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Landscape characteristics of Rejoso Watershed:
land cover dynamics, farming systems and community strategies

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INTRODUCTION

Rejoso Watershed (covering 16 sub-districts) lies at the foothill of Mount Bromo, Pasuruan District, East Java Province. The watershed strategically functions as the source of clean water for Pasuruan District and its surrounding districts and cities such as Sidoarjo and Surabaya – the metropolitan capital of East Java. Umbulan Spring - one of the springs with the highest debit in Java Island - is located in the midstream of the Rejoso watershed.

The Rejoso watershed provides vital livelihoods for the Pasuruan communities. Farming of annual and perennial crops, including agroforestry, timber plantations and livestock is the most dominant source of income. In the last decade, stone mining has gradually become an alternative source of income for the communities in the midstream area of the Rejoso Watershed. In the upper stream of Rejoso watershed, adjacent to Mount Bromo, the tourism becomes an alternative local revenue.

Population growth and economic pressure are causing dramatic changes in the Rejoso Watershed. Dominant anthropocentric development activities have been gradually affecting the environment's quality, especially the watershed's function of maintaining good quality and quantity of water resources. The most common environmental issues related to water resources are floods, droughts, erosions, and landslides.

An initiative that simultaneously conserves and strengthens the local economy and livelihoods is urgently needed. The 'Rejoso Kita' initiative was designed to achieve these aspirations. As an initial step towards the implementation of such an initiative, the World Agroforestry Centre (ICRAF) is leading a scoping study as basis for the 'Rejoso Kita' strategy implemented by a consortium coordinated by Social Investment Indonesia Foundation, CK-Net and partners supported by the Danone Ecosystem.

To this end data and information on the characteristics of the landscape and socio-economic conditions in the Rejoso Watershed has been collected, covering three main topics: (1) *land-use and land-cover (LULC) change* as well as community's perception on the drivers of change; (2) *water resources and their management*, covering their potentials and problems, knowledge and community practices on water and soil conservation, as well as adaptation and mitigation strategies for water resource issues; (3) *livelihood strategies and challenges* related to the agricultural sector, including farming practices, extreme events affecting farming as well as tree selection criteria and tree commodity preferences.

This report aims at understanding both problems and potential solutions in managing the Rejoso watershed and its water resources, which expectedly will provide inclusive and robust recommendations for relevant decision-makers. To derive unites of analysis, the watershed was classified into eight research clusters reflecting similar characteristics in terms of landscape and communities. The next section describes the selection method of clusters, the research framework and the steps of data collection and analysis. The result section provides a temporal analysis of land-use and land cover changes over the last twenty-five years. Results are presented as (1) LULC as well as drivers of change, (2) water resource management and (3) farming practices and are descried for each cluster located in the downstream (Gondangwetan, Grati, and Winongan sub-district, dominated by paddy field), midstream (Pasrepan 1, Pasrepan 2, and Lumbang dominated by complex agroforestry), and upstream area (Puspo and Tosari dominated by horticulture, Perhutani forest (state forest), and complex agroforestry).

METHODOLOGY

Selection of research sites

The criteria for site selection were: (1) position in the landscape i.e. an upstream, midstream and downstream area combined with land-cover information; (2) level of community wealth; and (3) sources of livelihood. Figure 1 shows the systematic site selection process.

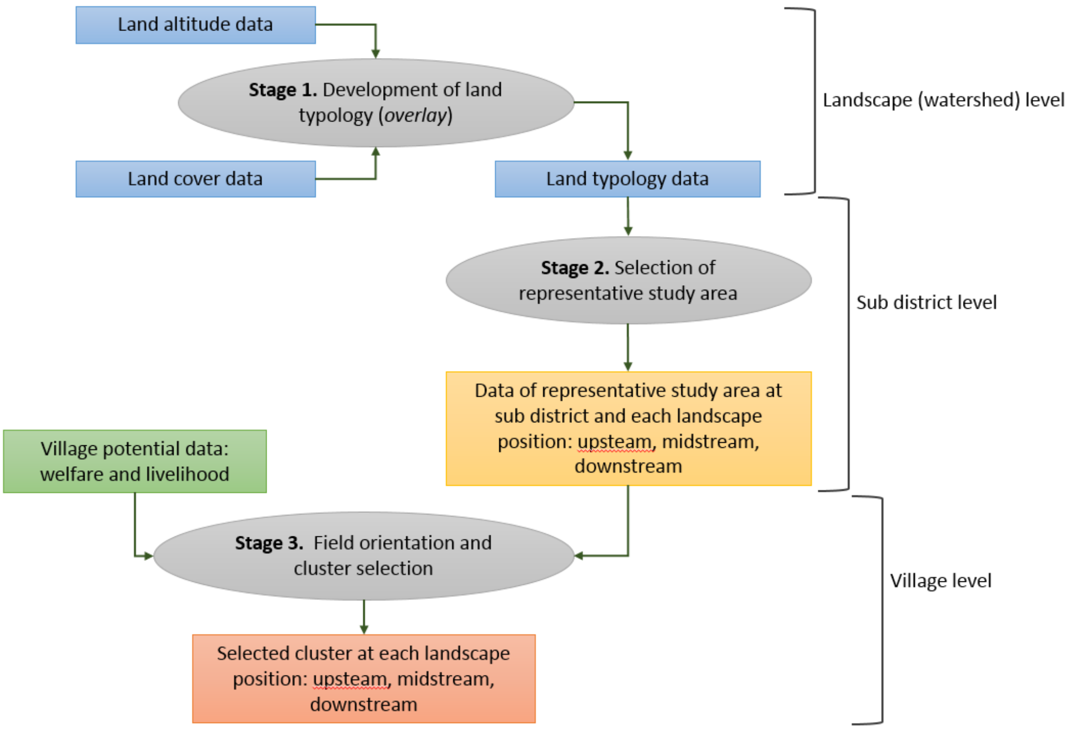


Figure 1. Stages in selecting research sites

Stage 1: Development of research site typology (watershed level)

The development of the research site typology aimed to classify the research sites through the overlay of (1) elevation and (2) land-cover spatial data. The overlay resulted in the typology map of the research sites based on the land-cover types at each cluster location in the landscape (upstream, midstream and downstream area).

Stage 2: Selection of study area (sub-district level)

Sub-districts in each landscape position were chosen by considering the existing land-cover variations and the selected sub-districts represented the dominant land-cover.

Stage 3: Field orientation and cluster selection

Based on the data from selected sub-districts, in each landscape position a field orientation was conducted, combined with data on villages' potentials (welfare and livelihood) from each sub-district. The aim was to attain a general overview of the study areas and to confirm the data previously collected from spatial data and the data of village potentials from the Central Bureau of Statistics (Badan Pusat Statistik-BPS). The existence of rock outcrops (the part of a rock formation that appears above the surface) and land tenure/management (privately owned land vs. State Forest or Perhutani) were also considered at this stage.

Data and information collection

The environmental quality of a given area is determined by the understanding and capacity of the people living in the area to manage their environment. Based on this, ICRAF employed the Capacity Strengthening Approach to Vulnerability Assessment (CaSAVA) framework to collect data and information related to the characteristics of the landscape and the communities' socio-economic condition in the selected research sites. CaSAVA also extracts information on disaster factors (shock/hazard) from biophysical and socio-economic factors and the communities' capacity to lessen and mitigate the impact (buffer) of disasters (Figure 2).

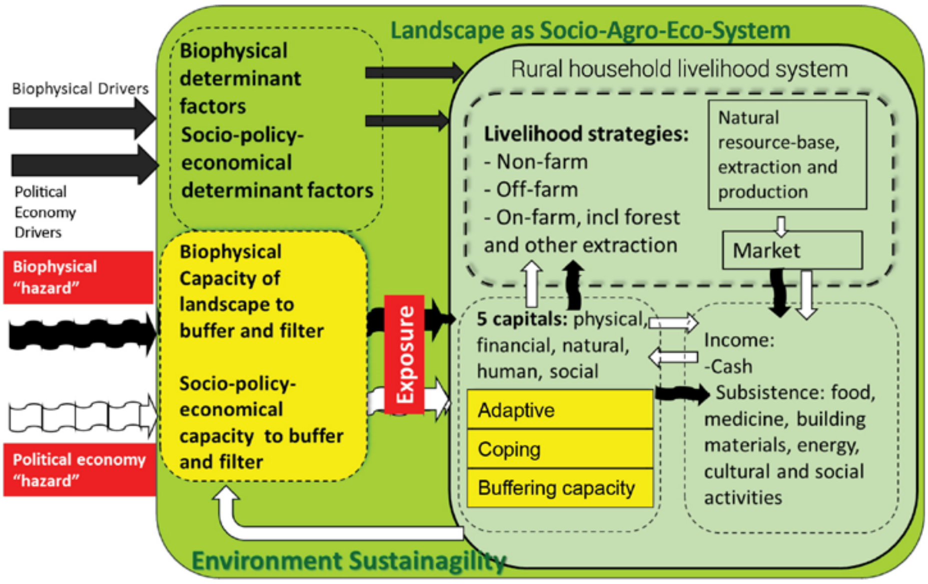


Figure 2. CaSAVA framework assessment methods

CaSAVA is a research framework combining biophysical and socio-economic research methods with a participatory approach. As a research framework, CaSAVA was not only utilized to collect data and information from the community but also to encourage them to reflect on the state of the environment and their socio-economy condition as parts of local community empowerment and capacity building (Dewi *et al,* 2012). The community's reflection on their environmental conditions will be useful in identifying the factors that make people socio-economically and environmentally vulnerable, and furthermore, provide input to the process of formulating recommendations to overcome vulnerability.

The data and information collection following CaSAVA was based on (1) a series of focus group discussions and interviews with the community, (2) spatial data analysis based on satellite imagery data and a ground-verification survey, (3) secondary data from the Central Bureau of Statistics. Ground-verification as part of the spatial data analysis was conducted in April 2016. Cluster selection and group discussions were conducted in July 2016 and October 2016, respectively.

In each cluster, the discussion was divided into three topics: 1) drivers of LULC change, (2) water resource management and (3) farming practices, that mainly discussed the perceptions of the community on the existing situation of each topic, and explore the perceived shocks, responses, exposures, and impacts (SERI) in each topic that influence community's livelihood. The discussion of each theme was divided into groups of male and female participants, with a total of 418 participants (239 males and 179 females) from 48 discussion groups (8 clusters × 3 topics × 2 groups: male and female groups) (Appendix 2).

JURISDICTIONAL AREA OF LANDSCAPE CLUSTERS

A cluster is a landscape consisting of several jurisdictional areas, including sub-districts and villages with similar biophysical and socioeconomic characteristics. The Rejoso Watershed was classified into a downstream, midstream, and upstream area based on their geographical elevations. Each elevation-based cluster consists of 3 sub-district clusters for downstream and midstream, respectively and 2 sub-district clusters for upstream areas. Table 1 summarizes the eight sub-district clusters.

Table 1. Landscape clusters: sub-districts and villages

No	Position in Rejoso Watershed	Clusters	Village Names
1	Downstream	Gondangwetan	Keboncandi, Tenggilis Rejo, Mendalan
2		Grati	Rebalas, Plososari, Kalipang
3		Winongan	Jeladri, Sruwi
4	Midstream	Pasrepan 1	Galih, Petung, Klakah
5		Lumbang	Karangjati, Watulumbung
6		Pasrepan 2	Tempuran, Ampelsari
7	Upstream	Puspo	Kedawung, Pusungmalang
8		Tosari	Sedaeng, Wonokitri

LAND-USE AND LAND-COVER (LULC) CHANGE

The Rejoso Watershed is a part of Welang-Rejoso Watershed, located in Pasuruan district, East Java. This study refers to the boundary of Rejoso Watershed based on the data from the Watershed Management Center (BPDAS) of KLHK Indonesia. The result of the spatial data analysis indicates differences between the enacted boundary from the BPDAS and the indicated boundary from SRTM-DEM (Shuttle Radar Topography Mission-Digital Elevation Model) and ground check. The data from BPDAS is indicated by light green line while the one based on the result of delineation by ICRAF is shown by the blue line (Figure 3). This section thoroughly discusses the LULC in the Rejoso Watershed. The LULC change in each cluster will be discussed in separate chapters.

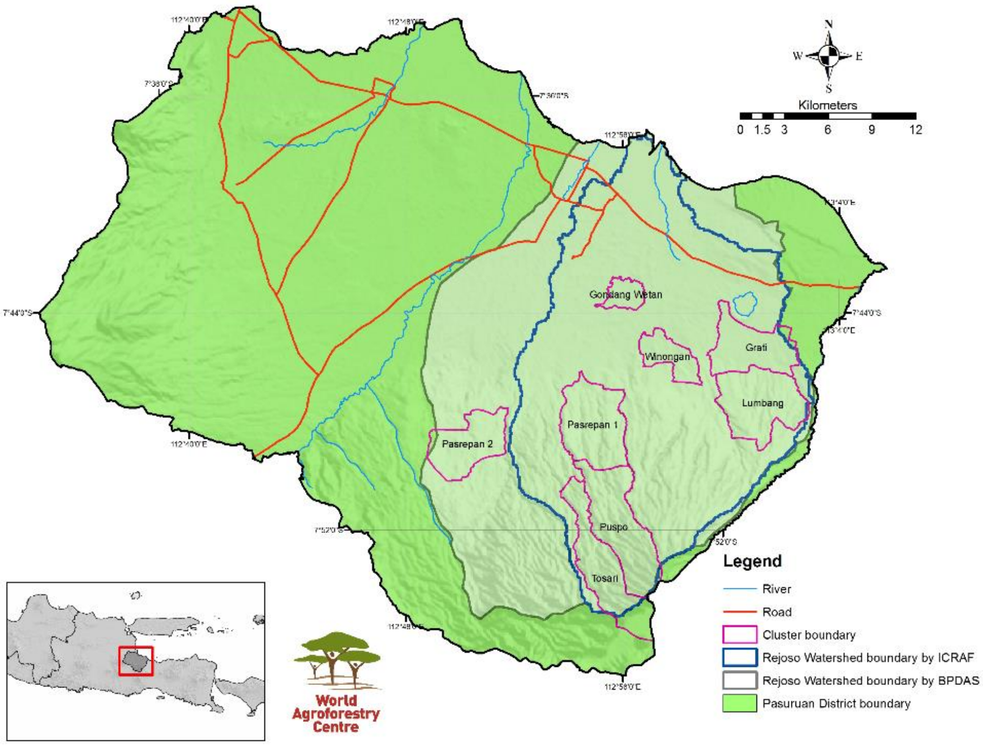


Figure 3. Map of Rejoso Watershed, Pasuruan District

Rejoso Watershed covers 16 sub-districts: Bugul Kidul, Gading Rejo, Gondang Wetan, Grati, Kejayan, Kraton, Lekok, Lumbang, Nguling, Pasrepan, Pohjentrek, Purworejo, Puspo, Rejoso, Tosari, Tutur, and Winongan. Based on the boundaries set by BPDAS (Watershed Management Agency), the total area of the Rejoso Watershed covers 62,773 ha. The determination of LULC types in the Rejoso Watershed, carried out by rapid ground verification and resulted in the classification of 17 LULC types.

LULC area

To understand the dynamics of LULC in the last 25 years, the LULC area was classified into the years of 1990, 2000, 2010, and 2015. Based on the classification, LULC are dominated by paddy field and complex agroforest (mixed garden). Horticulture, sugarcane and pine plantation are also relatively common practices. Paddy field and sugarcane plantation are abundant in the downstream area. Complex agroforest is dominated the middle stream area of the watershed, and horticulture and pine plantation are mostly found in the upstream area. The settlements are located in the center of the paddy field and complex agroforest.

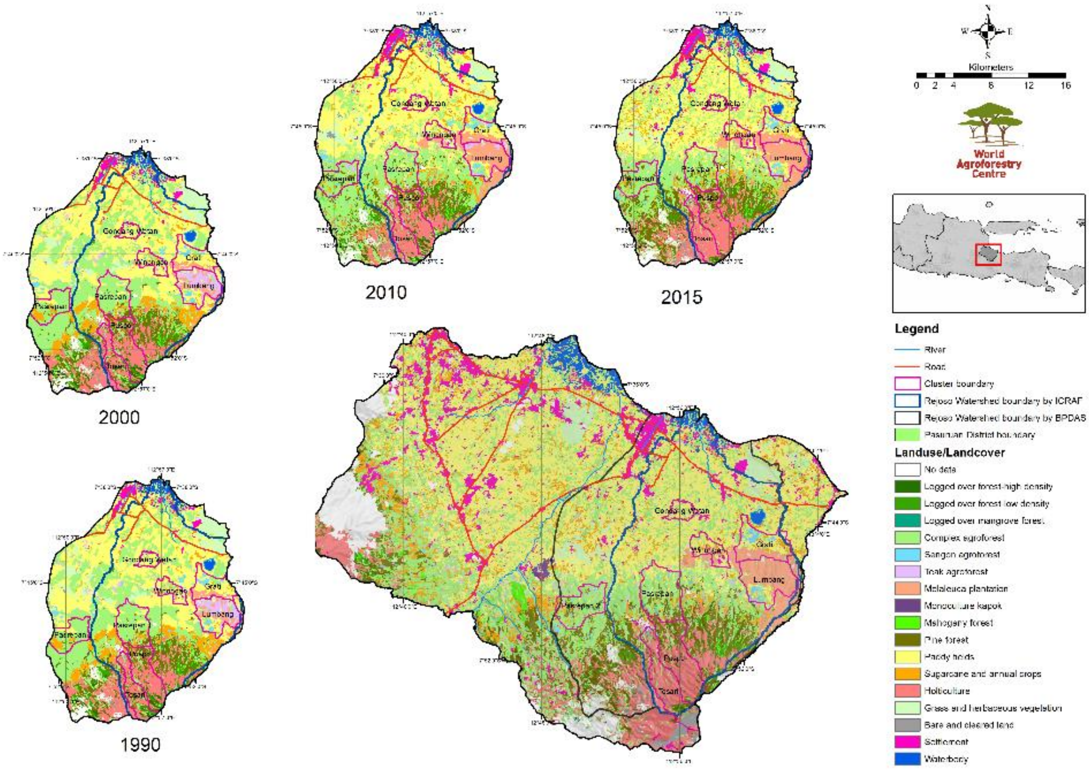


Figure 4. LULC map of the Rejoso Watershed

During the period of 1990-2015, paddy field decreased by roughly 2% from the initial area in 1990. While complex agroforest increased by approximately 5% from the initial area in 1990. In this period, kapok monoculture was introduced as new land-use, starting in 2010 and increasing by less than 1% for approximately 5 years. The *kapok* monoculture was located in the western part of the Rejoso Watershed and mostly outside the boundary of Rejoso Watershed. In 2015, the LULC in the Rejoso Watershed remained dominated by paddy field (28.87%) and complex agroforest (25.22%). Table 2 and Figure 5 provide the overview of the LULC during the period of 1990-2015.

Table 2. LULC area of the Rejoso Watershed

No.	Land-use and land-cover	Land-use and land-cover change (ha)							
		1990		2000		2010		2015	
		Area	Rank	Area	Rank	Area	Rank	Area	Rank
1	Logged over forest - high density	448	14	416	14	287	16	32	16
2	Logged over forest - low density	1,252	8	1,223	9	853	10	634	12
3	Logged over mangrove forest	39	17	15	17	3	18	3	18
4	Complex agroforest	19,162	2	17,793	2	16,604	2	15,834	2
5	*Sengon* agroforest	339	15	695	13	758	11	608	13
6	Teak agroforest	1,702	7	1,579	7	637	13	688	11
7	*Melaleuca* plantation	838	10	1,515	8	3,563	5	3,786	5
8	Monoculture kapok	-	18	-	18	23	17	23	17
9	Mahogany forest	460	13	313	15	343	15	393	14
10	Pine forest	4,289	5	3,916	4	4,259	4	6,114	4
11	Paddy field	19,279	1	19,378	1	20,586	1	18,123	1
12	Sugarcane and annual crops	4,315	4	3,715	5	3,414	6	3,112	6
13	Horticulture	4,664	3	5,941	3	5,333	3	6,506	3
14	Grass and herbaceous vegetation	3,452	6	3,401	6	2,227	7	2,149	8
15	Bare and cleared land	75	16	169	16	367	14	301	15
16	Settlement	816	11	1,059	10	1,871	8	2,822	7
17	Waterbody	725	12	725	12	725	12	725	10
18	No data	919	9	919	11	919	9	919	9
	Total	62,773		62,773		62,773		62,773	

Trajectory of LULC change

In the Rejoso Watershed, complex agroforest conversion to paddy field took place almost every year, especially in the period 1990-2010. Meanwhile, the change of paddy field to complex agroforest mainly occurred in 2010-2015. The LULC had undergone considerable dynamic change over the last 25 years. This was evident in the trajectory graph of the dominant LULC change for the period of 1990-2015 (Figure 6). In this period, approximately 51% of the cluster area experienced LULC change while 49% remained stable.

Overall, in 1990-2015, the land-use change occurred in about 2-3% of the area. Changes included paddy field to complex agroforest (and vice versa), complex agroforest to pine plantation, and paddy field to settlement. The conversion from complex agroforest to paddy field covered 9% of the total area, while the conversion of paddy field to complex agroforest covered 7% of the total area. Land-use change below 1% of the total area were pine plantation to horticulture plantation, complex agroforest to sugarcane and annual crops, and teak agroforest to *Melaleuca* plantation. The total non-agricultural land-use land-cover changes reached 13% of Rejoso Watershed area. (Figure 6)

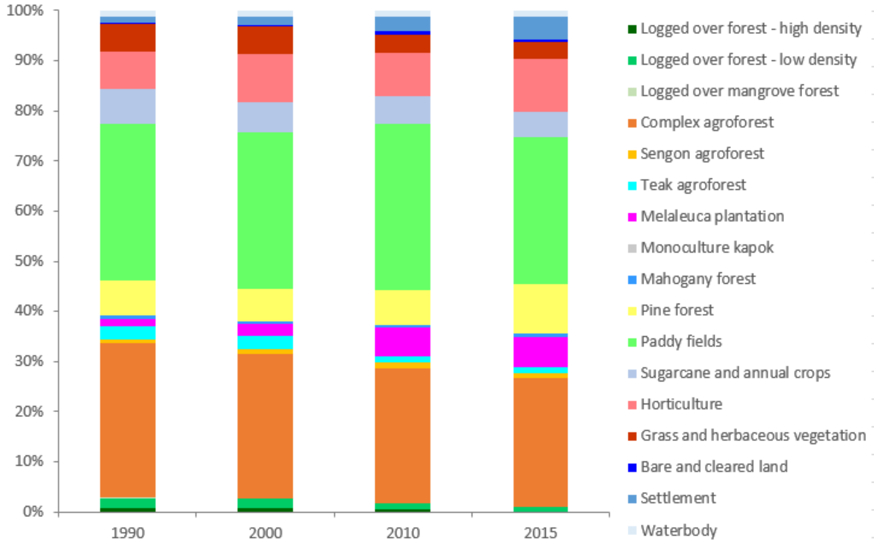


Figure 5. LULC area of Rejoso Watershed

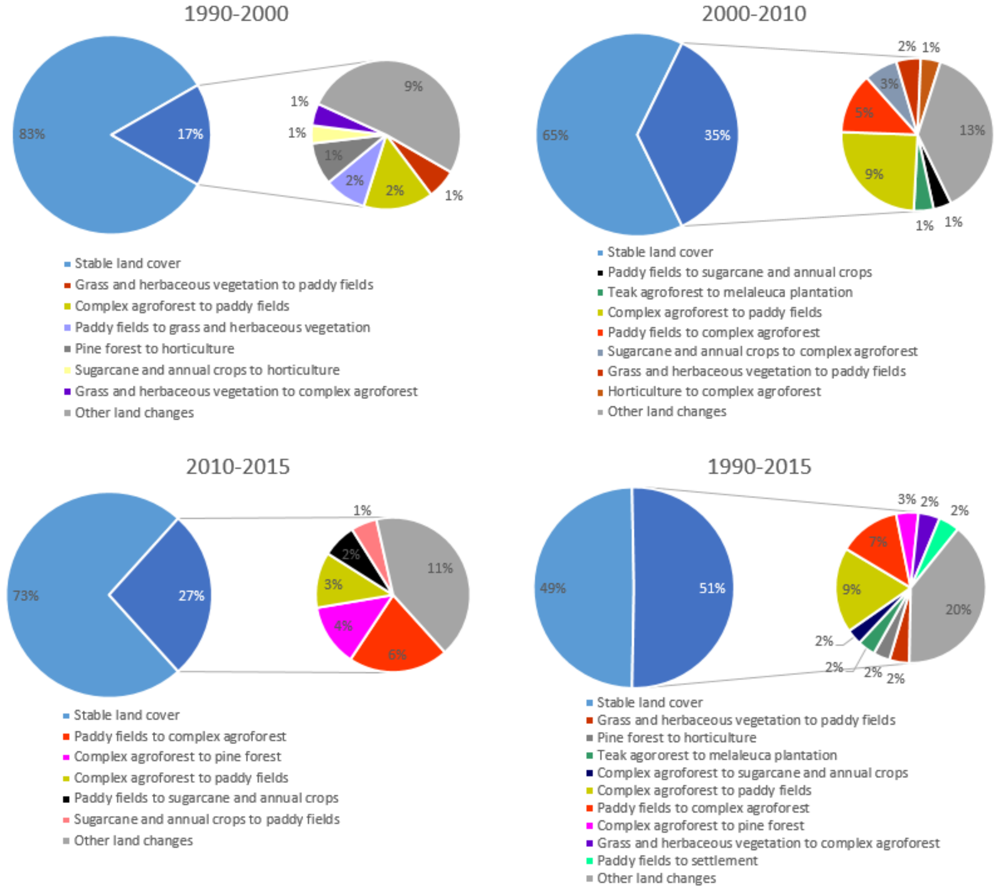


Figure 6. The trajectory of dominant LULC change in Rejoso Watershed

1. GONDANGWETAN CLUSTER

1.1 Cluster overview

The Gondangwetan cluster is located in the downstream area of Rejoso Watershed with relatively flat terrain and less than 100 masl consisting of three villages: Keboncandi, Tenggilis Rejo, and Mendalan.

The total population in this cluster was 7,601 people, dominated by the indigenous Javanese tribe of Pasuruan (Table 3). The community welfare in this cluster is relatively good with agriculture activities as income source for the local population.

Paddy field with relatively good irrigation condition and complex agroforest of *sengon* and fruit trees dominate the landscape. This cluster is close to urban areas with a relatively good road condition, providing good access to the three villages. These villages are benefitting from very good access to clean water. Due to water abundance in this cluster, several local and national drinking water factories operate in the area.

Surface wells are the most important water resources for the local community. However, in year 2000's, artesian wells were introduced and constructed by community members who had sufficient funds to increase the water supply for their agriculture and household needs. In many locations, unfortunately, the artesian wells were not efficiently managed. The water continuously overflows as local communities face difficulties in putting valves to the wells due to the enormously strong water pressure.

Table 3. General characteristics of villages in Gondangwetan Cluster

Villages	Village area (km^2)	Distance to sub-district capital (km^2)	State forests (ha)	Total population	Farmers (%)	Household living under poverty line (%)
Keboncandi	1.2	4.4	-	1,898	n/a	n/a
Tenggilis Rejo	1.7	3.3	-	3,298	n/a	n/a
Mendalan	2.4	2	-	2,495	n/a	32

n/a: no data available
Source: Gondangwetan Sub-district in Figures, 2015

1.2 Land use and land cover

1.2.1 LULC area

LULC classifications had been conducted for year 1990, 2000, 2010, and 2015 to determine the dynamics of LULC change over the last 25 years. Based on the classification results, the LULC were paddy field (61%) and complex agroforest (26%). Other land covers included sugarcane and annual crops plantation as well as grass and herbaceous vegetation. The settlement area was spread around the paddy field and complex agroforest.

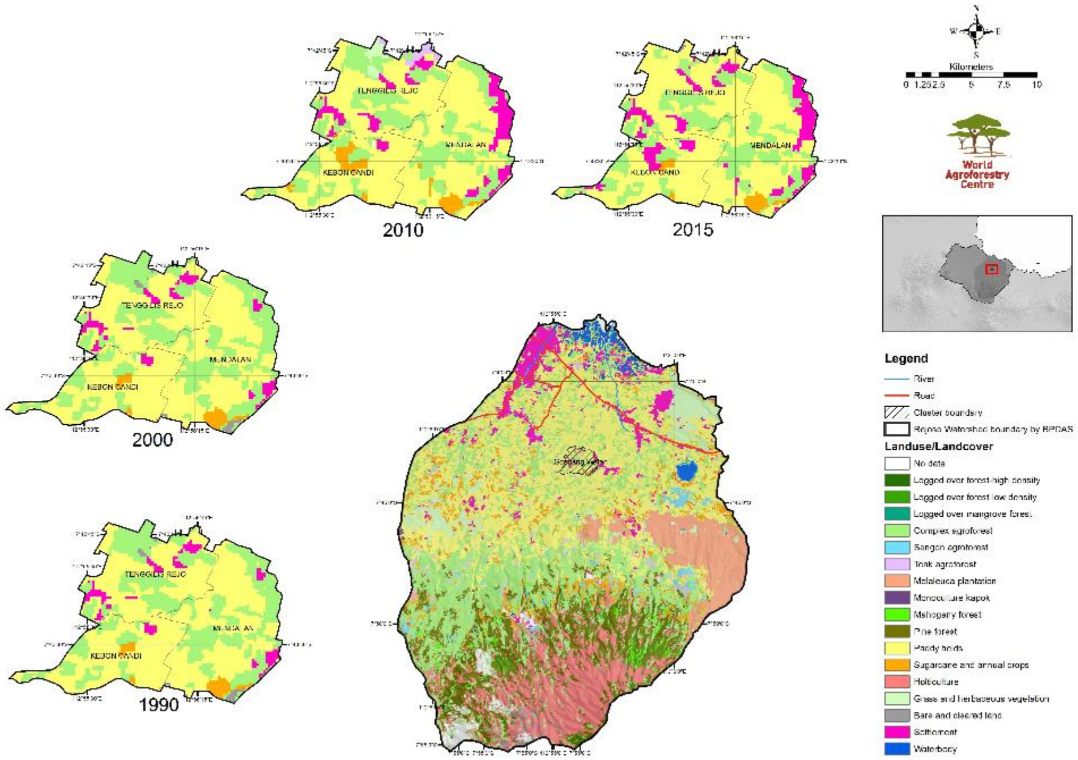


Figure 7. LULC map in Gondangwetan Cluster

During the period of 1990-2015, paddy field area had increased about 15% from its total area. The complex agroforest decreased by approximately 18% from its initial area in 1990. In this period, teak agroforest was introduced in 2000 and experienced an increase in its area of roughly 1% within approximately 10 years. However, in 2015, the teak agroforest had somehow disappeared. Thus, by 2015 the LULC remained dominated by paddy field (61%) and complex agroforest (26%). Table 4 and Figure 8 show the summary of the area of LULC during the period of 1990-2015.

Table 4. LULC area in Gondangwetan Cluster

No.	Land-use and land-cover	1990		2000		2010		2015	
		Hectare(s)	%	Hectare(s)	%	Hectare(s)	%	Hectare(s)	%
1	Complex agroforest	206.28	44	157.5	33	132.03	28	123.39	26
2	Teak agroforest	0	0	0.36	0	6.48	1	0	0
3	Paddy fields	219.33	47	281.7	60	270.63	57	288.27	61
4	Sugarcane and annual crops	2.43	1	9.99	2	18.18	4	9.99	2
5	Grass and herbaceous vegetation	27.36	6	3.24	1	6.3	1	0.63	0
6	Settlement	16.2	3	18.81	4	37.98	8	49.32	10
7	No data	0.18	0	0.18	0	0.18	0	0.18	0
Total		471.78	100	471.78	100	471.78	100	471.78	100

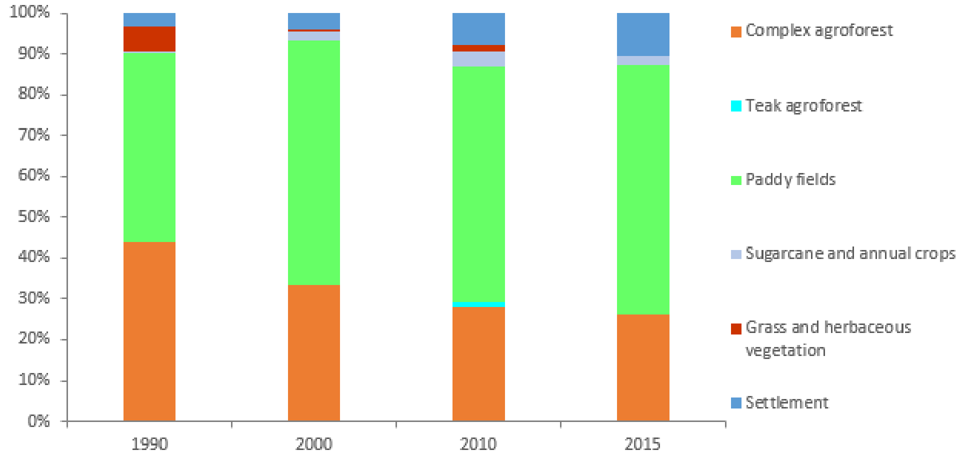


Figure 8. LULC area in Gondangwetan Cluster

1.2.2 Trajectory of LULC change

Based on the spatial analysis, the LULC were relatively stable in the last 25 years (Figure 9). Only approximately 28% of the area experienced LULC change while 72% of the cluster area remained stable. In 1990-2015, the land-use changes were dominated by complex agroforest converted to paddy field (approximately 14% of the area). The other LULC change in this cluster was not too significant, or about 2-6% of change during the 25 years period.

1.2.3 Perceptions of the community on the drivers of LULC change

Based on the group discussion results, the male and female groups shared a similar perception on land-use in Gondangwetan cluster. Rice cultivation dominated as the main income and main food consumption source. Other LULC mentioned were complex agroforest, sugarcane and annual crop plantation and settlement. Similar perceptions were also expressed between the male and female groups on the drivers of LULC change over the period 1990-2015. The male group argued that high income from crops, needs for settlement, and willingness to improve their income were the factors that led to land-use change. Crop production could improve people's livelihood and absorb more labors. Along with increased community’s living standard, more settlement could increase micro-climate temperature and somehow decrease number of water springs. Meanwhile, the female group added that the government or private programs were the factors causing the land-use to change as they provided incentives to improve people's livelihood.

The participants estimated that over the next 10 years, the trends in LULC change would lead to settlement development. They estimated that the paddy field and cleared land would be converted to settlement as the needs for housing would increase. The complex agroforest was estimated to remain the same since it was the source of income and investment for community inheritances. Common perceptions of the drivers and patterns of LULC change indicated that people have a preference for agroforestry systems because complex agroforest produces surplus commodities that could be shared with the poorer neighbors.

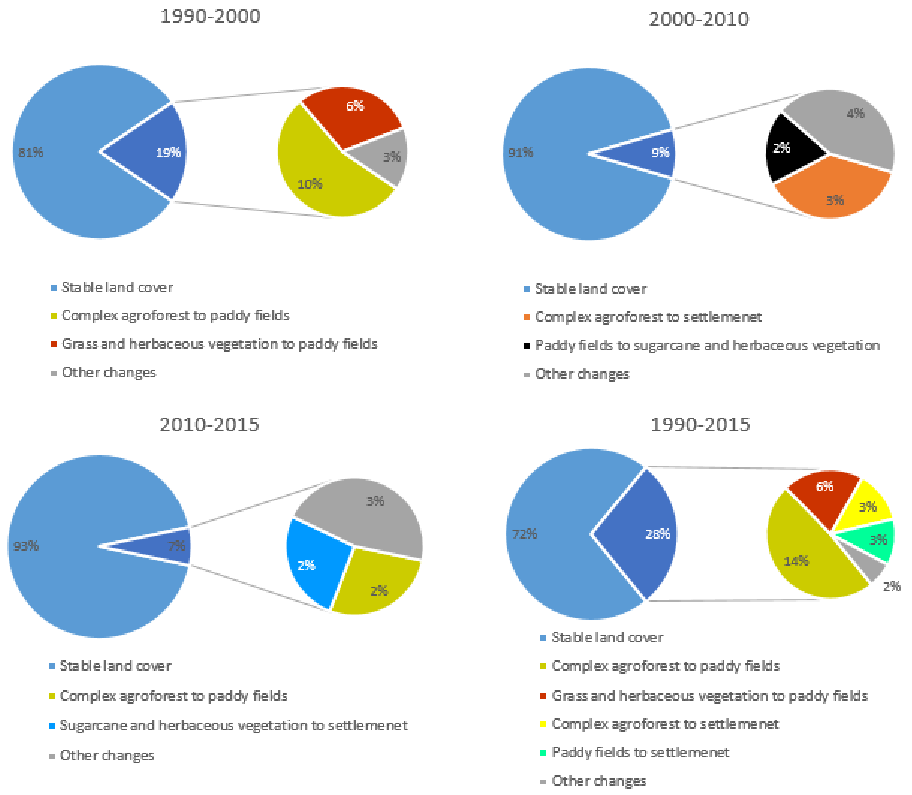


Figure 9. The trajectory of dominant LULC change in Gondangwetan Cluster

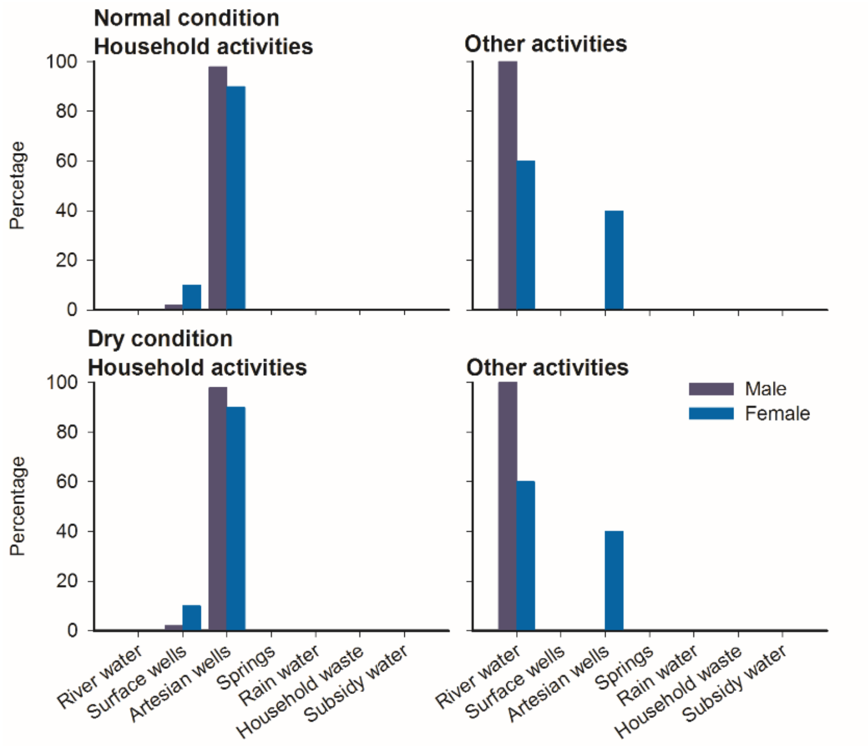
1.3 Water resource management

1.3.1 Water resource and utilization

Under normal conditions, the water resources for domestic use are mainly artesian wells (male: 98%; female: 90%) and surface wells (male: 2%; female: 10%). For agricultural and industrial activities (paddy field, annual crops such as maize and peanut, livestock and home industries), the water resource is river (male: 100%; female: 60%) and artesian wells (male: 0%; female: 40%) (Figure 10).

In dry season, no change occurred in the percentage of the dominant water resources used (artesian wells for household activities and river water for other activities). The local water regulatory officer *(ulu-ulu)* worked well (managing irrigating-turn for paddy field). Consequently, river water and artesian wells met the need for various activities during the dry season.

Prior to using artesian wells (around 2007), the community only used surface wells. The transition from using surface wells to artesian wells happened because people felt that the water from artesian wells was cleaner and cooler and also easier to retrieve (with a suction machine). There were two types of artesian wells: with the suction machine (± 8-20 m deep) and without a suction machine (± 80 m deep). Wells with suction machine were privately owned and existed in every household, while wells made without suction machine were commonly used for household needs or agriculture irrigation and owned by groups/public. In average, there was 1 public artesian well in every hamlet which was a common condition to meet household needs. Meanwhile, there were ± 8 wells (Mendalan village), ± 5 wells (Keboncandi village), and ± 9 wells (Tenggilis Rejo village) to meet other needs. To be able to utilize water from public wells, the people in the community were charged for ± Rp 4,000/month (Keboncandi village), ± Rp 2,000/month (Tenggilis Rejo village), and ± Rp 3,000/month (Mendalan village).



Note: other uses include agriculture and industry

Figure 10. Water resources for domestic and other uses based on the perception of female and male groups in Gondangwetan Cluster.

1.3.2 Water resource problems

According to the male and female groups, the main problem related to water resources was the overflowing river (flood) and turbid river water that often occurred in the rainy season (Table 5). The people living along or near the river estuary area, or those living in lowland locations were prone to flooding. However, not all people living in this area were prone to flooding as flood incidence could be reduced in locations where there had already been an embankment or parapet.

Flood causes included high rainfall during the rainy season and human-induced causes such as logging/land-cover change and rock mining (Table 6). Soil erosion in the upstream area was the cause of river water to become turbid during the rainy season.

Table 5. Water resource problems based on perceptions of female and male groups in Gondangwetan Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quantity	Flood	River water	1	Frequent	Rainy season	1	Occasional	Rainy season
Quality	Turbid	River water	2	Rare	Rainy season	2	Rare	Rainy season

Table 6. Causes of water resource problems in Gondangwetan cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quantity	Flood	High rainfall	Logging/land-cover change	Low community awareness1)
			Rock mining	
Quality	Turbid	High rainfall	Soil erosion in upstream area	

1) Littering waste into the river

1.3.3 Consequences of water resource problems

The turbid river water in the rainy season has insignificant consequences and losses for the community. On the other hand, flood causes serious material losses such as damaged houses and reduced agricultural production (female) and crop failure (male) (Table 7). This situation caused a loss in terms of money due to the inability to get returns from agricultural investments and moderately to greatly reduced income (Table 8).

Table 7. Perceptions on negative consequences due to water resource problems in Gondangwetan Cluster

Problems		Consequences		Score 1)	
				Male	Female
Quantity	Flood	Household activities	Sickness	1	-
			Material loss	-	4
		Other activities	Reduced agricultural production	-	5
			Crop failure	4	-
Quality	Turbid	Household activities	n/a	0	0
		Other activities	n/a	0	0

1) Score: 1 = very mild, 2 = mild, 3 = medium, 4 = serious, 5 = very serious

Table 8. Perceptions on material and non-material losses due to water resource problems in Gondangwetan Cluster

Problems		Losses		Score 1)	
				Male	Female
Quantity	Flood	Material	Money (reduced income)	3	-
			Money (business capital)	-	4
			Money (other additional expenses)	1	-
			Property (houses, plants, livestock)	-	3
		Non-Material	Time, human power	3	3
Quality	Turbid	Material	n/a	0	0
		Non-Material	n/a	0	0

1) Score: 1 = very light, 2 = light, 3 = medium, 4 = heavy, 5 = very heavy

1.3.4 Adaptation and mitigation strategies

The community had tried to solve the water resource problems (mitigation strategies) and to lessen its consequences (adaptation strategies). Scores for the undertaken adaptation and mitigation strategies are shown in Table 9, while potential future strategies are assessed in Table 10.

The communities claimed that their existing adaptation and mitigation strategies had achieved 50%-100% success rates. The effort to prevent floods by building infrastructure (embankments) was perceived as only had 25% success rate. This was due to temporary infrastructure made from sandbags only. In this case, the communities expected to construct a permanent infrastructure to prevent flood, however they were constrained by the fund to do so. Looking for extra income, borrowing and saving money were mentioned as alternatives to overcome negative consequences with the rating of 50%-100% successful.

Table 9. Existing adaptation and mitigation strategies in Gondangwetan Cluster

Problems/Consequences		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quantity	Flood	Evacuate	-	100	Build infrastructure (embankment)	100	25
					Social effort (cleaning garbage in the river)	-	50
Quality	Turbid	-	-	-	-	-	-
Consequences	Crop failure	Save on spending	100		-	-	-
		Borrowing money	100	100	-	-	-
		Looking for extra income		50	-	-	-

1 = 0% success, 2 = 25% success, 3 = 50% success, 4 = 75% success, 5 = 100% success

Table 10. Potential adaptation and mitigation strategies in Gondangwetan Cluster

Problems/Consequences		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quantity	Flood	-	-	-	Fix/build infrastructures (raising houses, embankments)	1	1
		-	-	-	Social effort (raising awareness on littering prohibition into the river)	-	2
Quality	Turbid	-	-	-	-	-	-
Consequences	Harvest failure	-	-	-	-	-	-

1.4 Farming practices

1.4.1 Farming systems and extreme events

The community in the downstream area of the Rejoso Watershed mainly cultivates rice withmaize, vegetables, taro, and occasionally sugarcane. On the borders of their paddy field (also known as *tegalan*), farmers plant various fruits and timber crops, such as bananas, snake fruit (*salak*), *melinjo*, teak, and *sengon* trees. The communities mostly cultivate private lands, including agroforests, sengon plantations and home gardens.

Farmers in Gondangwetan usually leased their sugar cane lands to companies or capital owners and did not manage the plantations by themselves. This was due to the limited access to the sugarcane value chains sugar cane processing companies. Some members of the community also manage small-scale fish ponds in their home yards, mostly for their own consumption.

The main sources of agricultural income in Gondongwetan were from selling rice, maize, taro, herbs, mangoes, limes, and sengon timber (Table 11). Except for sugarcane, most of the non-timber agricultural products were for own-consumption.

Table 11. Farming practices and commodities in Gondangwetan Cluster

Farming systems	Commodities	
	For sale	For own consumption
Paddy field	Paddy, maize, vegetables, chili, taro, sugarcane.	Paddy, vegetables, chili
Home garden	Mangos, banana, *salak*, herbs, *sengon*, lime	All non-timber commodities
Tegalan (paddy field boundary)	Banana, *salak*, *melinjo*, *sengon*, teak, *gmelina*, *jabon*	All fruit plants were also for own consumption
Timber	Sengon, banana, teak, taro, chili	Strip grass
Sugarcane	Sugarcane	n/a
Salak agroforest	*Salak*	*Salak*
Seasonal crops	Long beans, cucumbers, peppers, tomatoes, eggplants	Long beans, cucumbers, chili, tomatoes, eggplant
Fish ponds	Catfish, *tilapia, gurame* (carp fish)	All fish in the ponds were also for own consumption

Major extreme events in Gondangwetan were pest diseases, floods and a long drought that once happened in 2013. Particularly in Mendalan Vilage of Gondangwetan Cluster, water supply was abundant throughout the year contributing to paddy rice vulnerability to pest and disease (Table 12). During the discussion, the local communities also mentioned that sedimentation of the river increased, causing murky water for agricultural lands.

From a socio-economic point of view, unstable commodity prices were viewed by the community to disrupt the flow of their farming practices. Meanwhile, from the aspect of village institutions, the malfunction of *ulu-ulu* (village water regulatory officer) was regarded to contribute to excessive water supply in agricultural areas in Gondangwetan Cluster. The discussion participants argued that *ulu-ulu* should be capable of coordinating the schedule of *gotong-royong* (community social work) in planting and cleaning the land parcels of the farmers within an area. Nevertheless, such coordination was rarely conducted. Such a perspective needs to be re-clarified as the opposite was also found i.e. that *ulu-ulu* in their villages had appropriately carried out their task.

Table 12. Extreme events that have disrupted farming practices in Gondangwetan Cluster

Year	Extreme Events
2008	Flash flood
2006-2009	Rat and planthopper disease
2013	Drought
2014	Flood
Every year	Overflowing river
Every year	Unstable price

1.4.2 Criteria and preferences for tree commodity selection

The male group selected the criteria related to the economic value and practicality of maintenance for selecting tree crops. The criteria of 'household income', 'land suitability', 'climate' and 'saving and investment' were the main reasons for choosing certain trees. The crops' 'easy maintenance' and short harvest time', as well as 'marketability' of tree commodities were other reasons to select certain tree commodities.

According to the female group, the planted trees must provide benefits not only in economic and market terms but also for the smallholders' consumption (household consumption), including 'building materials' and the provision of 'shade' for the farmers and crops alike. Interestingly the community stated 'disaster prevention' as one criterion for selecting trees. Although, not highly prioritized, this shows the environmental awareness of female participants in Gondangwetan. The 'disaster prevention' criterion was especially targeted to prevent frequent floods and landslides on the river banks in this cluster area. A summary of the criteria for selection of tree commodities in Gondangwetan Cluster can be seen in Table 13.

Male and female groups selected quite diverse commodities. *Sengon* and teak woods were the selected timber trees with different priority ranks between male and female groups, while durians were chosen by both groups as the third priority (Figure 11).

Sengon was the main commodity selected by the male group due to its high selling price, its function as mid-term saving, and its good marketability. The least prioritized tree commodities selected by the male group were dominated by fruit crops such as *rambutan*, durians, avocados, and longans. Once harvested these fruits could contribute to daily household income as they are relatively easy to sell on the market. Other selected commodities included timber, such as gmelina and teak, which could be used as for the purpose of saving and investment (Figure 11).

Table 13. Ranking of criteria for tree commodity selection in Gondangwetan Cluster

Ranking	Criteria for selection of trees	
	Male	Female
1	Household income	Own consumption
2	Land suitability	Marketability
3	Saving and investment	Construction material
4	Easy maintenance	Shading (protection from the sun)
5	Fast yield	Disaster prevention
6	Marketability	Saving and investment

The female group selected banana and coconut as the main commodities because not only could they be sold, they could also be used for own consumption. The female group favored durian, mango and jackfruit plants as their next prioritized commodities. Meanwhile, *sengon* and teak trees were also considered as prioritized commodities although not the main ones (Figure 11).

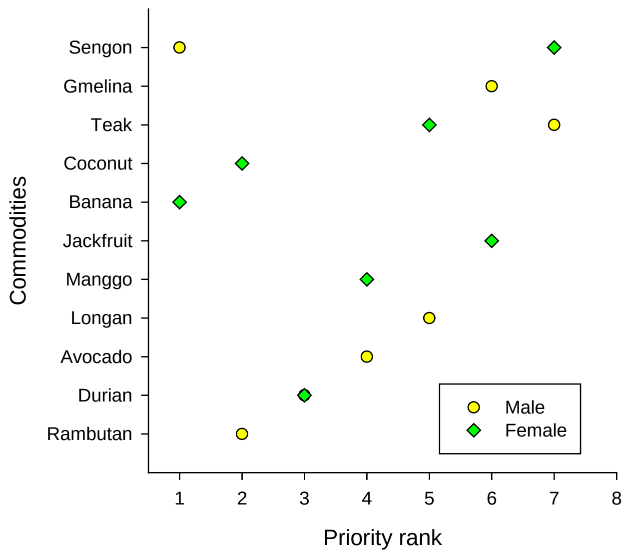


Figure 11. Priority rank of the preferred tree commodities in Gondangwetan Cluster

2. GRATI CLUSTER

2.1 Cluster Overview

The Grati Cluster lies in the downstream area of Rejoso Watershed, less than 100 meters above sea level with flat terrain. It is part of the Grati sub-district and consists of three villages: Rebalas, Plososari, and Kalipang, with a total area of 1,788.21 ha.

The land-cover is dominated by paddy field (both irrigated and rainfed systems) and sugarcane plantation. The cluster is located closely to the urban areas with good road condition, providing good access to the three villages. Plososari and Rebalas have several timber forest areas belonging to Perhutani (State Forest Company) and managed by the local community.

The total population in this cluster was 22.485 people, with 46% of the population living below the poverty (Table 14). Residents in this cluster not only originate from Pasuruan (East Java ethnicity) but also from Madura (migrant community) communities that have been living in the area for several generations. Based on interviews with local residents, agriculture activities were still the main source of livelihood for most of the residents.

Being in the downstream area of Rejoso provided those villages with a good access to clean water with most water coming from surface wells. Since ten years ago (the mid-2000s) the farmers had obtained the water for agricultural activities from artesian wells. Artesian wells were generally made by people who had financial resources, primarily used to meet the needs of agriculture. Unfortunately, in many locations, a lot of community-made artesian wells were not well managed, causing water to continuously overflow due to difficulties in closing the wells (similarly to Gondangwetan cluster).

Table 14. General characteristics villages in Grati Cluster

Villages	Area villages (km^2)	Distance to sub-district capital (km^2)	State forests (ha)	Total population	Farmers (%)	Household living below property line (%)
Rebalas	4.5	9.97	75	7,046	n/a	45
Kalipang	2.9	6.54	5	8,343	n/a	29
Plososari	14.7	13.7	891	7,093	n/a	64

Source: Grati Sub-district in Figures, 2015

2.2 Land use and land cover

2.2.1 LULC area

LULC classifications have been conducted for year 1990, 2000, 2010, and 2015 to find out the dynamics of LULC over the past 25 years (Figure 12). The LULC changes during this 25-year period can be seen in Table 15 and Figure 13.

Based on the satellite image analysis, paddy field was the dominant land-use in the cluster. Other land-use consisted of timber plantation, sugarcane, seasonal crops and complex agroforest. Settlement areas are surrounded by complex agroforest and *Melaleuca* plantation.

In 1990-2015, paddy field decreased by 35%. In the same period, *Melaleuca* plantation experienced an extensive increase of about 18%. Mahogany forest was only found in the year 1990. Teak agroforest disappeared in year 2000 and then increased for about 2% over the next 10 years.

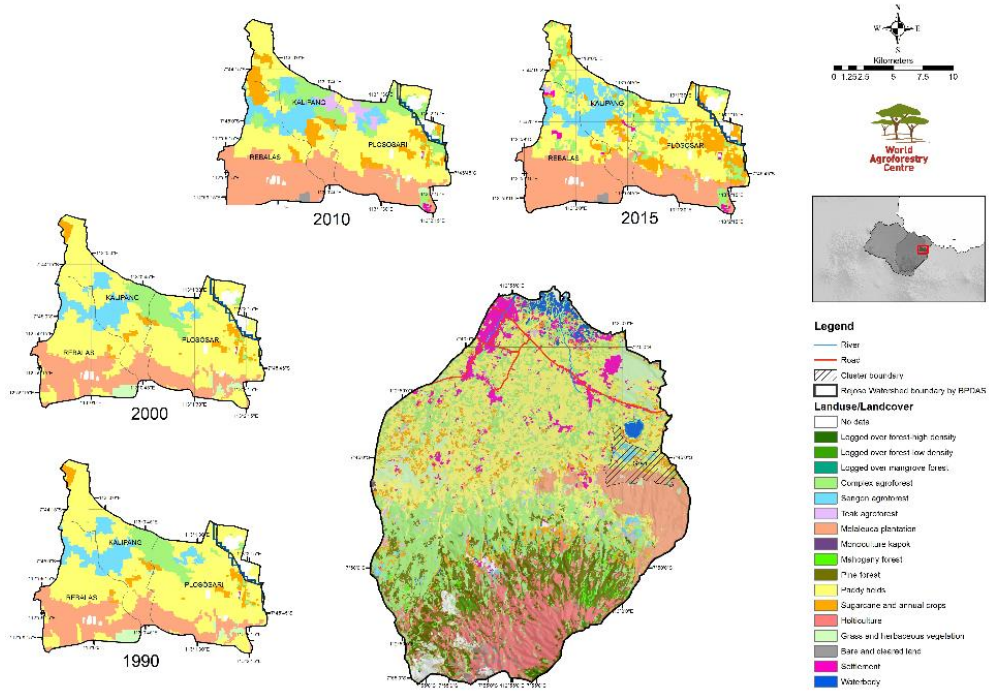


Figure 12. LULC map of the Grati Cluster

In the same period, *Sengon* agroforest area gradually increased with a total area increment of 6% over the 25-year period. In 2015, LULC of this cluster was still dominated by 36% paddy field and 29% *Melaleuca* plantation.

Table 15. LULC area of the Grati Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Complex agroforest	123.03	116.46	201.24	147.06
2	Sengon agroforest	83.07	142.2	147.6	186.66
3	Teak agroforest	2.88	0	45.36	6.75
4	*Melaleuca* plantation	191.52	360.36	517.77	518.85
5	Mahogany forest	4.05	0	0	0
6	Paddy field	1,279.08	1,027.71	661.23	655.83
7	Sugarcane and annual crops	23.13	57.33	142.47	200.52
8	Grass and herbaceous vegetation	35.28	38.97	17.28	6.39
9	Bare and cleared land	1.53	0.54	7.38	7.74
10	Settlement	0.54	0.54	3.78	14.31
11	No data	44.1	44.1	44.1	44.1
Total		1,788.21	1,788.21	1,788.21	1,788.21

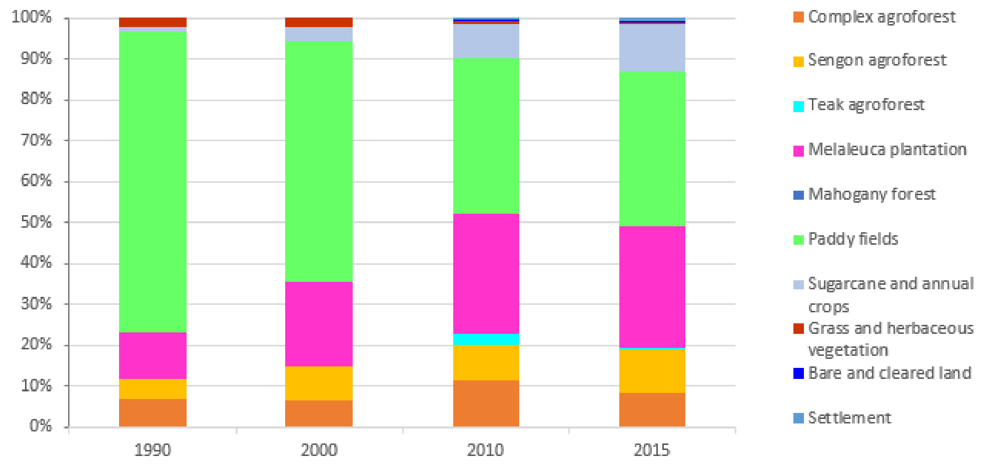


Figure 13. LULC area of the Grati Cluster

2.2.2 The trajectory of LULC change

Based on the spatial analysis, LULC in the cluster had experienced dynamic changes during the last 25 years, as shown in Figure 14, in which approximately 46% of the cluster area had experienced LULC change while the remaining 54% of the total area remained stable.

The land-use change was dominated by *Melaleuca* plantation, amounting to 14% of the total area, while conversion from paddy field to sugarcane plantation and from paddy field to complex agroforest amounted for 10% and 7%, respectively. Other land-use only changed for less than 5%, such as the conversion of complex agroforest to *Melaleuca* plantation and paddy field. Overall, other LULC changes represented 10% of the total Grati cluster area (Figure 14).

2.2.3 Perceptions of the community on the drivers of LULC change

The male and female groups shared a common perception of dominant LULC; paddy field, sugarcane and seasonal crops were perceived as the main income and food sources. The groups also mentioned other land-uses in the cluster such as *sengon* gardens, strip-grass area, bare-land, and settlements. There was a different perception between male and female groups on the drivers of land use change that occurred in 1990-2015. The male group perceived that the LULC changes were mainly driven by the decline of profitability of annual crop commodities and the increasing needs for housing. The local community responded by extending their agricultural lands. The declining agricultural yield would affect their wealth and standard of living. According to the women's groups, the main cause of land use change was due to increasing population and the willingness to increase household income.

The participants estimated that in the next 10 years, more land-use conversion into settlement will occur, mainly from paddy field and sugarcane plantation, as the need for housing would increase. *Sengon* agroforest area was estimated to remain stable since it was the source of income and investment for the community.

The discussions indicated that the communities in the Grati Cluster had a particular tendency to maintain their paddy, sugarcane, and annual crops, thus those land-uses were estimated to remain stable in the next 10 years. Sugarcane or maize were more likely to be replaced with paddy field if the community had more agricultural water supplies.

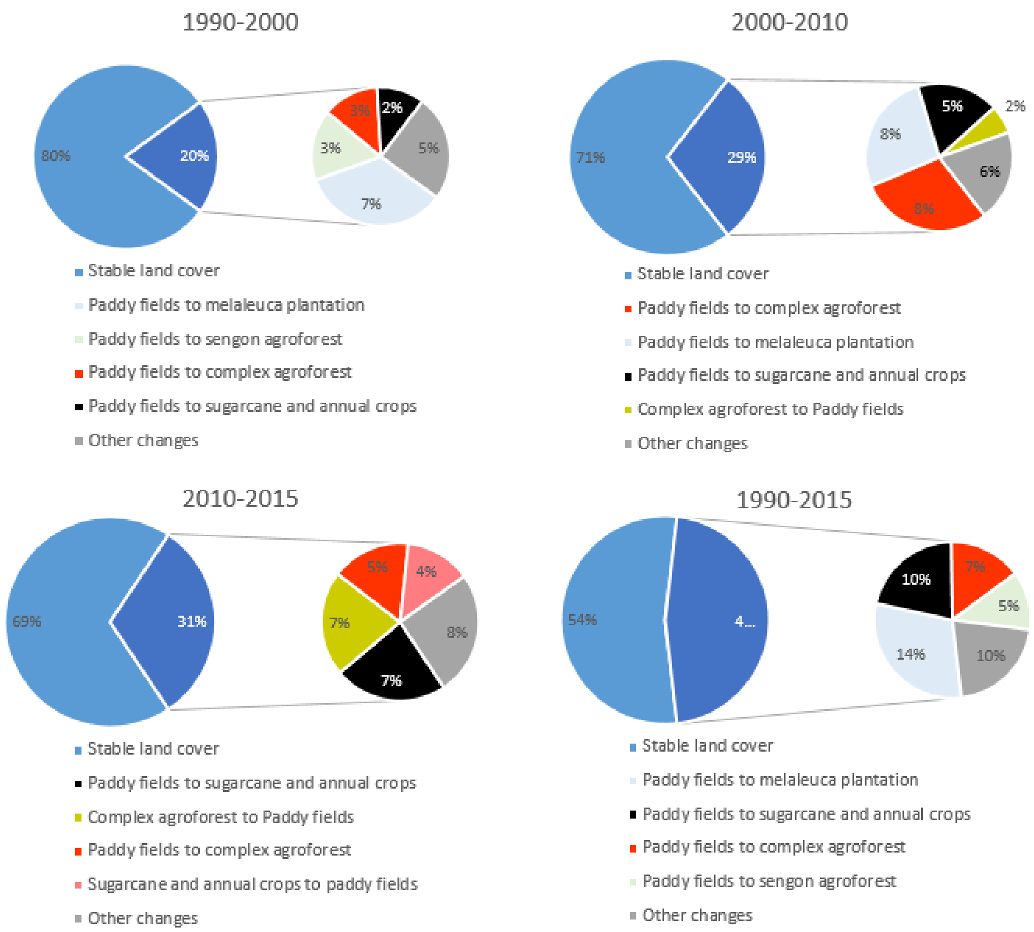


Figure 14. The trajectory of dominant LULC change in Grati Cluster

2.2.4 Shocks (Extreme events)

The prolonged drought had caused land-use conversion from rain-fed paddy field to factory area and settlement. This positively affected the surrounding community as they received many activities/programs from the government or private sectors while also enjoying the increased employment opportunity from the factories. Meanwhile, the negative impacts included the declining quality of life, particularly on the community's health, due to air pollution, noise pollution, and numerous flies from factory waste around the community settlement.

2.3 Water resource management

2.3.1 Water resource and utilization

There were no significant differences between male and female group perceptions in terms of water resources utilized for household consumption or other activities (agriculture i.e. paddy field, annual crops such as maize and cassava, *Melaleuca* trees, sugarcane, livestock and home industry) (Figure 15).

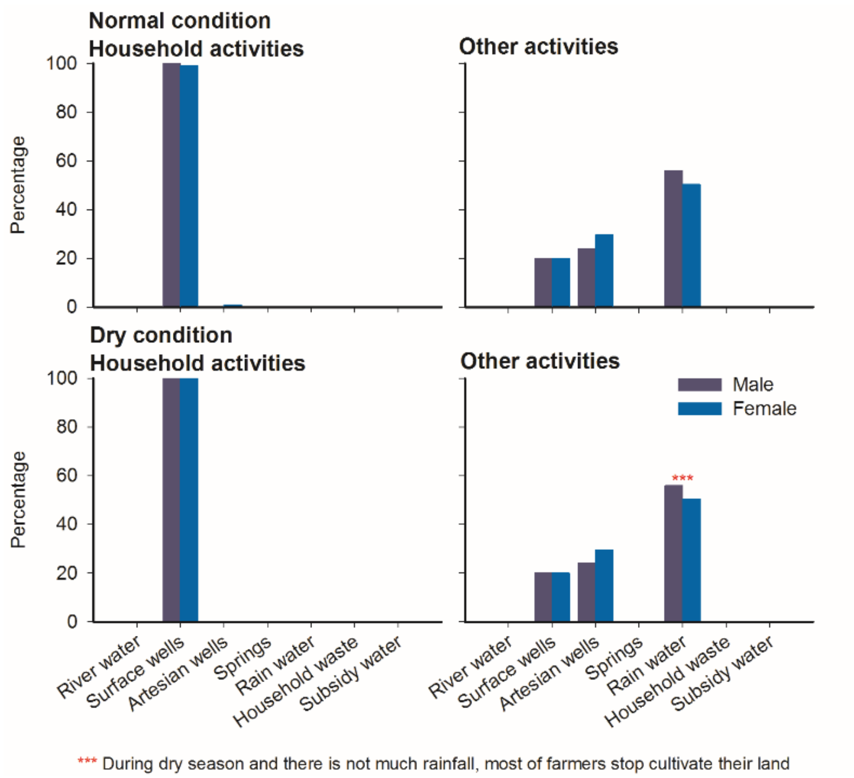


Figure 15. Water resources for domestic and other uses (agriculture, livestock, and home industries) based on the perception of female and male groups in Grati Cluster.

Under normal condition, the water resource used for household activities came from surface wells (100%), while for other activities, the water resources included surface wells (20%), artesian wells (25%), and rainwater (55 %). Artesian wells began to be used since 10 years ago to irrigate agricultural land (paddy field and seasonal crops such as maize). River water could not be used as a water resource since it fell dry during periods without rainfall. Currently, the number of artesian wells with communal ownership is 2 wells in Kalipang and 2 wells in Plososari. Meanwhile, artesian wells with private ownership were numerous. The artesian wells' depth could reach approximately 16-20 m with a stable annual water flow rate.

In dry season, surface wells could still support household activities, except for one hamlet in Rebalas (Ranukerto hamlet) needed to take water (surface wells) from the neighboring hamlet due to dry surface wells in the area. During the dry season, a lot of rainfed paddy field was not cultivated.

2.3.2 Water resource problems

According to the male group, the main problem related to water resources was flooding that often occurred in the rainy season (Table 16). The people living along the estuary area, or those living near the meeting point of two rivers were prone to flooding, especially in Kalipang and Plososari. In addition, river water was turbid almost all year long.

In contrast, the female group believed that the decreasing amount of water from surface wells and rivers every dry season was actually the major problem (Table 16). Reduced water in dry season as a problem was experienced more by people from Plososari (2 hamlets) and Rebalas (2 hamlets). Hamlets' location i.e. positions at higher elevation or on rocky outcrops was the cause of reduced water in the dry season.

Flood problems, other than high rainfall during the rainy season, included floods from the upstream area, inadequate drainage channels as well as human activities such as logging/land-cover change and rock mining. Vice versa, low rainfall in the dry season was the cause of reduced water quantities (Table 17).

Table 16. Water resource problems based on female and male groups' perceptions in Grati Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quality	Turbid	River water	2	Frequent	Non-Seasonal			
Quantity	Dry	River water, surface wells				3	Rare	Dry season
	Decreased flow rate	Artesian wells, surface wells				1	Frequent	Dry season
	Flood	River water	1	Frequent	Rainy season	2	Rare	Rainy season

Table 17. Causes of water resources problems in Grati Cluster

Problems		Drivers		
		Natural activities	Human activities	Human resources
Quality	Turbid		Logging/land-cover change	
			Rock mining	
Quantity	Dry	Low rainfall		
	Decreased flow rate	Low rainfall		
	Flood	High rainfall	Logging/land-cover change	Low public awareness[1)]
		Flood from upstream, clogged channels	Rock mining	

[1)] Throw waste into the river

2.3.3 Consequences of water resource problems

Since the community did not utilize river water (Figure 15), the turbid river water condition throughout the year did not have any impact on the community (Table 18). The dry surface wells during the dry season did not have any significant effect as well since not all surface wells were dried out. The community with dry surface wells could still collect water (surface wells) from the neighboring hamlets whose surface wells were not dried out.

Consequences of water quantity problems (i.e. reduced amount of water or floods) experienced by the community included reduced agriculture production with mild to very serious levels (Table 18). As a result, the community experienced material losses in the form of money (reduced income and extra spending to buy clean water) as well as non-material losses such as time and human power, ranging from very light to very heavy scale (Table 19).

Table 18. Perceptions on negative consequences due to water resource problems in the Grati Cluster

Problems		Consequences		Score[1)]	
				Male	Female
Quality	Turbid	Household activities	n/a	0	-
		Other activities	n/a	0	-
Quantity	Dry	Household activities	n/a	-	0
		Other activities	Crop failure	-	5
	Decreased flow rate	Household activities	n/a	-	0
		Other activities	Reduced agriculture production	-	1
	Flood	Household activities	Material losses	3	4
		Other activities	Crop failure	3	5

[1)] Score: 1 = very mild, 2 = mild, 3 = medium, 4 = serious, 5 = very serious

Table 19. Perceptions on material and non-material losses due to water resource problems in the Grati Cluster

Problems		Losses		Score[1)]	
				Male	Female
Quality	Turbid	Material	n/a	-	-
		Non-Material	n/a	-	-
Quantity	Dry	Material	Money (business capital)	-	5
		Non-Material	Human power	-	5
	Decreased flow rate	Material	Money (reduced income, buy clean water)	-	1
		Non-Material	-	-	-
	Flood	Material	Money (business capital)	4	5
			Property (house, livestock, plant)	4	5
		Non-Material	Human power	4	5
			Time	4	5

[1)] Score: 1 = very light, 2 = light, 3 = medium, 4 = heavy, 5 = very heavy

2.3.4 Adaptation and mitigation strategies

The community had tried to solve the water resource problems (mitigation strategies) and to lessen its consequences (adaptation strategies). Scores for the undertaken adaptation and mitigation strategies are shown in Table 20, while potential future strategies are assessed in Table 21.

Both existing adaptation and mitigation strategies had the success rates range from 50%-100%, except for overcoming floods by building infrastructure (embankment) where the female group awarded 0% success rate considering the embankment's often being broken. Accordingly, improving/building infrastructure was an effort that still required to be conducted to overcome flood as this effort was hindered by fund availability as the main obstacle. Another attempt that the community would take to overcome flood was to reconnect clogged drainage channels to other rivers. However, this effort was hindered by land ownership, as the channels need to be build through the personal land. Looking for extra income was the effort that the community wished to take to overcome the consequences of crop failure.

Table 20. Existing adaptation and mitigation strategies in the Grati Cluster

Problems/consequences		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Turbid	-	-	-	-	-	-
Quantity	Dry	-	-	-	Repair infrastructure (deepening surface wells)	-	5
	Decreased flow rate	Buying clean water	-	5	-	-	-
	Flood				Repair infrastructure (river normalization/build embankment)	3	0
		Gotong-royong (Community work) (securing possessions)	-	4	-	-	-
Consequences	Crop failure	Borrowing money	5	4	-	-	-
	Reduced agriculture products	Reducing expenses	-	5	-	-	-

[1)] Score 1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 21. Potential adaptation and mitigation strategies in the Grati Cluster

Problems/Consequences		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Turbid	-	-	-	-	-	-
Quantity	Dry	-	-	-	-	-	-
	Decreased flow rate	-	-	-	Look for new water resources (add artesian wells)	1	-
	Flood	-	-	-	Improve infrastructure (raising houses)	-	2
		-	-	-	Build infrastructure (embankment, channeling river to other drainage)	-	1
Consequences	Crop failure	Looking for extra income	-	1	-	-	-
	Reduced agriculture production	-	-	-	-	-	-

2.4 Farming practices

2.4.1 Farming systems and extreme events

Farming in the Grati Cluster mainly consisted of rainfed and irrigated paddy field, in which the commodities were cultivated using a rotation system. The cultivation of rainfed paddy field could only be carried out once a year. The irrigated paddy field was only available in Plososari and could be cultivated for 2-3 times per year.

Besides rice, maize was another staple food of the community. This cluster also had a lot of sugarcane plantation area that mostly were converted from paddy field. Most of the sugarcane plantations were leased to companies. However, participants in the discussion indicated a small number of farmers in Rebalas and Kalipang who grew their own sugarcane commodities and sold them directly to collectors. Timber plantation on community land (i.e. "community forest"), was dominated by teak and *sengon*, combined with fruit trees such as bananas, jackfruits, and mangos. *Melaleuca* and teak agroforest owned by Perhutani were present in all villages. Some of the Perhutani forest area was used by the community for planting annual crops such as rainfed rice, cassava, soybean, and beans. In Rebalas, the Village government owned about 10-hectare degraded land that can be planted with annual crops by the villagers entitled with annual utilization rights to manage the land given to them by the village officials.

The main source of income generally came from maize, paddy, cassava, sugarcane, and peanut. Many farmers grew strip grass on the sidewalks and around their agricultural land to be sold as extra income. They also grew *sengon* and teak for savings and future needs. As in other clusters, generally, all seasonal and non-timber crops planted by the communities were partially allocated for own-consumption. Table 8 summarizes the farming system and commodity utilization in the Grati Cluster.

Extreme events that disrupted agriculture activities in Grati included socio-economic events and natural disasters. In the late 1990s, people in the Grati Cluster experienced economic crises which prevented them to conduct agriculture activities. The community felt that economic crises could reduce their purchasing power, thus adding difficulties to fulfill their domestic and agriculture production (i.e. fertilizer and agricultural chemicals as inputs).

Table 22. Farming systems and commodity utilization in the Grati Cluster

Farming systems	Commodities	
	For sale	For own consumption
Rainfed paddy field	Paddy, maize, peanut, sugarcane, cassava, long bean, gmelina, jackfruit, mango	All commodities were partially kept for own-consumption
Irrigated paddy field	Paddy, peanut	Paddy, dried maize
Seasonal crops	Sugarcane, maize, bananas, cassava, long bean, pumpkin, seasonal crops	All commodities were partially kept for own-consumption
State forest/Perhutani (teak, *Melaleuca*)	Cassava, dryland paddy, soybean, nuts	All commodities were partially kept for own-consumption
Timber (community forests)	teak, *Melaleuca*, gmelina, *sengon*, jackfruits, mangos, bananas	Fruits
Village's degraded land (in Rebalas)	Cassava, maize (annual crops)	All commodities were partially kept for own-consumption
Home garden	Bananas, mangos, jackfruits, papaya, chili	All fruit commodities were kept for own-consumption
Sugarcane	Sugarcane	n/a
Strip grass	strip grass	-

The scarcity of fertilizer that occurred almost every year had made farmers unable to obtain optimal agricultural yields. Although some small farmers made their own organic fertilizers to replace chemical ones, the farmers in this Cluster would still look for additional chemical fertilizers outside the sub-district area as they believed that urea and NPK fertilizers were important to increase land productivity.

Regarding natural disasters, frequent drought that caused crop failure had been experienced by the farmers in Grati. During the drought period, farmers in Grati would use artesian wells as their agricultural water resource. Farmers who did not own artesian wells would rent the artesian wells. This, however, was not applicable to farmers who worked in Perhutani land since their land was located too far from the location of artesian wells. In addition to drought, pest diseases such as leafhoppers, termites, and rats also disrupted the community's agriculture production. The discussion participants perceived the prolonged drought, the use of low-quality seedlings, and low fertilizer inputs as the main drivers of pest and disease problems. Table 23 summarizes the perspectives on extreme events that disrupted agriculture activities in the Grati Cluster.

Table 23. Extreme events disrupting agriculture activities in the Grati Cluster

Year	Extreme Events
End of 1990's	Economic crisis
2001	Bromo eruption
2001	Flash flood and landslide
2009	Prolonged drought
2015	Drought
Every year	Fertilizer scarcity
Every year	Pest and diseases

2.4.2 Criteria and preferences for tree commodity selection

The male group selected tree crops based on practicality factors. This included 'fast yield', 'seed availability, and 'easy maintenance'. Nevertheless, the 'marketability' of commodities had also become one of the male group's main considerations to select tree commodities. The duration of the recent dry season, which was unpredictable, had caused 'drought-resilience' or 'not requiring much water' to be additional criteria selected by the male group (Table 24).

The female group considered the criteria of 'household income', could be harvested annually ('fast yield), and could be used for 'household consumption' as the main reasons for tree selection. In addition, the female group also considered the functions of trees as 'savings' as well as 'firewood' as reasons to choose certain tree species. The criteria to select tree commodities by the male and female groups in the Grati Cluster are summarized in Table 24.

Table 24. Ranking of criteria for tree commodity selection in the Grati Cluster

No	Tree selection criteria	
	Male	Female
1	Fast yield	Household income
2	Marketability	Fast yield
3	Seedling availability	Own consumption
4	Easy maintenance	Easy maintenance
5	Saving and investment	Saving and investment
6	Resilience to drought	Firewood

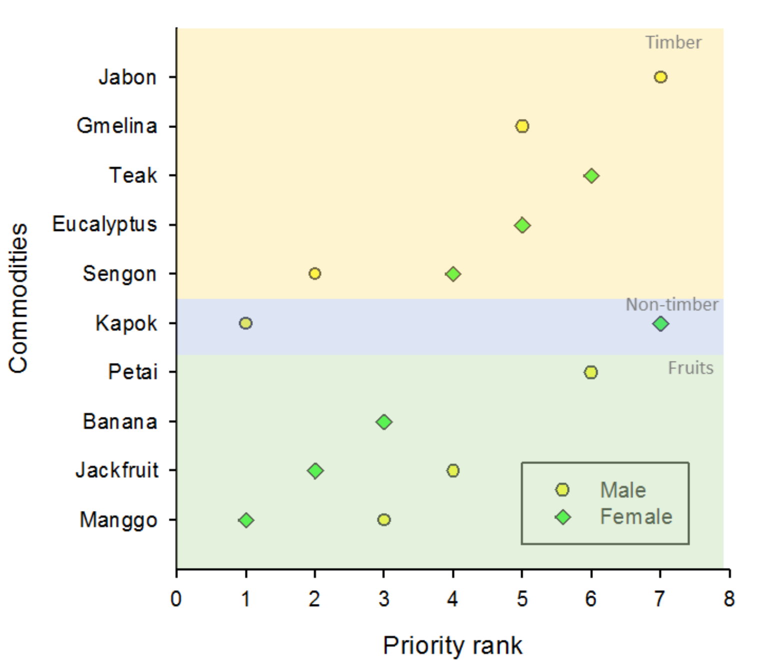


Figure 16. Priority rank of the preferred tree commodities in Grati Cluster

3. WINONGAN CLUSTER

3.1 Cluster overview

Winongan Cluster (842.82 ha) lies in the downstream area of the Rejoso Watershed and consists of two villages: Jeladri and Sruwi. Similar to the other downstream clusters, Winongan Cluster terrain is relatively flat with an altitude of less than 100 meters above sea level.

The land-cover is dominated by well-irrigated paddy field and sugarcane plantation. Recently, the local farmers have started to cultivate *sengon* agroforest. An asphalt and stone industry was operating in Jeladri Village. Based on the information from the local community, the stone materials were taken from the midstream area of the Rejoso Watershed. Winongan sub-district is located relatively close to the urban area. However, not all the road is connected, which made some hamlets less accessible with cars. The local community refers to the teak and *Melaleuca* plantation owned by Perhutani (the state forest company) as their leased land since they regularly pay the fee to cultivate on the plantation land.

The total population was 10,356 people, with around 45% of them living below the poverty line (Table 25). Most people who live in this cluster were Madurese migrants who have lived in this area for several generations, while there was also a of group Javanese residents who lived in Sruwi Village. According to the information from the discussion participants, agriculture activities were considered as the main livelihood source for most of the population.

Being in the downstream area of Rejoso made access to water relatively easy for the villages. The main water resources used by the local community, whether for daily needs or agriculture needs, came from natural springs located within the villages and distributed through natural canals. However, in the last five years, water supply for farming has mainly been obtained from artesian wells, either through individual or communal wells. As in cluster 1 and 2, some of these wells were not well managed and water overflow was common due to enormous water pressure.

Table 25. General characteristics of villages in the Winongan Cluster

Villages	village area (km^2)	Distance to sub-district capital (km^2)	State forest (ha)	Total population	Farmers (%)	Household living below poverty line (%)
Sruwi	3.3	3	174.9	2,282	n/a	40
Jeladri	3.2	5	92	8,074	n/a	53

n/a: no data available
Source: Winongan Sub-district in Figures (2015)

3.2 Land use and land cover

3.2.1 Area of LULC

LULC classifications have been conducted for year 1990, 2000, 2010, and 2015 to determine the dynamics of LULC change over the last 25 years (Figure 17). In 1990-2015, paddy field and *Melaleuca* plantation had increased by approximately 3% and 8%, respectively. Complex agroforest area had decreased by roughly 1% from the initial area in 1990. In 2015, the LULC in this cluster was dominated by paddy field (50.7%), *Melaleuca* plantation (13%), sugarcane and annual crops (12.9%) and complex agroforest (12%). The settlement area was surrounded by paddy field, *Melaleuca* plantation, and complex agroforest. A summary of the LULC area in Winongan Cluster in 1990-2015 can be seen in Table 26 and Figure 18.

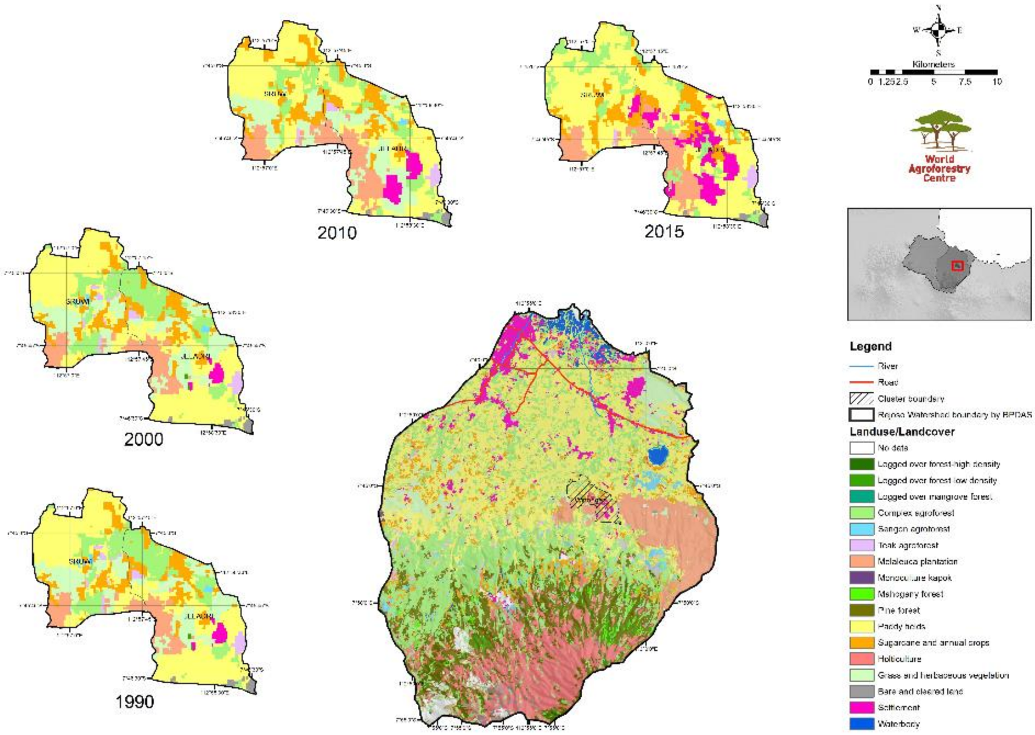


Figure 17. LULC map in Winongan Cluster

Table 26. LULC area in Winongan Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Logged over forest-low density	4.05	0.81		
2	Complex agroforest	110.7	131.67	86.13	101.43
3	Sengon agroforest	7.38	4.86	2.7	2.79
4	Teak agroforestn	22.05	19.17	13.05	10.08
5	*Melaleuca* plantation	41.13	72.63	105.3	109.62
6	Paddy field	398.07	351.72	319.5	427.5
7	Sugarcane and annual crops	89.01	101.25	117.36	108.9
8	Grass and herbaceous vegetation	169.29	142.47	162.72	
9	Bare and cleared land	0.9	8.01	8.01	8.01
10	Settlement	0.27	10.26	28.08	74.52
	Total	842.85	842.85	842.85	842.85

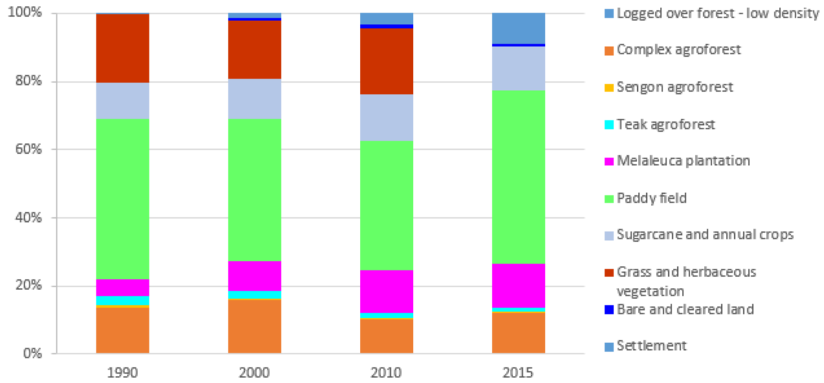


Figure 18. LULC area in Winongan Cluster

3.2.2 Trajectory of LULC change.

Based on satellite imagery analysis, LULC in Winongan Cluster had experienced significant changes during the last 25 years. Approximately 55% of the area experienced changes in LULC, while the other 45% remained stable (Figure 19).

Land-use conversion in 1990-2015 occurred mainly from grass and herbaceous vegetation to paddy field (roughly 14%), followed by the conversion of complex agroforest to paddy field (about 7%). In the same period, conversion of paddy field to complex agroforest and *Melaleuca* plantation amounted for approximately 7%, each. Other LULC conversions in 1990-2015 were not significant. However, total other dominant land-use changes reached 16% (Figure 19). This other land-use changes included grass and herbaceous vegetation to complex agroforest, paddy field to sugarcane and annual crop plantation as well as complex agroforest to *Melaleuca* plantation.

3.2.3 Perceptions of the community on drivers of LULC change

Male and female groups perceived that the land-use in Winongan was mainly dominated by paddy field, sugarcane plantation, and forest. The male group perceived that the conversion of natural forest to *Melaleuca* plantation and complex agroforest to paddy field were mainly driven by the community willingness to improve their income. The male participants also perceived that the increasing housing demand was the main factor that drove land-use conversion from paddy field to settlement area. Meanwhile, the women group considered that the demand for housing was the main driver of land-use change in Winongan, followed by the community's expectation to improve their livelihood standard through agricultural land expansion.

The male group predicted that in the next 10 years, the LULC in this cluster would be dominated by paddy field, sugarcane and *Melaleuca* plantation. The male group estimated that large areas of natural forest would be converted into *Melaleuca* plantation, as indicated by the increasing number of government programs supporting *Melaleuca* commodity. In contrast, the female group participants estimated LULC in Winongan to be dominated by settlement and sugarcane plantation, as they considered these land-uses more profitable and beneficial for improving community's livelihood.

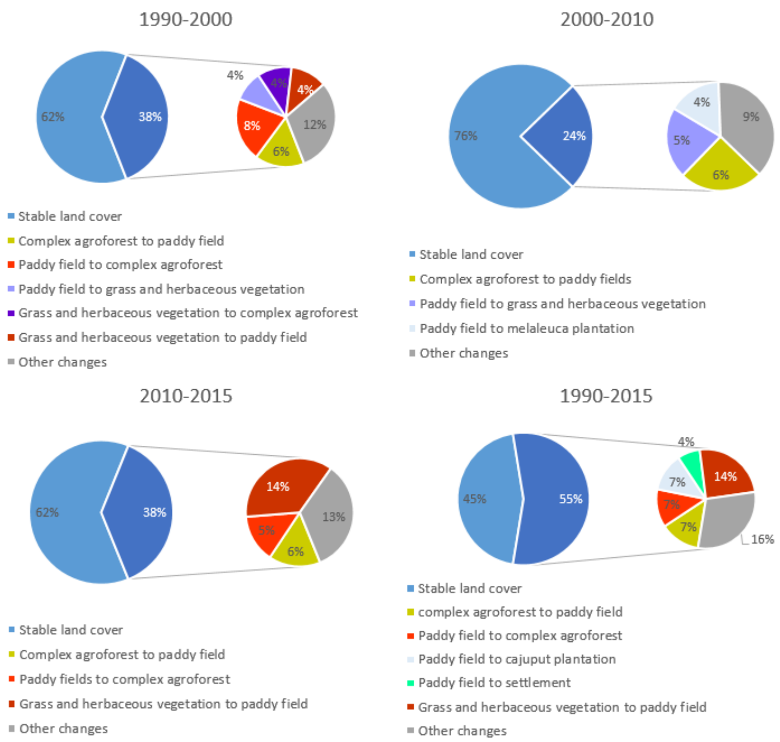


Figure 19. The trajectory of dominant LULC in Winongan Cluster

3.2.4 Shock (Extreme events)

The conversion of natural forest to *Melaleuca* plantation was initially driven by a government program in the 1990's. By the time of discussion, the government (represented by Perhutani) had issued a policy to rejuvenate the old *Melaleuca* trees. While waiting for the newly planted *Melaleuca* trees to grow, Perhutani allowed the community to cultivate crops below the trees. This program improved the local community's economic condition as it provided alternative livelihood sources and income.

The stone mine factory that operated in the area since 1995 was perceived to contribute to the LULC change. The factory operations had cleared the complex agroforest area into bare-land, and brought negative effects on community's health and quality of life due to aridity, sound, and air pollution. However, participants also acknowledged that the factory had positive impacts through generating employment for the local community. There were no efforts to prevent or reduce the negative impacts through the factory activities, although the local community expected support from the government for restoring the mining area.

3.3 Water Resources

3.3.1 Water resource and utilization

In normal condition, the water resources used either for daily activities or others (agriculture i.e. paddy field, annual crops such as maize and peanut planted between *Melaleuca* plantation and livestock) were varied, though the dominant one was artesian wells for household needs (according to 75% of male group and 39% of female group) in addition to surface wells and spring water; rain water (67%) was the dominant water resources for other activities according to the female group. Meanwhile, artesian wells (39%) were the dominant water resources for other activities according to male group (Figure 20).

During dry season the dominant water resources used remained unchanged for other activities. In Jeladri, however, rice relied on rainwater and thus could not be cultivated. Furthermore, 2 hamlets (out of 6 existing hamlets) in Jeladri experienced annual drought that required household to get water subsidies from the government for their domestic needs.

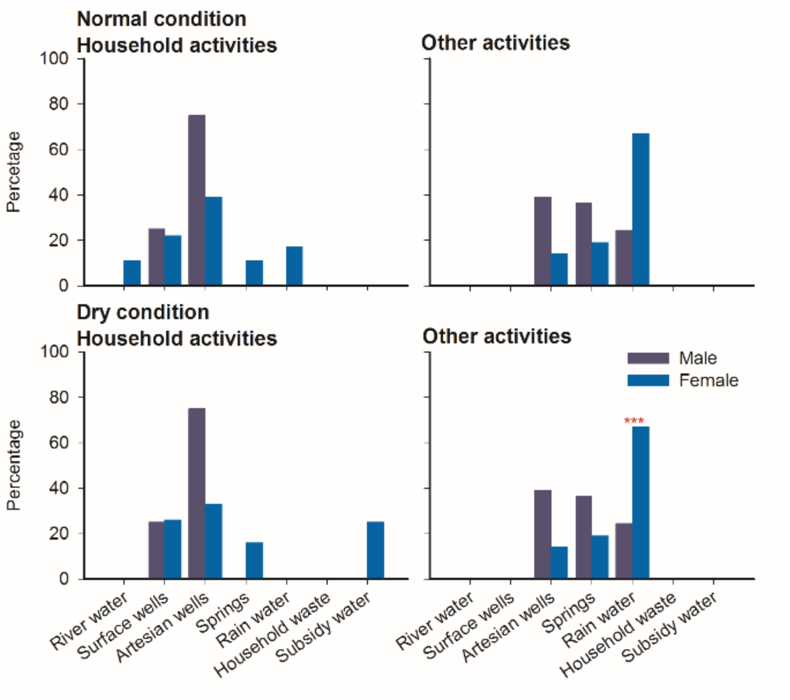
Few springs used (either for household or other activities) were located within the village (less than 1 km away). The spring water was distributed to agricultural land by utilizing natural canals. Nevertheless, the water flow rate was decreasing every time up to a point where some canals fell dry. Since year 2000, the local community had utilized the artesian wells (67-100m deep) for farming practices. The utilization of artesian wells had increased in the last 5 years for both, farming and household activities. Recently, 20 artesian wells were used in Sruwi and 7 in Jeladri, either owned individually or by the community. The local community was charged with Rp1000/house/month. Nevertheless, artesian well flow rates kept decreasing annually. Using suction machines could help distributing artesian well water to farmlands when the flow rates decreased. Yet, not everybody in the community had a suction machine.

3.3.2 Water resource problems

Both male and female groups perceived that the main problem related to water resources was the decreasing flow rate of surface wells and springs in the dry season (Table 27). Some hamlets (2 hamlets) in Jeladri even experienced drought every single year. Those two sub-villages were located at higher elevation than other hamlets, far from rivers and on rocky terrain.

Floods and landslides along the river banks during rainy season were also problems mentioned by the female group. The community members prone to flooding were those who owned land near the river. Nevertheless, not all parts of the community living in this area were prone to flooding. Through building an embankment, flooding could be considerably reduced in these areas.

The community assumed that the cause of decreasing flow rate and drought in the dry season were human activities like deforestation, LULC change.[1], stone mining and the increasing usage of water. Contrarily, high rainfall in the rainy season, deforestation and land-cover change were the causes of flooding and landslides along the riverbanks (Table 28).



*** During dry season and there is not much rainfall, most of farmers stop cultivate their land

[1] Before 1990, State-owned forests was a teak agroforest though since 1990 it was converted to *Melaleuca* plantation

Figure 20. Water resources for domestic and other uses (agriculture, livestock, and home industries) based on the perception of female and male groups in Winongan Cluster

Table 27. Water resource problems based on female and male perceptions in Winongan Cluster

Problems		Water resources	Rank	Male Frequency	Period	Rank	Female Frequency	Period
Quality	Polluted	River	-	-	-	5	Frequent	Not seasonal
Quantity	Drought	Rivers, artesian wells, springs	-	-	-	2	Frequent	Dry Season
	Decreased flow rate	Artesian wells, surface wells, springs	1	Frequent	Dry Season	1	Frequent	Dry Season
	Flood	River water	-	-	-	3	Occasional	Rainy Season
Others	Landslides	-	-	-	-	4	Frequent	Rainy Season

Table 28. Drivers of water resources problems in Winongan Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quality	Polluted			Low community awareness[1)]
Quantity	Drought/decreased flow rate	Low rainfall	Increasing water usage, deforestation, increasing number of artesian wells and stone mining	
	Flood	High rainfall	Deforestation	
Others	Landslide	High rainfall		

[1)] Throw waste into the river

3.3.3 Consequences of water resource problems

The decreasing flow rate of surface wells and springs in the dry season led to losses in both, household and other activities (Table 29 and Table 30). The consequences felt by the community included disrupted household activities due to wasted time for queuing for water subsidies (some even needed to buy clean water). The consequences to other activities included decreasing agricultural and dairy production as well as decreasing livestock weight. Some even experienced crop failure and had conflicts over the distribution of water.

Regarding these problems, material losses experienced included money (both reduced income and expenses to buy water) with proportion from heavy to very heavy level while the non-material losses including wasted time and human power with very light to very heavy level (Table 30).

Table 29. Perceptions on consequences of water resource problems in Winongan Cluster

Problems		Consequences		Score[1)]	
				Male	Female
Quality	Polluted	Household activities	n/a	-	0
		Other activities	Water flowing to farmland gets clogged	-	3
Quantity	Drought	Household activities	Disrupted activities (waiting times which cause delay)	-	5
		Other activities	Crop failure	-	5
	Decreased flow rate	Household activities	Disrupted activities (waiting times causing delay)	3	1
			n/a	-	0
			Conflict with others during water distribution	3	
		Other activities	Reduced agricultural production	5	5
			Crop failure	5	-

Problems		Consequences		Score[1])	
				Male	Female
			Reduced dairy production and Reduced livestock weight	-	5
			Conflicts with others during water distribution	-	5
	Flooding	Household activities	n/a	-	0
		Other activities	Crop failure	-	5
Others	Landslide	Household activities	n/a	-	0
		Other activities	Material loss (losing farmland)	-	5

[1]) Score: 1 = very mild, 2 = mild, 3 = medium, 4 = serious, 5 = very serious

Table 30. Perceptions on material and non-material losses due to water resource problems in Winongan

Problems		Consequences		Score[1])	
				Male	Female
Quality	Polluted	Material	n/a	-	0
		Non-Material	n/a	-	0
Quantity	Drought	Material	Money (extra expenses for clean water)	-	5
			Money (business capital)	-	5
		Non-Material	Human power	-	5
	Decreased flow rate	Material	Money (extra expenses for clean water)	2	-
			Money (Reduced income)	3	5
		Non-Material	Time	3	-
			Human power	-	5
	Flood	Materials	Money (business capital)	-	5
		Non-Material	Human power		5
			Time		5
Others	Landslide	Materials	Money (business capital)	-	5
		Non-Material	n/a	-	0

[1]) Score 1 = very light, 2 = light, 3 = medium, 4 = heavy, 5 = very heavy

3.3.4 Adaptation and mitigation strategies

The community had tried to solve the water resource problems (mitigation strategies) and to lessen their consequences (adaptation strategies). Scores for the existing adaptation and mitigation strategies are shown in Table 31, while potential future strategies are assessed in Table 32. Both, adaptation and mitigation strategies, had success rates of 50-100%. The adaptation strategies were applied to overcome decreasing flow rates of artesian and surface wells included saving water, buying water and managing water distribution. The existing mitigation strategies included fixing infrastructure like digging and drilling the wells deeper. Borrowing money, finding extra income or finding other jobs outside of the town were the adaptation strategies applied during reduced agricultural production or crop failure.

Even though the existing adaptation and mitigation strategies could overcome problems related to water resources, additional efforts were necessary to overcome decreasing flow rates during the dry season i.e. finding new water resources or building infrastructure like catchment wells.

Table 31. Successes of adaptation and mitigation strategies that had been done in Winongan cluster

Problems/Consequences		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Polluted	-	-	-	-	-	-
Quantity	Drought/Decreased flow rate	Saving water usage	-	75	Improve infrastructure (improve depth)	100	
		Buying water		100			
		Social effort (managing water distribution)	100	-			
	Flood	-	-	-	Build infrastructure (Embankment)	-	75
Others	Landslide	-	-	-	Build infrastructure (Embankment)	-	100
		-		-	Reforestation	-	75
Consequences	Disrupted household activities	Buying water	100	100	-	-	-
	Crop failure	Looking for other jobs	100	-	-	-	-
	Reduced agricultural productivity	Borrowing money		100			
		Looking for extra Income		50			
		Looking for other jobs		75			
	Material loss				Improving infrastructure (raising houses)		100

1) Score 1 = 0% success, 2 = 25% success, 3 = 50% success, 4 = 75% success, 5 = 100% success

Table 32. Potential adaptation and mitigation strategy in Winongan Cluster

Problems/consequences		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Polluted		-	-	-	-	-
Quantity	Drought/Decreasing flow rate				Find new water resources	1	1
					Build infrastructure (catchment wells)	3	
			-	-	Reforestation	2	-
	Flooding		-	-	-	-	-
Others	Landslide		-	-	-	-	-
Consequences	Disrupted household activities		-	-	-	-	-
	Crop failure		-	-	-	-	-
	Reduced agricultural productivity						
	Material loss		-	-	-	-	-

3.4 Farming practices

3.4.1 Farming systems and extreme events

Due to abundant water resources in this cluster, farming systems were dominated by irrigated paddy field that could be cultivated up to three times a year. In addition to rice, the local communities in Jeladri and Sruwi also plant long beans and cucumbers in their irrigated paddy field. Most of their harvest was sold to the market, and the farmers would use the generated income to buy cheaper rice.

In this cluster, it is common for farmers to lease their irrigated paddy field to the sugarcane plantation company. The company usually managed the sugarcane plantation with their own labors. Based on the information from the discussion participants, only one family in Jeladri leased out their plantation but managed it themselves. The farmers in this cluster cultivated seasonal crops, with cucumbers, nuts, maize, and cassava being the main commodities. In the surrounding of the seasonal crop area, the farmers usually plant mangoes and other fruit trees to indicate the borders of their land, for providing shade as well as for fruit production. The local community also works on their own timber garden, with the main commodities comprised of *sengon*, teak, *kapok*, and fruit trees. In the newly-planted timber plantation, farmers usually underplant seasonal crops such as maize, peanut, cassavas, and soybeans. The community also grew *sengon* trees, breadfruits, jack fruits, mangoes and star fruits in their home gardens.

In the state-owned teak and *Melaleuca* plantation (Perhutani area), the community underplanted rain-fed paddy field, maize, and cassava. People also use branches of the timber trees for firewood in their households. Even though the state-owned land cultivated by the community was known as the contracted area, the discussion participants did not explain the procedure to obtain a permit to manage that land. Thus, this requires further identification and clarification.

Farmers often used bulk-selling (tree-rent/contract) before harvest schemes. For example, for mango trees, farmers were paid Rp. 100,000 to Rp. 200,000 for each mango tree by the investors long before the trees yielded any fruits. At harvest, the investors would thus own every single fruit yielded by the trees that they paid for. The farmers always partially kept their non-timber commodity yields for own consumption. Several commodities that became community's main source of income included rice, cucumbers, peanut, *sengon*, *kapok*, and mangoes.

Extreme events that often disrupted farming practices of the smallholders in this cluster predominantly included natural disasters, such as typhoon with rain, floods as well as leafhopper pests. If flood, typhoon, and rain destroyed agricultural land, farmers would search for alternative livelihoods in the cities or borrow money from middle man to do replanting.

The scarcity of fertilizer occurred frequently due to ineffective allocation and distribution in the villages. The discussion participants perceived that the scarcity of fertilizer was also attributable to farmers that work on Perhutani land, who reduced the amount of fertilizers allocated to the villages.

Table 33. Farming system and commodity utilization in the Winongan Cluster

Farming system	Commodities	
	For sale	For own consumption
Irrigated paddy field	rice, long beans, cucumbers	A small portion was kept for own consumption, most portion was sold
Seasonal crops (*tegalan*)	cucumbers, long beans, peanut, mung beans, maize, cassava, mango and breadfruit	Cassava, maize, mung bean and peanut
Timber	*Sengon*, teak, gmelina, mango, kapok (*cotton*), maize, peanut, cassava, soybean	fruits, cassava, peanut, and *sengon*
State-forest/Perhutani (*Melaleuca* and teak)	Dryland paddy, maize, cassava, strip grass	Maize, cassava, peanut
Home garden	Banana, *sengon*, breadfruit (in Keladri), jackfruit, mangoes, star fruit	Fruits
Sugarcane	Sugarcane	n/a
Livestock	chickens, goats	-

Table 34. Extreme events that have disrupted farming practices in the Winongan Cluster

Year	Extreme events
1998	Flood
2013	Typhoon and rain
2015	Plant hopper disease
Every year	Fertilizer scarcity

3.4.2 Criteria and preferences for tree commodity selection

The male group considered the economic-related criteria in selecting tree crops, including 'fast yield', 'high market price' and 'marketability' as most important aspects to plant the commodity. The male group also chose 'easy maintenance' as one of the criteria, particularly for commodities that do not require a lot of water. 'Saving and investment' was also chosen by this group, mostly regarding timber commodities. The 'saving and investment' criteria usually referred to the function of commodities (usually timber) that can be sold for mid-term needs, such as children education or expenses for traditional ceremonies. This criterion also meant that trees are inheritable by the farmers' children and grandchildren. The last criterion chosen by the male group was the usability of the tree as livestock fodder (leaves and fruits), such as *gmelina*, kapok, *sengon*, jack fruit and mango.

The female group chose 'household income' as most important criteria to plant tree commodities. Further, criteria were 'own consumption' and 'seedling availability'. Table 35 summarizes the criteria for tree commodity selection according to the male and female groups in the Winongan Cluster.

The male and female groups shared similar preference in choosing tree commodities, especially regarding timber species. *Sengon* and teak were selected as their main commodities, followed by *gmelina* and *kapok*. *Sengon* and teak met the criteria of 'high price, 'easy maintenance', 'and household income' and could be used as 'investment and savings' for farmers (Figure 21).

Sengon can be harvested within 3-4 years. *Gmelina* was relatively easy to maintain and could be used as construction material. Breadfruit not only provided annual income for the household but also could be used as long-term cash crop and passed on to the farmers' offspring.

Table 35. Ranking of criteria for tree commodity selection in Winongan Cluster

Ranking	Tree selection criteria	
	Male	Female
1	Fast yield	Household income
2	High market price	Own consumption
3	Marketability	Seedling availability
4	Easy maintenance	Marketability
5	Saving and investment	Easy maintenance
6	Livestock fodder	Construction materials

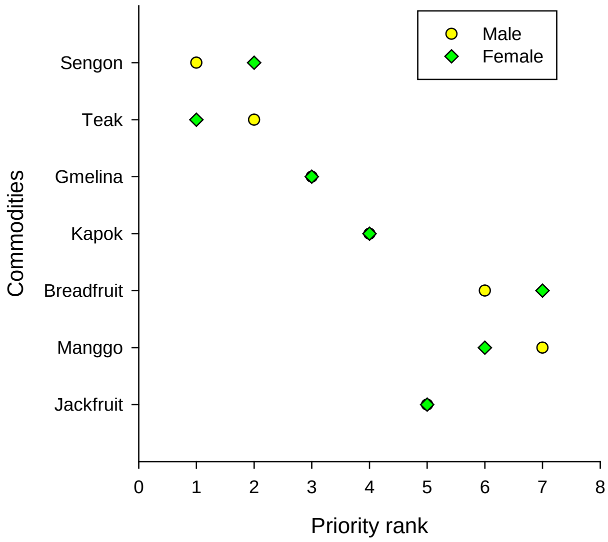


Figure 21. Priority rank of the preferred tree commodities in Winongan Cluster

4. PASREPAN 1 CLUSTER

4.1 Cluster overview

Pasrepan 1 Cluster (2,268.8 ha) lies in the midstream area of the Rejoso Watershed in Pasrepan sub-district at around 1,000 m above sea level and consists of three villages: Galih, Petung, and Klakah. LULC was dominated by complex agroforest and pine plantation. A rock mining is located in Klakah village. Besides complex agroforest and pine plantation, rainfed paddy field existed in the northern part of Klakah village.

This cluster is located relatively far from the urban area, with hilly and winding paths and poor road quality. In the southern part of this cluster, in Petung and Galih villages, a pine plantation owned by Perhutani (state forest) is currently cultivated by the local community. Based on the data of the Pasrepan Sub-district the total population was 8,393 inhabitants (Table 36), with 62% of the population living below the poverty line, mostly in Petung and Klakah villages. Most of the population belongs to East Java ethnicity with some Madurese migrants that have been residents in Petung for several decades.

The number of farmers in this area was 23% of the population, mostly from Galih village. However, based on the information from the discussion participants, the main occupation of all villages was farming. Pasrepan sub-district is renowned as durian producing area in Pasuruan Regency.

Being in the midstream of the Rejoso Watershed provides abundant water resources and allowed the local community to access clean water. In addition to springs, surface wells and river water, the residents of the three villages also relied on rainwater for clean water and farming practices.

Table 36. General Characteristics of villages in the Pasrepan 1 Cluster

Villages	Area (km^2)	Distance to district capital (km^2)	State forest (ha)	Number of population	Farmers (%)	Household living under poverty line (%)
Galih	7.34	7	155	3,796	34.2	45
Petung	8.97	9	42	3,282	17.6	72
Klakah	2.59	6	-	1,315	17.9	69

Source: Pasrepan Sub-district in Figures, 2015

4.2 Land use and land cover

4.2.1 Area of LULC

LULC was classified for year 1990, 2000, 2010, and 2015 to determine the dynamics of LULC change during the last 25 years (1990-2015). Based on the result of the satellite imagery analysis, the LULC in Pasrepan 1 Cluster was dominated by complex agroforest. In addition, there were paddy field, sugarcane, and annual crops, and pine plantation.

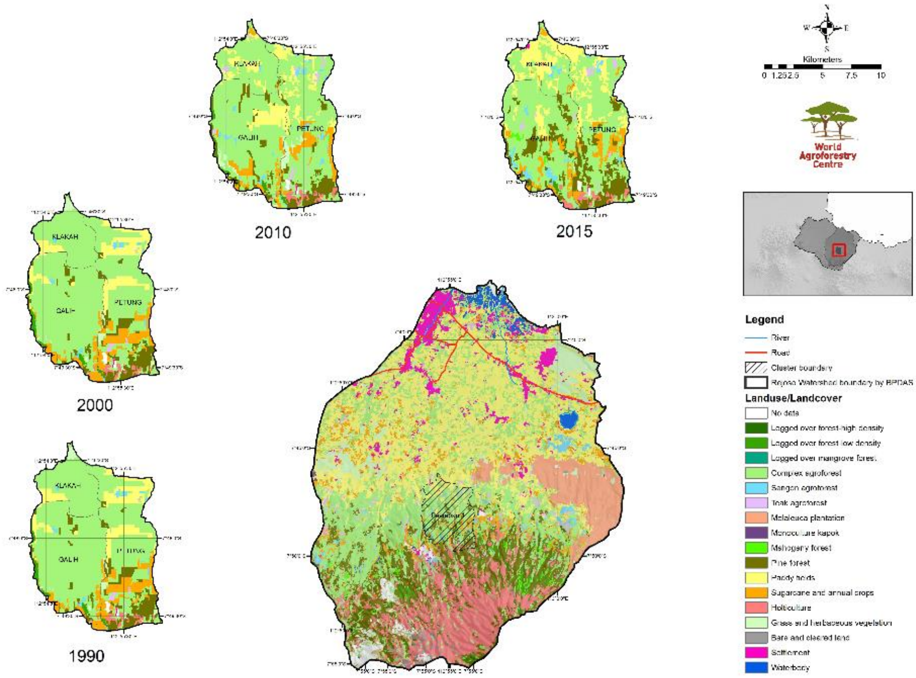


Figure 22. LULC map in Pasrepan 1 Cluster

In 1990-2015, paddy field and pine plantation area experienced significant increases compared to other land-use of 4.85% and 5.43%, respectively. Within the same period, complex agroforest, sugarcane, and annual crops plantation experienced a decrease in area. The complex agroforest area decreased by approximately 6.80% while sugarcane and annual crops decreased by roughly 3% in 1990-2015. *Sengon* agroforest and complex agroforest also experienced an increase of about 0.2% to 1.7%, respectively. In 2015, LULC in the cluster was still dominated by complex agroforest (56.09% of the total area). A general summary of the LULC in 1990-2015 can be seen in Table 37 and Figure 23.

Table 37. LULC area in Pasrepan 1 Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Logged over forest-high density	1.44	0.63	0.54	
2	Logged over forest-low density	34.74	30.6	21.15	5.4
3	Complex agroforest	1,426.77	1,532.25	1,486.8	1,272.51
4	*Sengon* agroforest	12.06	23.58	42.3	51.93
5	Teak agroforest	17.28	8.37	26.37	22.41
6	Mahogany forest	1.08	1.08	1.71	9.45
7	Pine plantation	199.44	181.8	190.08	322.56
8	Paddy field	254.97	238.95	256.41	365.04
9	Sugarcane and annual crops	232.65	182.61	156.69	165.42
10	Horticulture	7.47	26.37	30.87	40.41
11	Grass and herbaceous vegetation	72.27	33.93	46.71	1.8
12	Settlement	1.08	1.08	1.62	4.32
13	n/a data	7.56	7.56	7.56	7.56
Total		2,268.81	2,268.81	2,268.81	2,268.81

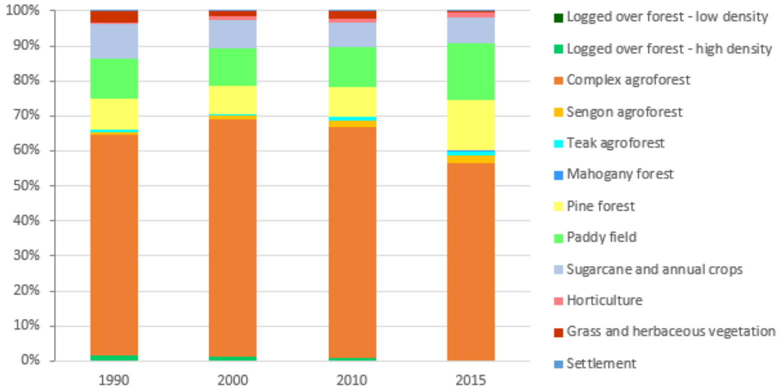


Figure 23. LULC area in Pasrepan 1 Cluster

4.2.2 Trajectory of LULC change

LULC had experienced significant changes over the last 25 years, as shown in Figure 24. In 1990-2015, approximately 45% of the cluster land-use has changed, while the other 55% remained stable. LULC change was dominated by complex agroforest converted to pine plantation, representing 6% of the total cluster area.

In 1990-2015, the other notable LULC included the conversion of sugarcane and annual crops area to pine plantation and the conversion of complex agroforest to sengon agroforest (LULC change 3% or lower). Individually, the other land-use changes were not significant, however, the total other land-use changes reached 23% of the total cluster area (Figure 24).

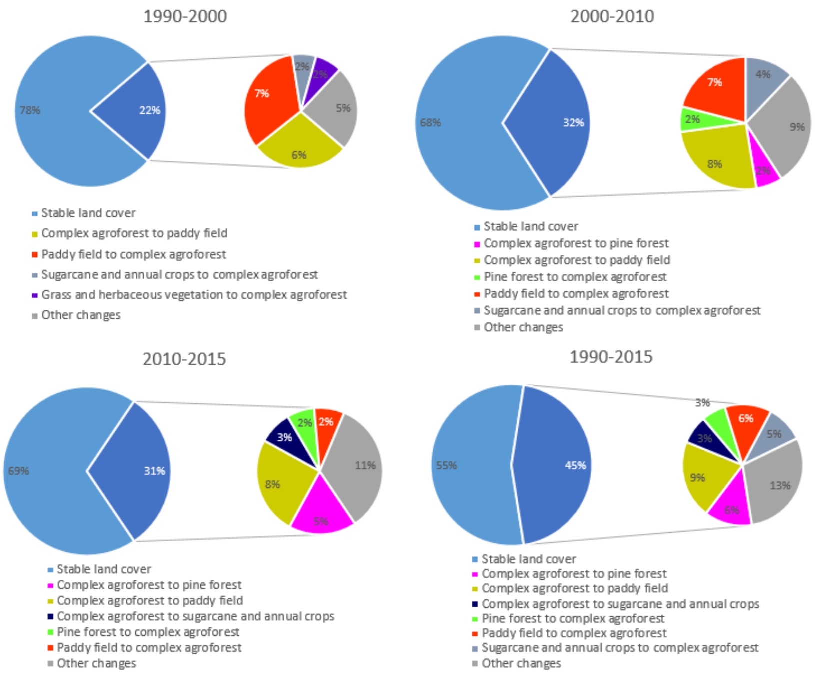


Figure 24. The trajectory of dominant LULC change in Pasrepan 1 Cluster

4.2.3 Perceptions of the community on the drivers of LULC change

The male and female groups similarly perceived that their cluster was dominated by complex agroforest with annual crops and medicinal plants. Male and female groups perceived slightly different drivers of LULC change in 1990-2015. The male group perceived that the increased needs and willingness to improve household income, demand for settlement, and the acquisition of land as an investment, were the main factors that caused LULC change. The female group perceived that the cultivation of previously non-productive/degraded land was the main factor that induced LULC change. LULC change was perceived to bring positive impacts for the lievlihood and wealth of the local community.

The discussion participants predicted that in the next 10 years, the LULC change in this cluster would be dominated by the expansion of settlement and complex agroforest area. This was in alignment with the graph of the trajectory of LULC changes in this cluster that showed that land conversion to complex agroforest occurred almost in all periods (Figure 24).

4.2.4 Shocks (Extreme events)

The government programs that was conducted around year 2000 succeeded to encourage the local community to plant *sengon*, teak, kapok, gmelina, *petai*, and guava on the degraded land in their villages. The positive impacts of the reforestation program included the improvement of water availability, soil fertility, and a greener environment. Yet, the program was not continued due to limited government budget, while the community expected a follow-up on the nursery development and fertilizer allocation through the same program.

4.3 Water resource management

4.3.1 Water resource and utilization

Under normal conditions, water resources used for either household or other activities such as agriculture (complex agroforest, annual crops such as maize and peanut, livestock farming (dairy cows and cattle) and household industries may vary. However, the dominant source was spring water for household activities (91% according to the male group and 77% according to the female group). In addition to surface wells, rainwater (48%) and river water were the water resources dominantly used for other activities according to male group. Meanwhile, spring water (43%) was the source dominantly used for other activities according to female group (Figure 25).

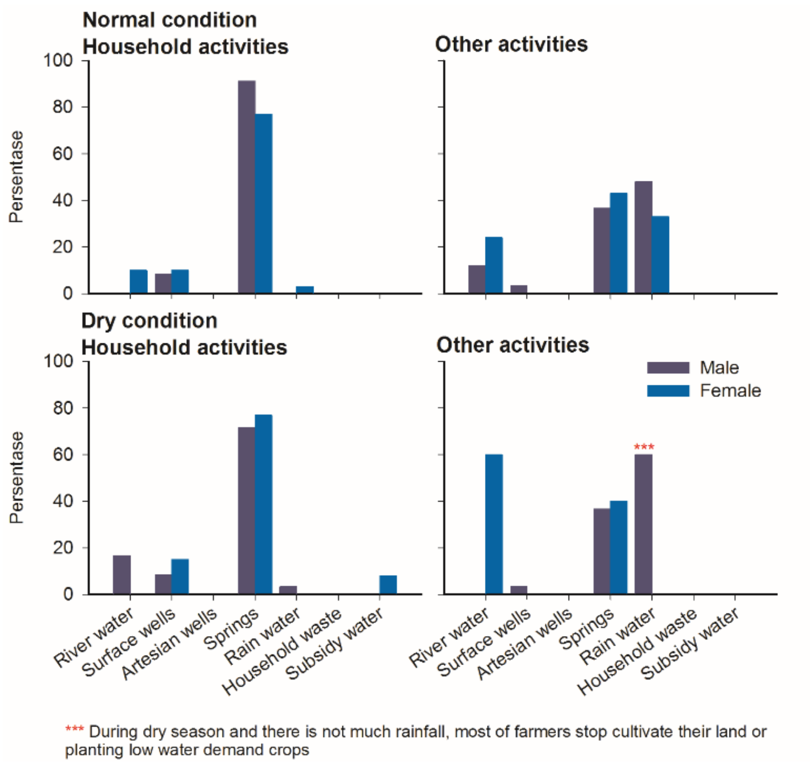


Figure 25. Water resources for domestic and other uses (agriculture, livestock farming, and households industry) based on male and female groups' perceptions in Pasrepan 1 Cluster

During dry season, there was no change in the dominant water resources used (either for household activities or other activities). Consequently, many agricultural lands, which relied on rain water, were not cultivated. During dry season/droughts, some agricultural land in Klakah was planted with tobacco which did not require much water. Meanwhile, for household activities, some hamlets in Klakah had to get a clean water subsidy every year when they experienced drought.

Some springs used for either household activities or other activities in Petung and Galih were located within the village (more than 3 km away). The springs were channeled through pipes. Nevertheless, the flow rate from the springs continues to decrease with some even falling dry. Klakah on the other hand utilized water resource located outside the village (more than 3 km away), which was also channeled through pipes.

4.3.2 Water resource problems

According to the perceptions of men and women, the main problem related to water resources was flooding, which frequently occurred in the rainy season and the flow rate decrease of surface wells and springs, frequently occurring in the dry season (Table 38). The community living along the river stream was prone to be affected by the flood. Meanwhile, not all hamlets in Galih, Petung and Klakah villages experienced the problem of decreased flow rate. Only a few hamlets in Klakah located far from springs that also had poor infrastructure received clean water subsidies when flow rates decreased. High tree cover was an indicator whether a village experienced water shortage. Landslides, which rarely occurred in the dry season, were another problem pointed out by the female group.

In addition to low rainfall, low flow rates were caused by this was caused by human activities such as logging, LULC change, rock mining and broken pipes due to landslide. Floods were caused by high rainfall in rainy season as well as by human activities.

Table 38. Water resource problems based on male and female groups' perceptions in Pasrepan 1 Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quantity	Decreased flow rate	Surface wells, spring	2	Rare	Dry season	1	Frequent	Dry season
	Flood	River water	1	Rare	Rainy season	2	Frequent	Rainy season
Others	Landslide	-	-	-	-	3	Rare	Rainy season

Table 39. Drivers of water resource problems in Pasrepan 1 Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quantity	Decreased flow rate	Low rainfall	Rock mining	
		Landslide (broken pipes)		
			Logging/land-cover change	Increasing water usage
	Flood	High rainfall	Rock mining	
			Logging/land-cover change	
Others	Landslide	High rainfall		

4.3.3 Consequences of water resource problems

The decreased flow rate of surface wells and springs in dry season caused losses for all activities (Table 40 and Table 41). For household activities, consequences included the delay of household activities until the water was available or subsidies became available. Some had to buy clean water. For other activities, consequences included disrupted farming practices as the community had to change the commodity to tobacco; reduced agriculture production because of decreased product quality; and disrupted livestock farming practices due to a lack of grass for livestock fodder, forcing the farmers to buy grass. Crop failure was caused by flooding.

Material losses included money (reduced income or expenses for buying clean water/grass) with heavy to very heavy level and non-material losses of human labor from very light to very heavy level (Table 41).

Table 40. Consequences of water resource problems based on male and female groups' perceptions in Pasrepan 1 Cluster

Problems		Consequences		Score[1)] Male	Female
Quantity	Decreased flow rate	Household activities	Disrupted household activities	1	3
		Other activities	Disrupted farming practices	3	4
			Reduced agriculture production	-	4
			Disrupted household industries		3
			Disrupted livestock farming (livestock fodder scarcity)		4
	Flood	Household activities	n/a	0	
			Experiencing material losses (broken houses)		4
		Other activities		3	5
Others	Landslide	Household activities	n/a	-	0
		Other activities	n/a	-	0

[1)] Score 1 = very mild, 2 = mild, 3=medium, 4=serious, 5=highly serious

Table 41. Material and non-material losses due to water resource problems based on male and female groups' perceptions in Pasrepan 1 Cluster

Problems		Losses		Score[1)] Male	Female
Quantity	Decreased flow rate	Material	Money (reduced income)	1	4
			Money (additional expenses to buy water/grass)		5
		Non-Material	n/a	0	
			Human power		4
	Flood	Material	Money (business capital)	3	5
			Possessions (houses)		4
		Non-Material	n/a	0	
			Human power		5
Others	Landslide	Material	n/a	-	0
		Non-Material	n/a	-	0

[1)] Score 1= very light, 2 = light, 3=medium, 4=heavy, 5=very heavy

4.3.4 Adaptation and mitigation strategies

The community had done some efforts to implement mitigation and adaptation strategies. Success rates are presented in Table 42, while potential future strategies are assessed in Table 43.

The existing adaptation and mitigation strategies had success rates range of 50%-100%. Avoiding floods by building stone embankments had 0% success as it had just been built and results could not immediately be felt. Overcoming decreased agriculture production by looking for extra income had a success rate of 50% as the female group could only cover approximately 50% of the income they could get from agriculture activities. Finding new water resources and building clean water infrastructures were the efforts taken to overcome the decreased water conditions in the dry season. Even though quite successful, funding was the main obstacle.

Table 42. The success of adaptation and mitigation strategies in the Pasrepan 1 Cluster

Problems/Drivers		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quantity	Decreased flow rate	Use other water resources	100	100	Fix infrastructure (fix pipes)		100
		Save water usage	-	100	Plant trees		100
		Crop rotation (plant tobacco)	100	100			
	Flood	Evacuate	-	100	Plant trees	100	100
		-	-	-	Build infrastructure (rock embankment)		0
Others	Landslide	-	-	-	Plant trees		100
Consequences	Disrupted livestock farming	Buy grass/livestock fodder	-	50	-	-	-
	Disrupted household activities	Buy water	-	100	-	-	-
		Borrowing money	-	100	-	-	-
	Decreased agriculture production	Save expenses	100	100	-	-	-
		Crop rotation	100	-	-	-	-
		Move to other city	-	50	-	-	-
		Looking for extra income	-	50	-	-	-

1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 43. Potential adaptation and mitigation strategies in the Pasrepan 1 Cluster

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quantity	Decreased flow rate	-	-	-	Look for water resources	1	1
		-	-	-	Build infrastructures (changing PVC pipes with metal pipes, bigger reservoir)	2	2
	Flood	-	-	-	Build infrastructure (permanent embankment)	-	3
Others	Landslide	-	-	-	-	-	-
Consequences	Disrupted livestock farming	-	-	-	-	-	-
	Disrupted household activities	-	-	-	-	-	-
		-	-	-	-	-	-
	Reduced agriculture production	-	-	-	-	-	-

4.4 Farming practices

4.4.1 Farming systems and extreme events

The sloping topography of this cluster made tree-based farming systems as the main option for the local farmers (Table 44). The local community called the mixed-farming system that consists of various tree-crops *tegalan* (commodity-garden). The various tree commodities being planted in the *tegalan* area included mangoes, durian, *petai*, bananas, jackfruits, bamboo, *jengkol*, avocado, cloves and *sengon*. In this cluster, bamboo grew naturally, not through cultivation. The farmers kept the bamboo in their garden as it could protect the soil and reduce erosion. Other than in the community's home gardens, bamboo could also be found along the riverbanks in the villages.

Table 44. Farming systems and commodity utilizations in Pasrepan 1 Cluster

Farming systems	Commodities	
	For sale	For own consumption
Commodity-garden (*tegalan*): *the naming is based on the dominant tree crops, i.e. sengon garden or teak garden*	Sengon, teak, oranges, mangoes, gmelina, *rambutan*, mahogany, *jabon* tree	All non-timber commodities partly allocated for own consumption
Mixed-garden (no dominant crops)	Mangoes, *petai*, bananas, *kapok*, durian, jackfruits, bamboo, *jengkol*, avocados, cloves, *sengon*	All non-timber commodities partly allocated for own consumption
Rainfed paddy field	Paddy, maize, peanut, tobacco, soy bean	All non-timber commodities partly allocated for own consumption
State forest/Perhutani (pine, teak, mahogany)	Avocados, *kapok*, maize, bananas, *medicinal herbs*	All non-timber commodities
Protected forest (pine and teak in Galih Village)	Teak, pine, strip grass, *kapok*, bananas	All non-timber commodities
Coffee and cloves agroforestry (in Petung Village)	Cloves, coffee, tobacco, durian	Coffee, durian, tobaccoo
Home garden	Bananas, durian, mangoes, *rambutan*, cocoa, chili (in polybag)	all

Sengon, teak, orange, mango, mahogany and *jabon* tree gardens could be found in many locations, both in commodity-garden (*tegalan*) and mixed-garden (*kebun campur*). The commodity garden was initially related to tree species provided through government programs, such as teak, *sengon*, mangoes and *jabon*. The "mixed-garden" term indicates that there is almost no dominant species planted in the garden. There were several rainfed paddy fields in Klakah Village that could only be cultivated once a year. In addition to rice, the rainfed paddy field was usually planted with tobacco, corn, soy bean and peanut.

The state forest (Perhutani) area could be found in Galih and Petung villages, with pine as the main commodity. The local community also cultivated the Perhutani area, in which they planted avocado and *kapok* trees, combined with corn, bananas, and medicinal herbs (lemongrass, ginger, turmeric and galangal). When the participants were asked on the land status and ownership of the trees planted in the state forest, they only mentioned that they were allowed to plant several specific tree commodities on state forest land.

The local community in Galih village planted the village protected forest with pine and teak. In this protected forest area, the community also planted bananas, *kapok*, and strip grass. In Petung Village, the community managed coffee and clove agroforestry systems that were usually combined with other tree-crops such as durian and tobacco. Besides cultivating their agricultural land, the community also cultivated bananas, durian, mangoes, cocoa and chili in their home garden area.

Like in the other clusters (see cluster 3), farmers used a bulk buying system or tree-rent/contract system before harvest time, mainly for durian, mango and *petai*. Through this tree-rent system, the tree-renters (the investor) pay the tree-owner in advance for the all the yields in the next harvest period. The transaction was usually carried out long before harvest time. The total value of advanced payment was significantly below the market-price.

The main income for the local community came from durian, mango, jackfruits, cloves, *kapok*, banana, and tobacco. Some part of the yields from non-timber commodities were usually allocated for own-consumption.

The community perceived natural events like floods, hailstones and hurricanes as well as pests and diseases that frequently lead to harvest failures, as disruption to their livelihood. Some efforts had been made to cope with rain and flood impacts including building water channels in the village public/agricultural land and the construction of *galengan* (stone embankment) in the village. The farmers had planted bamboo in the riparian area to mitigate the floods with less significant impact, as the effort was only conducted in a few locations. Farmers that acquired financial resources would re-plant their land after the flood. The farmers who did not have financial resources would borrow money from their neighbors, middlemen, or work in the city to gain income for replanting.

Other extreme events that were perceived as frequent disruptions for the community's farming practices included pests and diseases, especially plant diseases on *petai* and banana. The local farmers had requested the extension workers to help them overcome the pests and plant diseases but the extension office did not give adequate responses. One of the recurring socio-economic problems was the scarcity of urea fertilizers as distributed fertilizers did not meet demands. During scarcity, farmers usually planted their paddy field with other crops that required less fertilizer, such as cassava, taro and sweet potatoes.

Table 45. Extreme events disrupting farming practices in the Pasrepan 1 Cluster

Year	Extreme Events
2000	Flood
2000	Ice rain, typhoon
2009	Prolonged draught (almost 9 months)
2010	Fertilizer price hike
2015	Flood
2016	Pest and disease
2016	Prolonged rain

4.4.2 Criteria and preferences for tree commodity selection

Male and female groups chose economic-related criteria, such as 'household income', as their main criteria to plant a specific tree species. The smallholders in this cluster mainly relied on tree-based farming practices for their livelihood. Therefore, 'household income' was the crucial criteria.

The male group chose 'land suitability' as additional criterion, a result of the altitude and dry characteristics of the area which allowed only some commodities to be well-cultivated in the cluster. Considering the limited access of the cluster, the local community also chose 'marketability' as one of the criteria to select and plant tree species, meaning that the planted commodities should be the commodities being collected by the middlemen that came to the villages. The male group stated the 'disaster prevention' as one of the main criteria, mainly to prevent landslides and floods. Despite being the fourth priority, this criterion indicated some environmental awareness of the male discussion participants. The last two criteria chosen by the male group in tree selection were 'own consumption' meaning that they were interested in using the trees for domestic needs, and 'seedling availability'.

The female group chose 'saving and investment' criterion as their second priority in selecting trees. This criterion showed the importance of tree as an asset that can be liquidated during the time of needs, such as for cultural ceremonies or children education fees, and can be passed to their children as an inheritance. The female group also mentioned that they planted specific trees because of the influence from the government program and/or their neighbors. If the government or neighbor advised them to plant specific tree commodities, they became convinced that planting such tree species would give them benefits. The next criterion selected by the female group was that the tree should be suitable for the land characteristics in this cluster ('land suitability'), must be able to be used for 'own consumption', and provide 'shading' for other crops in the farm.

Table 46. Ranking of criteria for tree commodity selection in Pasrepan 1 Cluster

Ranking	Tree selection criteria	
	Male	Female
1	Household income	Household income
2	Land suitability	Saving and investment
3	Marketability	Influence from friends and neighbors
4	Disaster prevention	Land suitability
5	Various benefits	Own consumption
6	Seedling availability	Shading

The male and female groups chose similar tree commodities, with durian, jackfruits, *sengon*, *petai*, and mango as the preferred commodities (Figure 26). Both groups chose durian as the most prioritized tree commodity. Durian mostly provides household income for the smallholders, due to high marketability and being suitable for the growing conditions in the cluster. In addition, durian could also be used as saving or investment since it could be harvested after decades and when the tree reached maturity, its timber could be sold.

All selected fruit trees (banana, mango, jackfruit, and *petai*) mostly provided household income while also being used for domestic consumption. The participants stated that *sengon* and teak had good marketability and could also be used as construction materials by the local community.

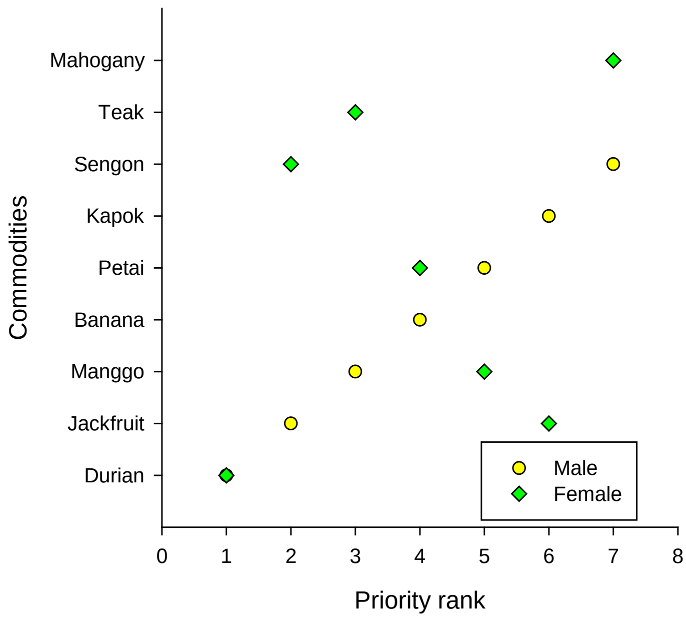


Figure 26. Priority rank of the preferred tree commodities in Pasrepan 1 Cluster

5. LUMBANG CLUSTER

5.1 Cluster overview

Lumbang Cluster (2,343.9 ha) lies in the midstream area of Rejoso Watershed and consists of two villages, Karangjati and Watulumbung. The topography of the cluster lying as 1,000 meters above sea level is dominated by hilly terrain. Lumbang Cluster is located quite far from the urban area with hilly terrain and poor road quality. The LULC is dominated by *Melaleuca* plantation belonging to Perhutani (in Karangjati), as well as complex agroforest. Many community members in Karangjati utilized Perhutani land in their village for their farming activities. In Watulumbung, farmers practice dry-land farming and community forestry.

Lumbang sub-district has a total population of 6,219 people, with 37% of the population living below the poverty (Table 47). The majority of the residents were immigrants, descendants of Madurese tribes, who had lived there for three generations as well as a small group of Javanese ethnics in Watulumbung. The number of farmers in the cluster amounted to roughly 38% of the total population.

Water supply in Lumbang Cluster is abundant. Yet, several areas still experience water shortages. In addition to surface wells, spring and river water, the community also relied on rainwater for clean water and agricultural needs. Every year, several hamlets in Karangjati Village needed to rely on clean water subsidies from the government to meet their domestic needs.

Table 47. General characteristic of villages in the Lumbang Cluster

Villages	Village area (km^2)	Distance to sub-district capital (km^2)	State forest (ha)	Number of population	Farmers (%)	Household living under poverty line (%)
Karangjati	7.6	5	458.5	3,204	42.3	44
Watulumbung	5.94	7	-	3,015	35.8	33

Source: Lumbang sub-district in Figures, 2015

5.2 Land use and land cover

5.2.1 Area of LULC

LULC classifications have been conducted for year 1990, 2000, 2010 and 2015 in order to understand the dynamics of LULC change during the last 25 years (1990-2015). LULC was dominated by *Melaleuca* plantation and paddy field. In addition, there were teak agroforest, *sengon* agroforest, complex agroforest, sugarcane and annual crops. The settlement pattern was not clearly visible since it occupied a relatively small area.

In 1990-2015 *Melaleuca* plantation experienced a significant increase in the area from 50% in 1990 to 73% in 2015. In the same period *sengon* agroforest increased by 3.62% compared to 1990. On the contrary, teak agroforest area strongly decreased by 49.03%. Complex agroforest and rice field declined by 6.19% and 7%, respectively. A summary of the LULC in 1990-2015 can be seen in Table 48 and Figure 28.

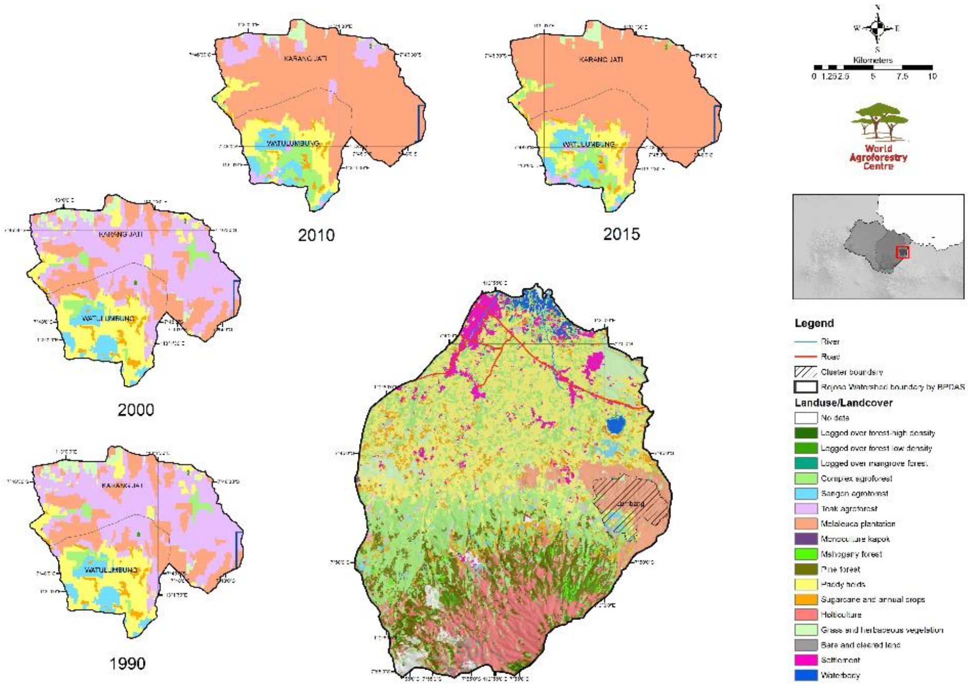


Figure 27. LULC map in Lumbang Cluster

Table 48. LULC area in Lumbang Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Logged over forest-low density	3.42	1.98	0.81	0.81
2	Complex agroforest	288.54	78.3	136.98	143.46
3	Sengon agroforest	22.77	125.28	118.89	107.64
4	Teak agroforest	1,203.48	1,010.43	189.45	54.36
5	*Melaleuca* plantation	324.63	566.64	1,549.8	1,705.77
6	Paddy field	414.72	436.23	262.89	250.56
7	Sugarcane and annual crops	58.32	50.58	40.14	39.15
8	Grass and herbaceous vegetation	26.46	72.54	42.84	39.6
9	Settlement	0.09	0.45	0.63	1.08
Total		2,343.87	2,343.87	2,343.87	2,343.87

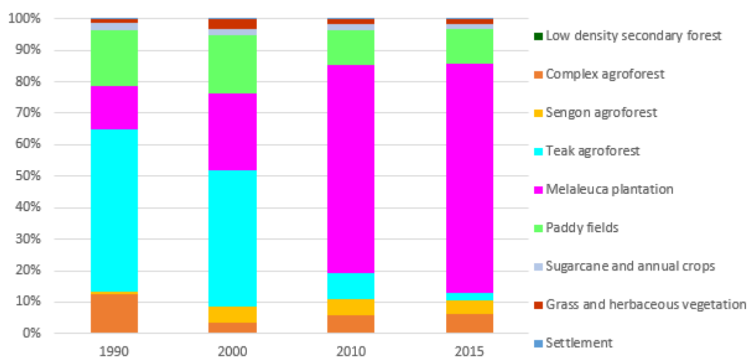


Figure 28. LULC area in Lumbang Cluster

5.2.2 The trajectory of LULC change

The spatial analysis showed that the LULC had experienced significant changes during the last 25 years. This was evident from the trajectory graph of the dominant LULC change (Figure 29), in which approximately 78% of the area had experienced LULC change while only 22% remained stable.

LULC change in each period was dominated by the conversion of teak agroforest to *Melaleuca* plantation, particularly in 2000-2010, reaching 50% of the total cluster area. Meanwhile, other dominant LULC only changed by approximately 2-5%, while other LULC change represented 11% of the total LULC change during the 25 year period.

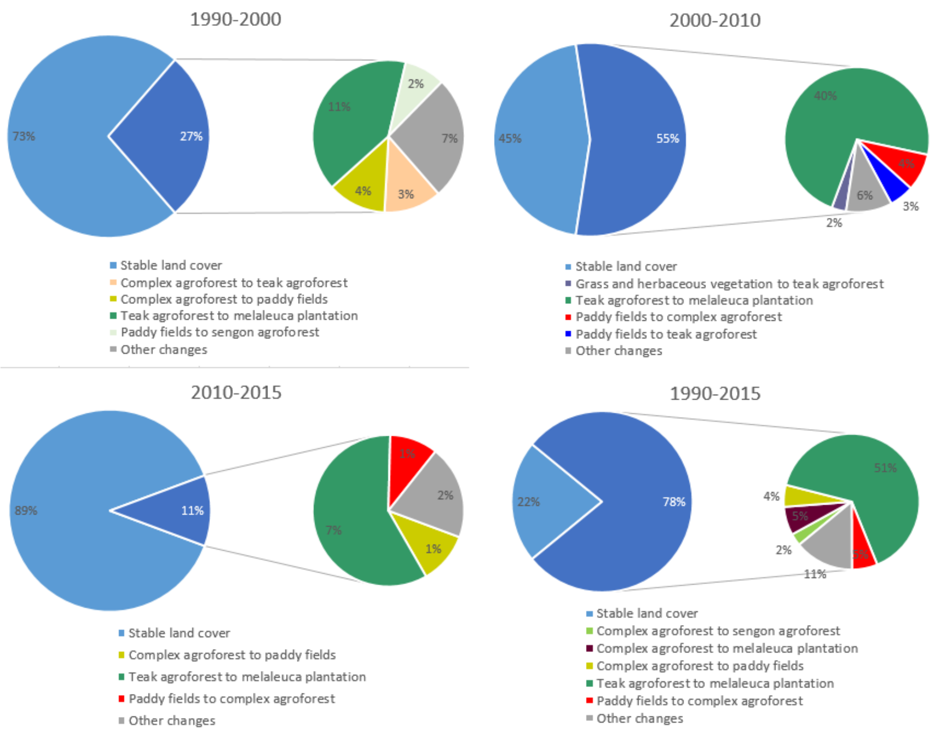


Figure 29. The trajectory of dominant LULC change in Lumbang Cluster

5.2.3 Perceptions of the community on the drivers of LULC change

The male and female groups shared similar perceptions, i.e. that LULC was dominated by complex agroforest and plantation. There were different perceptions between male and female groups on the drivers of LULC change in the period in 1990-2015. The male group believed that the benefits of crops, unproductive land and the need for settlement were the three main factors causing LULC change. On the other hand, the female group only considered the desire to increase revenue a causal factor.

The discussion participants predicted that over the next 10 years, LULC change would lead to settlement development and timber cultivation as this could improve the community's livelihood standard. In addition, timber plantation is supported by a government program (Perhutani), which allowed some land to be utilized by the community for cultivation.

5.2.4 Shocks (Extreme events)

The government program to convert forest plantation to *Melaleuca* plantation started in the 1990s. The government (in this case Perhutani) provided seeds of *sengon*, coconut, *gmelina*, and mangoes among others for underplanting in the *Melaleuca* plantations. This policy had a positive impact, increasing green space and community welfare. The community just accepted whatever activities/programs that the government provided, hoping that the program would run well and that there would be an increase in seedling distribution.

5.3 Water resource management

5.3.1 Water resource and utilization

Under normal conditions water resources used for either household or other activities were varied. Nonetheless, the dominant one was springs for household activities (80% according to the male group and 74% according to the female group) besides surface wells, artesian wells and rainwater. For other activities, rain water was the water resource dominantly used (70% according to the male and 66% according to the female group) apart from artesian wells, surface wells, and springs (Figure 30).

During dry season, the main water resources for other activities were not changed. Consequently, many annual crops that relied on rain water could not be planted or could only be planted for 1 season per year. For household activities, some hamlets in Karangjati depended on clean water subsidies during every drought.

The Madakaripura spring used for both household and other activities was located outside the village (more than 3 km away). Spring water was channeled to the village through pipes, however, were constantly decreasing. To use the spring water, the community was charged Rp2000, -/house/month.

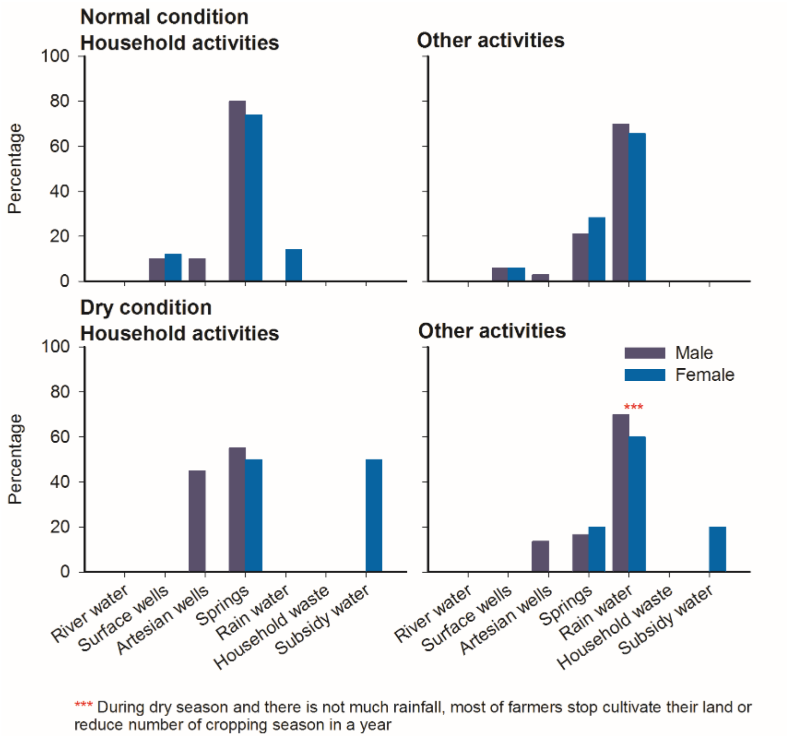


Figure 30. Water resources for domestic and other uses (agriculture, livestock farming and household industry) based on male and female groups' perceptions in Lumbang Cluster.

5.3.2 Water resource problems

According to both male and female group perceptions, main problems related to water resources were the spring and surface wells flow rates that frequently decreased during dry season (Table 3). Some villages in Karangjati even experienced drought every year. In addition to being far from the spring, some hamlets were located on rocky terrain.

According to the male group, landslides were another main problem. The areas susceptibility to erosion was caused through its location on steep slopes with low tree cover. According to the female group, turbid spring and surface well water during rainy season was the other main problem.

In addition to low rainfall, decreased/dried out water in the dry season was also caused by broken pipes (affected by a landslide) and the increasing number of water users. Surface runoff and erosion, garbage and landslides (broken pipes) were the main drivers for turbid water (Table 50).

Table 49. Water resource problems (quality and quantity) based on male and female groups' perceptions in Lumbang Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Time	Rank	Frequency	Time
Quality	Turbid	Springs, surface wells	3	Frequent	Rainy season	2	Frequent	Non-seasonal
	Smelly	Springs	-	-	-	3	-	Non-seasonal
Quantity	Drought	River water	-	-	-	5	Frequent	Dry season
	Decreased flow rate	Springs, surface wells	1	Frequent	Dry season	1	Frequent	Dry season
	Flood	River water	-	-	-	4	Rare	Rainy season
Others	Landslide	-	2	Frequent	Rainy season		-	-

Table 50. Drivers of water resource problems in Lumbang Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quality	Turbid	Surface run off, erosion or trash		
		Landslide (broken pipes)		
	Bad smell	Low rainfall		low community awareness in maintaining infrastructure[1)]
Quantity	Drought/decreased flow rate	Low rainfall	Logging/land-cover change	Increased number of water users
		Landslide (broken pipes)		
	Flood	High rainfall	Logging/land-cover change	
Others	Landslide	High rainfall		

[1)] Trash around farming area went to the reservoir

5.3.3 Consequences of water resource problems

The decreased flow rate of surface wells and springs during dry season caused problems for household and other activities (Table 51 and Table 52). The consequences felt by the community included the disruption of household activities such as wasted time for water subsidy queuing or even buying clean water. For other activities, the consequences felt by the community included decreasing milk production/livestock weight or even crop failure during long drought periods.

This led to material losses (reduced income or expenses for buying clean water) with medium level, while non-material losses included wasted time and human labour with a very light level (Table 52).

Table 51. Consequences of water resource problems based on male and female groups' perceptions in Lumbang Cluster

Problems		Consequences		Score[1)]	
				Male	Female
Quality	Turbid	Household activities	n/a	0	
			Disrupted household activities [2)]		1
		Other activities	n/a	0	0
	Bad smell	Household activities	n/a	-	0
		Other activities	n/a	-	0
Quantity	Drought	Household activities	n/a	-	0
		Other activities		-	3
	Decreased flow rate		Disrupted household activities	3	3
		Other activities	Decreasing milk production/livestock weight	2	
			n/a	-	0
	Flood	Household activities	n/a	-	0
		Other activities	n/a	-	0
Others	Landslide	Household activities	Experiencing material losses (Money)	1	-
		Other activities	n/a	0	-

[1)] Score 1 = very mild, 2 = mild, 3=medium, 4=serious, 5=highly serious

[2)] Water had to rest first to sediment

Table 52. Material and non-material losses due to water resource problems based one male and female groups' perceptions in Lumbang Cluster

Problems		Losses		Score[1)]	
				Male	Female
Quality	Turbid	Material	n/a	0	0
		Non-Material	n/a	0	0
	Bad smell	Material	n/a	-	0
		Non-Material	n/a	-	0
Quantity	Drought	Material	Money (business capital)	-	3
		Non-Material	Human power	-	3
	Decreased flow rate	Material	Money (additional expenses)	3	
			Money (reduced income)	2	
			n/a		0
		Non-Material	Human power and time	1	4
	Flood	Material	n/a	-	0
		Non-Material	n/a	-	0
Others	Landslide	Material	Money (additional expenses)	1	-
		Non-Material	Human power	1	-

[1)] Score 1= very light, 2 = light, 3=medium, 4=heavy, 5=very heavy

5.3.4 Adaptation and mitigation strategies

The community had invested efforts into mitigation and adaptation strategies. Scores for the undertaken strategies are shown in Table 53, while potential future strategies are assessed in Table 54.

So far, the existing adaptation and mitigation strategies had been perceived to have a 75% -100% success rate, with the exception of the effort to overcome decreased flow rates by planting trees for which the male group awarded 25% success rate. However, trees were only newly planted. In line with this, planting trees and searching for new water resources remained to the main strategies to overcome decreased amounts of water and flooding. However, funding limitation remained to be the main obstacle. Looking for extra income, borrowing money and saving expenses were all strategies to deal with decreased agriculture production.

Table 53. Success of adaptation and mitigation strategies in Lumbang Cluster

Problems/Drivers		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Turbid	Resting water to sediment	100	100	Fix infrastructure (broken pipes)	100	
	Smelly						
Quantity	Drought						
	Decreased flow rate	Buying water	100		Plant trees	25	
		Saving water usage	100		Looking for water resources		50
		Using other water resources	100	100	Fix infrastructure (diverting pipeline)		100
	Flood				Build infrastructure (embankment)		100
					Plant trees		75
Others	Landslide						
Consequences	Decreasing milk production/ livestock weight	Borrowing money	100	100			
		Saving expenses	100				
		Looking for extra income		100			

[1)] Score 1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 54. Potential adaptation and mitigation strategies in Lumbang Cluster

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Turbid						
	Smelly						
Quantity	Drought						
	Decreased flow rate				Looking for water resources	1	1
					Plant trees	2	
					Build infrastructure (pipeline to Banyubiru)		2
	Flood				Plant trees		1
Others	Landslide						
Consequences	Decreasing milk production/livestock weight						

5.4 Farming practices

5.4.1 Farming systems and extreme events

LULC being dominated by Perhutani's (state forest company) *Melaleuca* plantation forced the farmers in Lumbang to utilize Perhutani's land for their farming practices. The group discussion revealed that the local farmers that cultivated on the Perhutani's land needed to pay a contract fee, although the procedure and the amount of contract needs to be further clarified.

On the Perhutani's *Melaleuca* plantations area, the community cultivated dryland rice, cassava, and beans, whilestrip grass used for livestock fodder. In addition, the community grew cash crop trees, such as mango, banana, *petai* and *kapok*. The community acknowledged that they were not allowed to cut down the trees that they had planted on Perhutani's land, but they still harvested the fruits.

Besides farming on Perhutani land, the community in Watulumbung also cultivated seasonal crops. Generally, the seasonal crops area was planted with cassava, corn, dryland rice and strip grass. Occasionally, the crops area was also planted with peanut, horticulture, *petai*, and *empon-empon* (medicinal plants such as turmeric, ginger and lemongrass). The community also developed complex agroforestry systems, dominated by tree-crops. Main tree species in the complex agroforest included *sengon*, teak, mango, gmelina, *kapok*, durian, and *rambutan*. in the complex agroforest area, tree crops were occasionally mixed with dryland rice, cassava, corn and strip-grass for livestock fodder. In Watulumbung, trees and crops (teak, mahogany, and *sengon*, cassava and strip grass) were cultivated on a village forest area.

Similar to the other clusters in the Rejoso Watershed, smallholders in this cluster used bulk-sell (or tree-rent/contract) systems before harvests for e.g. durian and mango. The rent fee (payed in advance) would be significantly under the actual market value of the products, while the buyer owned all fruits on contracted trees.

The local farmers also raised livestock such as cows and goats as alternative source of income. The local community used several livestock management patterns: 1) the owner raised and sold their own livestock, 2) a person was entrusted by the owner to raise the livestock and is usually paid a fee, 3) sharing profit from livestock selling and 4) calf sharing.

Although LULC was dominated by tree plantation, the result of the group discussion indicated that most of the community's income came from non-timber commodities such as cassava, maize, peanut and bananas. Mango were the only tree commodity that was considered to give significant contribution to the household income, although the proportion was gradually decreasing. Table 55 summarizes the farming systems and agricultural commodity utilization in Lumbang Cluster.

Table 55. Farming systems and commodity utilization in Lumbang Cluster

Farming systems	Commodities	
	For sale	For own consumption
Seasonal crops	Dryland paddy, maize, cassava, peanut, long bean, spinach, strip grass, *petai*, medicinal herbs	Dryland paddy, maize, strip grass (livestock)
Mixed-garden	Sengon, teak, gmelina, mangoes, *kapok*, durian, *rambutan*, dryland paddy, maize, bananas, cassava, strip grass	Strip grass (for livestock), cassava, maize, medicinal herbs
State forest/Perhutani (*Melaleuca*)	Dryland paddy, cassava, maize, mangoes, bananas, peanut, *petai*, *kapok*, strip grass	Dryland paddy, maize, strip grass
Village forest in Watulumbung (teak, mahogany, gmelina)	Strip grass, cassava	Strip grass, cassava, firewood
Livestock	Cows, goats, chickens	Chickens

The community perceived that the extreme events associated with natural disasters frequently negatively influenced their farming practices (Table 16). The cluster's location in the proximity of Bromo Crater made this cluster prone to eruption impacts. While the local community usually did not have to take refuge outside of their village area during eruptions, volcanic ash from Bromo would likely effect community's activities, as the ashes led to growth failures in the seasonal crops. The community, however, believed that the eruption also brought benefits in terms of soil fertility increases.

The other extreme event that often negatively affected community's farming practices was heavy rain that made the local farmers unable to cultivate their land. The heavy rain periods usually added extra work, because the flooded agricultural required drying through building water channels which would increase the expenses for labor and worktime. In addition, the continuous heavy rain made the soil more solid and hard, thus difficult to cultivate. According to the female group, heavy rain also made the crops prone to pests and diseases.

Table 56. Extreme events that disrupted farming practices in Lumbang Cluster

Year	Extreme events
2010	Bromo eruption
2015	Heavy rain
2015	Pest and disease

5.4.2 Criteria and preferences for tree commodity selection

The male group chose the economic-related criteria 'commodity price' and 'commodity productivity' as the two main criteria for tree species selection (Table 57). The next tree selection criterion was 'could be intercropped with other commodities'. This criterion reflected mixed-farming practices to diversify tree and crop commodities to optimize production. Other tree selection criteria by the male group included more practical aspects such as 'fast yield', 'easy maintenance' and tree 'seedling availability'.

Considering that the cluster only had relatively low accessibility, it was quite surprising that the male group did not choose commodities' 'marketability' as one of the tree selection criteria. Thus, how the community markets their agriculture commodity, needs to be further investigated.

Like the male group, the female group selected three main criteria related to economic performance: 1) 'saving and investment', 2) had good 'marketability' and 3) 'can provide household income' (Table 57). In terms of practicality, the female group also stated that the tree 'could be harvested or bear fruit every year', 'easy to maintain', and 'fast yield'. These criteria indicate the importance of combining timber and fruit trees, as fruit trees could provide short-term income, while income from timber trees can serve as a saving account.

Table 57. Ranking of criteria for tree commodity selection in Lumbang Cluster

No	Tree selection criteria	
	Male	Female
1	High market price	Saving and investment
2	High productivity	Marketability
3	Mixed crops	Household income
4	Fast yield	Annual harvest
5	Easy maintenance	Easy maintenance
6	Seedling availability	Fast yield

Male and female groups chose durian and mango as main commodities. The next priority commodities chosen by both groups tended to vary (Figure 31). Durian, just like in Pasrepan, was the main agricultural commodity in Lumbang. The male and female groups chose durian and *sengon* as two priority commodities because those commodities met the criteria of 'high market price', 'high productivity', 'marketability' and could be used for 'saving and investment'. Durian, according to the female group, can be harvested for up to 18 years and the yields can be sold to the investor long before harvest (tree-rent scheme). Thus trees become an asset for community members in financial needs.

The male group also chose banana and kapok because these commodities were relatively simple to maintain. Banana and mango were also considered to be 'fast yield'. P*etai* and mango were the commodities with high productivity. All commodities chosen by the male group were suitable for mixed crops.

The female group chose mango, jackfruit, longan and coconut because these commodities were relatively easy to maintain and could be harvested every year. In addition, each commodity was relatively easy to sell on the market and provided stable household income throughout the year.

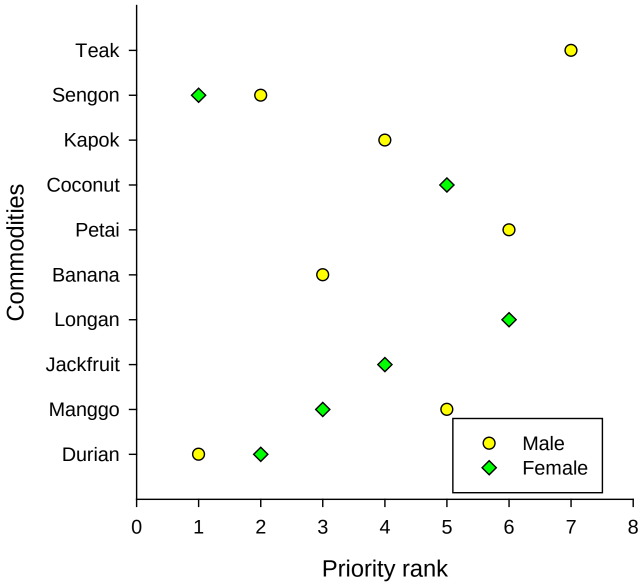


Figure 31. Priority rank of the preferred tree commodities in Lumbang Cluster

6. PASREPAN 2 CLUSTER

6.1 Cluster overview

The Pasrepan Cluster 2 (1,691 ha) lies in the midstream area of the Rejoso Watershed in Pasrepan sub-district and consists of two villages: Tempuran and Ampelsari. The cluster's topography is hilly and lies at an altitude of around 1,000 meters above sea level. Pasrepan sub-district is famous as one of the durian producing regions in Pasuruan District.

The LULC in this cluster is dominated by complex agroforest with a small area of paddy field and Perhutani (state forest company) teak forests area in Ampelsari. In Tempuran, the local community develops tree nurseries and small-scale coffee processing facilities. Most of the farming activities are carried out on the community's private land. This cluster is located quite far from the urban area in hilly terrain and with poor road quality. The wealth status of residents is lower than in the downstream clusters, such as Gondangwetan and Grati.

The total population in 2015 was 10,260 inhabitants, with 46% living below the poverty line (Table 58). Most of the population was a mixture of Javanese ethnicity with Madurese migrants that have been residents in the cluster for several decades. The number of farmers in this area is about 50% of the total population. Apart from the agricultural sector, residents in both villages worked in the forestry and livestock farming sectors. There is a local chicken farm that belongs to one of the villagers in Tempuran.

The water resources in Pasrepan 2 Cluster consisted of springs, surface wells and river water. However, the residents in both villages still relied on rainwater and government support to meet their domestic clean water and agricultural needs.

Table 58. General characteristics of the villages in Pasrepan 2 Cluster

Villages	Village area (km^2)	Distance to sub-district capital (km^2)	State forests (ha)	Number of population	Farmers (%)	Household living under poverty line (%)
Tempuran	8.36	9	-	5,817	44.4	49
Ampelsari	7.76	7	-	4,443	55.9	43

Source: Pasrepan Sub-district in Figures, 2015

6.2 Land use and land cover

6.2.1 Area of LULC

The spatial analysis was conducted for year 1990, 2000, 2010 and 2015 to assess the dynamics of LULC changes during the last 25 years. Based on the satellite imagery analysis, the LULC in this cluster was dominated by complex agroforest, followed by pine plantation, sugarcane, annual crops and paddy field. The settlement area was not clearly shown in the LULC maps in 1990-2010, as it only represented a small area. In 2015, the settlement area started to be visible in the map, indicating a high conversion of other land-use into settlement area.

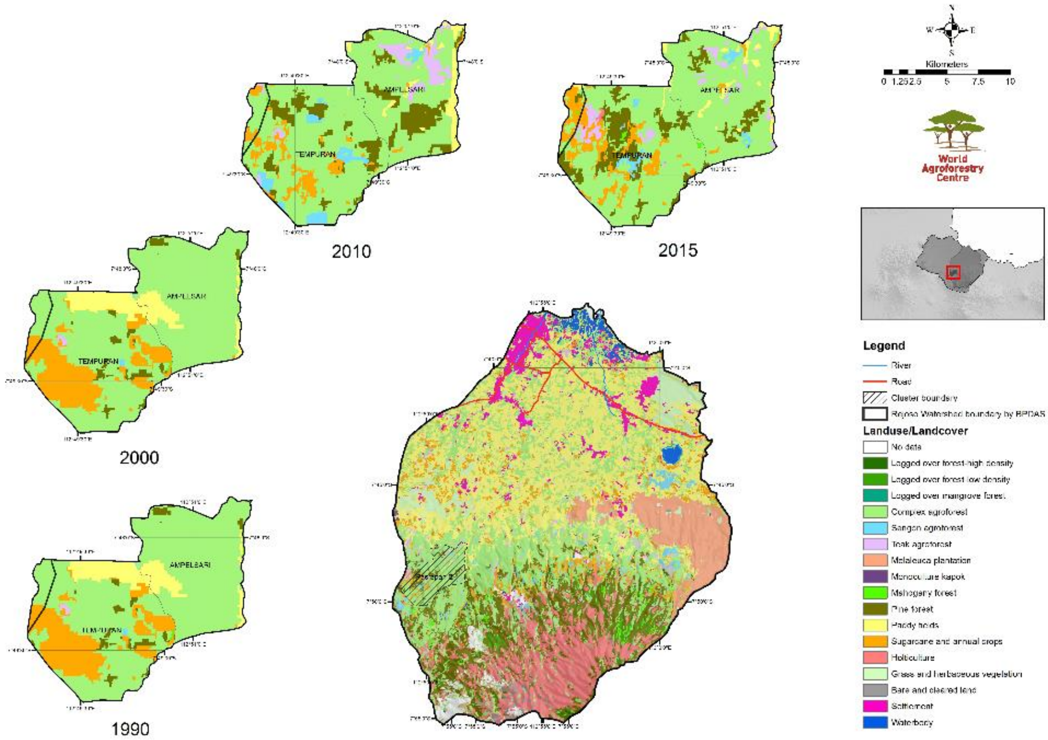


Figure 32. LULC map in Pasrepan 2 Cluster

In 1990-2015, LULC of pine plantation and complex agroforest increased by 10.2% and 7.6%. Smaller LULC types such as *sengon* agroforest and *teak* agroforest also experienced area increases of approximately 1.7% and 3.8%, respectively. Meanwhile, paddy field, sugarcane and annual crop experienced a decrease of approximately 9.2% and 12.5%, respectively. In year 2015, the LULC were still dominated by complex agroforest (68.1% of the total cluster area). The summary of the LULC change in Pasrepan 2 in 1990-2015 is shown in Table 59 and Figure 33.

Table 59. LULC area in Pasrepan 2 Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Complex agroforest	1,022.67	1,194.39	1,152.63	1,151.82
2	*Sengon* agroforest	3.06	3.06	62.19	33.03
3	Teak agoforest	2.25	4.23	81.18	67.5
4	Mahogany forest	1.71	2.7	0.54	3.69
5	Pine plantation	38.16	48.24	214.74	211.59
6	Paddy field	212.22	162	69.03	57.42
7	Sugarcane and annual crops	373.86	275.94	110.25	162
8	Grass and herbaceous vegetation	36.63	0	0	3.33
9	Settlement	0	0	0	0.18
Total		1,690.56	1,690.56	1,690.56	1,690.56

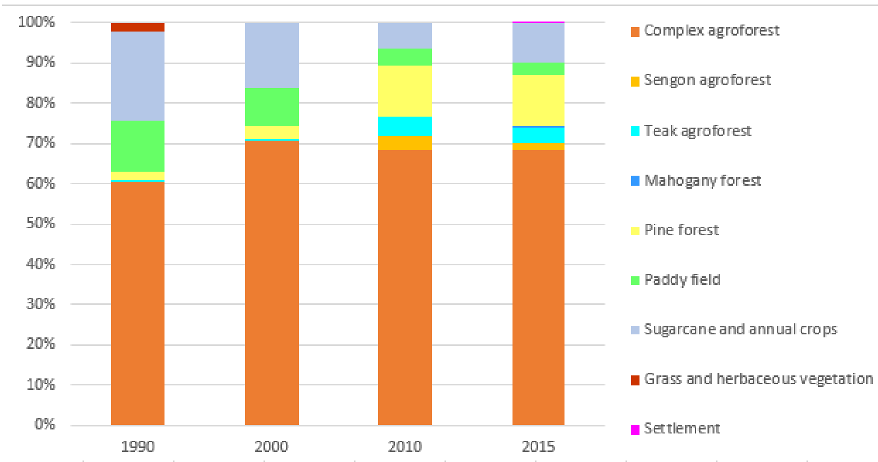


Figure 33. LULC area in Pasrepan 2 Cluster

6.2.2 The trajectory of LULC change

Based on the spatial analysis, the LULC in this cluster experienced significant changes during the last 25 years. LULC change had occurred to approximately 53% of the total cluster area (Figure 34).

The LULC changes in 1990-2015 was dominated by the conversion of sugarcane and annual crops to complex agroforest, representing 14% of the total cluster area, followed by the conversion of paddy field to complex agroforest, approximately 10% of the total area. In the same period, LULC change also occurred from complex agroforest to pine plantation (7%) and annual crops (5%) (Figure 34).

In 1990-2015, other LULC changes under 4% of the total area were the conversion from complex agroforest to teak agroforest, sugarcane and annual crops to pine plantation, and complex agroforest to paddy field. Individually, other land-use land-cover change that occurred in the cluster were not very large and covered in total 14% of the cluster area (Figure 34).

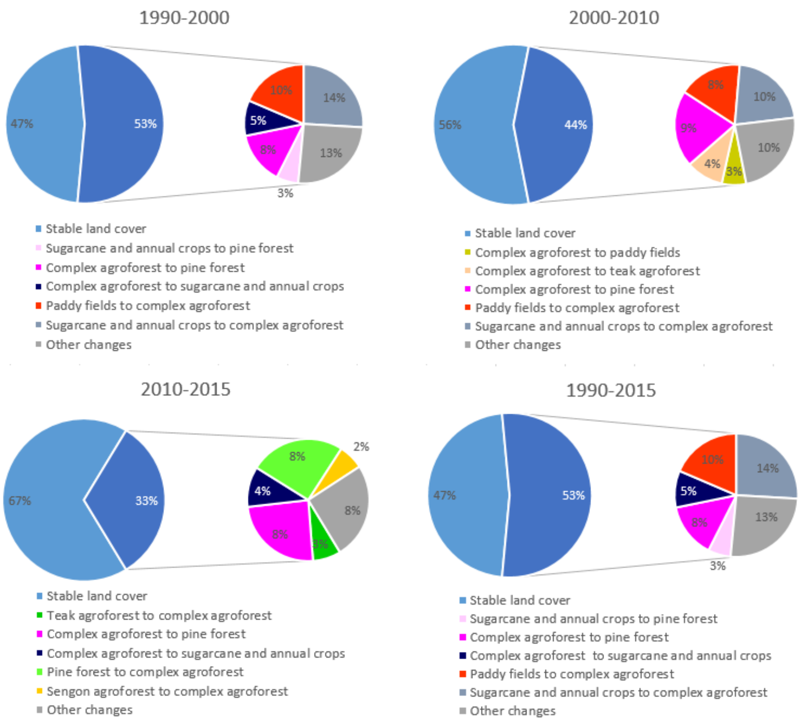


Figure 34. The trajectory of dominant LULC changes in Pasrepan 2 Cluster

6.2.3 Perceptions of the community on the drivers of LULC change

The male and female groups similarly perceived that the LULC in the cluster was dominated by complex agroforest. Both groups agreed that the willingness to improve household income was the main factor that caused LULC conversion. The female group added that the increased demand for housing was a driving-factor.

The discussion participants predicted that over the next decade, the LULC change in their area would be dominated by settlement and *sengon* agroforest, along with increased demand for housing, and an increased interest in cultivating more *sengon* in their agricultural land. *Sengon* was perceived as a good investment for increasing household income, while the timber can also be utilized as construction material for the local house.

6.2.4 Shocks (Extreme events)

The government initiated a rehabilitation program in 2005, in which the community's complex agroforest was converted into *sengon* agroforestry. The community joined the program to improve their welfare. Several factors, however, led to suboptimal performance of *sengon* agroforests including land suitability, the community's limited knowledge on good agricultural practices and pest and disease management. The local community still expected the government to help them overcome these constraints.

6.3 Water resource management

6.3.1 Water resource and utilization

Under normal conditions, spring water (65%, according to the male group and 80%, according to the female group) and river water were the main water resources for household activities. Water resources for other activities were rain water (69%, according to male group), river water (42%, according to female group) and spring water (Figure 35).

According to the male group, there was no change in the dominant water resources for households and other activities during normal dry season, leading to the abandonment of agriculture fed by rain water. According to the female group, for household activities, the use of river water increased while some hamlets received clean water subsidies. For farming practices, the community only relied on rainwater and river water.

Some springs, used for either household or other activities were located both in (distance less than 1 km away) and outside the village (more than 3 km away). The water from springs was channeled through pipes. For springs located outside the village, the villagers had to 'buy/pay a fee' to the village officials in which the springs were located. To utilize water from the springs, the community would be charged Rp3,000-Rp10,000,-/house/month. The charges excluded reparation costs for broken pipelines. Nevertheless, the spring water flow rate was felt to decrease annually.

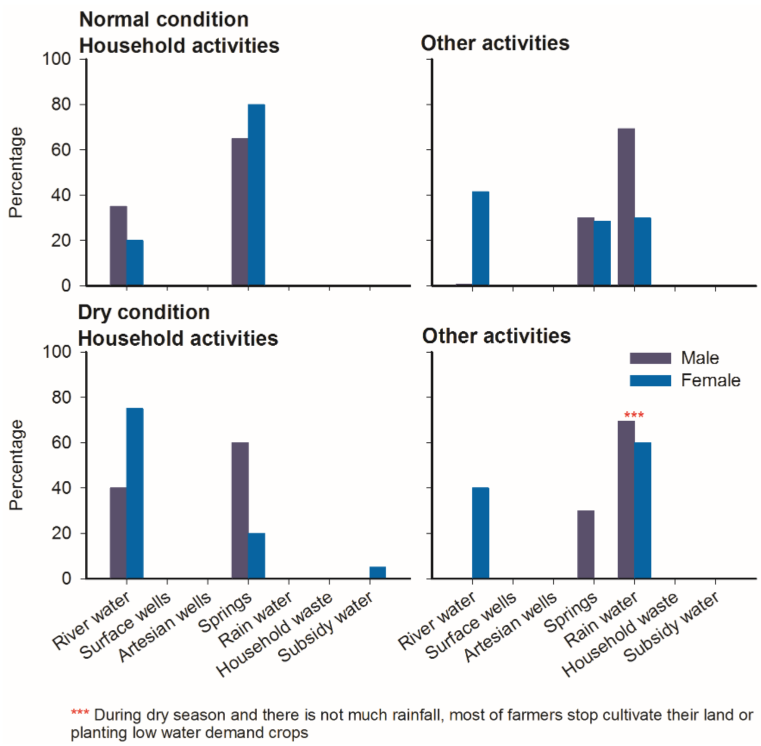


Figure 35. Water resources for domestic and other uses (agriculture, livestock, and home industries) based on the perception of female and male groups in Pasrepan 2 Cluster

6.3.2 Water resource problems

According to both male and female, the main problem related to water resources was the decreased flow rate of the springs in the dry season (Table 60). Some hamlets even experienced drought every year. In addition to being located at higher elevation than other hamlets, these hamlets were far from the springs and had land with low tree cover. However, the consequences of decreased flow rates were not seriously felt by the community as they had alternatives sources of income and could afford to buy water. The main income of the community came from bananas, dairy cows, and *sengon* as well as from complex agroforest (*kapok*, mangoes, and durian).

Turbid water and riverbank landslides, occasionally occurring in the rainy season, were also pointed out as problems by the female group. Yet, not all the community experienced these. People living near the river were the most prone to riverbank landslides, while in some locations embankments could reduce the occurrence of landslides in the riparian area.

Decreased water quantity (not caused by low rainfall) was resulted from human activities, such as logging/LULC change, rock mining, and an increasing number of water users. High rainfall in the rainy season was the driver of turbid water and riverbank landslide (Table 61).

Table 60. Water resource problems based on male and female groups' perceptions in Pasrepan 2 Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quality	Turbid	River water, spring				2	Frequent	Rainy season
	Smelly	Springs				4	Frequent	Dry season
Quantity	Decreased flow rate	Springs	1	Frequent	Dry season	1	Frequent	Dry season
Others	Landslide (riverbank)					3	Rare	Rainy season

Table 61. Drivers of water resource problems in Pasrepan 2 Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quality	Turbid	High rainfall		
		Location water resources		
	Smelly			Increasing water usage
Quantity	Decreased flow rate	Low rainfall	Logging/land-cover change	Increasing water usage
			Rock mining	Low community awareness
Others	Landslide	High rainfall		

[1] Wisdom in utilizing clean water

6.3.3 *Consequences of water resource problems*

The decreased spring water flow rate in the dry season caused problems for other but not for household activities (Table 62 and Table 63). The consequences felt by the community included decreased agricultural production, decreased milk production/livestock weight, disrupted household industries and even some people experienced crop failure.

Material losses experienced included money (reduced income or expenses for buying clean water) with the level of very heavy and non-material losses (wasted human power) with a very light level (Table 63).

Table 62. Consequences of water resource problems based on male and female groups' perceptions in Pasrepan 2 Cluster

Problems		Consequences		Score[1]	
				Male	Female
Quality	Turbid	Household activities	Disrupted household activities (water must be sediment first)		4
		Other activities	n/a		0
	Smelly	Household activities	n/a		0
		Other activities	n/a		0
Quantity	Decreased flow rate	Household activities	n/a	0	4
		Other activities	Decreased agriculture production	5	4
					5
			Decreased milk production/livestock weight		5
			Disrupted household industries		4
Others	Landslide	Household activities	n/a		0
		Other activities	Experiencing material losses (destroyed plants)		4

[1] Score 1 = very mild, 2 = mild, 3=medium, 4=serious, 5=highly serious

Table 63. Material and non-material losses consequences on water resource problems based on male and female groups' perceptions in Pasrepan 2 Cluster

Problems		Losses		Score[1)]	
				Male	Female
Quality	Turbid	Material	Possessions (clothes got dirty faster)		4
		Non-Material	n/a		0
Quantity	Decreased flow rate	Material	n/a	0	
			Money (business capital)		5
			Money (reduced income)		5
			Money (additional expenses to buy water)		5
		Non-Material	n/a	0	
			Human power		1
Others	Landslide	Material	Money (reduced income)		5
		Non-Material	n/a		0

[1)] Score 1 = very light, 2 = light, 3=medium, 4=heavy, 5=very heavy

6.3.4 Adaptation and mitigation strategies

Scores for the existing adaptation and mitigation strategies are shown in Table 64, while potential future strategies are assessed in Table 65.

The existing adaptation and mitigation strategies so far had 75% -100% success rates, except for planting trees to overcome decreased water flow rates where the female group awarded 50% success rate considering that the trees were newly planted. Accordingly, planting trees and searching for new water resources were potential strategies to overcome the decreased water flow rate. Nonetheless, limitations included limited funds and the remote tree planting location outside the village. Looking for extra income and borrowing money were the efforts undertaken to overcome agriculture production decrease.

Table 64. The success of adaptation and mitigation strategies which had been done in Pasrepan 2 Cluster

Problems/Drivers		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Turbid	Rest water to sediment		75			
	Smelly				Plant trees	-	50
Quantity	Decreased flow rate	Using other water resources		100	Plant trees	100	50
		Buy water		100	Social effort (water management by *ulu-ulu*, official)	100	0
					Fix infrastructure (clean reservoir)	100	0
Others	Landslide				Plant trees		80
					Build infrastructure (Rock embankment)		90
Consequences	Decreased agriculture production	Looking for extra income	100	75			
		Borrowing money		100			

[1)] Score 1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 65. Potential adaptation and mitigation strategy in Pasrepan 2 Cluster

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Turbid						
Quantity	Decreased flow rate				Looking for water resources	1	1
					Build infrastructure (make reservoir, install water meter)	2	2
					Plant trees	3	
Others	Landslide						
Consequences	Reduced agriculture production	Looking for extra income		1			

6.4 Farming practices

6.4.1 Farming systems and extreme events

Farming systems in Pasrepan 2 Cluster were dominated by complex agroforests (*kebun campur in local language)*. Generally, mixed gardens were planted with various tree commodities such as *sengon*, durian, jackfruits, mangoes, *petai*, *kapok*, cloves and coffee, combined with seasonal crops such as corn, cassava and *empon-empon* (medicinal plants such as ginger and turmeric).

Other agroforestry farming systems included mixed timber plantation with *sengon* and teak as the dominant commodities. In addition to *sengon* and teak, the timber plantation area was usually planted with fruit trees, tubers, medicinal herbs, and strip-grass used for livestock fodder. The community also cultivated their home garden with tree-crops, such as durian, *rambutan*, jackfruits, mango, mangosteen, *petai*, and chili among others. Two irrigated paddy field areas could be found in Tempuran and Ampelsari villages. Besides rice as the main commodity, the irrigated paddy field was usually planted with corn, cassava, coconut and sweet potatoes that were mostly used for own consumption.

In the east of Ampelsari Village, lies forest land that belonged to the state forest company (Perhutani), which was also cultivated by the villagers. In the forest area, the community cultivated corn, tubers (such as cassava and sweet potatoes) and peanut.

The community in Tempuran also cultivated complex agroforest, in which the farmers usually cultivated durian, avocado, *sengon*, and medicinal herbs. A household-scale coffee processing unit and a small scale plant nursery for durian, *sengon*, coffee and cloves seedlings were operating in Tempuran Village. At the time of discussion, the nursery was only used for the local farmers in Tempuran.

Cow-livestock farming was one of the local community's main livelihood sources, in addition to agriculture. Several farmers raised the livestock for a fee from the owners, shared the profit or took part in calf sharing.

The main source of income for the farmers in this cluster came from tree-commodities such as durian, banana, mango, jackfruits and cloves. All non-timber commodities were usually allocated for domestic consumption. Table 66 summarizes various farming systems and commodity utilizations in Pasrepan 2.

Table 66. Farming systems and commodity utilization in Pasrepan 2 Cluster

Farming systems	Commodities	
	For sale	For own consumption
Irrigated paddy field	Paddy, maize, cassava, coconuts, sweet potatoes	All commodities partly kept for own consumption
Mixed-garden(complex agroforests)	Sengon, durian, avocadoes, jackfruits, mahogany, *petai*, papaya, *kapok*, *jengkol*, mangoes, cloves, coconuts, coffee, maize, cassava, medicinal herbs	Non-timber commodities partially kept for own consumption, strip grass for livestock
Home-garden	Bananas, durian, *rambutan*, jackfruits, mangoes, mangosteen, *sengon*, cloves, coffee, chili	Except for cloves, all commodities partly kept for own consumption
State forests in Ampelsari (teak, mahogany)	Cassava, sweet potatoes, maize, peanut	Non-timber commodities partially allocated for own consumption, strip grass for livestock
Timber	Sengon, teak, cassava, sweet potatoes, coconuts, durian, mangoes, medicinal herbs	Non-timber commodities partially allocated for own consumption, strip grass for livestock
Coffee agroforestry	Coffee, durian, *sengon*, *empon-empon*, *kapok*, bananas, avocadoes	Non-timber commodities partially allocated for own consumption
Livestock	dairy cows, dairy products (candies, milk tofu, and soaps)	All allocated for own consumption

Community's farming practices were disrupted through pests and diseases of various plants, such as bananas, cassava, durian, cloves and *sengon* (Table 67). In 2013-2014, the tuber and tree commodities such as cassava, sweet potatoes, durian, banana and *salak* experienced crop failure due to a long drought. Drought also caused the young *sengon* trees (less than one year old) failing to grow. In 2016, excessive rain in this cluster resulted in harvest failures of many fruit-trees and made the farmers unable to cultivate their agricultural land.

Table 67. Extreme events that disrupted farming practices in Pasrepan 2 Cluster

Year	Extreme events
1998/1999	Pest and disease (Nematodes)
2013-2014	Prolonged drought
2016	Heavy rain

6.4.2 Criteria and preferences for tree commodity selection

The male discussion participants chose 'fast yield' and 'land suitability' as the main criteria for tree selection. The 'land suitability' criterion was related to the altitude and the water difficulties in this cluster (Table 68). The male group also consider economic reasons, such as 'household income', 'marketability' and as' saving and investment' i.e. that the trees could be inherited by their offspring. The selected trees needed to comply with 'easy maintenance' because the farmers only had limited resources and knowledge to manage the tree.

The female group chose 'high selling price' as the main tree selection criteria, triggered by community's agricultural income reliance on tree commodities. In addition, selected trees needed to be 'resilient to pest and disease', 'resilient to drought' and 'easy to maintain'.

Table 68. Ranking tree selection criteria in Pasrepan 2 Cluster

No	Tree selection criteria	
	Male	Female
1	Fast yield	High market price
2	Land suitability	Resilience to disease
3	Household income	Fast yield
4	Easy maintenance	Resilience to drought
5	Marketability	Marketability
6	Saving/investment	Easy maintenance

Durian, mangoes, cloves and *sengon*, were the four main commodities chosen by the male and female groups (Figure 36). The female group chose durian as their first priority because of its high market price, marketability, and resiliency to drought. The group chose the non-timber commodities *kapok* and coffee as their second and third priority. *Kapok* was chosen for its resilience to drought, pest and disease, and relatively easy maintenance. Coffee, in addition to being resistant to drought, was chosen due to its fast yield. Sengon, mango, *petai*, and clove were considered as the commodities with good marketability and fast yields.

The male group chose *sengon* as their main commodity because of its good marketability, could be used for savings, had a significant contribution to household income, relatively fast yielding and could be considered as saving and investment for their offspring. Banana, jackfruit, mango and durian, which can be harvested every year, were the households' main source of income.

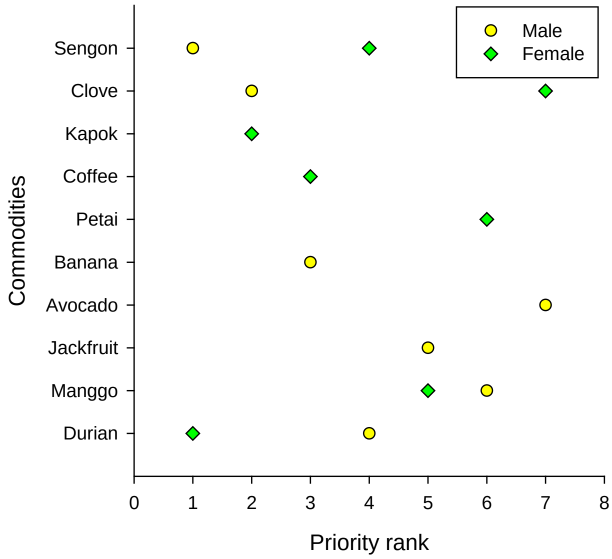


Figure 36. Priority rank of the preferred tree commodities in Pasrepan 2 Cluster

7. PUSPO CLUSTER

7.1 Cluster overview

Puspo Cluster (2,615 ha) lies is in the upstream area of the Rejoso Watershed in Puspo Sub district and consists of two villages: Keduwung and Pusungmalang. This cluster has hilly topography with many slopes and lies at an altitude of more than 1,000 meters above sea level. Most of the agricultural land is in foothills with steep slopes.

The LULC was dominated by complex agroforest and pine plantation owned by Perhutani. In addition to the complex agroforest, the community cultivated seasonal crops in the foothill slopes. In Keduwung village, the community develops small-scale plant nurseries, which produce clove, coffee, *gmelina*, *jabon*, onion and cabbage seeds and seedlings.

Puspo Cluster is far from the urban area, with poor road access. The total population in 2015 was 5,567 people, with 41% of the population living below the poverty line. Most of the population was a mixture of Javanese ethnicity with Tengger tribe who came from the Bromo Mountain area.

56% of the total population were farmers with the main source of income coming from the seasonal crops such as potatoes, cabbage scallions and from tree crops such as coffee and clove. Both villages also had cow livestock. Due to limited access and low quality of infrastructure, community wealth in this cluster is comparably lower than in the in the downstream and midstream communities of the Rejoso watershed.

The two villages in this cluster got their clean water straight from springs channeled to houses. For their farming practices, the villagers used rainwater and springs that flow to the farmland.

Table 69. General characteristics of villages in the Puspo Cluster

Villages	Village area (km^2)	Distance to sub-district capital (km^2)	State forests (ha)	Number of population	Farmers (%)	Household living under poverty line (%)
Keduwung	9.52	15	536	2162	60.2	45
Pusungmalang	6.93	19	325	3405	52.2	37

Source: Puspo Sub-district in Figures, 2015

7.2 Land use and land cover

7.2.1 Area of LULC

LULC classifications had been conducted for year 1990, 2000, 2010 and 2015 to analyze the dynamics of LULC change during the last 25 years. Based on the spatial analysis, the LULC in this cluster was dominated by horticulture land, followed by pine plantation and complex agroforest. The settlement area was not visible in the land-use map as it only represented a relatively small area.

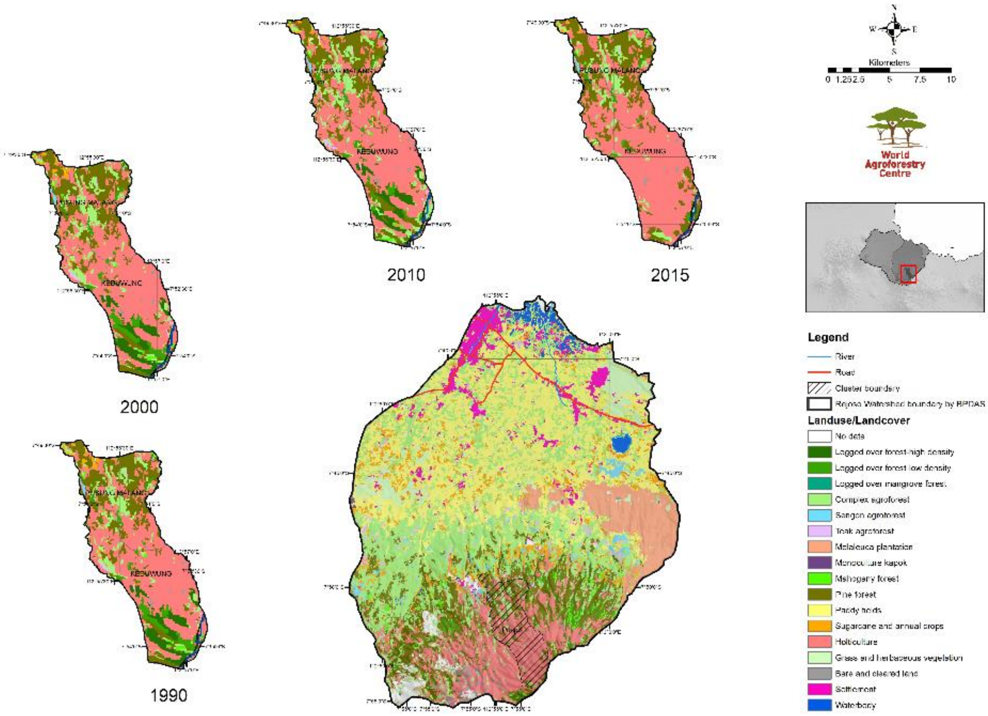


Figure 37. LULC map in Puspo Cluster

In 1990-2015, the horticulture land that initially accounted for 24.6% of the total area in 1990 increased to 62.9% in 2015. Pine plantation area was slightly decreased (1.6%) and represented 25% of the total cluster area in 2015. In 1990-2015 complex agroforest also experienced a decrease by approximately 4.3%. The other LULC's were relatively stable and represented only a small proportion of the cluster. A summary of the LULC in 1990-2015 can be seen in Table 70 and Figure 38.

Table 70. LULC in Puspo Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Logged over forest-high density	195.39	171.54	142.83	0.99
2	Logged over forest-low density	126.72	127.62	82.17	43.83
3	Complex agroforest	335.88	270.81	323.91	224.82
4	*Sengon* agroforest	5.31	7.92	7.92	7.92
5	Teak agroforest	13.59	14.31	18.27	2.07
6	Mahogany forest	39.96	27.09	25.74	10.98
7	Pine plantation	697.23	595.98	614.7	655.02
8	Sugarcane and annual crops	196.92	39.78	21.51	13.77
9	Horticulture	1002.15	1349.91	1364.4	1645.02
10	Grass and herbaceous plants	1.44	1.53	5.04	0.36
11	Bare and cleared land	0.45	8.55	8.55	10.26
Total		2,615.04	2,615.04	2,615.04	2,615.04

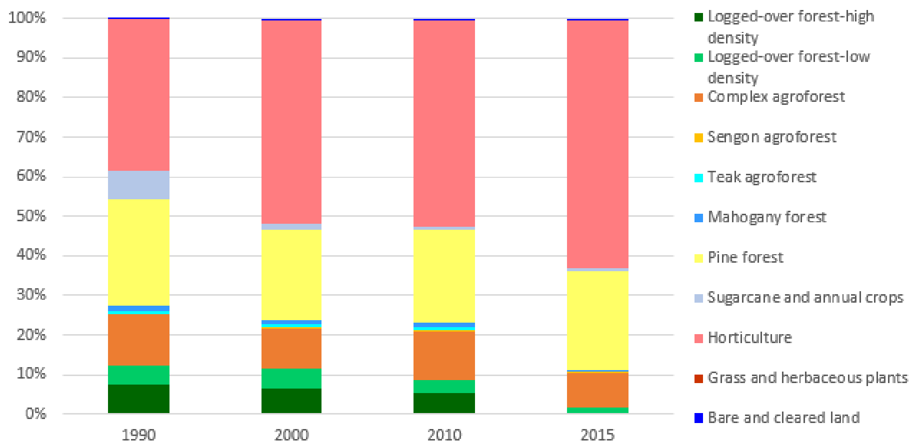


Figure 38. LULC area in Puspo Cluster

7.2.2 The trajectory of LULC change

Based on the spatial analysis, LULC in this cluster experienced significant changes during the last 25 years. Approximately 44% of the total cluster LULC had changed (Figure 39).

In 1990-2015, the LULC changes in the cluster was dominated by the conversion of pine plantation to horticulture (10% of the total area), followed by the conversion of logged forest and complex agroforest to horticulture (6% each). Other LULC changes accounted for 12% of the total cluster area (Figure 39).

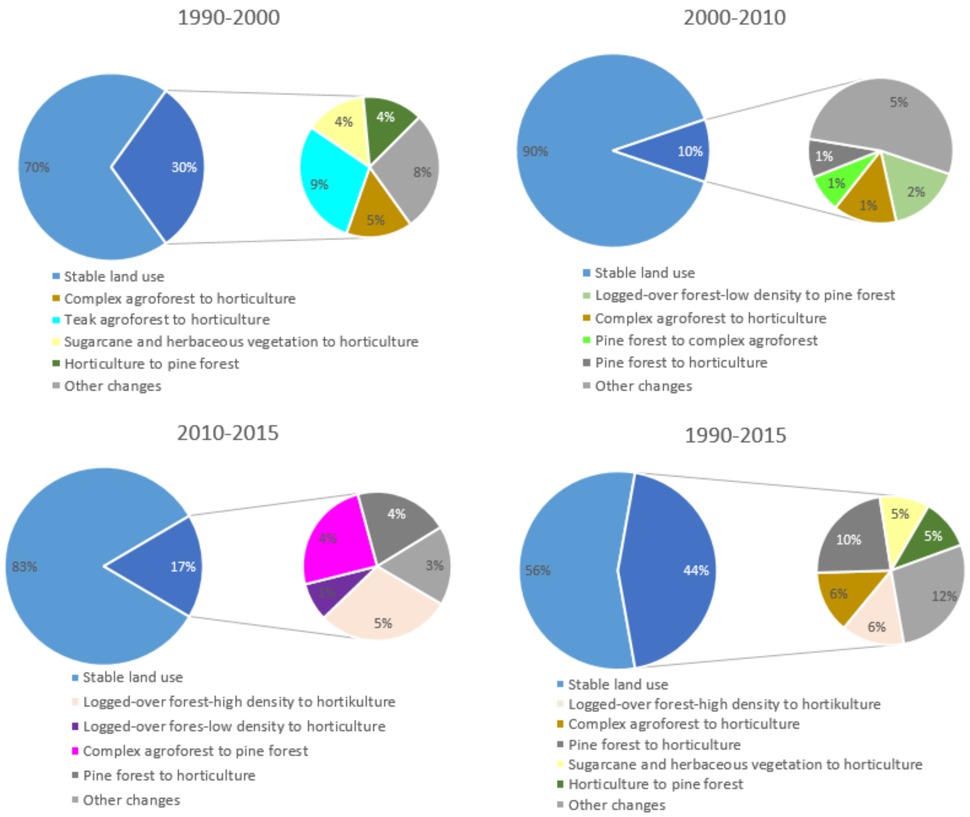


Figure 39. Trajectory of LULC change in Puspo Cluster

7.2.3 Perceptions of community on the drivers of LULC change

The male and female groups similarly perceived LULC to be dominated by complex agroforest and horticulture plants but they had different opinions on the drivers of LULC change during 1990-2015 period. The male group argued that the willingness to increase household income, the need for settlement, and the ease to cultivate plants were the three main driving factors of LULC change. The female group argued that the commodity pattern, the need for settlement and the need for cultivation area were the three main factors that caused LULC change.

Both groups predicted that over the next 10 years, LULC change would lead to the development of settlements and horticulture crops driven by the needs for settlement and income generation. Horticulture plants were expected to increase revenues and meet main food consumption.

7.3 Water resource management

7.3.1 Water resource and utilization

Under normal conditions, springs were the water resources used for household activities (100% according to both male and female groups). For other activities, the dominant water resources used were rain water (80% according to the male group and 63% according to the female group) and springs (Figure 40).

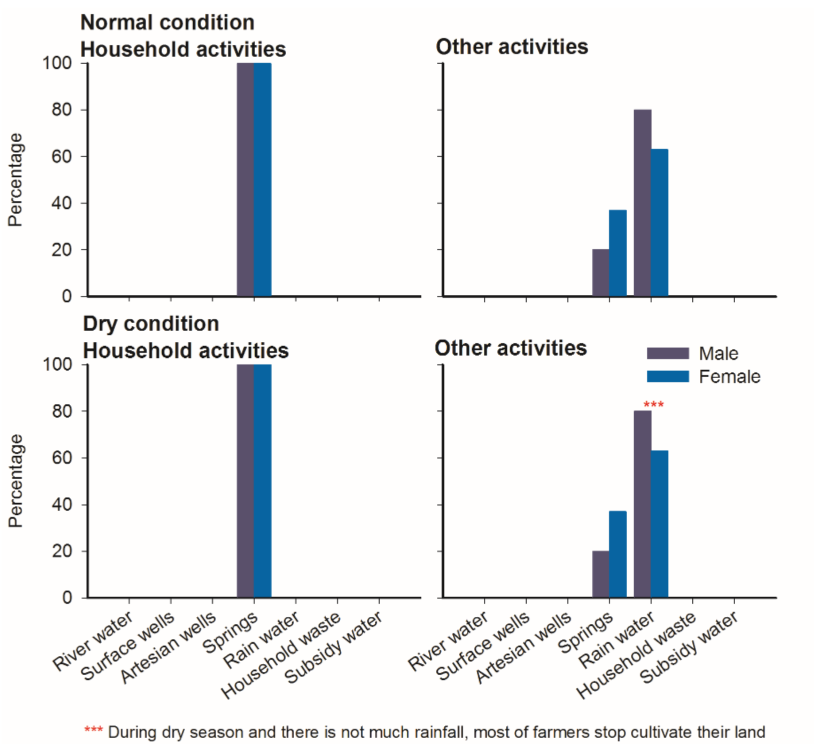


Figure 40. Water resources for domestic and other uses (agriculture, livestock, and home industries) based on the perception of female and male groups in Puspo cluster

During dry season, there was no change in the main water resources used for both household and other activities. Consequently, a lot of agricultural land which relied on rain water was not cultivated.

Springs used for household and other activities were situated within village (less than 1 km away) and outside the village (more than 3 km away). The springs were channeled to farms and houses through pipes. Using the spring water was free of charge and only pipe repair would lead to costs for the community. Yet, the flow rate from some springs had decreased annually.

7.3.2 Water resource problems

According to the male group, the main problem was the decreased amount of spring water which occasionally occurred during the dry season (Table 3). According to the female group, landslides (frequently occurring in rainy season) were the main problem (Table 4). The people who lived or had agricultural land in the area with steep slopes were exposed to landslides. In the landslide prone area, conservation techniques had been applied, that had reduced landslide occurrence.

Low flow rates were the result of low rainfall in dry season, human activities such as logging/LULC change and broken pipes due to landslide. Contrarily, high rainfall in the rainy season as well as logging/LULC change were the drivers of landslides (Table 72).

Table 71. Water resource problems based on male and female groups' perceptions in Puspo Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quality	Turbid	Springs	5	Rare	Rainy season	2	Frequent	Rainy season
	Smelly	Springs	-	-	-	5	Rare	Non-seasonal
Quantity	Decreased flow rate	Springs	1	Rare	Dry season	4	Frequent	Dry season
	Flood	River water	4	Rare	Rainy season	3	Frequent	Rainy season
Others	Soil Erosion	-	3	Rare	Rainy season	-	-	-
	Landslide	-	2	Rare	Rainy season	1	Frequent	Rainy season

Table 72. Drivers of water resource problems in Puspo Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quality	Turbid	High rainfall		
		Erosion		
	Smelly	Bromo eruption		
Quantity	Decreased flow rate	Low rainfall	Logging/land-cover change	
		Landslide (broken pipes)		
	Flood	High rainfall		Low community awareness[1)]
Others	Soil erosion	High rainfall	Logging/land-cover change	
	Landslide	High rainfall		
		Natural condition (cliffs and landslide prone areas)		

[1)] Throw rubbish to the river

7.3.3 Consequences of water resource problems

Both household and other activities were negatively impacted by decreasing flow rates during dry season (Table 73 and Table 74). For household activities, consequences included spending time for water queuing or for some even to buy clean water. For other activities, consequences included decreased agriculture and milk production and livestock weight. The consequences were of the same on problems due to landslides.

Material losses experienced included money (business capital, reduced income or expenses for buying clean water) and property (broken plants) while non-material losses included time and human power, ranging from very light to heavy level (Table 74).

Table 73. Consequences of water resource problems based on male and female groups' perceptions in Puspo Cluster

Problems		Consequences		Score[1)]	
				Male	Female
Quality	Turbid	Household activities	n/a	0	
			Water could not be consumed		5
		Other activities	n/a	0	0
	Smelly	Household activities	Water could not be consumed	-	1
		Other activities	n/a	-	0
Quantity	Decreased flow rate	Household activities	Disrupted household activities (queuing for water)	5	5
		Other activities	Decreasing milk production/livestock weight	4	5
			Decreased agriculture production	-	5
	Flood	Household activities	n/a	0	
		Other activities	Decreased agriculture production	3	
Others	Landslide	Household activities	n/a	0	-
		Other activities	n/a	0	-
	Landslide	Household activities	Experiencing material losses (falling houses)	5	
			Drivers of water shortage in households		5
		Other activities	n/a	0	
			Decreasing milk production/livestock weight		5
			Decreased agriculture production		5

[1)] Score 1 = very mild, 2 = mild, 3=medium, 4=serious, 5=highly serious

Table 74. Losses due to water resource problems based on male and female groups' perceptions in Puspo Cluster

Problems		Losses		Score[1)]	
				Male	Female
Quality	Turbid	Material	n/a	0	
			Money (to buy clean water)		5
		Non-Material	n/a	0	0
	Smelly	Material	n/a	-	0
		Non-Material	n/a	-	0
Quantity	Decreased flow rate	Material	Money (reduced income)	3	5
			Money (business capital)		5
		Non-Material	Human power	1	
			Time	1	
			n/a		0
	Flood	Material	Money (business capital)	3	
			Possessions (plants destroyed)		5
		Non-Material	sadness	3	
			n/a		0
Others	Landslide	Material	n/a	0	-
		Non-Material	n/a	0	-
	Landslide	Material	Possessions (houses)	5	
			Additional expenses		4
			Money (business capital)		5
			Money (reduced income)		5
		Non-Material	Sadness	3	
			Human power		3

[1)] Score 1 = very light, 2 = light, 3=medium, 4=heavy, 5=very heavy

7.3.4 Adaptation and mitigation strategies

Scores for the existing adaptation and mitigation strategies are shown in Table 75, while potential future strategies are assessed in Table 76.

So far, both the undertaken adaptation and mitigation strategies had reached 75%-100% success rate, except for the effort to overcome landslides and odor problems. According to the female group, the bad smell, the consequence of Mount Bromo's eruption, was accepted and there had been no effort to overcome it. The efforts to overcome landslide by applying conservation techniques included planting trees on the farm (25% success rate awarded by the male group), considering the relatively small number of trees planted. In line with this, the future strategy against landslides was planting trees. However, fund remained to be the main obstacle. In addition, finding new water resources and raising community awareness to plant trees were the future strategies to combat decreasing water resources. Looking for extra income was an effort to take to overcome the consequences of reduced water quantities.

Table 75. The success of adaptation and mitigation strategies which had been done in Puspo Cluster

Problems/Drivers		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Turbid	Save water usage		75	Build infrastructure (build reservoir with filter)	100	-
		Rest water to sediment		100	Social effort (clean the reservoir)	100	-
	Smelly	-	-	-	-	-	-
Quantity	Decreased flow rate	Using other water resources	100	-	Plant trees	100	-
		Save water usage	-	100	-	-	-
	Flood	-	-	-	Fix infrastructure (deepen water channels)		100
Others	Landslide	-	-	-	Implement conservation technics	50	
	Landslide	-	-	-	Social effort (working together to fix pipes)		100
Consequences	Disrupted household activities	Using other water resources	-	100	-	-	-
	Decreased agriculture production	Looking for extra income	100	100	-	-	-
		Borrowing money	100	100	-	-	-
		Go to another city	100		-	-	-

[1)] Score 1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 76. Potential adaptation and mitigation strategies in Puspo Cluster

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Turbid	-	-	-	-	-	-
	Smelly	-	-	-	-	-	-
Quantity	Decreased flow rate	Looking for extra income	3	-	Facility and infrastructure procurement for clean water (water suction machine)	2	-
		-	-	-	Looking for water resources	1	-
	Flood	-	-	-	Increase community awareness to plant trees in their land	2	-
		-	-	-	Fix infrastructure (widen water channels)	-	1

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Others	Soil erosion	-	-	-	Plant trees	2	-
		-	-	-	implement conservation technics	1	-
	Landslide	-	-	-	Plant trees	1	-
Consequences	Disrupted household activities	Looking for extra income		1	-	-	-
	Decreased agriculture production	-	-	-	-	-	-

7.4 Farming practices

7.4.1 Farming systems and extreme events

Most of the community in the Puspo Cluster cultivated mixed gardens (complex agroforest) and horticulture plantation both in private and in Perhutani land. The high altitude of Puspo Cluster limited the type of fruit-trees that could be cultivated in the area. Some fruit-trees that were relatively suitable in the cluster included jackfruits, guava and avocado.

A lot of bamboo was grown in the plantation, riverbank and alongside the road. Generally, bamboo used to grow naturally and was not really cultivated. The community had just begun to plant bamboo for the last five years, due to significantly decreasing bamboo cover, to reduce landslides and to maintain the water quality.

Complex agroforest, which was referred to as "*tegal*" by the local community, was commonly planted with various timber and non-timber comodities such as cemara (*Casuarina junghuhniana*), *sengon*, mahogany, acacia, cloves, coffee, bamboo and *gmelina*, combined with fruit trees such as jackfruits and avocados as well as seasonal crops such as sweet potatoes, potatoes, cabbage and strip-grass. Cemara (*Casuarina junghuhniana*) was still widely planted by the local community, mainly to utilize its twigs as firewood for domestic cooking purposes, as not many villagers in Puspo used propane stoves. In addition to pine twigs, acacia twigs were also used for cooking. Meanwhile, strip grass was grown for cows which were largely farmed.

Other farming systems included coffee agroforestry, combined with mahogany, avocado, ginger and strip grass. Coffee, fruits and medicinal herbs harvested from coffee agroforestry were partially kept for the farmers' domestic consumption. The community also cultivated their home-gardens with coffee, banana, chayote, pomelo, guava, avocado, jackfruits, *empon-empon* (medicinal herbs) and strip-grass. Coffee and strip-grass planted in home gardens were mostly used for own consumption (coffee) and livestock fodder (strip-grass).

Although the LULC was dominated by complex agroforest, the community relied on horticulture commodities as their main livelihood. Since the water resources for agriculture activities were limited and most of the available land located on the hillside, the three major crops included potatoes, cabbage and scallions in rotation systems, usually combined with carrots, chili, maize, cassava and taro. The community also planted their home-gardens with trees such as cemara (*Casuarina junghuhniana*) and *sengon*, especially if the area was located on slopes.

The farmers also worked on Perhutani's land by practicing horticulture (potatoes, cabbage, and scallions) in between mahogany and pine tree plantations. The community also planted corn as household staple food reserve and strip-grass for livestock fodder. The community needed to pay a contract fee collected by Perhutani. The detail on the procedure to use the state forest land, however, needs to be further clarified. Timber and non-timber nurseries were developed by the local farmers e.g. for coffee, clove, gmelina, *sengon*, scallion and cabbage. T

The community also raised livestock such as cows (for meat and dairy products), goats and chickens, as one of their main sources of income. The dairy milk was usually sold to collectors that frequently came to the villages. The local farmers practiced two livestock management schemes: 1) being the direct owners that raised and sold their livestock or 2) being the person entrusted by the livestock owners to raise livestock with a service fee, profit sharing, or livestock calf sharing.

Table 77. Farming systems and commodity utilization in Puspo Cluster

Farming systems	Commodities	
	For sale	For own consumption
Home-garden	Coffee, bananas, chayote, *medicinal herbs*, *pomelo*, cloves, guava, avocados, jackfruits, strip grass	Strip grass, *medicinal herbs*
Mixed-garden (*tegalan*)	Cemara (*Casuarina junghuhniana*), *sengon*, mahogany, jackfruits, acacia, gmelina, *jabon* tree, bamboo, *suren*, cloves, coffee, sweet potatoes, potatoes, cabbage, strip grass	Maize, acacia (firewood), cemara (*Casuarina junghuhniana*) (firewood), mahogany (construction), coffee, strip grass
Coffee agroforestry	Coffee, mahogany, *lamtoro*, bananas, avocadoes, *dadat, medicinal herbs*, strip grass	Coffee, fruits, *medicinal herbs*, strip grass,
Seasonal crops	Potatoes, cabbage, onion, carrots, chili, maize, cassava, and taro, cemara (*Casuarina junghuhniana*), *sengon*	All commodities were kept for own consumption
State forest/Perhutani (mahogany, pine, cemara (*Casuarina junghuhniana*))	Maize, potatoes, cabbage, scallions	Strip grass, maize
Livestock	Dairy cows, cattle, goats, chickens	All commodities were kept for own consumption

Extreme events disrupting farming practices were dominated by natural events. Being located closely to Bromo crater had made the cluster prone to the direct impact of the eruption, as occurred in 2011 and 2016. When an eruption occurred, the community would not be able to work on their agricultural land, and the crops and grass would be dead covered with ash from the eruption.

Farming practices were mostly done on the hill slopes, which made the community's agricultural land prone to landslide, especially during rainy season. As response, the community planted trees such as cemara (*Casuarina junghuhniana*), *sengon* and cloves that were perceived to prevent landslide.

From a socio-economic perspective, the significant decline of potato prices occurring in 2015 that led to excess production was considered as disruption for livelihood, particularly because potatoes were the major source of households' income in Puspo. As response, the community shifted to cultivate other commodities and focused on milk production.

Table 78. Extreme events that disrupted farming practices in Puspo Cluster

Year	Extreme events
2010	Heavy rain and typhoon
2011	Bromo Eruption
2014	Landslide
2015	Potato price fall
2016	Bromo eruption
2016	Prolonged rain

7.4.2 Criteria and preferences for tree commodity selection

Male and female groups stated that 'marketability', 'high market price', 'own consumption' and 'easy maintenance' were the important criteria to select tree commodities. The remote location made farmers dependent on collectors that frequently came to their area. Thus, cultivated trees needed to be commodities that could be easily sold or marketed to the collectors. 'Own-consumption' was an important criterion because the community still used the tree as firewood and as construction material for their domestic needs.

The male group perceived that the 'land suitability' as the most important criteria in selecting tree species, since the agricultural area in this cluster was located in a sloping area (1,000 meters above sea level). With only limited water available for the agricultural activities, the farmers required tree commodities that would be able to adapt to the cluster's condition. The other criteria to select tree commodities were 'resilience to pest and disease', as well as 'marketability' and 'high market price'.

The female group mentioned the economic-related criteria such as 'high market price' and 'marketability' as the main consideration for selecting tree commodities. The 'own consumption' criterion was the third most important criteria for this group, followed by “easy maintenance’. The female group mentioned an interesting criterion ‘water resource protection', indicating the awareness of planting trees for water protection. In addition, shading of their agricultural land was important, especially for coffee agroforestry.

The male and female groups preferred similar commodities, such as coffee, cloves, jackfruits, cemara (*Casuarina junghuhniana*) and *sengon*. The male group chose bamboo as their priority plant because of its good marketability, ease of maintenance, suitability to be cultivated in the cluster, good market price and resiliency to pests and diseases. Cloves were selected as the next prioritized tree-commodity because due to its high selling price and marketability, although clove was relatively more difficult to maintain and prone to diseases.

Table 79. Ranking of criteria for tree commodity selection in Puspo Cluster

Ranking	Tree selection criteria	
	Male	Female
1	Land suitability	High market price
2	Resilience to pest and disease	Marketability
3	Marketability	Own consumption
4	High market price	Easy maintenance
5	Own consumption	Water resource protection
6	Easy maintenance	Shading

Coffee’s market price was relatively high and the crop was suitable to the land condition in this cluster. Coffee and cemara (*Casuarina junghuhniana*) were also consumed by the households; coffee was served as daily beverage while cemara (*Casuarina junghuhniana*) was used as firewood and building material. Jackfruits and avocados were suitable to be cultivated in the area, while *sengon* was chosen as the crop that was vastly planted by the community and highly sought by commodity collectors.

The female group chose coffee and cloves as their main commodities mainly for economic reasons and as these could also be consumed by the households. The market price of both commodities, particularly cloves, were relatively high and both had good marketability. Jackfruit was as the only fruit crop chosen by this group (Figure 41). The next commodities selected by the female group included cypress, acacia, *sengon* and mahogany. Sengon, cemara (*Casuarina junghuhniana*) and jackfruits were used as shade for coffee plants. Cemara (*Casuarina junghuhniana*) and acacia were used by the households for firewood and construction materials.

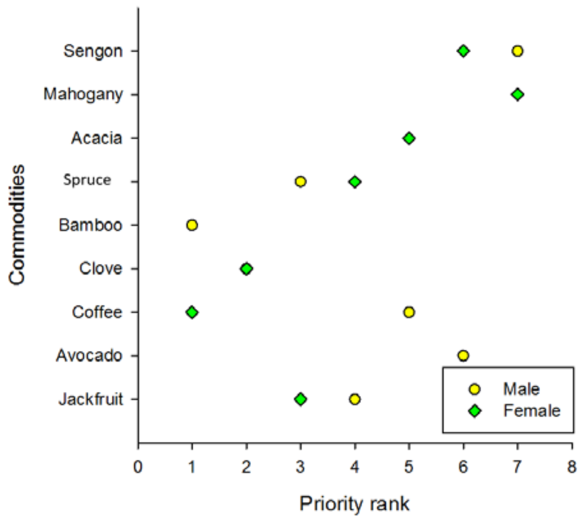


Figure 41. Priority rank of the preferred tree commodities in Puspo Cluster

8. TOSARI CLUSTER

8.1 Cluster overview

Tosari Cluster (2,277.9 ha) is located at the highest altitude of Rejoso Watershed (more than 1,000 meters above sea level with mountainous terrain) and directly adjacent to Bromo National Park in Tengger. The cluster covers two villages: Sedaeng and Wonokitri of Tosari Sub-district. Tosari Sub-district is one of the main gateways to Bromo Tourism Area.

The dominant land-cover is seasonal crops with the main commodities comprised of potatoes, onion, cabbage and the pine forest plantation owned by Perhutani (State Forest Company). The community conducted practices in their private farmland and on Perhutani's land. The high elevation and the number of protected forests in the surrounding areas limit commodity options and areas that can be cultivated by the local farmers, thus pushing the farmers to cultivate the slopes in the foothills.

Although the Tosari Cluster is located quite far from urban areas with hilly terrains, the road access to this area is good due to its status as a major tourism area. The poverty level of most of population is slightly above the one of the downstream villagers (Gondangwetan and Grati).

The total population was 5,754 people in 2015 with 38% of the population living below the poverty line. The ethnicity of the community is Tengger – or native Bromo - who have lived in the foothill of Mount Bromo for hundreds of years. 60% of the total population are farmers. Apart from the agricultural sector, the community of both villages, especially in Wonokitri, depend on the tourism sector for their main source of income.

Despite being in the upstream area of the Rejoso Watershed, the water availability in both villages was quite limited, particularly for agricultural activities. The community used spring water for their domestic water supply and relied on rain water to fulfill their farming practice needs.

Table 80. General characteristics of the villages in the Tosari Cluster

Villages	Village area (km^2)	Distance to sub-district capital (km^2)	State forests (ha)	Number of population	Farmers (%)	Household living under poverty line (%)
Wonokitri	38.18	4	2,870	3,034	61.6	34
Sedaeng	9.56	6	919.7	2,720	57.5	42

Source: Tosari Sub-district in Figures, 2015

8.2 Land use and land cover

8.2.1 Area of LULC

Based on the satellite image analysis, the LULC in this cluster was dominated by horticulture plantation, followed by the pine plantation and complex agroforest. The settlement was not clearly shown in the land-use land-cover map as it only represented a relatively small area.

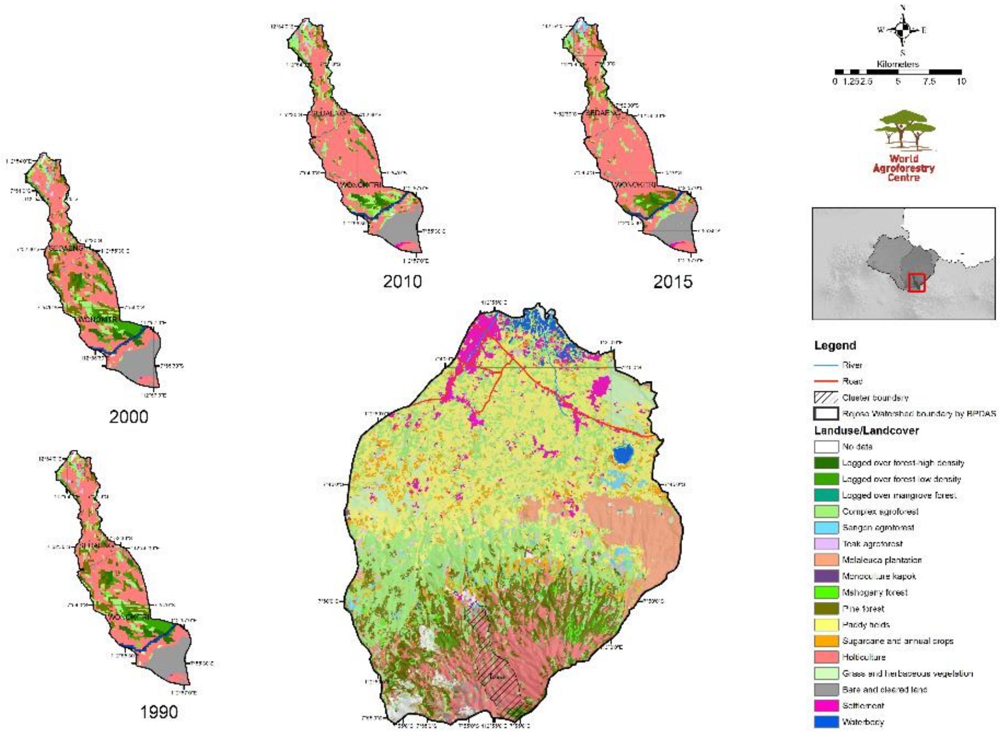


Figure 42. LULC map in Tosari Cluster

In the period of 1990-2015, the horticulture area was increased from 20.6% to 62.8% of the total cluster area. The pine plantation and complex agroforest areas were decreased by 7.2% and 4.0%, respectively. In 2015, pine plantation and complex agroforestry covered about 9.6% and 10.3% of the total cluster area. Other LULC area were relatively stable. Table 81 and Figure 43 show a summary of the LULC in the Tosari cluster in 1990-2015.

Table 81. LULC area in Tosari Cluster

No.	Land-use and land-cover	Area (hectares)			
		1990	2000	2010	2015
1	Logged over forest-high density	117.99	110.7	62.37	17.64
2	Logged over forest-low density	161.1	153.09	44.46	24.39
3	Complex agroforest	326.16	258.75	323.91	234.36
4	*Sengon* agroforest	3.15	14.58	9.27	29.07
5	Teak agroforest	13.23	10.71	13.5	12.51
6	Mahogany forest	23.85	11.88	15.66	12.15
7	Pine plantation	382.95	278.19	137.43	219.51
8	Sugarcane and annual crops	13.41	10.35	4.14	4.32
9	Horticulture	961.47	1,132.11	1,368.72	1,430.37
10	Grass and herbaceous vegetation	23.4	14.58	10.8	9.36
11	Bare and cleared land	240.03	270.9	269.73	266.04
12	Settlement	3.69	4.59	10.44	10.71
Total		2,277.9	2,277.9	2,277.9	2,277.9

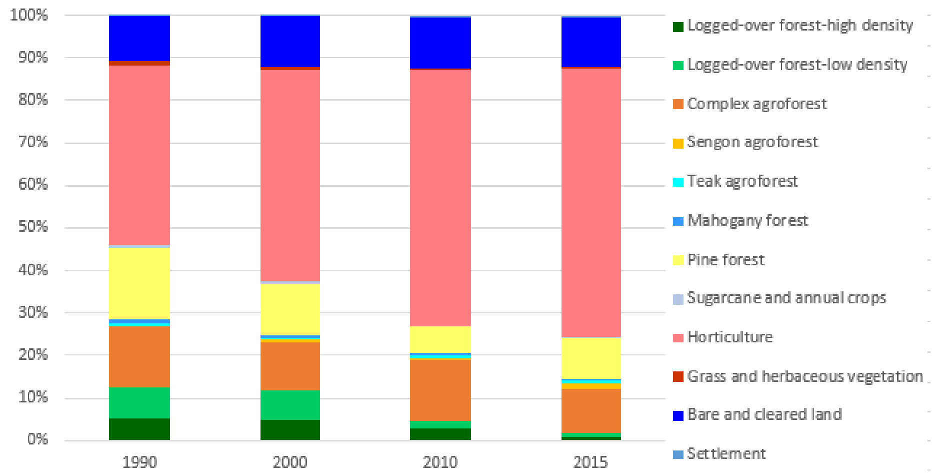


Figure 43. LULC area in Tosari Cluster

8.2.2 The trajectory of LULC change

The spatial analysis indicated that the LULC experienced a significant change over the last 25 years. Figure 44 shows that approximately 49% of the cluster area were converted in 1990-2015. LULC changes in 1990-2015 were mainly dominated by the conversion of pine plantation to horticulture (12%), followed by the conversion of complex agroforest to horticulture (9%). The overall LULC changes were mainly dominated by the conversion of various land-uses to horticulture. The conversion of horticulture and complex agroforest LULC to pine plantation; and horticulture land to bare and cleared land covered below than 3% of the total area. The non-agricultural land-use changes represented about 16% of the total cluster area.

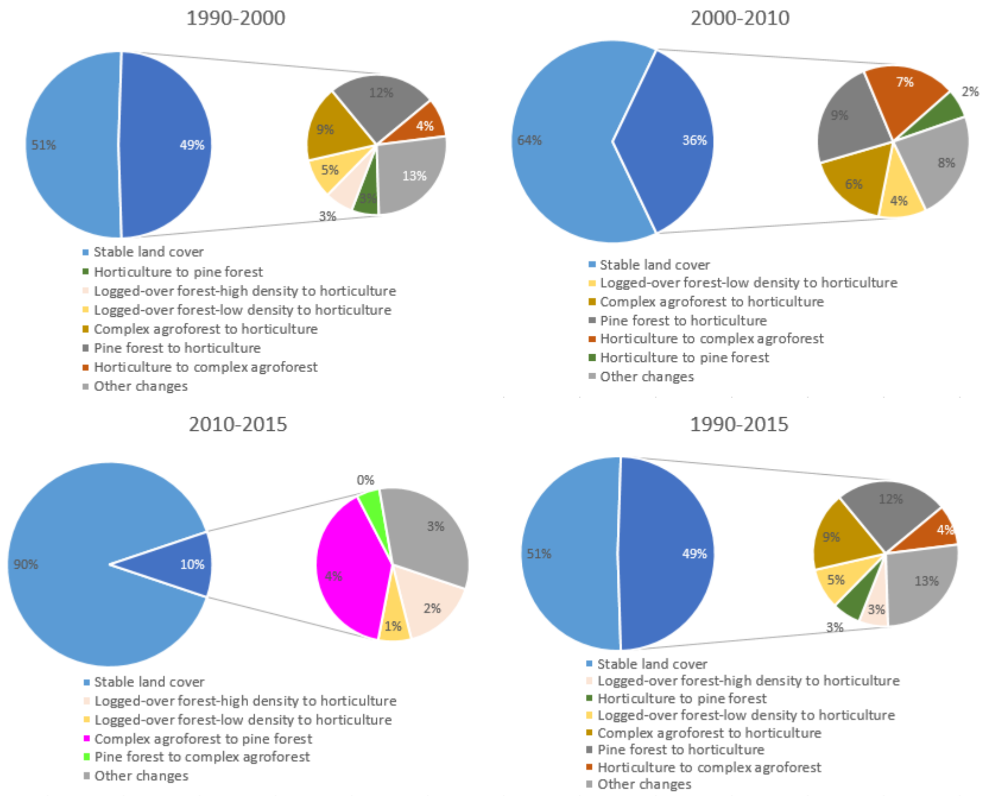


Figure 44. Trajectory of LULC change in Tosari Cluster

8.2.3 Perceptions of community on the drivers of LULC change

The community perceived the dominant LULC in this cluster was dominated by forest and horticulture land. The group perceived that increased demand for settlement and the willingness to improve household income were the main drivers that induced LULC. A lot of residents converted their agricultural land into hostels for the tourists to increase their household income. The local community perceived that conversion of agricultural land into settlement area had increased the risk of landslides – particularly in the sloping area and reduced the number of springs and green open space.

The discussion participants predicted that over the next 10 years, the LULC change would be dominated by the conversion of seasonal crops/horticulture lands into settlement area. The participants also estimated that several LULC's, comprised of forests, tree plantation, horticulture and bare/cleared land that are located close to the border of Bromo National Park would remain stable, as most of the LULC would be conserved to maintain the integrity of the park.

8.3 Water resources

8.3.1 Water resource and utilization

According to the male group, the water resource used for household activities, both in normal and dry conditions, were only springs. Meanwhile, according to the female group, the water resources used for normal conditions included springs (80%) and rain water (20%) (Figure 45). In Wonokitri, there were 3 main springs located within the village whose water was channeled through pipes. In Sedaeng, there were 3 main springs to use. Two of the springs were located outside the village with a distance of 2-7 km and were channeled through pipes. In the last 5 years, the springs' flow rate had remained stable, both in the dry season and rainy season and was able to meet the household needs.

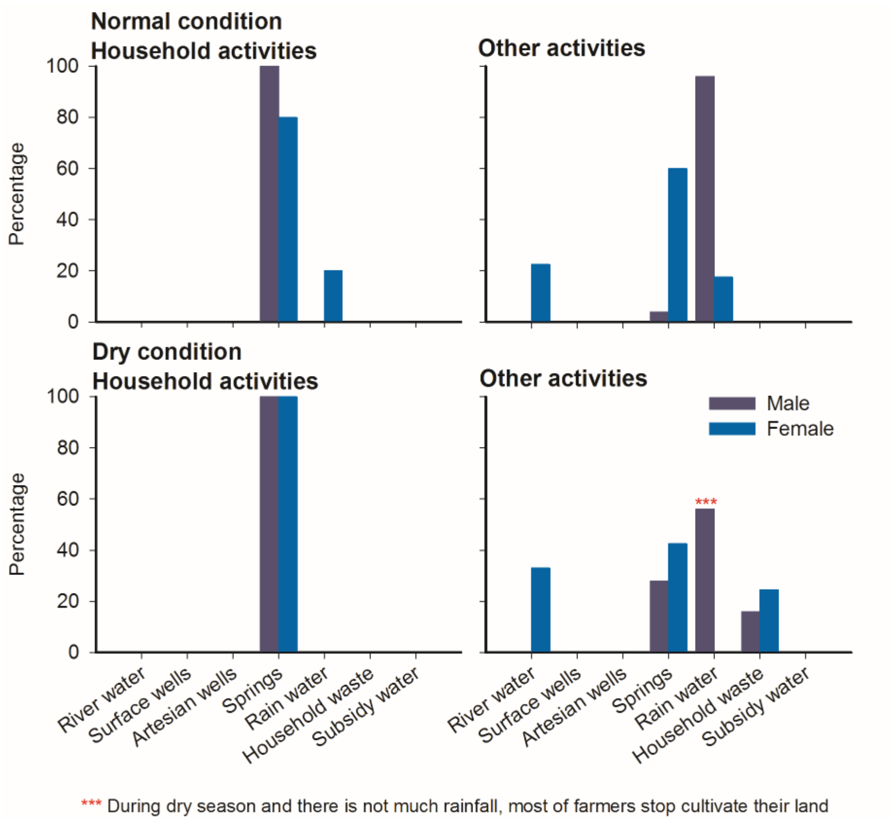


Figure 45. Water resources for domestic and other uses (agriculture, livestock, and home industries) based on the perception of female and male groups in Tosari cluster

For other activities, the water resources used were more varied. According to the male group, the water resources used under normal conditions included rain (94%) and spring water (4%). According to the female group, the water resources were springs (amounting 60% since there were many water resources with small flow rate near the farmland), river water (22%) and rain water (18%). Under dry conditions, both female and male groups mentioned that the land close to the settlement area was irrigated with household waste water while farmland far from the springs was not cultivated.

8.3.2 Water resource problems

According to the male and female groups' perceptions, the main problem related to water resources was the decreasing amount of spring water in the dry season (Table 82). However, for household activities, the amount of reduced water could still meet household needs. For other activities, especially agriculture, some land area close to settlement area was irrigated with household waste water while part of the farmland far from the springs was not cultivated.

Other main problems were landslides and erosion. The community living in steep terrain locations with few trees was prone to landslides, while the farmland which did not apply conservation technique was prone to erosion.

Drivers of reduced water quantity, other than low rainfall, included human activities such as logging/LULC change and a lack of community awareness in maintaining water infrastructure. Contrarily, high rainfall in the rainy season, human activities such as logging/LULC change and community's lack of awareness to apply conservation techniques caused landslides and erosion (Table 83). The community also believed that the decreasing amount of water or landslides took place due to the lack of ritual ceremonies.

Table 82. Water resource problems based on male and female groups' perceptions in Tosari Cluster

Problems		Water resources	Male			Female		
			Rank	Frequency	Period	Rank	Frequency	Period
Quality	Turbid	Springs	4	Rare	Rainy season	3	Rare	Rainy season
	Water not iodized	Springs				4	Frequent	All year
Quantity	Decreased flow rate	Springs	1	Frequent	Dry season	1	Frequent	Dry season
Others	Erosion	-	3	Rare	Rainy season			
	Landslide	-	2	Frequent	Rainy season	2	Frequent	Rainy season

Table 83. Drivers of water resource problems in Tosari Cluster

Problems		Drivers		
		Nature activities	Human activities	Human resources
Quality	Turbid	High rainfall and surface runoff water went through reservoir		Less appropriate infrastructure condition
		landslide		
	Water not iodized	Village condition in highland	-	-
Quantity	Decreased flow rate	Low rainfall	Logging/land-cover change especially around spring	Low community awareness in maintaining water infrastructure
				less religious ritual ceremony
Others	Erosion and landslide	High rainfall and slanted land condition	Logging/land-cover change	Low community awareness to implement conservation technics
		Natural condition (steep land)		Less spiritual ceremony

8.3.3 Consequences of water resource problems

According to the male group, the main problems of springs (decreased flow rate), landslide and erosion did not cause significant material losses and consequences (Table 84 and Table 85), except for erosion problems. Erosion problems caused non-material losses of time with a very small level. In average, the people in Wonokitri and Sedaeng had more than one land to manage with various access to water resources.

The female group, on the contrary, stated that the decreasing amount of spring water in the dry season caused a decrease of agricultural production, leading to income decreases. Moreover, dry season resulted in difficulties to find livestock fodder (a lot of grass could not grow), so some people had to buy grass from elsewhere. The occurrence of landslides also caused material losses in the form of property and money (business capital).

Table 84. Consequences of water resource problems based on male and female group perceptions in Tosari Cluster

Problems		Consequences		Score[1)]	
				Male	Female
Quality	Turbid	Household activities	n/a	0	0
		Other activities	n/a	0	0
	Water not iodized	Household activities	Mumps		3
		Other activities	-		
Quantity	Decreased flow rate	Household activities	n/a		0
			Disrupted household activities	1	
		Other activities	n/a	0	
			Disrupted livestock farming (fodder scarcity)		5
			decreased agriculture production		5
Others	Erosion	Household activities	n/a	0	0
		Other activities	Experiencing non-material losses (time)	1	0
	Landslide	Household activities	n/a	0	
			Experiencing material losses (broken houses		5
		Other activities	n/a	0	
			Experiencing material losses (plants destroyed, livestock died)		4

[1)] Score: 1 = very mild, 2 = mild, 3 = medium, 4 = serious, 5 = very serious

Table 85. Material and non-material losses due to water resources problems based on male and female group' perceptions in Tosari Cluster

Problems		Losses		Score[1)]	
				Male	Female
Quality	Turbid	Material	n/a	0	0
		Non-Material	n/a	0	0
	Water not iodized	Material	Money (additional expenses)		1
		Non-Material	n/a		0
Quantity	Decreased flow rate	Material	n/a	0	
			Money (reduced income)		5
			Money (additional expenses)		3
		Non-Material	Time	1	0
Others	Landslide	Material	n/a	0	
		Non-Material	Time	1	
	Landslide	Material	n/a	0	
			Possessions (houses, plants)		3
			Money (business capital)		3
		Non-Material	n/a	0	0

[1)] Score: 1 = very light, 2 = light, 3 = medium, 4 = heavy, 5 = very heavy

8.3.4 Adaptation and mitigation strategies

Scores for the undertaken adaptation and mitigation strategies are shown in Table 86, while potential future strategies are assessed in Table 87.

Mitigation strategies had a success of 50%-100% and included planting trees (to overcome decreased flow rate, erosion/landslides), repairing/building infrastructure (to mitigate decreased flow rate), applying conservation techniques (to overcome landslide/erosion), having social assistance such as *gotong-royong* to fix infrastructure, reporting to the village officials on damaged pipes and promoting the ban on logging around the spring. The development of clean water infrastructure such as piping and reservoirs as well as tree planting were efforts which still needed to continue to overcome the problems of water quality and quantity. However, funding was the main obstacle. Looking for other extra income and borrowing money were the efforts undertaken to overcome the consequences of reduced agricultural production.

Table 86. The success of adaptation and mitigation strategies which had been done

Problems/Drivers		Adaptation Strategies	Score[1)]		Mitigation Strategies	Score[1)]	
			Male	Female		Male	Female
Quality	Turbid	Rest water to sediment	-	100	Plant trees	-	75
					Social effort (gotong-royong clean the reservoir	100	100
	Water not iodized	Consume iodized salt	-	100	-	-	-
		Consume sea products		50			
Quantity	Decreased flow rate	-	-	-	Plant trees	50	75
		-	-	-	Social effort (forbid logging round the spring)	100	100
		-	-	-	Social effort (reporting to officials of the village)	50	-
					Social effort (perform religious ritual ceremony)		100
		-	-	-	Build infrastructure (reservoir on agriculture land)		75
					Search water in other water resources		100
Others	Erosion	-	-	-	Implement conservation technics	75	-
		-	-	-	Plant trees	75	-
	Landslide	-	-	-	Implement conservation technics	-	75
		-	-	-	Plant trees	-	75
		-	-	-	Build infrastructure (embankment)	-	75
Consequences	Decreased agriculture production	Looking for other extra income	-	50	-	-	-
		Borrowing money	-	50	-	-	-
	Disrupted livestock farming				Sell livestock		75

[1)] Score 1= 0% success, 2=25% success, 3=50% success, 4=75% success, 5=100% success

Table 87. Potential adaptation and mitigation strategies in Tosari Cluster

Problems/Drivers		Adaptation Strategies	Rank		Mitigation Strategies	Rank	
			Male	Female		Male	Female
Quality	Turbid	-	-	-	Build infrastructure (build reservoir)	-	1
	Water not iodized	-	-	-	-	-	-
Quantity	Decreased flow rate	-	-	-	Build infrastructure (disseminating piping program, making reservoir)	2	1
Others	Erosion	-	-	-	-	-	-
	Landslide	-	-	-	Plant trees	1	-
					Implement conservation technics (making water channels in farming land)		
Consequences	Reduced agriculture production	-	-	-	-	-	-

8.4 Farming practices

8.4.1 Farming systems and extreme events

The farming systems in Tosari Cluster consisted of the community-owned tree plantation (commonly referred to as the community forest), Perhutani's (state forest company) land, protected forests and livestock farming. As the cluster was situated in the foothills of a mountain, a lot of the community’s agricultural land was located on steep slopes that were prone to landslides. The local community’s main source of income came from potatoes, cabbage and scallions.

The community forest was commonly planted with horticultural commodities, such as potatoes, cabbage, onion and maize. In Sedaeng, the community planted carrots in the community forest, while in Wonokitri, carrots were not planted as they did not grow as well. The land’s altitude limited the choices of commodities that could be cultivated by the community in Wonokitri, as not many commodities were suitable for the high altitude.

The community forest was also planted with tree crops such as cemara (*Casuarina junghuhniana*), acacia, coffee and bamboo. Most of the commodities were utilized for household domestic needs, such as for firewood, construction materials, or household consumption (coffee and maize). Besides cemara (*Casuarina junghuhniana*) and acacia were planted to avoid erosion in the agricultural land. In addition, the community also planted strip-grass to provide fodder for their cows and pigs. The local community also cultivated on the Perhutani land, planting potato, cabbage, onion and maize. According to the discussion participants, the whole yields from the commodities cultivated on the Perhutani land would be sold and they would only collect cemara (*Casuarina junghuhniana*) branches for their domestic firewood needs from this land.

Livestock, particularly cows and pigs, was another source of income. Pigs were raised for own-consumption by the Hindu’s Tengger community in the cluster.

The community’s had a high awareness on the importance of maintaining protected forest in their area, particularly to maintain the hydrological function and prevent disasters such as landslides and erosion. In addition, they still used the acacia flowers that existed in the protected forest for sale, as well as strip-grass, edelweiss flowers, acacia flowers, and amethyst flowers for their cultural ceremonies.

Table 88. Farming systems and commodity utilization in Tosari Cluster

Farming systems	Commodities	
	For sale	For own consumption
Community forests	Potatoes, cabbage, scallions, carrots (Sedaeng)	Cemara (*Casuarina junghuhniana*), acacia, maize, coffee (in Sedaeng), strip grass, bamboo
State forest/Perhutani (mahogany, cemara (*Casuarina junghuhniana*))	Potatoes, cabbage, onion, and maize	Part of harvest yields were kept for own consumption. Cemara (*Casuarina junghuhniana*) branches for firewood
Livestock	Beef cattle (pigs, cows)	Pigs
protected state-forest/national park border (acacia, cemara (*Casuarina junghuhniana*)	Acacia tree flowers	Strip grass, edelweiss flower

The extreme events that often disrupted farming practices mainly came from eruptions of Bromo volcano (Table 89), as the cluster is located closely to crater. In several incidents, the community had to take refuge outside their villages when the eruption status of Bromo Crater was raised to alert. Landslides in the plantation area were unavoidable as most of the farming practices were carried out on the sloping hills. Nevertheless, the discussion participants claimed that the consequences from the landslides were rarely fatal.

The most disruptive socio-economic event was the fall of potato prices. Potato was the main commodity for most farmers livelihood. If the potato price fall was accompanied by a Bromo eruption, the community's livelihood would be severely disrupted.

Table 89. Extreme events that have disrupted farming practices in Tosari Cluster

Year	Extreme events
2006	Bromo eruption, landslide
2008	Bromo eruption and typhoon
2010-2011	Eruption
2015-2016	Eruption
2014, 2015	Potato price fall
Every year	Small-scale landslide on garden and main road

8.4.2 Criteria and preferences for tree commodity selection

Both the female and male groups showed a high degree of environmental awareness reflected in their tree selection criteria (Table 89). The female group chose 'disaster prevention' as main criteria, which is mainly related to the tree function to strengthen the soil in order to prevent landslides and erosion in their agricultural land. The male group chose the 'protection to water resources' as main criteria in selecting tree species, particularly to maintain the water quantity in the springs, and to 'prevent landslide' in their agricultural land.

The male group also chose 'land suitability' as one of the criteria, due to the limited choice of tree commodities that could be planted in the high altitude, followed by the 'shading' criterion that indicated the tree were used for providing shade and a land boundary marker. The group also stated 'own consumption' as one of the main criteria, particularly to utilize the tree for firewood because many villagers still used firewood and charcoal for their domestic cooking purpose. 'Marketability', the only criteria related economy, was selected as the last criteria.

The second and third criteria stated by the female group were trees that could be 'used as firewood', 'for own consumption and cultural ceremonies'. The female group also selected the criteria of 'land suitability', 'easy maintenance', and 'construction materials' as the reasons to select tree commodities.

Table 90. Ranking of criteria for tree commodity selection in Tosari Cluster

No	Tree selection criteria	
	Male	Female
1	Water resource protection	Disaster prevention
2	Landslide prevention	Firewood
3	Land suitability	Own consumption and cultural ceremony
4	Shading	Land suitability
5	Own consumption	Easy maintenance
6	Marketability	Construction materials

The commodities chosen by the male and female groups were quite diverse (Figure 46). Both male and female groups chose cemara (*Casuarina junghuhniana*) tree as their main priority due to the multiple benefits that cemara (*Casuarina junghuhniana*) provided, including landslide prevention, firewood and land boundary delineation. In addition, the mature cemara (*Casuarina junghuhniana*) timber could also be sold as construction material.

The second prioritized tree-crop, was bamboo for the female group due to its function in ritual activities, as source of income, and as landslide prevention. *Terpasan* was chosen as the third prioritized tree species because it could be used for firewood, maintain the soil, to prevent landslide and was relatively easy to maintain. Banana and coffee could be used for own consumption and ritual offerings in the cultural ceremonies. Amethyst was the least prioritized commodity that was selected by the female group and could be used for ritual ceremonies.

In contrast to the female group, the male group chose amethyst as their second priority. Amethyst was perceived to provide benefits in maintaining the quality and quantity of spring water. After amethyst, the male group chose coffee, *tunjung* (lotus), *kerangean*, mountain guava and bamboo, which were considered suitable to be cultivated in the cluster.

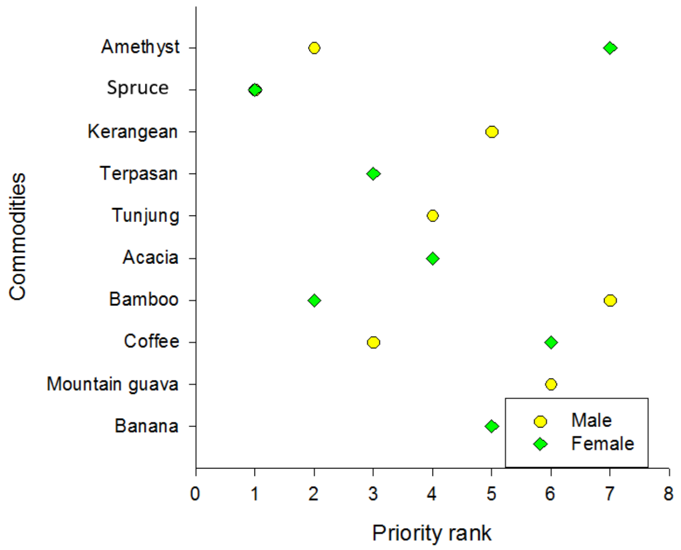


Figure 46. Priority rank of the preferred tree commodities in Tosari Cluster