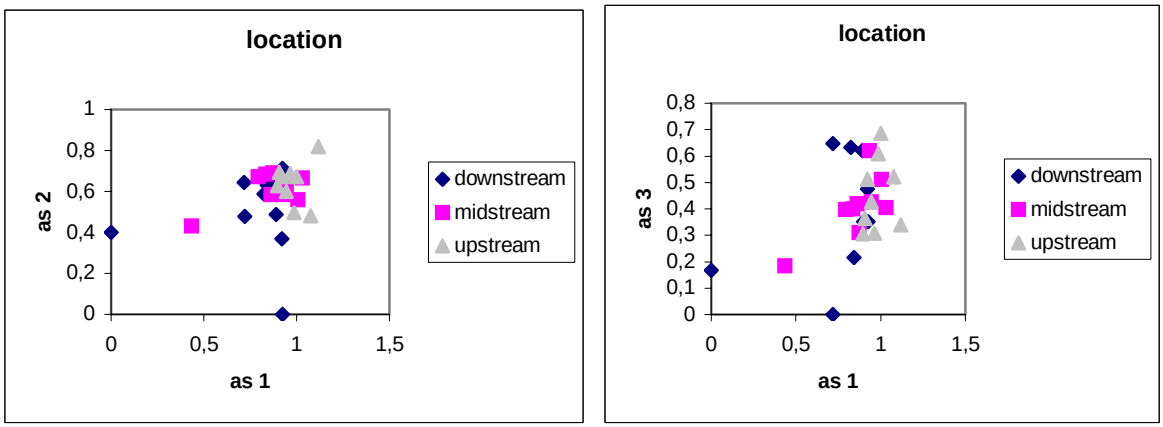


Figure 2: scatter plots of axis 1 vs. axis 2, 3 and 4 respectively for the independent variable 'subcatchment'

The same thing can be said for the different catchments, few differences can be detected. However, one notices that, although the dots are grouped around the same area, the variability within the largest and flattest watershed Way Petai is high compared to the variability within the two other catchments.



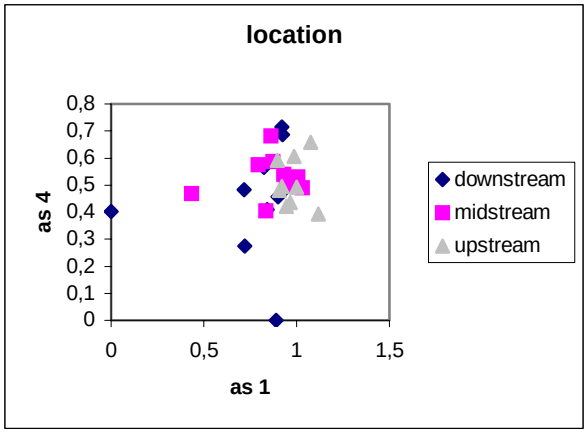


Figure 3: scatterplots of axis 1 vs. axis 2, 3 and 4 respectively for the independent variable 'location'

Likewise, for the different locations in the catchments, farmer knowledge does not seem to differ much when one observes the scatter plots. However, also in this case, a higher variability can be noticed for the downstream farmers, perhaps indicating lower knowledgeability (see below).

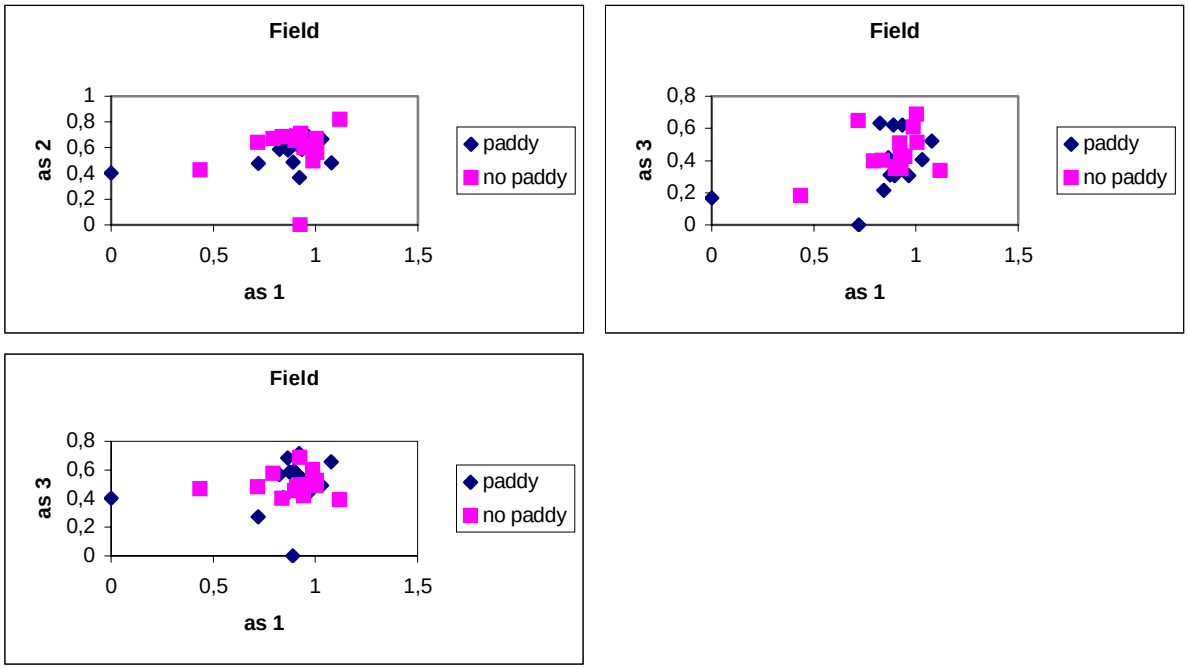


Figure 4: scatter plots of axis 1 vs. 2, 3 and 4 for the independent variable 'field'

Knowledge of farmers with and farmers without paddy rice fields doesn't differ either.

A closer look at the exact figures per farmer subgroup for every independent variable gives some interesting indications, especially when considering individual statements[9].

In general, looking at the total number of validated statements, we see that Javanese farmers seem to agree a little more with the constructed knowledge base than Semendonese and Sundanese do. The differences however, mainly exist for those statements that had a certain degree of ambiguity, as mentioned above. There is also a slight increase of validated statements noticeable from Way Petai to Way Ringkih and Way Kumpai, at least partially due to the increased skills of the interviewers.

More important is that downstream farmers validated fewer statements (78%) than midstream farmers (90%) and upstream farmers (94%). These figures are exaggerated as in a repeated number of statements downstream farmers score just below 75%, which is the case where 2 or more out of the 7 interviewed downstream farmers disagreed with the KB. When the threshold value is reduced to 70%, downstream farmers come to 87% validation, compared to the unchanged 90 and 94% for respectively mid and upstream farmers. Nevertheless, one cannot deny that it seems that more upstream, farmers appear to be more knowledgeable. This is indicated to be the case for clean-weeding and erosion, flooding and forest influence (although this particular statement has also been experienced to be confusing for a number of farmers), turbid runoff water fertilising the paddy fields, a decrease of turbidity of irrigation water when passing through the paddy fields and problems with pesticide residues in river water. It is important to remark that for all these topics, high figures of validation are noted for downstream, midstream and upstream farmers, but that it seems that the percentages of validation are slightly higher for more upstream farmers. A possible explanation could be because downstream farmers are less involved in HKm farmer groups as most fields downstream are on private land and not on state land, compared to the disputed upstream fields close to the forest. This organisation of farmers in groups might have led not only to a higher homogenisation of knowledge but also to its complete expansion to all farmers in the area.

The fact that weeds can retain water and soil seems to be slightly less known by Sundanese and Way Petai farmers, which is probably because the testing was started in the Way Petai catchment were also the greatest concentration of Sundanese people live. This particular statement has experienced to be difficult to explain during the very first testing trials, which is probably the reason for this small deviation. Sundanese and Way Petai farmers

[9] These figures can be checked in the excel file ‘test results.xls’ on this cd-rom.

are also noted to disagree more with the statement that herbicides can cause coffee hair roots to die.

Slightly less coffee farmers who also have paddy fields believe that herbicide causes a decrease of coffee yields, compared to coffee farmers who don't have paddy fields. Upstream farmers and farmers who also have paddy fields seem to agree more than mid and downstream farmers that forking increases soil erosion, although, as mentioned in Annex XVII, this statement depends a lot on the considered conditions.

The more upstream the more the farmers seem to be convinced of the fact that clean weeding causes soil erosion to increase. Also Javanese farmers versus Sundanese and Semendonese and Way Ringkih/Way Kumpai versus Way Petai agree slightly more.

Considering the following statement: “A terraced coffee garden with a lot of shade trees gives less turbid runoff water”, Sundanese, Way Ringkih, midstream and paddy farmers agree slightly less with the turbidity aspect, but also for these minor differences, a logical explanation cannot be given.

For the ambiguous statement that water in the furrows of the coffee gardens still brings a lot of mud along and still is turbid, clear differences in response are found as Semendonese farmers do not agree at all, Sundanese a bit more and Javanese a lot more. But keeping in mind that the way this statement was formulated caused confusion and misinterpretation, it is also hard to draw a conclusion from this difference between ethnic groups, which might have been caused simply by different understanding and interpretation by each ethnic group.

The fact that rivers only flood for short times was less accepted by Way Petai and downstream farmers (80-85% versus 100%), which is logical because in downstream areas flooding always takes longer and because the Way Petai is the largest of the three investigated subcatchments.

The statement that before the forest was cleared, the river water was less turbid and more stable, was sometimes also confusing for some farmers that did not experience the time that the forest cover was still abundant, although they are aware of the beneficial effects of a large forest cover. Way Petai, Sundanese, downstream and paddy farmers agree slightly less, having the longest history of deforestation.

Two downstream farmers do not agree with the fact that turbid water from coffee gardens contains organic matter and fertilises the paddy field, which immediately lowers the figure for downstream farmers with respect to their colleagues of higher zones.

The more upstream the more farmers are convinced that when it rains, the water that comes out of the paddy fields is turbid, probably because they experience more influence of

runoff water during rainfall. Also Way Ringkih and Javanese farmers mostly share this opinion, the former probably because of the same reason since the Way Ringkih valley is characterised by very steep slopes.

An interesting difference is displayed for the following statement: “When turbid irrigation water enters the paddy field, the water flowing out of the paddy field is less turbid.” Only one third of the downstream farmers agree with this, against 80% of the midstream and 100% of the upstream farmers. Also Way Ringkih farmers agree slightly more than Way Petai farmers do. This is not visible from the initial knowledge base as more than one downstream farmer says that sedimentation of soil in the paddy fields reduces the turbidity of the water flowing back to the river. Possibly, the downstream water is already so turbid that the minor decline in turbidity caused by sedimentation in the paddy field is negligible?

Midstream farmers agree slightly more than downstream and upstream farmers that shrubs and bushes can filter turbid runoff water.

Javanese farmers seem to agree slightly more than Sundanese and Semendonese that pesticide residues can enter the river and poison fish in fishponds. Also the more upstream, the more farmers share this opinion; maybe because the upstream water is less polluted so the effect of pesticides is more visible.

Annex XIX: Map of Sumberjaya

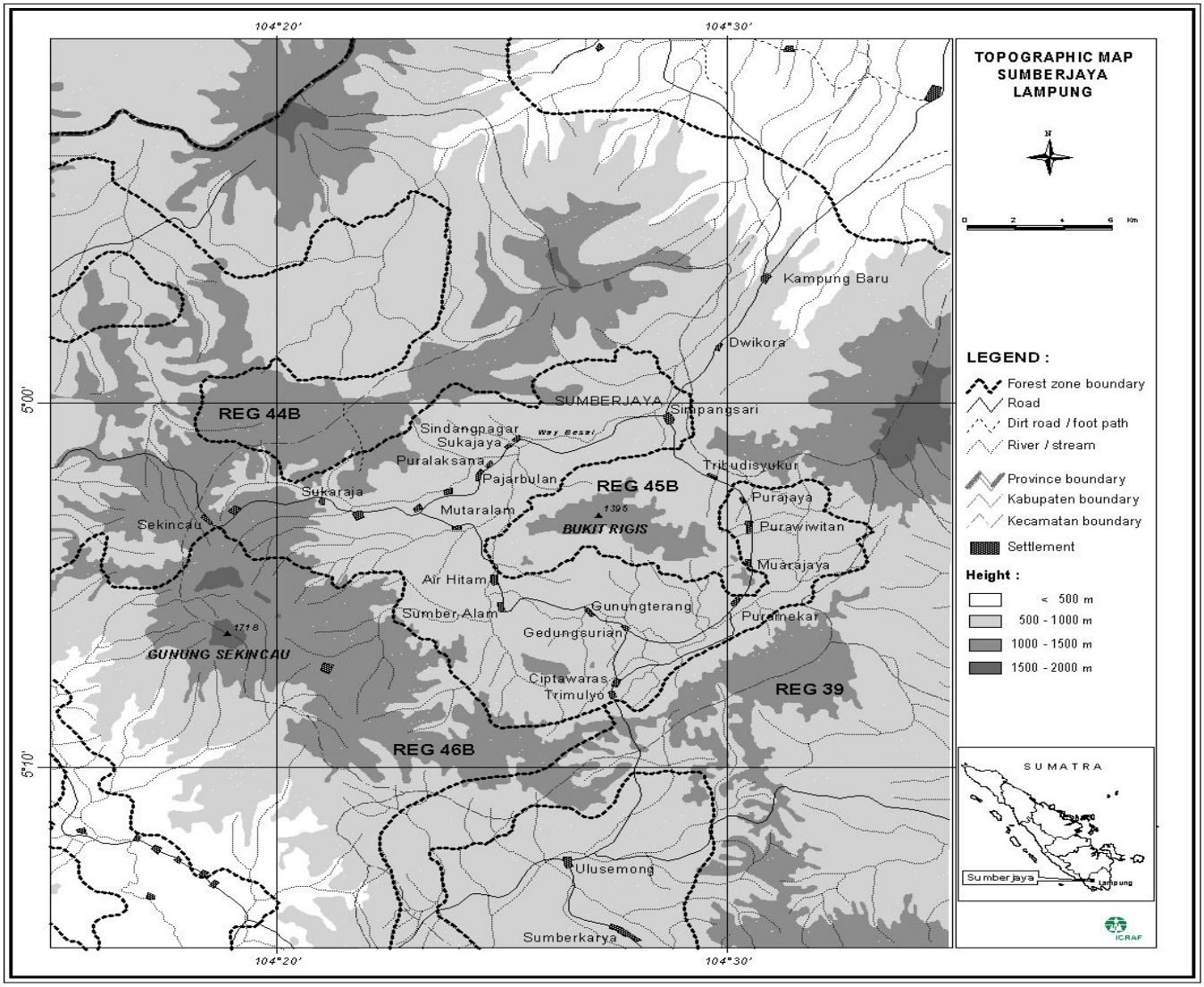


Figure 1: Topographic Map of Sumberjaya.

gure 28: Topographic map Sumberjaya

Annex XX: Note on local awareness of biodiversity issues

When talking about the advantages of shade trees and agroforestry, none of the farmers mentions preservation of biodiversity as one of the beneficial effects of the agroforest, although in scientific literature, this is an important aspect of shade cultivation systems. Dicum and Luttinger (1999) write that the diversity of some wild animals in traditional coffee plantations reaches levels similar to those found in undisturbed tropical forests, although regarding biodiversity richness, they can simply not compete with the undisturbed primary forest (Van Noordwijk, Tomich *et al.*, 1997). Still, coffee agroforestry systems can maintain some of the habitat features required by native wildlife. Shaded coffee plantations are often the last refuges for forest-adapted organisms (SMBC, 1997). Farmers do not yet seem to be aware of this kind of benefits, or if they are, they think it is of lower importance. O'Connor (personal communication, 2002) who investigated avian biodiversity in the coffee gardens of Sumberjaya, revealed the same preliminary conclusion.