Mapping of Land Use System, Soil Degradation, Sustainable Land Management and Assessing Impacts on Ecosystem Services in Ciwidey Sub Watershed in West Java

Masterarbeit

der philosophisch-naturwissenschaftlichen Fakultät
University of Bern

Vorgelegt von:

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2011

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Master's Thesis submitted to the
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Cover photo: Farming lowland in Ciwidey sub watershed
(Cinzia De Maddalena, summer 2010)

World Overview of Conservation Approaches and Technologies

centre for development and environment

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Preface

My interest in the integration of bio-physical and social aspects rose already during high school when I wrote a thesis about the impacts of monsoon on the Indian population. The courses in integrative geography with the focus on bio-physical issues were the main focus of my career as student of Geography at the University of Bern. In addition to this I absolved several courses relating to natural hazards, water issues, and human geography. Furthermore, I wrote my bachelor thesis in context of sustainable land management, particularly about the social movement of organic agriculture in Switzerland.

During an around-the-world-trip I became increasingly interested in South East Asia's land use systems and landscapes. I realized that sustainable land management technologies are an important asset for land users not only in arid regions, but also in the tropics. In particular, regions which have considerable seasonal variability of rainfall triggered my interest. Thus, Indonesia with its monsoon climate, where humid conditions are prevalent and pressure on natural resources is threatening for the environment, offered a very interesting and challenging research setting.

I got attentive to the *world overview of conservation technologies and approaches* (WOCAT), a program documenting best practices for different bio-physical conditions and social environments. My main motivation in doing this case study was to assess a watershed in order to provide knowledge for an integrative watershed management.

Acknowledgment

The realization of this research project was enabled by the support, consultation, advice, and assistance of numerous persons. I highly appreciate the interest which those persons gave to my master thesis.

First, I like to express my gratitude to the *center for development and environment* (CDE), particularly Hanspeter Liniger, the coordinator of the WOCAT program and supervisor of this master thesis, and Hans Hurni, examiner of the master thesis. Furthermore I thank the staff of CDE such as Elias Hodel and Christian Hergarten for their assistance and support in ArcGIS related topics.

In addition, I appreciate much that the ministry of forestry in Jakarta, its director Dr. Silver Hutabarat, Syaiful Anwar, and Hari Tri Budianto gave me the possibility to conduct research in the Citarum watershed. I would like to say thank you to Syaiful Anwar's wife, Mayang, who was an excellent host during my stay in Jakarta and helped me to receive all the requested documents for the research permit.

A special thank is devoted to Desi Aprilliana Dewi who assisted me as translator in the workshop and the expert interviews. Without her translation and organizing skills the field research would not have been conducted that successfully. I express my gratitude to all of my interview partners namely Andre Supriatna, Ruddy Fadilah, Naik Sinukaban, Ms. Nilda, Eyang Kautsar, Avid Rollick Septiana, and Pakit Usman.

I am deeply grateful to Lebrecht Gerber for his support during the field work. Furthermore I thank Andreas Gerber for its detailed review of my master thesis.

Last but not least, I am very grateful to my colleagues Sarah Achermann, Natalie Ernst, Miriam Andonie and family members for their interest, conceptual support, and discussions related to my master thesis.

Summary

Indonesia is a developing country that is threatened by considerable pressure of population, land conversion and economic growth. Consequently, this leads to overexploitation of soil and water resources, what results in degradation of ecosystems. The cultivation of steep mountainous areas and increased soil erosion is a consequence. Soil erosion is mainly influenced by deforestation or inadequate crop and soil management and is triggered by strong rainfall events in the wet season. Production failures through floods or droughts due to *El Niño Southern Oscillation* (ENSO) or the monsoon seasons are common. The most important and also most threatened watershed in West Java is the Citarum watershed. There is an alarming rate of soil erosion in the upper Citarum watershed. Ciwidey is a sub watershed of the upper Citarum watershed and has one of the highest soil erosion rates. Hence it provides an adequate research area for this master thesis. The research area has a size of 22,169 ha and ranges from 660 m a.s.l. to 2,386 m a.s.l.

The goal of this research thesis is to map the prevailing land use systems, land degradation and conservation in Ciwidey sub watershed. More specifically this spatial assessment aims at examining the area- and intensity-trends of land use system, the types, cause, extent, degree, rate of land degradation, and the effectiveness of sustainable land management technologies. In addition, the impacts of land use systems on ecosystem services are to be assessed. Based on the gained knowledge and generated maps further planning of initiatives and decision making towards sustainable land management can be supported.

In order to achieve the objectives, the mapping methodology of the *World Overview of Conservation Approaches and Technologies* (WOCAT) program, is applied. The methodology consists of three methodological tasks. First, the prevailing land use systems are categorized and defined. Second, the land use systems in Ciwidey sub watershed are mapped. Third, expert interviews, based on the WOCAT mapping questionnaire are conducted.

Several findings arise from this master thesis which can be summarized as follows:

On one side there are the land use systems in forest land (*primary forest*, *forest plantation*, and *secondary natural forest*) which remained stable over the last decade. Major shifts are observed in cropland and mixed use. The *farming lowland* and *upland* areas increased strongly whereas *irrigated rice* declined slightly. This can be explained by the changing orientation of farmers towards more commercial cultivation of crops. Another shift is observed in the category *irrigated rice*. In addition to the conversion to *farming lowland* or *upland*, *irrigated rice* paddies disappear and are replaced by *settlements* (hotels, restaurant etc.) and *textile industries*.

The mixed land use systems differ regarding their trends. *Agroforest* (a combination of natural or planted trees with crop production) remained stable. *Bush and farming* (a mosaic of farming plots and adjacent wild shrubs and small trees), decreased slightly. *Cut and carry with farming* (rotational system with rainfed rice in rainy season, grass planting in dry season, and annual farming plots increased strongly. Based on the findings it is likely that *bush and farming* converted to *farming upland*. *Cut and carry with farming* has a strong increase due to the fact that it is a suitable land use system for overpopulated areas.

Every land use system shows signs of land degradation. In the middle watershed the extent of land degradation is largest. Predominately in *farming lowland* 50% of the area indicates a fertility decline. Top soil erosion affects 40% of the *farming upland* in the middle and lower watershed. Moreover, land degradation types such as topsoil erosion and change of quantity of surface water amount to 60%. The degree of this erosion types is moderate in farming upland and between moderate and strong in farming lowland. In the *agroforest* of the lower watershed (where no laws restrict the farmers) 20% of the area is affected by topsoil erosion or landslides. In this land use system degree of degradation is moderate and the rate increasing whereas in the middle and lower watershed the rate declines. In the forest areas illegal logging and fire is a threat that leads to a 10%-reduction of the vegetation cover.

Waterbodies such as rivers reflect inappropriate crop, soil, and waste management. Rivers are mostly threatened by pollution in the lower watershed. Therefore the degree of degradation is higher than in the other land use systems. The increased use of water for consumption or irrigation leads to water scarcity in the dry season. In contrast, floods occur in the wet season due to declined infiltration rate of soils and buffer capacity of land use systems.

In general, the Ciwidey sub watershed is broadly conserved: The highest number of different technologies is applied in cropland. Terraces are common in *farming lowland* and *irrigated rice* but rarely seen in the mixed land use systems. In contrast vegetative strips are established in mixed land use systems such as *agroforest* and *bush and farming*. The evaluated technologies contribute to a reduction of degradation in all land use systems, except obviously in *waterbodies*.

The mapped land use systems with their degradation or conservation, respectively, have an influence on ecosystem services. The degradation in cropland and mixed use has high negative effects on productive and ecological services. On the other hand the conservation impacts of these land use systems are high as well.

The synthesis of the obtained information and field observation leads to define hot spots of degrading and bright spots of conserved areas. ***Cut and carry with farming*** and the adjacent ***farming upland*** *are* the most critical areas and need additional conservation support. This could be a restart of introducing tree planting or mulch in *cut and carry with farming* fields. Financial and consulting support would be especially beneficial for farmers in *farming upland*. The planting of permanent grass strips or shrubs or improving of terraces would be a suitable practice.

The best conserved land use system is **tea plantation** because its area remained stable, is well conserved and has high positive impacts on ecosystem services. Tea planting is multifunctional and compensates for many land degradation types due to the permanent vegetation cover. The second best conserved land use system is ***irrigated rice*** that produces basic food supply and has buffering capacity to prevent or mitigate flood events. Therefore it is important to stop or slow down its conversion to *settlements* in the lower and to *farming lowland* in the middle watershed. The "legowo" system has high potential and produces, due to fish farming, an additional income. Therefore the knowledge about "legowo" should be spread more thoroughly among farmers

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Abbreviations

DPSIR Framework	Driver - Pressure - State - Impact - Response Framework
MEA Framework	Millennium Ecosystem Assessment Framework
CDE	Centre for Development and Environment
GDEM	global digital elevation map
WOCAT	World Overview of Conservation Technologies and approaches
FAO	Food and Agriculture Organization
QM	Mapping Questionnaire (Spatial assessment of WOCAT)
QT	Technologies Questionnaire (Case Studies of WOCAT)
SWC	Soil and Water Conservation
SLM	Sustainable Land Management
LADA	Land Degradation Assessment in Drylands
LUS	Land Use System
LUT	Land Use Type
ES	Ecosystem Service
ENSO	El Niño Southern Oscillation
BKSDA	Balai Besar Konservasi Dan Sumber Daya Alam (Center for Conservation and Natural Resources)
BPDAS	Balai Pengelolaan Das (Center for Management of the Citarum and Ciliwung watershed)
BKPH	Bagian Kesatuan Pemangkuan Hutan Perum Perhutani (State Company for Secondary Forest)
PHBM	Pola Hutan Bersaaja Masyarakat (Management of the Community Forest)
USLE	Universal Soil Loss Equation

1 Introduction

1.1 General Information

Indonesia is a developing country that is threatened by a considerable pressure of population growth on the natural resources. Tatin (2005: 1) states that more than half of the total land area of this archipelago – made up of 13,677 islands ranging from specks of rock to huge islands such as Sumatra, Java, Kalimantan, Sulawesi and Papua – is unsuitable for agricultural development because of very steep slopes (> 15%). According to FAO (2010), only 20 % of the entire area of the country (37.1 million ha) was identified as cultivated land in 2008. However, it has to be taken into account that some islands such as Sulawesi are less cultivated, whereas Sumatra and Java are much more heavily cultivated despite their drawback of steep slopes. Driven by the population pressure, farmers are cultivating land which is very steep and actually inappropriate for farming activities.
The major part of this steep land was forest area in the past and then it had been converted to cropland. According to Indonesia LCLUC Team (2001: 6), Indonesia lost at least 1.5 million hectare of forest every year between 1986 and 1997. This vast deforestation process negatively impacts the natural environment, implies land degradation, and diminishes land productivity.

In addition, Indonesia's rainy season (November to February) and a dry season (March to August) are amplifying the above mentioned trends. Heavy rainfall during the rainy season accelerates soil erosion since the high amount of rainfall cannot infiltrate or be stored completely during this period. The lack of infiltration can be explained by land conversion from forest land to agricultural land and from agricultural land to settlements. A large amount of precipitation triggers floods and is lost as runoff into the sea. By contrast, a lack for water for irrigation during the dry season can trigger food scarcity. According to UNEP (2003) in Wiratmo (n.d.), "rainfall has generally declined in the tropic of both hemispheres; when rain does fall, it is frequently so heavy that it causes erosion and flooding. "
Due to these circumstances *sustainable land management* (SLM) technologies and approaches are required to sustain productivity in order to strengthen the ability to deal with such disasters and hence to achieve a sustainable land by adapting SLM technologies.

However, Java is more suitable for agricultural production than the other islands of the archipelago due to fertile soil and weather condition on higher altitude. As a result of these favorable conditions for agricultural production and decent education or job opportunities in the mega cities of Java, 59% of all Indonesian people are living in Java in 2008 (FAO 2010). This census carried out by FAO (2010) measured in total 227 million inhabitants for Indonesia, of which 48.5 % are rural people.

Anyway, land conversion is a concerning issue and especially in Java it shows significant magnitude since the last 50 years assumed by Indonesia LCLUC Team (2001: 5). Indonesia LCLUC Team (2001: 5) argues that the main cause of land cover changes has been the expansion of agricultural activities, and the extraction of timber logs from natural forests. Since the Dutch period the forest was exploited to make economic benefits. According to McCauley (1986: 194) this period is characterized by conversion of forest to sedentary culture system which exported tea, coffee, cinchona and timber. This trade led to extending overexploitation and large scale conversion of forest. Even after

Indonesia reached independency in 1945, Gus Dur the fourth president of Indonesia who reigned from 1999 to 2001 animated the people to use the forest. “Due to Gus Dur, the period of mass crime on forestland had its starting point. Gus Dur told its population that the forest belongs to the people and it is empty land and has to be used (Ruddy Fadilah (2010) in Appendix 1).” This caused an increase in logging activities and the conversion of forest to agricultural land and thus clearing of significant forest area. Deforestation was still a concerning issue. Nasoetion (1999) in Indonesia LCLUC (land cover land use changes) Team (2001: 6) estimated that between the periods of 1985 to 1995, the rate of land use conversion had reached 50,000 hectare per year in the island of Java.

Nowadays, deforestation has stagnated in Java because the state controls large parts of forest and regreens cleared area by replanting programs. But illegal logging and conversion of forest land to farming plots is still not under control and an unsolved issue in several parts of Java.

The Impact of land conversion connected with considerable population growth results in a vast and over proportional need for water and productive soil for food production to secure livelihoods of the Javanese people. According to McCauley (1986: 191) the large population is primary supported by intensive dryland farming and irrigated paddy rice cultivation which has decreased considerably in the last two decades. Rustiadi (2000) in Indonesia LCLUC Team (2001: 6) reveals that in the islands of Java and Bali alone, more than 37,000 hectares of rice fields were converted to other uses between 1981 and 1986 with nearly 44% of which were converted to non-agricultural uses such as housing areas and industries. Particularly West Java where Jakarta is located had such a considerable land cover conversion. Other estimates by Indonesia LCLUC Team (2001: 6) indicate that in the areas surrounding the National Capital of Jakarta, the conversion of prime rice fields to housing estates amounts to 2,000 out of 23,000 ha rice fields in 1986 alone.

Ongoing land conversion, economic- and population growth leads to the overexploitation of the soil and water resources. These issues are predominantly crucial in upland areas because these areas represent an important land resource for Java’s crowded population since approximately 60% of the island is hilly and is situated above 200 m a.s.l. reported by McCauley (1986: 193). There is a significant issue of resource management in the upland area. According to Asdak (2006: 16) disruption to lowland resources from upland erosion will inevitably induce greater costs in the allocation of Indonesia’s already scarce water supplies during dry season. Inadequate soil and cropland management in the uplands triggers soil erosion and causes concerning on site effects in the upland regarding disruption of irrigation channels, soil fertility and in lowland regarding water supply, losses in agriculture, aquaculture and fisheries and decreases hydropower capacities highlighted by Asdak (2006: 16). Therefore it is crucial to monitor and asses land management in the upper watershed of Java in order to adapt SLM technologies for reducing soil degradation.

With regard to the outlined issues, this master thesis supports the W*orld Overview of Conservation Approaches and Technologies* (WOCAT) program. WOCAT was launched with the mission to exchange globally knowledge about soil and water conservation technologies and approaches reported by WOCAT (a) (2011). This master thesis focus on mapping *land use system* (LUS), soil degradation, SLM technologies and assessing impacts of degradation and conservation on the functionality of *ecosystem services* (ES) in the Ciwidey sub watershed that is part of the upper Citarum watershed in West Java.

1.2 Relevance of the Research

Citarum watershed is considerable valuable because it provides water resources for irrigation, energy, and for domestic use by the performance of Saguling, Cirata, and Jatiluhur dam. According to Nana Terangna Bukit (1995: 2) the tree dams generate a total of 1,350 MW of hydroelectric power. In other words, it is important to maintain the dams function for the local economy and social life because it provides water for agriculture, fisheries, industry, public water supply, and recreation. In total these reservoirs supply water for 300,000 ha of rice fields (Enviroscope n.d.: 45). Additionally, Nana Terangna Bukit (1995: 2) reports that Jatiluhur dam supplies Jakarta's 9 Million inhabitants with drinking water. These mentioned benefits and dependencies on economy, agriculture, and energy supply regarding the dams in the Citarum watershed point out the significance and relevance of sustainable development for the Citarum watershed.

However, Asdak (2003: 1) explains that population pressure implies that high numbers of people concentrated on a too small land area, lead to watershed degradation. This negative trends of population pressure harm the natural function of the ecosystem and are typical for West Java's high populated upland areas. According to Asdak (2006: 2) the Citarum upper watershed is with 700 people per km² such a densely populated area. Citraum river is higly polluted due to inappropraite waste management and soil erosion. Owing to ongoing industralisation and economic growth in the upper Citarum watershed the situation is expected to worsen in the next decade and may result in inreversible land degradation.

Nowadays, there is an alarming rate of soil erosion in this upper watershed and Ciwidey can be derived as the sub watershed with the highest erosion rate in the upper Citarum watershed (Anwar 2010 in Appendix 1). Soil erosion impacts negatively on availability of organic material and nutrients, and crop productivity. It makes land more vulnerable for natural hazards. Consequently, soil erosion also accelerates sedimentation. As measured in Poerbandono et al. (2003: 24), an increase of sediment yield (>7,000tons / km² / year) is observed at the western part of Ciwidey within seven years. Due to considerable high rainfall the transport of sediment by water is one among natural processes that occurs over a river basin and can be triggered and accelerated by sensitive soil, heavy rainfall, and inadequate land use practices. At the end of the upper watershed water with its sediment particles flow into Saguling dam and sediments there. According to Anwar (2010) in Appendix 1 sedimentation amount that flows in total into Saguling dam is more than 8.4 million tons / year.

A section of the Indonesian ministry of forestry, namely BPDAS Citarum – Ciliwung, is responsible to manage this critical and important Citarum watershed. In 2009, they launched an integrated management action plan for the upper Citarum section where Ciwidey is one of eight sub watersheds in order to extend the useful life of existing reservoirs in Citarum with the aim of controlling pollution and maintaining the water quality in the Citarum basin (Anwar 2010 in Appendix 1). This integrated watershed management plan, as Anwar (2010) in Appendix 1 states aims at improving the level of social welfare in both the upstream and downstream area. The upper area as starting point of the integrated watershed management plan has first priority in preparing the Citarum river basin management where many industries and high productive agricultural areas are located. Anyway, it is important to manage upper area of watershed accurately hence taking into account effects of inappropriate upstream land use on reducing downstream quantity and quality of natural resources. According to Anwar (2010) in Appendix 1, the Citarum watershed management team tries to find solutions for the ideal land use in the villages of the upper watershed. Sustainable LUS should reduce runoff and decrease soil erosion. For concluding Anwar (2010) in Appendix 1 summarize “openness, coordination, collaboration and synergy are the key words in conducting land management activities on watershed scale.”

To achieve SLM in the upper part of Citarum watershed and enhance or at least maintain life of Saguling dam more efficient soil and water conservation technologies for the different LUS are required. In other words, this high amount of soil erosion can just be diminished by accurate and efficient SLM technologies and approaches whereby the functions of the dams can be maintained. Due to this issue WOCAT shows feasible tools to documents SLM technologies and by mapping them it identifies local hot and bright spots. This recognition of hot spots on local level such as in Ciwidey sub watershed leads to more detailed evaluation in addition to the regional level and assessment of significant erosion areas by BPDAS Citarum – Ciliwung.

1.3 Objectives and Research Questions

This research project will identify hot spot areas of degrading LUS and will analyze bright spots of well conserved LUS. It will help assisting stakeholders of the watershed management of Citarum in decision making and planning process with regard to achieve sustainable water and land management. On the basis of the highlighted overall research objectives the guiding specific objectives and research questions of this master thesis will be presented subsequently:

1: Localisation of the prevalent LUS in August / July 2010 in Ciwidey sub watershed.

- What is the main area / intensity -trend per LUS?
- What are reasons for the land use change?

2: Assessment of land degradation in the Ciwidey sub watershed.

- Which types of land degradation can be perceived?
- How much of the area is affected by land degradation per LUS?
- How large is the degree and rate of land degradation per LUS?
- What are direct and indirect causes of land degradation per LUS?
- Where does soil erosion occur?

3: Assessment of land conservation in the Ciwidey sub watershed.

- How large is the area covered by SLM technologies per LUS?
- How efficient is the implementation and the effectiveness trend of SLM technologies per LUS?

4: Evaluation of impacts of land degradation and conservation on ES in the Ciwidey sub watershed.

5: Deriving hot spots and bright spots of land management in the Ciwidey sub watershed.

The main personal motivation of this research project is to support farmers in the upper Citarum watershed to enhance their LUS in order to achieve higher productivity and, thus, better livelihoods despite the governmental pressure of reducing soil erosion. Specific gains of this research project for farmers will therefore be the increase of food productivity due to decrease in soil erosion and increase the water availability. Above all, inputs provided to farmers shall be in line with SLM technologies / approaches to ensure that ecosystem issues are dealt with a sustainable and generally accepted way.

1.4 Study Area

Image 1 illustrates the location of the research area of this master thesis. The research area is bound by the watershed boundary of the Ciwidey sub watershed which is situated in the mountainous upper Citarum watershed in West Java.

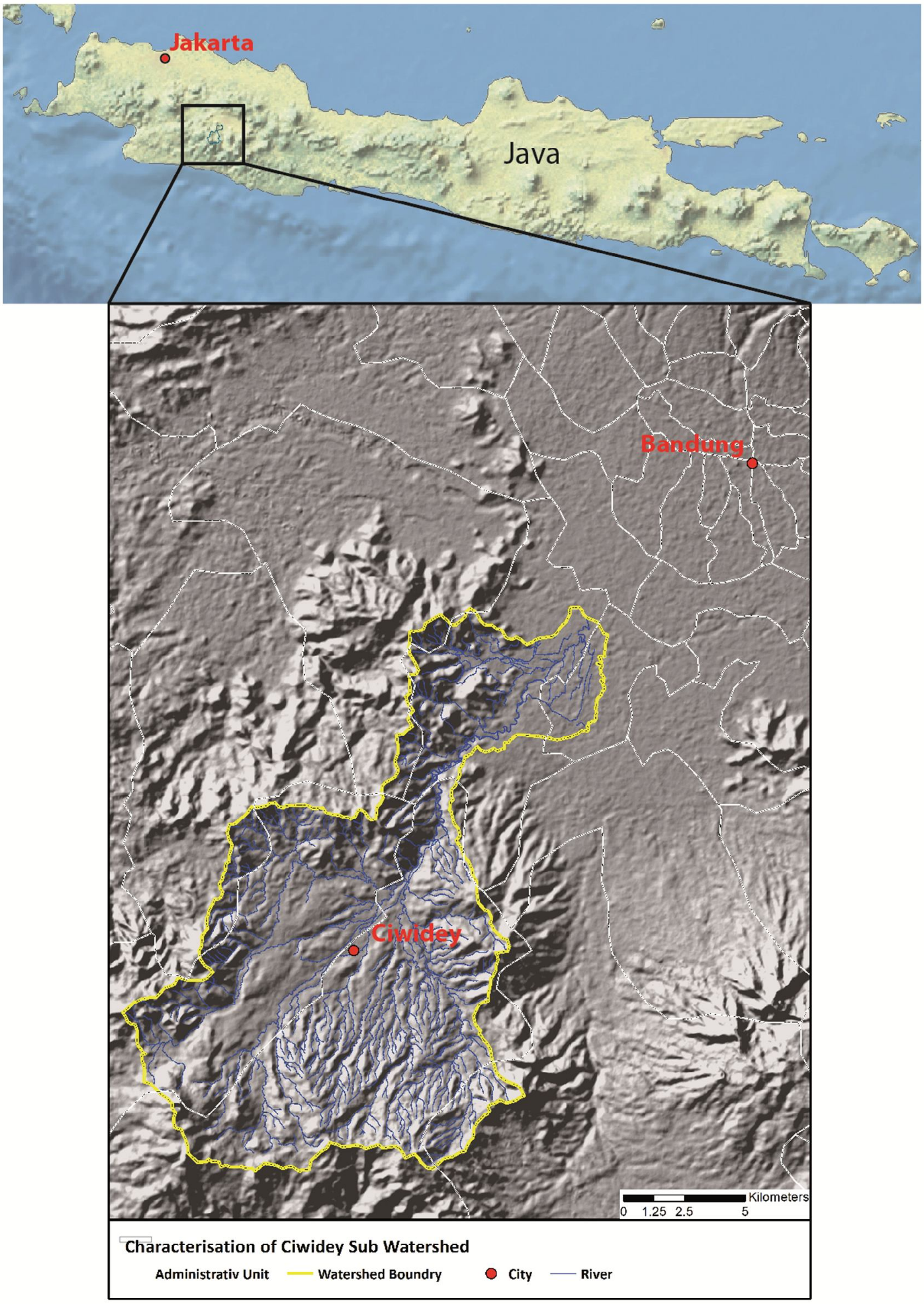

Image 1: Research area in West Java, Indonesia (De Maddalena 2010, data source: www.gdem.aster.ersdac.or.jp/index.jsp)

The entire upper Citarum watershed and its division in eight sub watersheds such as Ciwidey watershed is illustrated in Image 2.

As reported in Sriwana et al. (1997: 162), the research area forms part of the southern margin of the Bandung Basin an intramontane basin which is drained by the upper watersheds of the Citarum River. According to Poerbandono et al. (2006: 12) the topography is dominated by this mountainous landscape and a flood plain, namely Bandung basin, which covers the center of the basin. All the tributaries of the Citarum river such as Ciwidey river source either in extinct or still active volcano summits around the Bandung basin and enter the Saguling dam on the outbound of the upper Citarum watershed reported by Sriwana et al. (1197: 162).

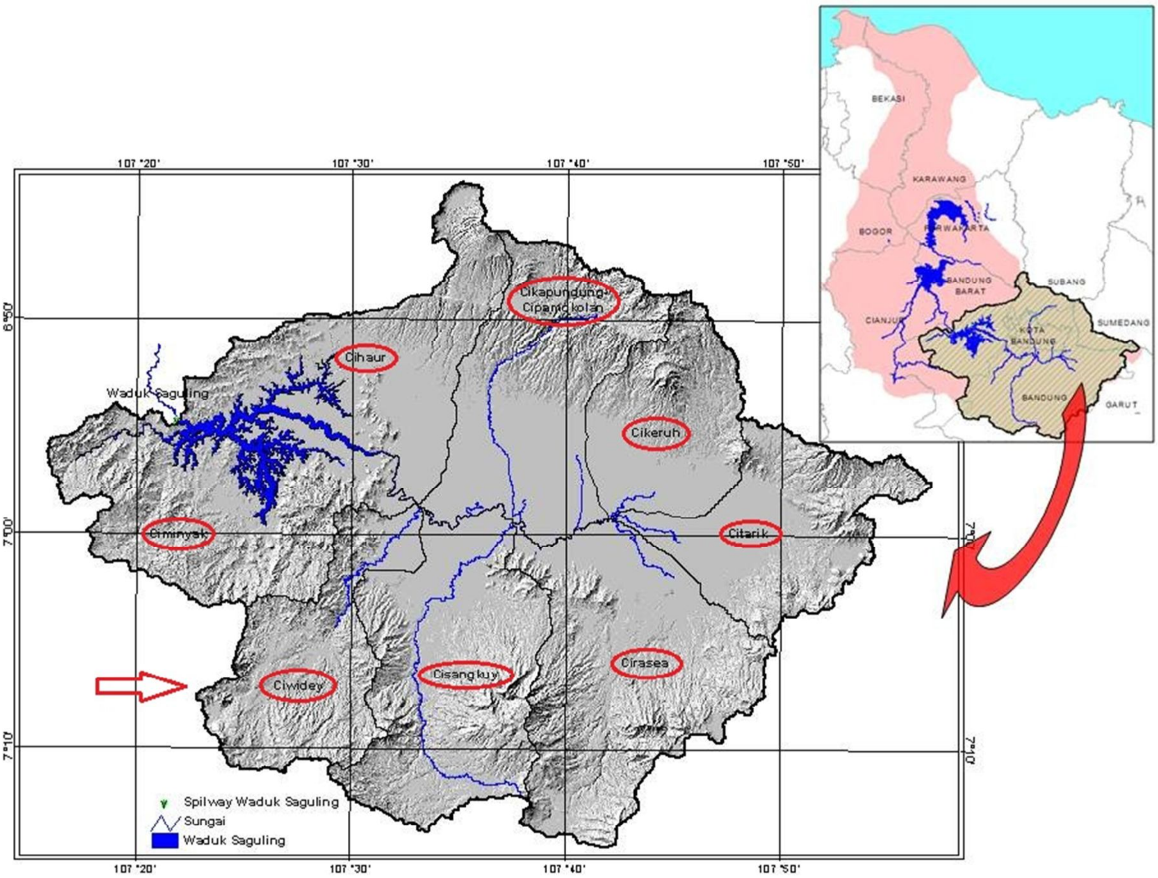

Image 2: Upper Citarum watershed (BPDAS Citarum – Ciliwung 2009)

There are in general three comprehensive environments of sustainability to describe a study area. In other words, to achieve a general idea of this research area the ecological, social, and economic environment will be highlighted in the following chapters.

Since major current literature describes the area of the entire upper Citarum watershed and none specifically Ciwidey sub watershed the description is to some extent only applicable on this higher scale but can be generalized for the research area as well.

1.4.1 Ecological Environment

Climate and Rainfall

Asdak (2006: 17) reveals that the climate in Ciwidey is dominated by the East and West monsoon and by the inner tropical convergence zone. This results in an annual climate pattern consisting of a rainy season (from November to February) and a dry season (from March to August). As shown in Figure 1 August with 50 mm precipitation is the driest and January with 300 mm the wettest month.

Figure 1: Average precipitation in Bandung 2009 (http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,bandung,Indonesia)

The field research for data collection of this master thesis was carried out in July / August 2010 in the dry season. This dry season was not as dry as expected and contained therefore more rainfall as usual (Voice of America News 2010). In general, rainfall initiated almost daily in the upper watershed at 2pm and expanded to the middle watershed during the afternoon. Such a daily rainfall pattern is very common for tropic areas but in Ciwidey watershed it even rained at night which is rather untypical for the dry season.

Furthermore, Ciwidey's agricultural land is considerably vulnerable to ENSO events which imply droughts or floods and consequently this has negative impacts on crop production (Boer and Surmaini 2007: 1). As reported in Voice of America News (2010), La Niña brings cooler-than-usual sea temperatures in the Pacific Ocean, which usually triggers a depression and heavy rains in Indonesia. During a La Niña year the dry season can be very wet and the summer 2010 has been such a unusually wet dry season (Voice of America News 2010). Some crops such as chilies do not grow in too wet climate and thus cannot be planted in a wet dry seasons. In addition to this consequence unexpected amounts of rain can seriously damage harvest and lead to lack of food.

The opposite climatic pattern of La Niña is El Niño that also can impact food production negatively. In El Niño years rainfall in the wet season declines extremely and causes a very dry year with reduced availability of water for the irrigation of cropland, and rainfed rice terraces. This results in decreasing harvest and leads consequently to food scarcity. Dealing with such extreme climate events is a challenge for planning land management.

In ordinary years without El Niño events the average rainfall recorded in Soreang weather station by Asdak (2006: 17) amounts to 1,200 mm which arises predominately from convective origin. In another research project conducted by Kartasasmita et al. (1995: 10) annual precipitation sums up to 2,233 mm and there are in average 127 rainfall days per year. According to Asdak (2006: 17) rainfall intensity can increase to 20-25 mm per hour in the rainy season or even to 100 mm per hour during storms whereas the average rainfall intensity amounts to 17.6 mm per hour by Kartasasmita et al. (1995: 10). Additionally, the annual average temperature in Ciwidey watershed lies at 24°C (Asdak 2006: 17).

Climate change is a threat for the environment and humans in various regions in the world. Some of the areas are profiting of more suitable climate conditions and others are affected by negative climate scenarios. For the Citarum watershed climate change is expected to bring more drawbacks than gains. There are impacts on biodiversity, human health, food, and water availability. According to the report written by WWF Indonesia (2007: 27), the raising temperature alters the rainfall rate. This means that the rainy season will become much wetter, and the dry season drier. Thus, significant impacts emerge. The possibility of floods, landslide, and disease rise heavily in the rainy season. Hence, higher runoff accelerates soil erosion. In contrast, in the dry season aridification, crop failure, and lack of water supply can imply relevant production losses (WWF Indonesia 2007: 27).
To cope with the climate variability because of ENSO and climate change issues, is a challenge for the management of a watershed. It allows at applying adequate SLM.

<u>Topography and Geology</u>

Ciwidey sub watershed ranges from 660 m a.s.l. where Ciwidey River reaches confluence with Citarum River and climbs rapidly during 50 km up to the summit of Gunung Patuha at 2,386 m a.s.l. (cf. Figure 2). According to Sriwana et al. (1997: 162), Gunung Patuha is a recently extinct Quaternary volcano.

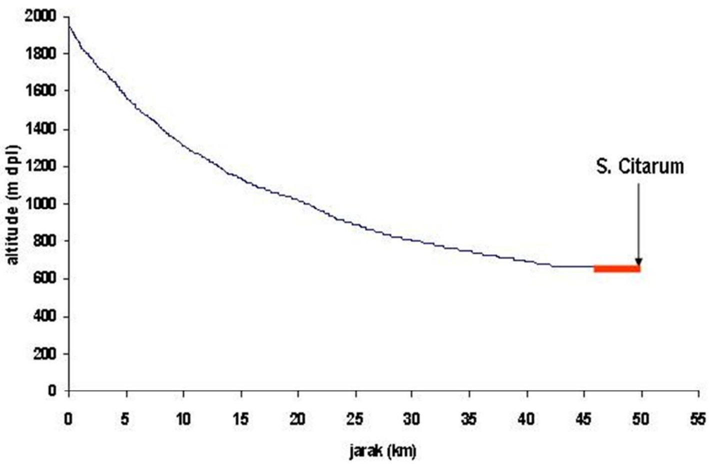

Figure 2: Topographic profile of Ciwidey sub watershed (BPDAS Citarum - Ciliwung 2009)

Image 3, illustrates Ciwidey watershed's altitudinal zones and some characteristics of the watershed. The altitude increases from north to south. The red line signifies the flat Bandung plain. In almost all parts of the watershed settlements are widespread but are numerous in the middle watershed around Ciwidey city and along the main road to Soreang sub district. In addition to Soreang there are

Ciwidey, Pasir Jambu which are main sub districts and Chilin, Pangalengan, Banjaran, Sindangkerta, and Ketapang subsidiary sub districts of the Ciwidey sub watershed.

There are several tributaries of Ciwidey River flowing down the mountains and hills until reaching the Bandung plain. Ciwidey River springs on the flanks of volcano Patuha which contains an acid crater lake having high contents of sulphur and chlorine examined by Srivana et al. (1997: 162). These authors state that Ciwidey River has a catchment area of approximately 22 km^2 and a total length of 35 km.

According to Srivana et al. (1997: 162) “the upper part of the Ciwidey River and most of its tributaries run through volcaniclastic debris flows forming foot slopes near the town of Ciwidey, where the narrowly confined river channel is moderately to deeply incised in coarse bedding. Further downstream the river passes through a valley in late Tertiary volcanic terrain before entering the Bandung plain near the town of Soreang. Downstream from Soreang, the river forms a slightly incised meandering channel in predominantly fine grained alluvial sediments until it reaches the confluence with the Citarum River.“

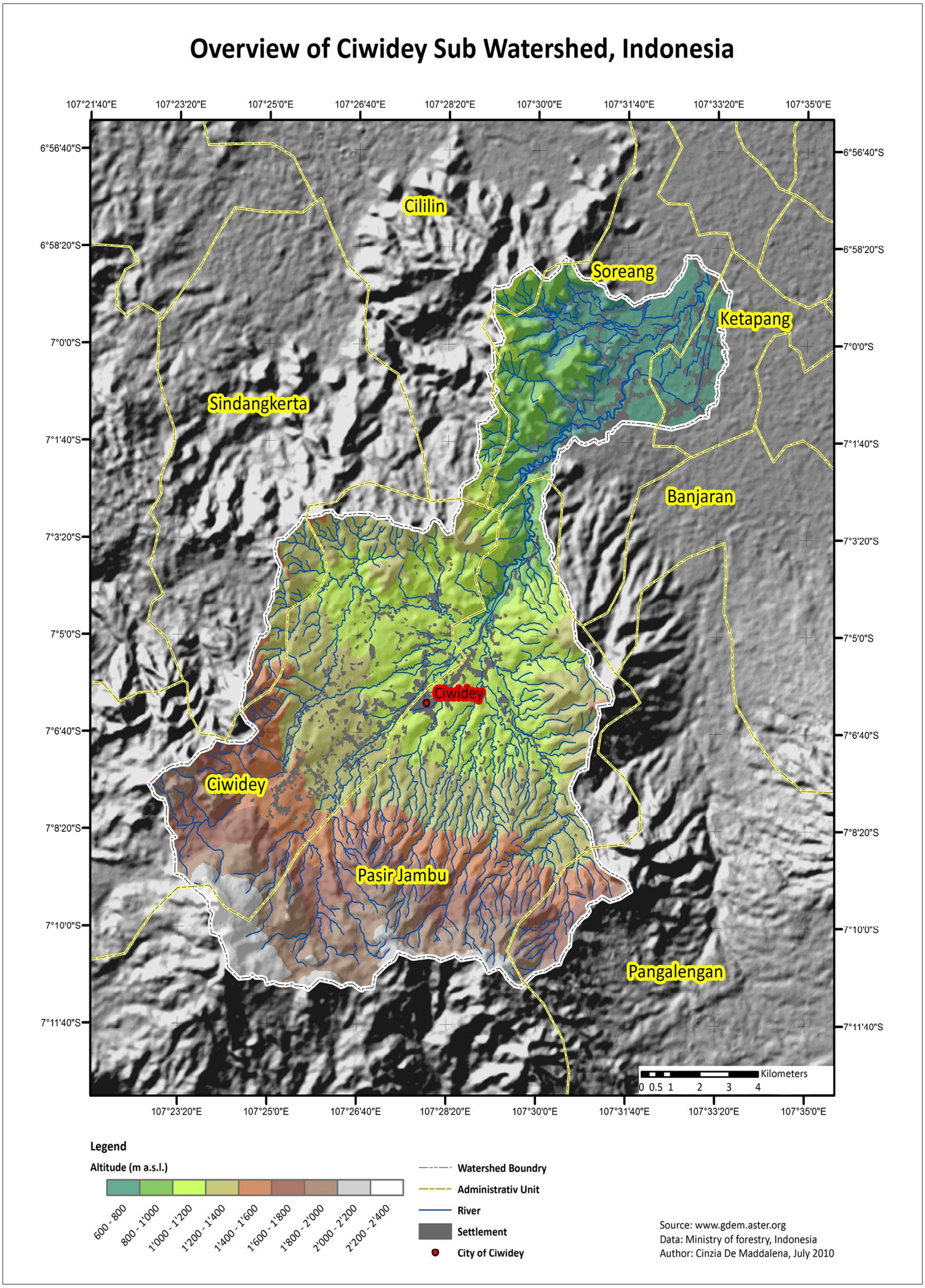

Image 3: Overview of Ciwidey watershed (De Maddalena 2011)

Geomorphology and Soils

Previous geological formation in combination with volcanism developed high variability of land forms in Ciwidey sub watershed. The hilly terrain alternates with plains and creates the diverse topography. In Image 4 this different geomorphologic land forms are shown. A brief translation from Indonesian into English clarifies the legend:

Landforms	
Indonesian	**English**
dataran berbukit kecil	small hilly terrain
dataran lakustrin	lacustrine plain
gunung berapi	volcano
kipas alluvial	alluvial fan
Punggung gunung	ridge
lereng lahar	lava slopes
aliran lava	lava flow

Table 1: Legend for geomorphology map (De Maddalena 2011)

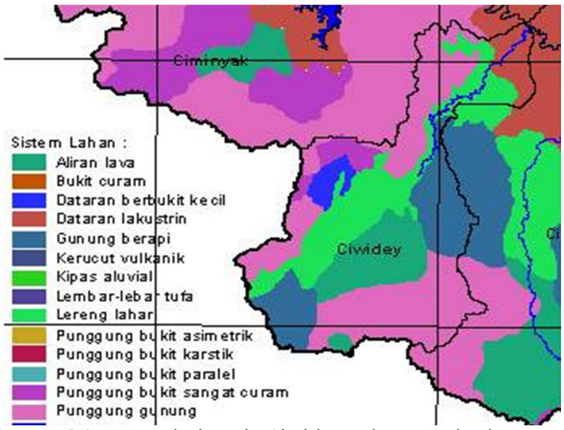

Image 4 Geomorphology in Ciwidey sub watershed (BPDAS Citarum – Ciliwung 2009)

Soil types in the research area highly correlate with previous and ongoing geologic activity, topographic conditions, and climate factors (Kartasasmita et al. 1995: 10). However, there are two different main soil types in the research area: The high permeable Andosol can be found in the upper watershed and Latosol which attributes low permeability is identifiable in the middle and lower watershed (BPDAS Citarum - Ciliwung 2009).

Natural Hazards and Pollution

Ciwidey sub watershed is considerable vulnerable to natural hazards such as landslides and floods because there are steep slopes and an alluvial basin where high amounts of rainfall surpassing the infiltration capability of the soils result in floods. According to Takara et al. (2008: 1) floods and associated landslides occur frequently during rainy reason. Landslide can be triggered by different natural events such as heavy rain, fast runoff, steep slope, flash flood, erosion, earthquake and volcanic debris during eruption reported in Takara et al. (2008: 2). Earthquakes are very common in Indonesia. However, land use change such a conversion of forest land to agriculture or irrigated rice field to settlement lead to decreasing infiltration rate and increase run off. This causes floods in areas where the water cannot flow away. Image 5 shows low to moderate flood risk in the middle watershed, in the Ciwidey plain, and in the lower watershed. However, the erosion map (cf. Image 5) assigns large areas of Ciwidey watershed with very strong erosion risk. These are according to Takara et al. (2008: 2) predominately steep areas with inappropriate lithology type, geological structure, weathering condition, land degradation, and low rainfall infiltration rate. In general shallow landslides in Indonesia can be classified into both a slow movement, creeping and no provoking causalities and but large damage area, and rapid movement with rock, soil, and debris flows with causalities and significant damaged area explained by Takara et al. (2008: 3).

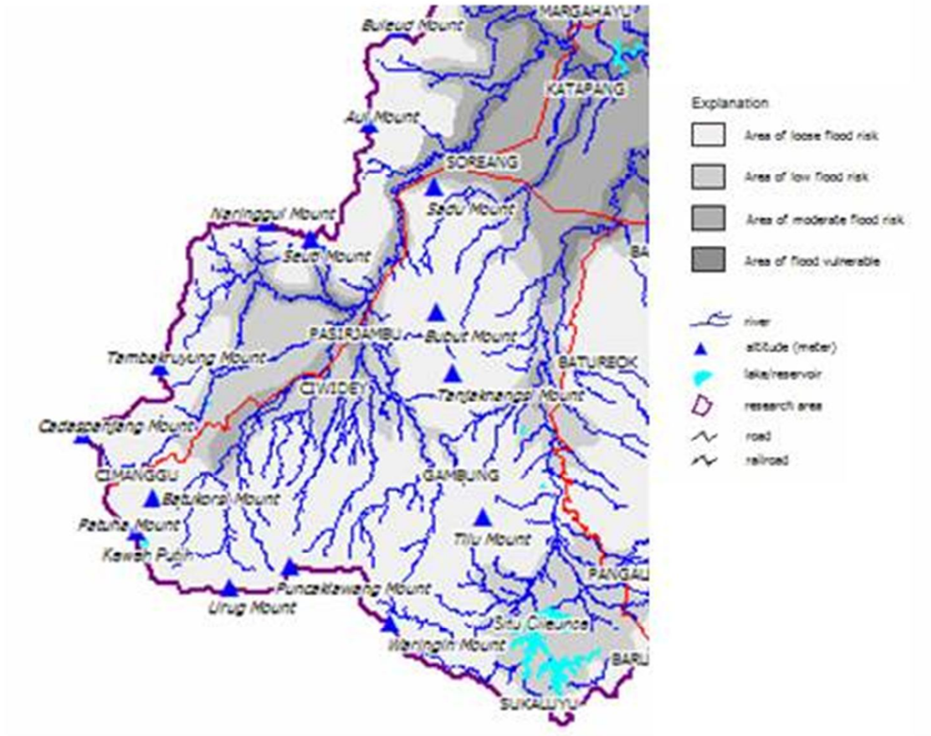

Image 5: Flood map for Ciwidey sub watershed (Sukijah et al. 2004)

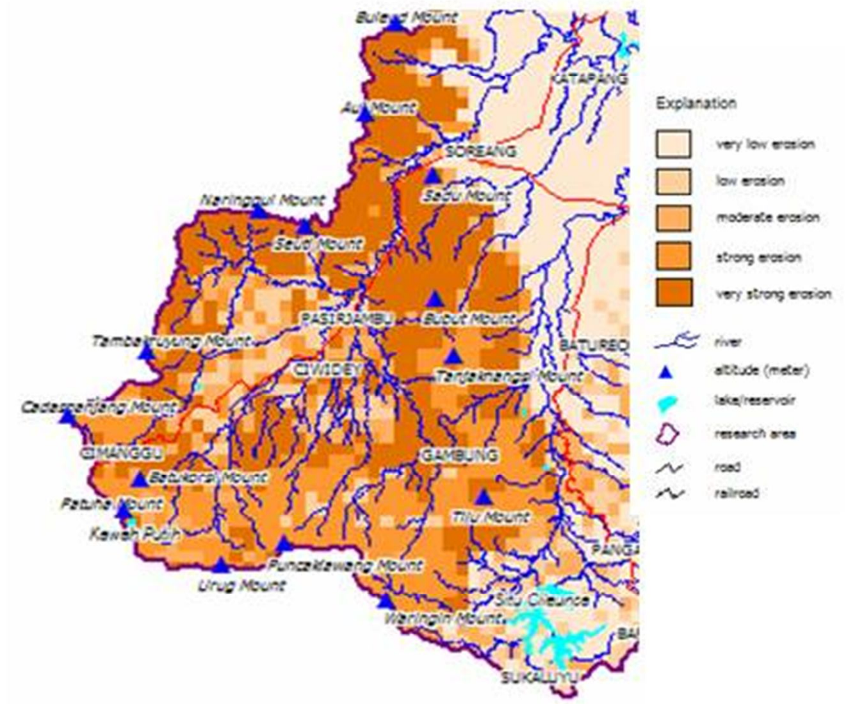

Image 6: Flood map for Ciwidey sub watershed (Sukijah et al. 2004)

For example, in February 2010 a landslide hazard occurred in Tenjolaya village, Pasir Jambu, by WHO emergency situation report (2010: 1). According to WHO emergency situation report (2010: 1) this large landslide triggered by heavy rain hit housing facilities for workers at the Dewata tea plantation company, damaged 27 houses, 1 official building, and 2 worship buildings, killed 12 people and 31 were missing.

Image 7: Landslide in Tenjolaya village, Pasir Jambu (WHO 2010)

In addition to erosion and floods, droughts exist as well due to ENSO (see climate and weather). Furthermore, there is volcanogenic pollution triggered by Gunung Patuha volcano in the research area reported by Srivana et al. (1997: 162). Srivana et al. (1997: 162) reveals that elements in fumaroles and solfataric gases and associated sublimates, hot-spring and geothermal waters, which are affected by mineralization or rock alteration cause pollution of waterbodies. These waters derived from the acid crater lake Kawah Putih and other acid streams are capable of transporting large amounts of chemical constituents which may reach the human environment while contaminating of surface and groundwater resources (Srivana et al. 1997: 162).

However, air pollution was not measured in Ciwidey watershed but due the enormous emission of motorbikes and vans the air may be considerably polluted. Thus, air pollution emerging trough the increase of motor vehicle traffic will deteriorate in future. The daily burning of household waste causes additional airborne pollution.

1.4.2 Social and Economic Environment

The majority of people living in West Java are Sundanese whereas people from central and east Java are Javanese. Educated people speak Sundanese, their native language, and Bahsa Indonesia the official language of Indonesia. Many farmers who did not have the opportunity to go to school speak only Sundanese in Ciwidey sub watershed. As everywhere in Indonesia, except the island of Bali, people believe in Islam.

West Java is in comparison with Central and East Java much higher populated because many young people not only from Java, but from all over Indonesia move to west Java due to better education and working opportunities. For instance, in 2003 the population in Metropolitan Bandung situated 30 km north of Ciwidey amounts to approximately 5,854,340 people, and is predicted to reach up to 9,706,363 people by 2025. The average density in 2003 in Bandung is 340 persons/km^2 measured by Enviroscope (n.d.). This enormous population pressure concentrating on limited land resources of the mountainous area is already a challenging issue and will increase in future. A more detailed study in the Ciwidey sub watershed by Asdak (2006: 16) reports that there is an average population density of 700 people per 1 km^2, with land holding averaging 0.2 ha or less in Soreang district. He mention in his research that most of the households are poor, predominately subsidence households which have an upland rice and corn yield of 0.5-1 ton per ha.

In Ciwidey sub watershed every village produces a specific good. There are large areas in the middle watersheds where almost every house possesses a strawberry field. In other villages people manufacture bamboo which serves as raw material for exterior walls of cheap houses or design carpets. In addition, there are also small manufactories managed by villagers who carve “sate” sticks with collected timber. “Sate” is a traditional skewer.

2 Theoretical Background

2.1 Definitions

Significant terms will be defined in the following chapter in order to understand the underlying conceptual framework in which this research is embedded.

2.1.1 Ecosystem Services

The term *ecosystem* is particularly crucial in SLM research. An ecosystem is a complex system or model characterized by interacting components which quest stable balance. There are interactions between organisms and their habitat. An ecosystem forms an interactive system which is self-regulating defined by Hitzmann and Grünwald-Schwark (2010).
If one part of a functioning ecosystem is damaged it has an impact on the other components. In other words, if considerable deforestation is destroying the habitat of native animals they are forced to migrate to other places. The same deliberation can be conducted with humans. Namely, if a farmer overuses his soils owing to enormous inputs such as herbicide, fertilizer, fungicide, or the lack of fallow periods the soil loses its fertility and the capability to produce crops decreases. As result of this overuse of farming fields this farmer has to shift to another field (if it is available) or in the worst case search other solutions.

For this research the definition of *ecosystem service* (ES) is important and has to be clarified. As derived from *Millennium Ecosystem Assessment* (MEA) elaborated by World Resources Institute (2005), ES denote *provisioning, regulating, cultural* and *supporting services*. Provisioning services are products of basic needs provided by the ecosystem such as food, water, fiber and fuel. According to Liniger et al. (2008: E14), the provisioning services are termed as *productive services* and incorporate:

- production of animal / plant quantity and quality including biomass for energy
- water quantity and quality for human, animal and plant consumption
- land availability

Furthermore, *regulating services* aim to buffer the impacts of human activities. Climate, soil-, water- and air cycle regulation, and prevention of disease are at the center of MEA's attention. *Supporting services* are a necessity for the provision of all other services and therefore provide support for the regulating services in terms of primary production or soil formation, for instance. For this reason Liniger et al. (2008: E14) summarize the regulating and supporting services and affirm them as *ecological services*.
Cultural services define all immaterial components such as spiritual, aesthetic, recreational, educational which appear in everyone's life. Resumed it can be claimed that the ES steer the ecosystem and constitute human well-being.

2.1.2 Land Use System

According to FAO (2011) "*land use* is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it". Thus, a typical land use in Indonesia for instance is farming whose land cover changes through different land use practices such as irrigation or ploughing. Theses farming practices may aim to maintain the productivity or fertility of the land use. In other words, ploughing itself is just an activity and if the farmer applies various inputs and activities which involve further components such as harvesting, selling products on markets a LUS can be described. Thereby, LUS concern the products and / or benefits obtained from use of the land, as well as the land management actions (activities) are carried out by humans to produce those products and benefits defined by FAO (2011).

In other words, if land use and management practices are grouped, LUS can be determined. The land is used to produce goods, such as crops. Land management is the land user's way to achieve this aim. There are various means of production inputs to produce a similar crop harvest. For some farmers it is obvious to till the soil to prepare it for sowing and with it to achieve their goal of a good harvest. Others might use no - till techniques and will achieve the equal goals. Therefore, different management practices pursue the same aim, which is the production of a certain good through LUS.

Research on LUS highlights specific questions which were listed by the FAO (2011): "Investigations on land use focus on identifying the current use of the land. (1) What? - the purpose of activities undertaken (2) Where? - the location (3) When? - the temporal aspects of various activities undertaken (4) How? - the technologies employed (5) How much? - quantitative measures e.g. areas, products (6) Why? - the reasons underlying the current land use". The master thesis bravely answers these entire questions. It will briefly describe the different land use system's purpose, inputs, temporal aspects, and map the location of relevant land use systems. Additionally, the current notable land use change in Indonesia implies to address with this research also the reason of land use change.

2.1.3 Land Degradation

In the LADA forum LADA (n.d.) several definitions of land degradation have been summarized:

- FAO, 1979: Land degradation is a process which lowers the current and/or potential capability of soils to produce (quantitatively and/or qualitatively).
- UNCCD, 1994: Decrease or loss of economic and biological productivity and complexity of land.
- MEA, 2005: The reduction in the capacity of the land to perform ecosystem goods functions and services that support society and development.
- LADA, 2008: The reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time for its beneficiaries

For this research project which applies the WOCAT/LADA methodology a more detailed definition of land degradation by LADA will be termed because land degradation is considerably multifaceted:

Ponce-Fernandez and Koohafkan (2004: 8) claim that "land degradation is a complex set of processes of impoverishment of terrestrial ecosystems under the impact of human activities. Land degradation can be understood as the gradual or permanent loss of productivity of the land resulting from human activities, mainly from the mismatch between land quality and the intensity of activities part of the actual land use."

Thus, land degradation results from unsustainable land management and leads to both reversible and irreversible damage of the natural resources. This master thesis does not intent to describe and assess all manifestations of land degradation in the Ciwidey watershed. It captures the most important and observable ones and focuses predominately on soil degradation. Referred to Liniger et al. (2008: E6f), the following soil degradation phenomena will be examined in the Ciwidey sub watershed:

- Soil erosion by water (topsoil / rill erosion, gully erosion, mass movements, riverbank erosion, off-site degradation)
- Wind erosion (loss of topsoil, deflation and deposition, off-site degradation effects)
- Chemical soil deterioration (fertility decline, reduced organic matter content, acidification, salinization, soil pollution)
- Physical soil deterioration (soil compaction, surface sealing / crusting, water logging, subsidence of organic soils, loss of bio-productive function)

In addition to soil degradation water and biological degradation can be as well a crucial indicator of unsustainable land management. Therefore these terms will be presented briefly (Liniger at al. 2008: E7f):

- Water degradation (aridification, change in quantity of surface or ground water, decline of surface water / groundwater quality, reduction of buffering capacity of wetland areas)
- Biological degradation (reduction of vegetation cover, loss of habitat, biomass decline, detrimental effects of fires, diversity decline, loss of soil life, increase of pests)

2.1.4 Sustainable Land Management

WOCAT (a) (2010) defines SLM as follows: "SLM is defined as the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions."

Consequently, SLM aims at preventing, mitigating, and restoring land degradation and desertification in order to obtain natural resources for coping with population's demand for basic needs such as food, water, timber and shelter. Humans have to learn to live in coexistence with nature without overexploiting its capacity. The goal of ensured provisioning, regulating, cultural, and supporting ES does not just count for nowadays population. It should especially guarantee a life for future generations. In other words, SLM is a prerequisite for sustainable development.

SLM technologies are associated in SLM practices because they address land degradation and may reduce it. The major part of technologies aims at conserving soil and water, but for this research the scope of SLM practices might be widened for additional SLM activities such as conserving biodiversity.

2.2 Conceptual Framework

For a better understanding of the conceptual framework in which this master thesis is embedded the overall framework of SLM will be explained prior to the more specific concept of WOCAT's mapping approach.

2.2.1 Overall Framework of Sustainable Land Management

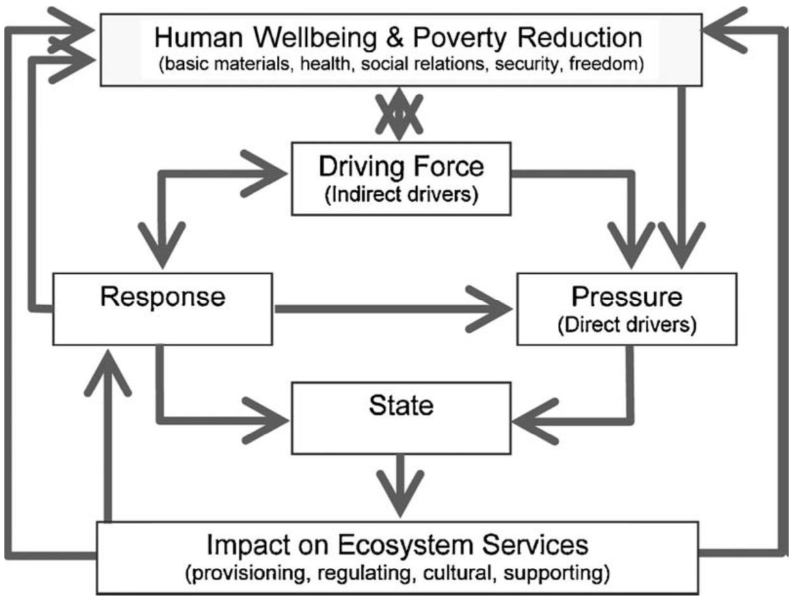

Figure 3: Hybrid SLM conceptual framework (Schwilch et al. 2010)

The hybrid conceptual framework of SLM is a combination of the MEA framework which was elaborated by stakeholders of the Millennium Assessment under the auspices of the United Nations and the DPSIR framework by Smeets and Weterings (1999) in (Schwilch, Bestelmeyer, Bunning, Critchley, Herrick, Kellner, Liniger, Nachtegale, Ritsema, Schuster, Tabo, Van Lynden and Winslow (2010: 2)).

According to Schwilch et al. (2010: 2) the hybrid conceptual framework provides an overview of the cause-effect interactions of degradation and SLM on environment and human wellbeing. SLM or more specifically the WOCAT program is a response to the *drivers, pressures* and *states* of land degradation. Furthermore this response manifests itself in SLM technologies such as organic fertilizer which affects the productivity of the soil and with it the availability of basic materials such as food. In other words, the implementation of sustainable soil and water conservation technologies has a positive impact on human wellbeing and leads thereby to poverty reduction. It is obvious that human wellbeing and poverty reduction is not just the result of impact on ES and responses; indeed it can influence the pressures. Less poverty and more secured livelihoods through SLM activities for instance lead to higher birth rate and with it to population growth which determines a new direct driver. The population growth consequently has an impact on the state. Schwilch et al. (2010: 2) states that "the state component can be used as a proxy for changes in ecosystem services and subsequently human well-being. "

2.2.2 Specific Framework of WOCAT Mapping Approach

WOCAT has developed a well-accepted framework for documentation, monitoring, evaluation and dissemination of SLM knowledge reported by WOCAT (e) (2010). The framework consists of questionnaires that document and evaluate SLM practices (QT) or approaches (QA) and assess the spatial coverage of conservation and degradation in an area (QM). Consequently, these tools allow SLM specialists to identify fields and needs of action, share their valuable knowledge in land management, that assist them in their search for appropriate SLM technologies and approaches, and that support them in making decisions in the field and at the planning level by WOCAT (d) (2010).

The Drivers-Pressures-State-Impact-Responses (DPSIR) model gives the crucial theoretical framework for the applied methodologies in the WOCAT program and with it the specific theoretic foundation of this master thesis. Therefore, this chapter comments and illustrates the DPSIR model in order to understand the theoretical background of WOCAT and thereby the one of this master thesis.

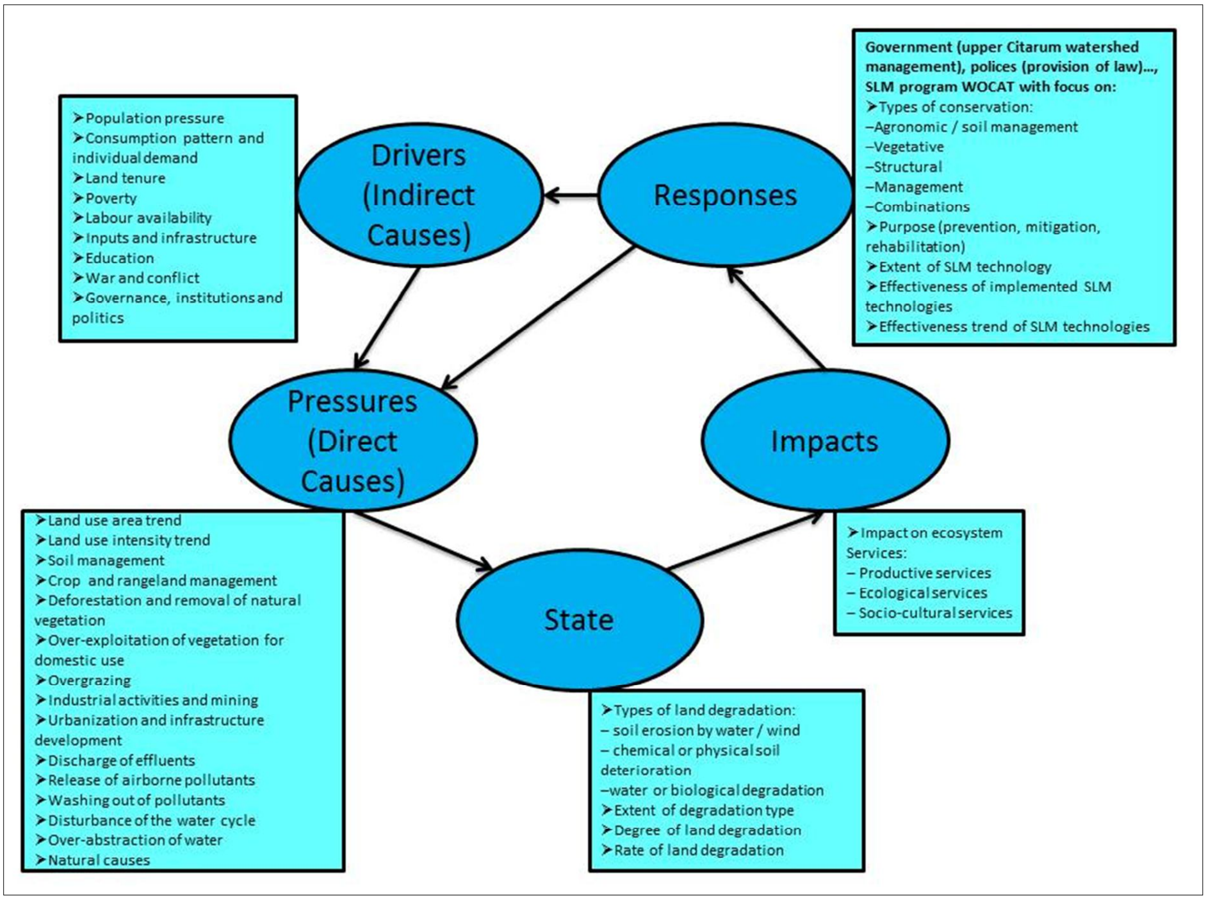

Figure 4: DPSIR framework with WOCAT indicators (De Maddalena 2010; data source: Liniger et al. 2008)

As displayed in Figure 4 the framework consists of five variables (drivers, pressures, state, impact, responses) which interact with each other and imply changes in ecosystems. In other words, the concept describes chains of the dynamic interface between environment and human claim towards the use of nature. The framework has been applied by different scientists in order to understand the dynamics between environment and humans and to identify the crucial steering indicators of this dynamic system. Consequently, some assertions will be cited in the next paragraphs:

Geeson (2001: 2) argues that "DPSIR can be used to describe interactions between different types of indicators and also observe feedback loops. The DPSIR framework seeks to classify indicators by highlighting the ways in which human activities relate to environmental problems. For example the state of the soil may be affected by human management practices or changes in climate and this may perhaps affect crop yields or population size."
Capuzano and Mateus (2008: 31) claim that "the general idea behind the DPSIR concept is that human activities i.e. the drivers exert a certain pressure on a particular part of the natural environment causing a change in its components and/or in its overall state. The outcome of this process is an environmental impact which usually results in certain response by the society. The response can run across different segments of society, from the political arena, to socio-economic and purely economic sectors. Eventually, responses can modify the nature of the driving forces (thus mitigating or enhancing the actual pressure) and/or compensate for the impact. Finally, the driving forces may also be altered directly by the impact."

After the basic idea of the DPSIR has been highlighted the single components of the framework will be described in the following paragraphs in detail. The components which are relevant for the research concept of this master thesis and whose labeling has therefore been adjusted for this reason are pointed out:

Kristensen (2004: 2) assumes that *drivers* are needs. Primary needs are basic human requirements such as shelter, food and water whereas secondary needs are culture, mobility, and education (Kristensen 2004: 2). These driving forces are the origin of human activities such as transportation and food production (Kristensen 2004: 2). In the WOCAT program *drivers* are termed as indirect causes of land degradation and will be surveyed corresponding to the master thesis.

According to Kristensen (2004: 2) "these human activities exert *pressures* on the environment, as a result of production or consumption processes, which can be divided into three main types: (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil." *Pressure* or in other words direct causes of ecosystem degradation are relevant factors influencing the state of land degradation and will therefore be discussed in this master thesis.

It is widely believed and examined that *pressures* have direct or indirect effects on the *state* of ecosystems. Following Kristensen (2004: 2) the quality of the various environmental compartments (air, water, soil, etc.) in relation to the functions that these compartments fulfill are affected by the *pressures*.

Furthermore Kirstensen (2004: 2) claims that "the *state* of the environment is thus the combination of the physical, chemical or biological conditions." This master thesis aims at evaluating the *state* of LUS in Ciwidey watershed. Reliable factors thereby are the type, extent, degree of land degradation, and conservation effectiveness.

However, each *state* has an *impact* on ecosystem services which can be affirmed as positive or negative regarding the functioning of ecosystem and with it the influence on welfare of human beings. In other words, changes of the *state* component may have environmental or economic impacts on performance of ecosystems, their life supporting abilities, and ultimately on human health and on the economic and social performance of the society (Kristensen 2004: 3). In this master thesis the *impacts* on ES are divided into indicators such as productive, ecological and societal ecosystem services. The purpose lies on evaluating the different *impacts* on ES in the Ciwidey watershed.

Responses by society, policy makers, or researchers, are a result of undesired impact and can affect any part of the chain between *drivers* and *impacts* reported by Kristensen (2004: 3). Response indicators such as SLM technologies described by structural, vegetative, management, and agronomic measures will be identified in this master thesis. However, the *responses* are significant and powerful components of the chain which steer and alter the ES and societal efforts towards SLM.

All in all *drivers* (indirect causes), *pressures* (direct causes), *state* of land degradation, *impacts* on ES, and *responses* shape the conceptual framework of the WOCAT mapping approach on which this master thesis is based on.

2.3 State of the Art

The subsequent chapter is divided in two sub chapters which show what has already been predicated in terms of the relevant issue of this master thesis. Firstly, the state of WOCAT in Indonesia is revealed by Tatin's master thesis. Secondly, prior research underlying a bio-physical perspective in the Ciwidey watershed will be presented.

2.3.1 WOCAT Research in Indonesia

In 2005, Julia Tatin from the Cranfield University at Silosoe, conducted research on *the assessment of the WOCAT methodology in Indonesia*. Julia Tatin's thesis aimed to show how WOCAT is employed in evaluating existing SWC technologies and approaches in Indonesia (Tatin 2005: 3). In order to support this general objective the research was divided into three sections: Tatin (2005: 3) reported that after presenting the framework of WOCAT the present execution of WOCAT in the three provinces West Java, Central Java, and Bali has been assessed. The interpretation of these findings led to the evaluation of the Indonesian WOCAT program. The question is if WOCAT has achieved its goals and objectives in Indonesia or struggles in the implement of its methodology.

Tatin (2005: 18) reveals that the adoption of WOCAT in Indonesia is still weak; only a few specialists are familiar with this methodology. Furthermore, Tatin (2005: 18) explains that the extension of WOCAT for each scale is the most difficult part in Indonesia. Moreover, in four years only eight provinces were involved in WOCAT and some of them have not yet completed the first step of SLM technologies identification, others have to be re-motivated to continue their efforts and some ceased to work with the program (Tatin 2005: 18). Therefore, this master thesis resumes the WOCAT approach in Indonesia and promotes WOCAT on different levels – from the ministry of forestry to the extension workers.

Differences could be perceived among provinces depending on their own work and organization (Tatin 2005: 15). There are strengths and weaknesses in carrying out WOCAT from the national to the field level in all provinces which joined WOCAT. Tatin (2005: 14) states that the West Java province, where this master thesis focuses on, is the most involved one and strongly motivated in the diffusion of WOCAT. At the time of her research the staff was still identifying SWC technologies in West Java's provinces. The main one such as mangrove rehabilitation, stone terraces and land rehabilitation has been uploaded into the WOCAT database but without translating it into English (Tatin 2005: 36). Unfortunately these technology questionnaires are missing in the database and couldn't be accessed for the current master thesis. A main disadvantage in West Java, as Tatin (2005: 36) mentioned, is the lack of extra funds and facilities such as GPS devices and internet access to develop WOCAT efficiently. Moreover, WOCAT is almost unknown in the field level (Tatin 2005: 36).

In consequence, it is important to bring WOCAT back into use and to make it known in every stakeholder's level by means of the implementation of this master thesis.

2.3.2 Research in the Ciwidey Sub Watershed

In the past, several researches have been conducted in the Citarum watershed but just a few studies which took place in the Ciwidey watershed focused on issues related to LUS(s), land degradation, or conservation. The subsequent chapter will report first of all two studies focusing on the regional scale of the upper Citarum watershed and the regency Bandung. Hence, Ciwidey is part of this superordinate watershed and the district of Bandung the findings will also apply to the research area. The latter research paper which will be mentioned investigate the local level particularly soil erosion and runoff, of test plots in Soreang, a sub district of Bandung situated in the Ciwidey watershed.

<u>Integrated Watershed Management Action Plan Section Upper Citarum</u>

The BPDAS Citarum – Ciliwung (Centre for Management of the Citarum and Ciliwung watershed) mapped geographic information for the entire upper Citarum watershed in 2009. Thus, maps with attributes regarding soil, precipitation, geology, geomorphology, slope and land cover were produced in order to develop the new integrated watershed action plan of the upper Citarum watershed (BPDAS Citarum – Ciliwung 2009).

Although this master thesis focuses on the Ciwidey watershed which is a part of the upper Citarum watershed the research carried out by BPDAS Citarum – Ciliwung identifies problems in the upper Citarum watershed and shows thereby some facts about the sub watershed of Ciwidey.
In total the upper Citarum watershed amounts to an area of 227,446 ha in which Ciwidey holds 22,169 ha. A major part, 60 % of the Ciwidey sub watershed is denoted as non-forest area. The residual area of 40 % is still forest land. The forest area of Ciwidey contributes with its 8,958 ha precious forest land to the ecosystems of the upper Citarum watershed which measures in total 60.835 ha.

It is necessary to translate the land use classes from Indonesian into English in order to understand the meaning of the existing land use system of this land use map for Ciwidey. The mapped LUS(s) in which can be found in Ciwidey watershed are the following:

Land Use System			
Indonesian	English	Indonesian	English
hutan	forest	Belukar /semak	bush
Kebun / perkebunan	crop estate	Rumput / Tanak Kosong	grass
Tegalan / Ladang	dryland farming	Air Tawar	fresh water
Sawah Irigasi	irrigated rice	Gedung	building
Sawah Tadah Hujan	rainfed rice	Pemukiman	settlement

Table 2: Translation of land use system in upper Citarum watershed (De Maddalena 2011)

Image 8 shows the upper Citarum watershed with its eight sub watershed and the LUS in 2009.

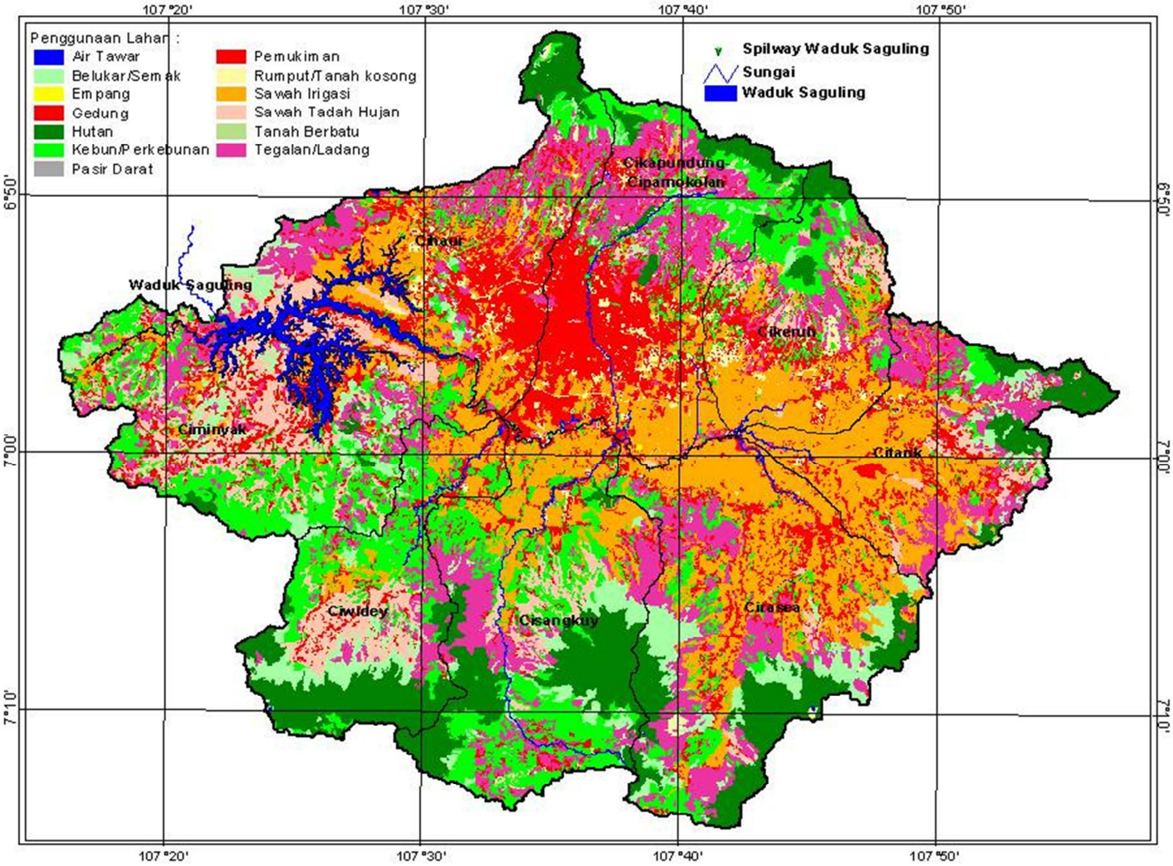

Image 8: Land use map for the upper Citarum watershed (BPDAS Citarum – Ciliwung 2009)

Beside the LUS map the research conducted by the BPDAS Citarum- Ciliwung identified areas of land degradation using the methodology of *universal soil loss equation* (USLE). A conclusion of the erosion index displayed in Image 9 reveals that Ciwidey has with 39,8 % of high erodible land the highest index values for erosion of the entire watershed in the upper Citarum. The scale of the erosion index for Ciwidey can be abstracted from Image 9.

Erosion class		
Indonesian	English	Area of erosion class
Sangat baik	very good	24,5%
Baik	good	9,7%
Sedang	moderate	6,2%
Buruk	bad	19,7%
Sangat buruk	very bad	39,8%

Table 3: Erosion class for Ciwidey sub watershed (De Maddalena 2011)

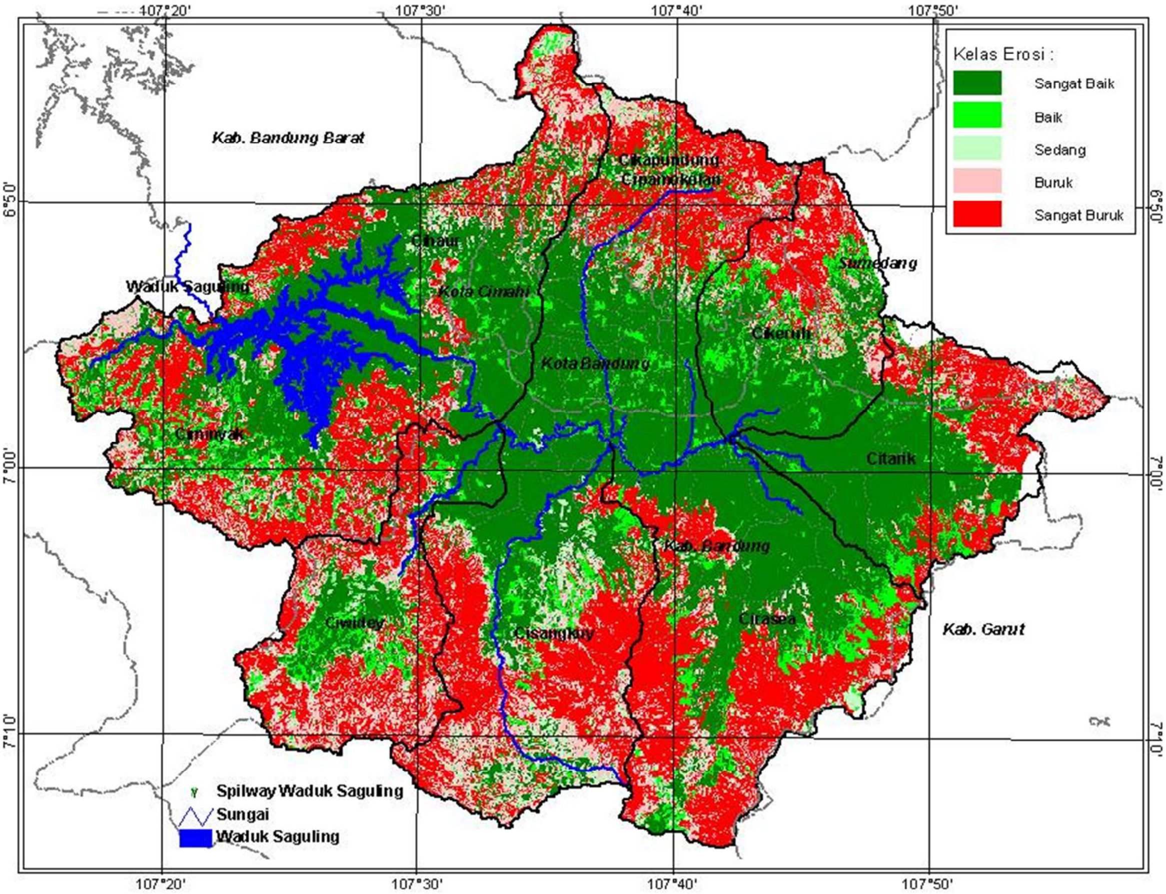

Image 9: Erosion index map for the upper Citarum watershed (BPDAS Citarum – Ciliwung 2009)

<u>RTL – RLKT Technical Field Preparation Plan for Land Rehabilitation and Conservation</u>

Further research has been conducted by the department of agriculture (Dinas Pertanian) of Bandung district in 2007. The department of agriculture launched a technical field preparation plan regarding land rehabilitation and conservation activities for the regency Bandung. This research has been considered because the watershed of Ciwidey is located in the district Bandung.

The technical plan abbreviated as RTL – RLKT (Penyusunan Rencana Teknik Lapangan – Rehabilitasi Lahan Dan Konservasi Tanah) includes short term goals such as bio - physical, social and cultural conditions and politics for the district Bandung, consequently also in the Ciwidey watershed. In addition to the short term plan of 5 years, a long term plan of 15 years conceived, as well.

The background of the RTL – RLKT determines the politics of the department of forestry which insist on avoiding illegal logging, rehabilitation of burned forest, rehabilitation and conservation of forest resources and the decentralization of the forestry sector. Therefore, it aims at using this technical plan as an annual guideline in terms of land rehabilitation and conservation activities. Land conservation should be enhanced owing to professional advice for reforestation and regreening activities. The multi – level technical plan represents a policy, technical and participatory approach.

Hence, different methodology and data was used to create the RTL – RLKT. For instance, in one part of the working process the researcher collected data on soil, erosion, geology, land use, and socio economic activities directly in field through observation, measures or sample plots. Qualitative data such as interviews with extension workers was gathered, as well. As an important working step in the elaboration of the technical plan, data from remote sensing with Spot 5 images was gained.

As result of this research a wealth of maps which describe the bio - physical and socio - economic conditions in the regency Bandung could be presented. The most interesting ones for this master thesis can be reviewed in Appendix 7 (Data Indonesia). These are maps containing information about rain erosivity, soil erodibility, type, class, longitude and steepness, erosion hazard and level, geomorphology, and land use.

The combination of elevation, erosion, management, and land use factor, results in a critical land use map for the upper Citarum region. This map is very crucial for the planning of land rehabilitation and conservation activities.

As conclusion of this research it can be stated that this technical plan contributes an important tool for land rehabilitation and conservation and is a particular step towards sustainable land management. At the moment there is no evidence how far the process owing to RTL -RLKT preceded.

Hydrological Implementation of Bamboo and Mixed Garden in the Upper Citarum Watershed

Chay Asdak from the institute of ecology in Bandung investigated on *hydrological implementation of bamboo and mixed garden in the upper Citarum watershed.* The research was carried out by collecting runoff and soil loss from four runoff / erosion plots in the rainy season of November 2004 to April 2005 (Asdak 2006: 17). According to Asdak (2006: 17), the site was selected as being representative because of the natural vegetation and regional topography of the upstream area of West Java.

The study aims at investigating the impact of different land use types such as bamboo plantation, mixed garden, small shrub, and agricultural fields with various species and stand structures on surface runoff and soil erosion at plot level (Asdak 2006: 17). In science the effect of rainfall, soils, slope steepness and canopy structure is well known but will be proofed for the specific research area in the upper parts of the Ciwidey watershed.

Data concerning soil erosion and runoff were collected both before and after 20 rainfall events. After these 20 rainfall impacts the researcher removed undergrowth and litter from the bamboo and mixed garden test plots and measured again (Asdak 2006: 19). According to Asdak's research study (2006: 22) the outcome was the following: runoff from bamboo plantation increased from 0,4 to 1,02 l/m^2 and soil erosion from 1.47 to 11,65 g/m^2 while the runoff and erosion in mixed garden raised from 0,36 to 1.65 l/m^2 and from 1,36 to 10.88 g/ m^2. In other words, stand/canopy structures are more important factors that influence the magnitude of soil erosion than runoff.

Asdak (2006: 23) concluded that "for the mixed cropping systems, the existence of well-maintained terraces and drainage systems is very important in preventing soil detachment and slowing down running water, and hence, making more rainfall to infiltrate into the soil. But, in sloping lands with high rainfall intensities, the existence of multi – layering plant canopies, undergrowth, and ground litter is very important to reduce both runoff and soil erosion."

3 Methodology

3.1 Methodological Framework

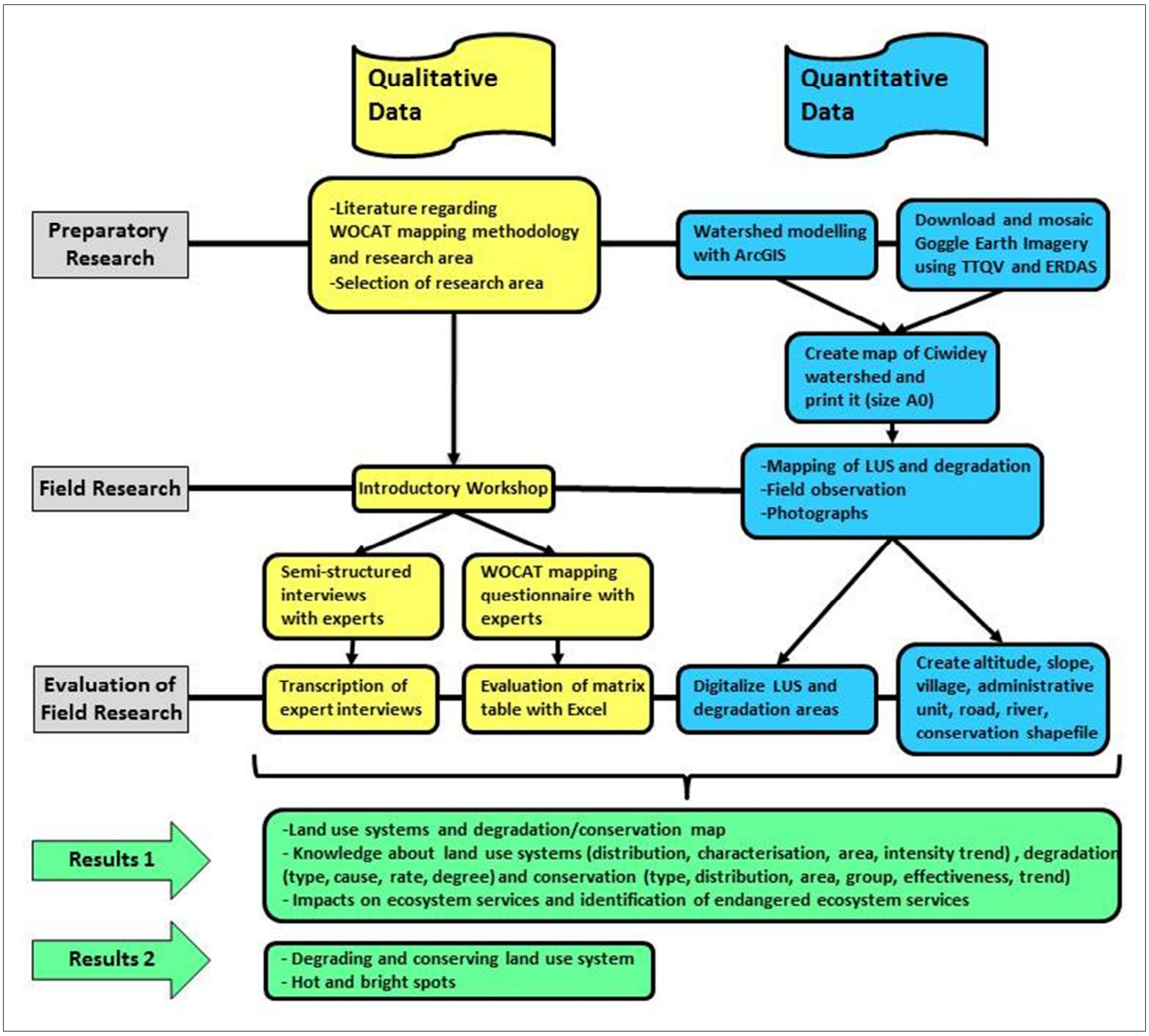

Figure 5: Methodological framework (De Maddalena 2011)

Figure 5 illustrates the methodological framework in a manner of a workflow. This framework is shaped by three research phases (grey boxes). After starting with preparatory research, it advances in field research and ends up with the evaluation of the field research in order to provide results. The work steps in yellow (left) can be assigned to qualitative data or methodology even though the WOCAT mapping questionnaire consists of closed answers. The way of how these questions are formulated leaves the possibility open for additional answers but does not neglect the standardized categories. Furthermore, semi-structured interviews are open and can lead to a sudden change and extension of the conversation topic. The contrast of the qualitative data is quantitative data or methodology (blue work steps). For instance watershed modeling, or the digitalization of LUS areas with ArcGIS belong to the quantitative methodology. In order to achieve final results the quantitative and qualitative data will be merged and evaluated. The subsequent chapters will describe the single methodological steps in detail.

3.2 Preparatory Research

3.2.1 Selection of Research Area

For this master thesis a watershed in the upper Citarum area has been chosen because of its high significance in the issue of integrated watershed management of the Citarum watershed which is managed by the BPDAS Citarum Ciliwung, a department of the ministry of forestry. Several criteria led to choose Ciwidey sub watershed as one of the seven sub watersheds of the upper Citarum section for the investigation.

1. Erosion Rate
First criterion is that Ciwidey can be derived as the watershed with the highest erosion rate in the upper Citarum watershed. Based on the findings from BPDAS Citarum-Ciliwung (2009), Ciwidey is categorized as critical watershed.

2. Variety of Land Use System and Altitude
Secondly, the watershed elevation ranges from 600 to 2000 m a.s.l. and therefore consists of various altitudinal belts. Consequently, several LUS such as tea plantation, mixed farming, rice fields, protected, and conserved forest can be identified (cf. Appendix 1).

3. Precipitation Amount and Intensity
The third criterion is the precipitation amount and intensity in the area because of their consequences on soil erosion. Ciwidey sub watershed belongs to climate type A where average precipitation counts 2,233 mm/year and rainfall intensity has been quantified to an average of 17.6 mm/day (Asdak 2006: 17). Ciwidey which belongs to one of the four watersheds south of the Citarum River is much wetter than the three watersheds north of the Citarum River.

4. Quality of Goggle Earth Imagery
The resolution of Google Earth imagery must be of good quality and the year of the image (2006) is rather recent. This criterion is very significant in order to create a base map for the field mapping.

5. Catchment Area and Access
Furthermore, the size of the area and the availability of roads are important, as well. It should be feasible to map the watershed and fulfill the WOCAT mapping questionnaire within a time period of six weeks. Ciwidey watershed is not the smallest in the upper Citarum, indeed the catchment ranges over 22,169 ha (221.69 km²) (De Maddalena 2010).

3.2.2 Watershed Modeling with ArcGIS

After the research area has been selected regarding various criteria the subsequent methodological task was to delineate the perimeter of the Ciwidey sub watershed. This was conducted by applying the watershed modeling methodology on a GDEM. The modeling is accomplished in Arc Map using the spatial analyst and hydrological tools:

1. Download GDEM (from www.gdem.aster.ersdac.or.jp/index)

After the GDEM had been downloaded spatial reference should be assigned and projection be defined. WGS 1984 and UTM 48s had been selected as spatial reference and UTM 48s as projection. The spatial analyst surface tool is convenient for visualizing the GDEM as a hill shade in order to get a first impression on the topography.

2. Create flow direction and flow accumulation layer

Before running the flow direction tool the sinks in the GDEM were filled with the spatial analyst tool *fill.* Furthermore the resulting depression-less GDEM was used to calculate *flow direction*. This tool calculates every altitudinal value of a single cell and its relation to the neighboring cells. The outcome is a grid with arrows per cell which indicates the flow direction. By running the tool flow accumulation (cf. Figure 6) the accumulated weight of all cells flowing into each downslope cell was calculated (Krauer 2010). The figure flow direction consisting of arrows shows the direction of water travel route from each cell to the neighboring. The flow accumulation illustrates the number of cells that flow into each cell. In other words, by running the tool flow accumulation (cf. Figure 6) the accumulated weight of all cells flowing into each downslope cell is calculated (Krauer 2010).

Figure 6: Flow direction and flow accumulation (ArcGIS desktop help, http://webhelp.esri.com/arcgiSDEsktop/9.3/index.cfm?TopicName=Calculating_flow_accumulation)

3. Generate a pour point shape file

The pour point for will be the junctions of a stream network derived from flow accumulation (ArcGIS Desktop help).This pour point is defined in Google Earth first and then imported in ArcGIS in a kml file. As the Ciwidey River flows into Citarum River the location of this pour point is the ending point of Ciwidey river.

4. Run the watershed tool and convert to polygon shape file

The watershed tool needs poor point and flow accumulation as input files for the calculation. There appear difficulties to create the correct boundary because the lower part of the watershed is to flat, thus flow accumulation has the same value. In other words the watershed can just be calculated in the remaining area where values differ sufficiently.

5. Extension of the watershed boundary

Due to this complication the lower part of the watershed was extended by drawing a broader polyline. The information to set this extended boundary was derived from BKSDA's integrated watershed management plan.

3.2.3 Downloading and Mosaicing Google Earth Imagery Using TTQV and ERDAS

The next step downloaded single images from Google Earth relying on the mentioned watershed area and mosaiced them so that a base map could be created. For this working process *Google Earth* 5.0.1, *Touratech QV* 4, and *Leica ERDAS Imagine* 9 constitute the necessary software (Achermann 2010: 4). For more detailed information on this methodological working step refer to Achermann (2010).

However, the created mosaic of the Google Earth image and the watershed boundary shape file were afterwards added to ArcGIS. Furthermore, they were designed and printed out in A0 size for the field work.

3.3 Field Research

The following chapter presents first the WOCAT mapping methodology in general (cf. 3.3.1), secondly highlights administrative and organizational tasks (cf. 3.3.2), and furthermore describes the modified and applied mapping methodology in the field (cf. 3.3.3).

3.3.1 WOCAT Mapping Methodology

WOCAT has developed a set of standardized tools to monitor, evaluate, and document soil and water conservation know-how world-wide. Namely, three comprehensive WOCAT questionnaires and corresponding databases have been developed to document and map relevant aspects of SWC technologies and approaches (Liniger, Van Lynden, and Schwilch, 2007: 1). The aspect of SWC has been expanded so that it nowadays implies additional SLM technologies such as the conservation of biodiversity for instance. The first WOCAT questionnaire on SLM technologies which addresses the human and natural environment of SLM technologies as well as the technologies as such, and the second questionnaire on SLM approaches which assesses implementation, are more pervasive than the mapping questionnaire which allows a spatial assessment of SLM.

The mapping questionnaire will be used as guideline which aims at capturing land use, degradation and conservation and spatially assessing the impact on ecosystem services, including agricultural production, organic matter, and water availability, for this research project (WOCAT b 2011). It evaluates what is happening where, by linking the information obtained through the questionnaire to a *Geographical Information System* (GIS). GIS permits the production of maps as well as area calculations on various aspects of soil and water conservation (Liniger, Van Lynden, Schwilch, 2007: 1). It points out where land management needs to be adjusted due to ongoing land degradation and which SLM technologies are efficient and accurate and should be disseminated.

However, it has to be mentioned by Liniger et al. (2008: 4) that the questionnaire should be used as evaluation tool for land degradation and conservation activities on a regional or national level. To improve quality and reliability of the compiled data additional information from former research, satellite image and maps had essentially been considered. Reliable sources of information are local extension workers and specialists for SLM. Hence, effectual outcome of the questionnaire will be generated by a team of different land degradation and conservation specialists in consultation with land user with different backgrounds and experiences (Liniger et al. 2008: 4). A negotiation process in a participatory expert assessment will contribute the specific information.

<u>Defining Mapping Units</u>

According to Liniger et al. (2008) the first methodological step of this mapping methodology is to establish a comprehensive base map consisting of closed polygons. This can be any kind of map such as a physiographic satellite image, an aerial picture, or a map with administrative boundaries. Above all, the main criterion for map selection is that the polygons should be identifiable in the field. An existing LUS map is a starting point for mapping degradation and conservation is LUS (WOCAT c 2011). The LUS is the crucial driver of degradation and conservation. Therefore LUS is considered as the basic unit of evaluation. If no LUS map is available it has to be created at the beginning in the field before the degradation and conservation mapping exercise starts on the basis of a satellite image, for instance.

As the guideline for defining base map units WOCAT (c) (2011) affirms a hierarchical system for defining LUS mapping units. The LUS underlies a hierarchical order which consists of three levels (WOCAT c 2011). Definitions can be found in Appendix 3:

1. Land use type: Cropland, Grazing land, Forest/woodland Mixed, Other

2. Subcategories of land use type: (e.g. Cropland: annual, perennial, extensive, intensive, rainfed, irrigated etc.)

3. Further subdivisions: (e.g. geomorphologic criteria, watersheds, administrative units districts, village etc.)

According to Liniger et al. (2008: E1), LUS units in combination with administrative units for instance, permit to evaluate trends and changes in time of land degradation and applied SLM technologies. Every LUS polygon from different administrative units or watersheds forms a particular polygon with assigned information which is documented in a matrix table and has a concrete mapping unit.

However, for each mapping unit a matrix table providing information regarding LUS (cf. Table 4), land degradation per LUS (cf. Table 5), land conservation (cf. Table 6), and expert recommendation (cf. Table 7) has to be compiled with the expert knowledge of specialists. The following tables do not list the entire possible answers of the WOCAT mapping questionnaire. Only the answers gained through the conducted field research (explanation follows in chapter 3.3.3) will be listed in order to reduce the table to the most important values. Since abbreviations for land degradation types, conservation groups and measure are used in the compiled mapping questionnaire (cf. Appendix 7) it is recommended to refer to Liniger et al. (2008) for better understanding of the data.

Land Use System

Area trend of the LUS	Land use intensity trends
2 area coverage is rapidly increasing in size; i.e. > 10% of the LUS area/10 years	**2** major increase: e.g. from manual labor to mechanization, from low external inputs to high external inputs, etc.
1 area coverage is slowly increasing in size, i.e. < 10% of the LUS area/10 years	**1** moderate increase, e.g. a switch from no or low external inputs to some fertilizers/pesticides; switch from manual labor to animal traction.
0 area coverage remains stable	**0** no major changes in inputs, management level, etc.
-1 area coverage is slowly decreasing in size, i.e. < 10% of the LUS area/10 years	**-1** moderate decrease in land use intensity, e.g. a slight reduction of external inputs.
-2 area coverage is rapidly decreasing in size, i.e. > 10% of that specific LUS area/10 years	**-2** major decrease in land use intensity, e.g. from mechanization to manual labor, or a large reduction of external inputs.

Table 4: Answers for land use system matrix table (Liniger et al. 2008)

Land Degradation per Land Use System

Type and Extent in %	Degree	Rate	Direct causes	Indirect causes	Impact on ESS	Level of impact
Soil erosion by water: **-** Loss of topsoil - Gully erosion - Mass movements - Riverbank erosion **Chemical soil deterioration**: **-** Fertility decline and reduced organic matter content - Soil pollution **Water degradation:** - Aridification - Change in quantity of surface water - Decline of surface water quality **Biological degradation:** **-** Reduction of vegetation cover - Loss of habitat -Biomass decline	**1** Light **2** Moderate **3** Strong **4** Extreme	**3** Rapidly increasing degradation **2** Moderately increasing degradation **1** Slowly increasing degradation **0** No change **-1** Slowly decreasing degradation **-2** moderately decreasing degradation **-3** Rapidly decreasing degradation	- Soil management - Crop and rangeland management - Deforestation / removal of natural vegetation - Over-exploitation of vegetation for domestic use - Industrial activities / mining - Urbanization / infrastructure - Discharges Release of airborne pollutants - Disturbance of water cycle - Over abstraction of water - Natural causes	- Population pressure - Consum-ption pattern Individual demand -Land Tenure - Poverty -Labor availability - Inputs infrastructure - Education / Awareness raising - War / conflict Governance / politics	**Productive services:** - production and risk - water for human, animal, plant consumption -land availability **Ecological services:** -regulations of excessive or scarce water - organic matter status - soil cover - soil structure - nutrient cycle - biodiversity - greenhouse gas emission - micro climate **Socio-cultural services:** - education and knowledge - poverty - health, - net income - marketing opportunities - tourism - protection / damage of infrastructure	**-3** high negative **-2** negative **-1** low negative **1** low positive **2** positive **3** high positive

Table 5: Land degradation assessment categories used in this master thesis (De Maddalena 2010; data source: Liniger et al. 2008)

Land Conservation per Land Use System

Group / Extent in %	Measure	Purpose	Effectiveness	Effectiveness trend	Impact on ESS	Level of impact
Manuring **Composting** **Vegetative strips** **Agroforestry** **Afforestation** **Forest protection** **Gully control** **Terraces** **Water harvesting** **River bank protection** **Waste management** **Conservation of natural biodiversity**	**Agronomic:** - Vegetation / soil cover - Organic matter/soil fertility - Soil surface treatment - Subsurface treatment **Vegetative:** - Tree and shrub cover - Grasses and perennial herbaceous plants - Clearing of vegetation **Structural:** - Bench terraces (slope of terrace bed<6%) - Forward sloping terraces (slope of terrace bed>6%) - Bunds / banks - Graded ditches / waterways - Level ditches / pits - Dams / pans - Reshaping surface - Walls / barriers / palisades **Management:** - Change of land use type - Change of management / intensity level - Layout according to natural and human environment - Change in timing of activities - Control / change of species composition - Waste management	- Prevention - Mitigation - Rehabili-tation	**4** Very high **3** High **2** Moderate **1** Low	**1** increase in effectiveness **0** no change in effectiveness **-1** decrease in effectiveness	**Productive services:** - Production and risk - Water for human, animal, plant consumption -Land availability **Ecological services:** -Regulations of excessive or scarce water - Organic matter status - soil cover - soil structure -nutrient cycle - Biodiversity - Greenhouse gas emission - Micro climate **Socio-cultural services:** - Education and knowledge - Poverty - Health, - Net income - Marketing opportunities - Tourism - Protection / damage of infrastructure	**-3** high negative **-2** negative **-1** low negative **1** low positive **2** positive **3** high positive

Table 6: Land conservation assessment categories used in this master thesis (De Maddalena 2010; data source: Liniger et al. 2008)

Expert Recommendation

Expert recommendation	
Adaptation: to the problem: the degradation is either too serious to deal with and is accepted as a fact of life, or it is not worthwhile the effort to invest in.	**Prevention:** implies the use of conservation measures that maintain natural resources and their environmental and productive function on land that may be prone to further degradation, where some has already occurred. The implication is that good land management practice is already in place: it is effectively the antithesis of human-induced land degradation**.**
Mitigation: is intervention intended to reduce ongoing degradation. This comes in at a stage when degradation has already begun. The main aim here is to halt further degradation and to start improving resources and their functions. Mitigation impacts tend to be noticeable in the short to medium term: this then provides a strong incentive for further efforts. The word 'mitigation' is also sometimes used to describe reducing the impacts of degradation.	**Rehabilitation:** is intervention when the land is already degraded to such an extent that the original use is only possible with extreme efforts as land has become practically unproductive. Here longer-term and more costly investments are needed to show any impact

Table 7: Recommandation matrix table (Liniger et al. 2008)

3.3.2 Administrative and Organisational Tasks

Prior to the concrete field research in the Ciwidey sub watershed the researchers Andonie and De Maddalena had to cope with various administrative and organizational tasks. Essential was the process of applying for a research permit in order to conduct research legally. This included visits of the immigration office, institute of research (RISTEK), and the police headquarter in Jakarta. With the support of Syaiful Anwar, his wife and her sister this challenging task could be handled.

Afterwards, contact with the director of watershed management of the ministry of forestry in Jakarta. Dr. Silver Hutabarat, had to be established and this research concept was presented. He agreed with the purposes and ensured support for it. In addition, a revealing interview with Syaiful Anwar about the currently integrated watershed management plan of the Citarum watershed verified the relevance of this research (cf. Appendix 1)

Additive arrangements were made with the office of the ministry of forestry in Bandung (BPDAS Cisanduy) where Mr. Komar was the main contact person. His assistant Pakit Usman supported this research project by contacting the extension workers and inviting them to the introductory workshop in Ciwidey.

The overall goal of the introductory workshop was to present the research project to the extension workers and convince them to work temporarily for the WOCAT initiative. Furthermore it was a chance to pose some basic questions about the research area and SLM technologies. The most important LUS and for each LUS a set of SLM technologies were defined. After lunch research partner Andonie tried to fill out QT (Questionnaire on SLM technologies) for some mentioned technologies. The aim of the second day was to split the group of extension worker. One part discussed the approaches of SLM technologies with Miriam Andonie and the other part visited one well conserved and one degraded field of each LUS. During this two workshop days it became apparent that communication was the major issue and led to misunderstandings. Additionally, due to the lack of time of the extension workers, different perceptions of soil erosion, and a missing translator for the following weeks, the mapping approach methodology had to be modified.

Consequently, a participatory expert assessment or the visit of the LUS polygons with extension worker in the field as highlighted in chapter 3.3.1 could not be done as planned. However, the amendment of these crucial methodological steps of the research process resulted in new appropriate methodological solutions which will be presented in the next chapter.

3.3.3 Modified WOCAT Mapping Methodology

Defining Mapping Units

Mapping units of the base map in form of a LUS map were defined during the first day of the workshop with the extension workers and Pakit Usman. First, the Ciwidey sub watershed was divided in an upper, middle, and lower part. This task was conducted fast and uncomplicated. Secondly, the LUS mapping units were discussed. It was considerably challenging to translate Indonesian names of forest areas into English so that accurate mapping categories resulted. The aim to simplify biological LUS classes in order to assign categories which are visible in the field led to the alternative choice of biological (primary forest) instead to management LUS classes (protected forest). This *forest land* mapping units were defined as: *primary forest, forest plantation, secondary natural forest* and *agroforest*. In addition, the designation of *cropland* categories did not cause problems and resulted in categories such as *farming lowland, farming upland, irrigated rice, rainfed rice* and *tea plantation*. Nonagricultural land which can be designated under the category *others* are consequently *waterbodies* such as rivers and lakes, *settlements*, *industry and mining* areas. Due to the enormous size of the catchment obviously no further subdivisions were taken into account for the land use classes. During the mapping in the field two not clearly identifiable LUS attracted attention. In order to define these LUS new categories such as *bush with farming* and *cut and carry with farming* were established. The subsequent Image 10 -25 will show the mentioned LUS classes on a Google Earth image and highlight their most reliable observation indicators for identification in the field.

Primary Forest

Image 10: Primary forest (Goggle Earth 2006)

dense vegetation cover / old endemic trees / wide trunks/ huge trees / different canopy layer

Secondary Natural Forest

Image 11: Secondary natural forest (Goggle Earth 2006)

naturally regrowing / bamboo / small trunks and moderately high trees / logging

Agroforest

Image 12: Agroforest (Goggle Earth 2006)

farming activities in forest land / coffee, cassava, banana / endemic, pine, and eucalyptus trees

Forest Plantation

Image 13: Forest plantation (Goggle Earth 2006)

plantation of pine, eucalyptus or endemic trees in rows or spread

Bush

Image 14: Bush (Goggle Earth 2006)

small shrubs and young trees

Recreation Grassland

Image 15: Recreation Grassland (Goggle Earth 2006)

cut, planted or wild grass surrounded by forest / anthropogenic grassland for recreation purpose.

Irrigated Rice

Image 16: Irrigated rice (Goggle Earth 2006)

irrigated, ploughed field, field with young seedlings, rice prior grain growth, rice with grains flooded, rice with grain dry, harvested field, burned field)

Rainfed Rice

Image 17: Rainfed rice (Goggle Earth 2006)

no irrigation or dried out channels / rice field is at end state (can contain rice with dry grain or be burned)

Farming lowland

Image 18: Farming lowland (Goggle Earth 2006)

irrigation channels /,plant crops , and fertilize / moderate vegetation cover / predominately monoculture cash crops (onions, tomatoes, potatoes, cabbage, carrots, celery

Farming upland

Image 19: Farming upland (Goggle Earth 2006)

no irrigation / dry land / scarce soil cover / annual crops (banana, cassava, chilies, beans, tomatoes) / mixed crops (chilies / beans, corn / beans, tomatoes / chilies,

Tea Plantation

Image 20: Tea plantation (Goggle Earth 2006)

evergreen tea plant / harvested tea plant / artificially established

Bush with farming

Image 21: Bush with farming (Goggle Earth 2006)

chaotic distribution / bamboo, small endemic trees, shrubs, fruit trees (banana, papaya, cassava) / farming (beans, tomatoes, chilies, corn)

Cut and Carry with Farming

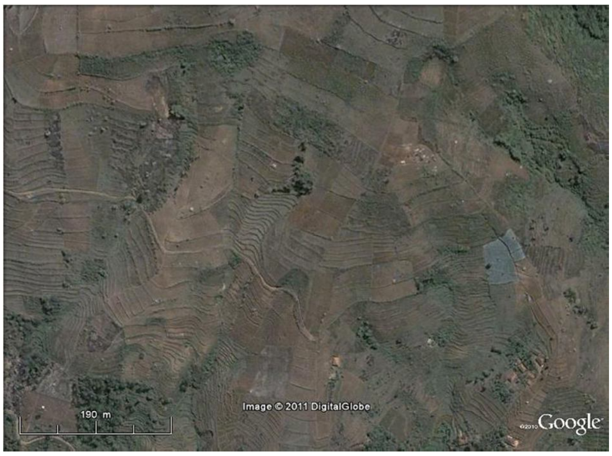

Image 22: Cut and Carry with farming (Goggle Earth 2006)

grassland / rainfed rice paddies which are cultivated with diverse crops /-livestock (especially cows) in barns / farmers with grass baskets

Settlement

Image 23: Settlement (Goggle Earth 2006)

constructed with bamboo or concrete

Industry

Image 24: Industry (Goggle Earth 2006)

large industrial factories

Waterbodies

Image 25: Waterbodies (Goggle Earth 2006)

rivers, lakes, irrigation channels, reservoirs

In addition to the observed LUS which were mapped, visible soil degradation was identified as well and marked on the prepared A0 printings. Thus, observed phenomena such as landslide, topsoil erosion, fires, loggings and bare land were mapped. It has to be noted that just a single part of soil degradation is captured in this mapping and that numerous spots of soil degradation were missed because the access to every single area was not possible and the catchment area is considerably large.

Equipped with photo camera, binocular, and GPS the mapping of the entire Ciwidey sub watershed was nevertheless feasible. The driven km by motorbike resulted in approximately 410 km. Image 26 displays the existing roads (black line) which are either paved, graveled or corrugated, and the effective driven tracks by motorbike (red line). In three weeks the mentioned LUS and soil degradation classes where mapped successfully on the created Goggle Earth AO printings of the Ciwidey sub watershed.

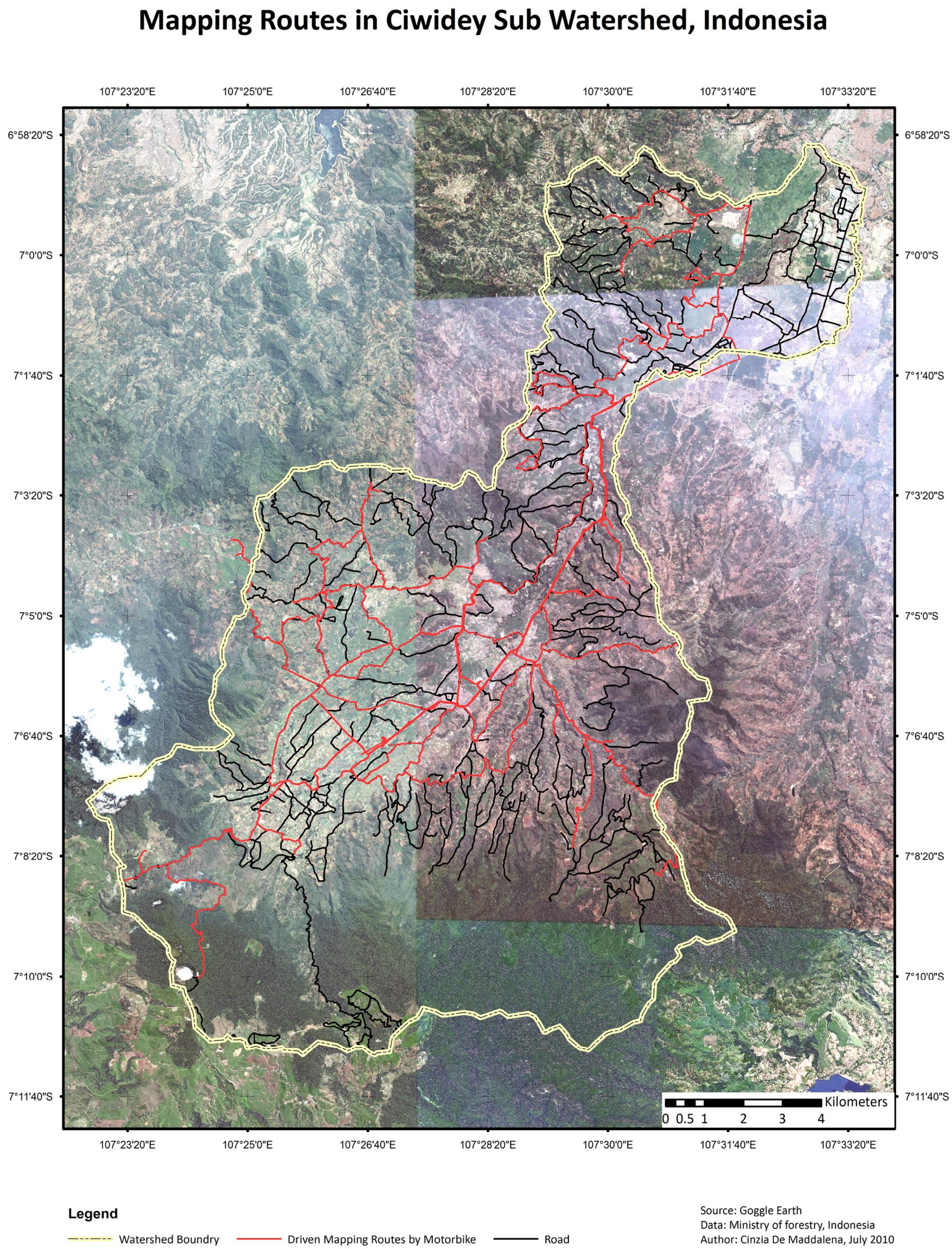

Image 26: Mapping routes in Ciwidey Watershed, Indonesia (Goggle Earth 2006)

After the mapping of LUS was finished, it was essential to extent this obtained information based on observations. Therefore, specialists were called in and as consequent step the WOCAT mapping questionnaire with its matrix tables was filled out. Additionally to this mapping questionnaire semi structured interviews were conducted with experts to conclude the data collection. The following sub chapter will thus present these two final steps of data collection:

Mapping Questionnaire and Semi-Structured Interviews with Experts

Desi Aprilliana Dewi, the translator of the introductory workshop arranged appointments with several specialists to fill out WOCAT questionnaire's matrix table. She assisted with her translation skills at the four interviews in the Ciwidey / Bandung area with Memet Ahmad Surahman from PHBM, Ande Supriatna from Dinas Pertanian, Avid Septiana from Perum Perhutani, and Wawan Suryamin from BKSDA. Furthermore Hari Tri Budianto from Syaiful Anwar's staff arranged the appointments at BPDAS Citarum - Ciliwung in Bogor where one mapping questionnaire was fill out together by Nilda and Agus Has. Table 8 illustrates the mapping units divided in watershed boundaries which were discussed in the interviews. Consequently, the Mapping ID allows assigning the obtained information to the LUS polygons of Image 28.

Land Use Type	Land Use System	Watershed Boundary	Geomorphologic Boundary	Specialist	Institution	ID
Forest	primary forest (BKSDA)	upper	hillslope	Mr.Wawan	BKSDA	1
	primary forest (Perhutani)	upper	hillslope	Mr.Avid	Perhutani	2
	forest plantation (BKSDA)	upper	plateau	Mr.Wawan	BKSDA	3
	forest plantation (Perhutani)	upper/middle	hillslope	Mr. Avid	Perhutani	4
	secondary natural forest (Perhutani)	middle	hillslope	Mr.Avid	Perhutani	5
	secondary natural forest (PKSM)	lower	hillslope, plain	Mr.Memet	PKSM	6
	bush	no data	no data	no data	no data	9.1
	grassland	no data	no data	no data	no data	9.2
Cropland	irrigated rice	middle	valley, plain	Mr. Ande	Pertanian	10
	irrigated rice	lower	plain	Mr. Ande	Pertanian	11
	rainfed rice	middle	valley	Mr. Ande	Pertanian	12
	farming lowland	middle	plain	Mr. Ande	Pertanian	13
	farming upland	middle/lower	hillslope/plateau	Mr. Ande	Pertanian	14
	tea plantation	middle	hillslope	Mr. Ande	Pertanian	15
	tea plantation	middle(Gambung)	hillslope	Mr. Memet	PKSM	16
Mixed	agroforest (Perhutani)	upper/middle	hillslope	Mr.Avid	Perhutani	7
	agroforest (community forest)	lower	hillslope	Ms. Nilda, Mr. Ande, Mr. Memet	BPDAS Citarum, Pertanian	8
	bush with farming	middle / lower	hillslope/valley	Mr. Ande	Pertanian	17
	cut and carry with farming	middle	hillslope/plateau	Mr. Ande	Pertanian	18
Other	settlements	upper/middle	Valley	Mr. Memet	PKSM	19
	settlements	lower	Plain	Mr. Memet	PKSM	20
	industry	lower	plain	Mr. Memet	PKSM	21
	mining	middle	Valley	Mr. Ande	Pertanian	22
	waterbodies	upper	hillslope	Mr. Ande	Pertanian	23
	waterbodies	middle	hillslope/valley	Ms. Nilda, Mr Ande	BPDAS Citarum, Pertanian	24
	waterbodies	lower	hillslope/plain	Ms. Nilda, Mr Ande	BPDAS Citarum, Pertanian	25

Table 8: Mapping units (De Maddalena 2010)

As introduction for filling in the mapping questionnaire, pictures of the mapped LUS were shown and the LUS map draft was displayed. The manner of introducing specialists into the mapping questionnaire remained equal for all the interviews. Before starting to pose questions about a mapping unit it had to be clarified if the concerning LUS differ in the upper, middle, and lower watershed. If this was not the case one single questionnaire was completed and its information was assigned to all the watershed areas.

The WOCAT mapping questionnaire remained unmodified, thus the questions and probable answers coincide with the illustrated Table 4, Table 5, Table 6, from chapter 3.3.2. Due to lack of time Table 7 (recommendation) has not been discussed with the experts.

Successful implementation of the mapping questionnaire varied depending on the different representatives of the institutions. Whereas the meeting and the subsequent interviews at Dinas Pertanian, BKSDA, and BPDAS were considerably efficient, extensive hurdles appeared at the institution of Perum Perhutani and Memet's house.

First, it was very difficult to get information from Perum Perhutani because this profit oriented organization of the government requires formal security before they deliver oral information and a GIS layer of their management area. Without research permit and the accompanying letters the interview would not have been possible. Anyway, the questionnaire about the so called protected forest (it includes primary forest, agroforest, and forest plantation areas) was filled in but its answers are not regarded as very objective.

Secondly, the interview at Memet's house which was a little bit chaotic because students from Bandung visited him at the same day resulted in a discussion about this research project and WOCAT. But it offered a change to talk with these students that are part of the green care initiative. Beside of Desi Aprilliana Dewi there was another woman assisting with her translation of Mr. Memet's statements. Two translators and a group of students which were all interested in Mr. Memet's mission and vision and WOCAT are not the best conditions for completing a WOCAT mapping questionnaire. However, the gathering of information about settlements, community forest (mapping unit of agroforest lower watershed), and waterbodies could be achieved and additional information about Memet and his replanting project could be collected, as well.

After the major information was compiled trough the WOCAT mapping questionnaire some open questions remained. These questions were gathered and answered in further semi - structured expert Interviews. For this reason revealing interviews with Prof. Naik Kaban from the agricultural university in Bogor and Ruddy Fadilah from BKSDA were conducted (cf. Annex 1).

Summarizing the period of data collection, it can be stated that all important information except mapping questionnaire on bush and grassland (which concerns only two small polygons) could be collected.

3.4 Evaluation of Field Research

The evaluation of field research uses predominately ArcGIS software to digitalize and edit LUS, degradation and conservation polygons (cf. 3.4.1). Furthermore, Microsoft Excel allows analyzing the information obtained through the WOCAT mapping questionnaire (cf. 3.4.2). Hot spots of degrading LUS and bright spots of well conserved LUS are resulting from the synthesis of WOCAT mapping questionnaire with the digitized LUS areas.

3.4.1 Digitizing Land Use System, Degradation, and Conservation

<u>Land Use System</u>

After the GPS tracks were imported to Arc Map it turned up arose that they deviate apparently from the roads in the Google Earth image. The shift between them amounted to approximately 100 m in some parts and in others they were almost identical. Due to this variance the Google Earth image has been corrected with the georeferencing tool by adding control points in order to clinch the image in the concerning areas.

After this correction step was accomplished LUS polygons drawn on the A0 printings of Google Earth image were delineated to the new corrected image in Arc Map. This was done by applying two different digitizing tools. After creating a new shapefile named LUS the sketch tool was applied first to draw the polygons. Every mouse click results in a vertex which at the end shapes the border of a single polygon. After a certain number of LUS polygons were created the process could be accelerated by using the streaming tool. Thereby, vertices are added automatically at an interval by moving the mouse. In total, 739 single polygons were created with these tools. This generated LUS shapefile had to be checked for gaps resulting from imprecise digitization. Therefore, this LUS shapefile was clipped from the former created watershed shapefile (cf. 3.2.2). In addition to the data about the area coverage of the polygons the attribute table was assigned with the information of the mapping questionnaire (cf. 3.4.2).

<u>Degradation</u>

Observed degradation polygons (landslides, topsoil erosion, fire, logging, and bare land) were mapped in the field and were delineated with the same tools as the LUS polygons. In total, 452 single polygons of observed degradation were drawn by hand.

<u>Conservation</u>

Since conservation was not mapped in the field this shape file with its features had to be created in the most feasible manner. The gained knowledge from field research was a crucial factor to attempt such a conservation shape file. Table 9 shows the selected conservation features in order to create the conservation shapefile and why they have been selected.

Conservation classes	Benefit of conservation	Feature creation	Mapping ID
	Management measure		
Provision of law	The law allows only restricted farming. In other words only the cultivation of coffee and “terong kori” is allowed under an agroforestry system. It decreases soil erosion and increases infiltration rate.	The area which is managed by Perum Perhutani	Conser_
Protected forest	Strict conservation leads to maintenance of natural ecosystem function	The area which is managed by BKSDA	Conser_PF
Rotational system	Combination of livestock and farming which is adapted to monsoonal rainfall pattern. No erosion emerging from animal tracks, production of animal fertilizer in the farm, increase of production.	Cut and carry feature of land use map	Conser_R
	Vegetative measure		
Agroforest	Improve soil fertility, reduce soil erosion, keep topsoil in place, reduce runoff, increase biodiversity, increase production	Agroforest feature of land use map	Conser_AF
Perennial vegetation cover	protects topsoil from strong rainfall, increases infiltration rate, increase soil fertility, prevent landslides	Tea plantation feature of land use map	Conser_GC
	Structural measure		
Terraces	Make steep land arable, diminish soil loss, increase productivity	Raster calculator: Terraces are detected in irrigated rice and lowland farming where the slopes are => 5	Conser_S

Table 9: Creation of conservation shape file (De Maddalena 2011)

3.4.2 Analysis of Mapping Questionnaires

A large amount of data accumulated from the WOCAT mapping questionnaire. For the evaluation of the matrix tables a selection of the most important values was chosen and visually displayed with charts. The additional data was integrated in the description and discussion of the mentioned charts. The entire mapping questionnaires can be looked up in Appendix 7.

Since there are several LUS matrix tables completed by different experts the average of values or the most reliably estimated values were applied. For example, the intensity trend of the *waterbodies* matrix table in the lower watershed amounts in one interview to -2 and in the other to 0 hence the value between is -1. Degradation types, conservation names, causes and impacts which consist of letters instead of numbers were not averaged but tabulated.

However, a further issue was the aggregation of the WOCAT mapping questionnaire data with the LUS map particularly for the forest areas. This methodological step attributed LUS polygons with information obtained through the WOCAT mapping questionnaire. A problem occurred because the classification of the forest LUS classes made by the researcher were more detailed and the specialists compiled the information according to their management area. In order to solve this problem the management mapping units were allocated to the LUS classes of the LUS map. This was possible because forest management shapefiles from several institutions were available. Hence, it resulted in a primary forest area for instance, where one polygon obtained the attributes from nature reserve and the others the one of Perhutani’s protected forest. As result all the information from the mapping questionnaire was linked through ArcGIS with the mapping units of the LUS map.

Biological Mapping units by researcher	Management mapping units by specialists
Primary forest	Nature reserve (BKSDA) / protected forest (Perhutani)
Forest plantation	Recreation forest (BKSDA) / protected forest (Perhutani)
Secondary natural forest	Protected forest (Perhutani) / community forest (PHBM)
Agroforest	Protected forest (Perhutani) / community forest (PHBM)

Table 10: Allocation of biological mapping units by researcher with management mapping units (De Maddalena 2011)

Furthermore, the WOCAT mapping questionnaire was analyzed in reference to the impacts of degradation and conservation on ES. First the values of ES-subcategories were assigned to productive, ecological, or socio-economic ES. Secondly the impacts of degradation and conservation (-3,-2,-1, 0, +1, +2, +3) of these three categories were allocated to their respective surface. Actually the idea was to use the extent of degradation and conservation per LUS, but this was not possible for lack of information. It remained unclear if degradation or conservation phenomena appear overlapped or not. For every LUT the summed-up impacts for the three main ES-categories are to be displayed in charts. For further information on the calculation refer to “impacts_evaluation.xls” in Appendix 8.

4 Results and Discussion

This chapter illustrates several results of this master thesis. The first part of the analysis aims at characterizing the observed LUS which are displayed in the LUS map. In addition, the information about LUS change, degradation, and conservation in the area, resulting from the WOCAT questionnaire is shown in figures (cf. 4.1).

The second part of this chapter regards the degradation and conservation map (cf. 4.2) that locate degradation and conservation per land use system and relate it to SLM. Furthermore in the third subchapter the impacts of conservation and degradation on ES are analyzed (cf. 4.3).

4.1 Land Use System Map

The created LUS map (cf. Image 28) is composed of different land use polygons. Before the analysis of the map and the LUS attributes will be described, the land use classes are summarized and illustrated in the subsequent chapter.

4.1.1 Characterization of Land Use Systems

LUS observable in Ciwidey sub watershed are described and categorized in four main land use types: forest, cropland, mixed use and others. Their division in sub categories is more detailed and highlighted subsequently.

<u>Forestland</u>

Primary Forest

Primary forest is an intact natural forest which has not been disturbed by human activities such as logging for several hundred years and is characterized by an abundance of mature trees. This type of forest has several well developed, dense, canopy layers. Favorable environmental conditions lead to high biodiversity including animals such as tigers, monkeys, snakes, deer, and endemic plants and trees. The primary forest is protected and belongs to the government. There are two institutions, Perhutani and BKSDA, that manage different parts of the primary forest area.

Secondary Natural Forest

Secondary forest is a forest which has re-grown after a major disturbance such as fire or logging without the regreening or replanting programs. This forest is predominately not used for timber harvesting or farming. However, illegal logging activities and soil removal can be identified in some parts. The canopy is dense and variable with different vegetation layers. Due to logging of trees and fires deep cuts in the canopy can be found in parts of the forest. Land degradation is predominately found in the logged areas. Perhutani and BKSDA are sharing the task to manage and protect this area.

Forest Plantation

Forest plantation is a forest which has re-grown supported by human activities after a major disturbance such as fire or logging. For afforestation the government has planted endemic trees, pine, eucalyptus, and bamboo. There is almost no cultivation of crops or other farming activities in this land use category. The trees are aligned in rows. Trees from the same species have almost the same size and thickness. This land use system is managed by the government, especially the institution of Perhutani.

Bush

Bush is defined by dense shrub cover with some single trees. Vegetation is affected by past logging and farming activities and thus, is currently regrowing. There are no human support activities to rehabilitate or reforest this category.

Recreation Grassland

The *grassland* area is dominated by grasses and other plants. In general, the grass has been cut once or more times during a year. Grasslands occur naturally or as the result of human activity. The grassland area in Ciwidey maintained by human activities is called recreation grasslands because of human maintenance. The purpose of this grassland at Ranca Upas is commercial and either consisting organized adventure trips for youths or campground rentals.

Cropland

Irrigated Rice

Irrigated rice paddies are either located on hillsides stabilized by bench terraces, or in the plain separated by soil bunds. There are drainage channels to direct the water into the paddies. Waterlogging is used to create favorable condition for rice growing. Due to the annual irrigation system, rice can be harvested twice or more times a year. Irrigated rice paddies can be in different states depending on their planting time and growing seasons: a) ploughed field, b) field with young seedlings, c) rice prior grain growth, d) rice with grains flooded, e) rice with grain dry, f) harvested field, g) burned field.

Rainfed Rice

Rainfed rice needs rainwater to grow and has therefore only one planting and harvesting season (annual), i.e. the wet season. This land use has irrigation channels, which are dried out in the dry season but flooded in the wet season. Visually, these plots resemble irrigated rice paddies with their level bench terraces and soil bunds.

Farming Lowland

Farming lowland is a land use system in a plain or valley which has enough humidity or stream flow usable for irrigation. The plots either are irrigated or rainfed, depending on the crop species and its need of humidity. In general, annual species such as onion leaves, tomatoes, carrots, potatoes, strawberries, and cabbage are commonly cultivated. The scales vary from small-scale subsidence oriented to large-scale market oriented farmers. Vegetables are planted as a monoculture system. Within this category, chemical fertilizer is intensively used, contrary to organic fertilizer which is rarely used. The farming plots are either divided by soil bunds or in steeper regions, by stone terraces.

Farming Upland

Upland farming is a land use system managed by small-scale farmers on elevated and steep slopes having no access to stream water. The most frequently planted annual crops are chilies, beans, corn, banana and cassava trees. Mostly, there are mixed fields with beans/corn or tomatoes/chilies. Few structural conservation technologies such as soil terrace and mulching can be identified.

Tea Plantation

All areas of systematically planted, non-timer based plantations such as tea or quinine. This land use system includes both young and mature plantations that have been established for commercial non-timber production. The plantations are always monocultures and are producing crops to sell in national and international markets. Tea plantation is a specific type of farming economy. Most of these plantations are owned by a great landowner that employs a number of tea pickers carrying out the work.

Mixed Use

Agroforest

Agroforest is a combination of trees and crops. The agroforest has re-growned both with and without human activities (regreening, planting trees) after a major disturbance such as fire or logging. It is still intensively used for small-scale farming activities but not for timber harvesting. There are several small-scale farming plots in the forest and at the edge of the forest. The farmers apply agroforestry systems with pine/eucalyptus and coffee, or production commodities such as bananas, cassavas, tomatoes, chilies, potatoes and beans. Soil erosion can be found in some areas. One part of this forest area is managed by Perhutani. The other very intensively cultivated part belongs to the local communities and is labeled community forest.

Bush with Farming

Bush with farming are all areas which are situated on hills or ridges. They are unstructured and inappropriately managed. There are much kind of crops such as tomatoes, chilies, beans, maize, cabbage, potatoes, cassava and fruit trees such as banana and papaya. Crops and fruit trees are spatially mixed with shrubs and endemic trees. Most of this land belongs to wealthy people from Jakarta that care little about their production system and environment, causing high land degradation.

Cut and Carry with Farming

Cut and Carry are all areas that cover grassland for fodder production and farming plots. The small-scale farmers possessing livestock such as goats, chickens or cows. Therefore the fodder grass is planted in the plots or on the edge of them. Besides grass production, cutting and carrying, farmers are cultivating mixed vegetables (beans and corn, tomatoes and chilly) for self-subsidence. This farming system is extremely labor-intensive and has a sparse tree and shrub cover.

Others

Settlement

Settlements are all formally built up areas in which people reside on a permanent or near-permanent basis. They are identifiable by the high density of residential and associated infrastructure. Settlements including cities, towns, villages and infrastructure such as schools, mosque, hotels, restaurants and public buildings. Some settlements consist of home gardens, small livestock or fishponds for domestic use.

Industry and Mining

The main *textile industry* factories of Indonesia are situated in Bandung and its surroundings. Major textile industries are owned and run by international companies. Coal energy is the most common energy delivery system in this category and has replaced the more expensive oil energy system. Sub -surface and surface based mining activities. Including both hard rock and gold extraction sites.

Waterbodies and Rivers

Waterbodies are areas of permanent open water. The category includes both natural and man-made waterbodies, either static or flowing. This category consists of objects such as rivers, irrigation channels, reservoirs, fish ponds and lakes

Image 27: Description of LUS classes (De Maddalena 2010)

4.1.2 Spatial Distribution and Area of Land Use System

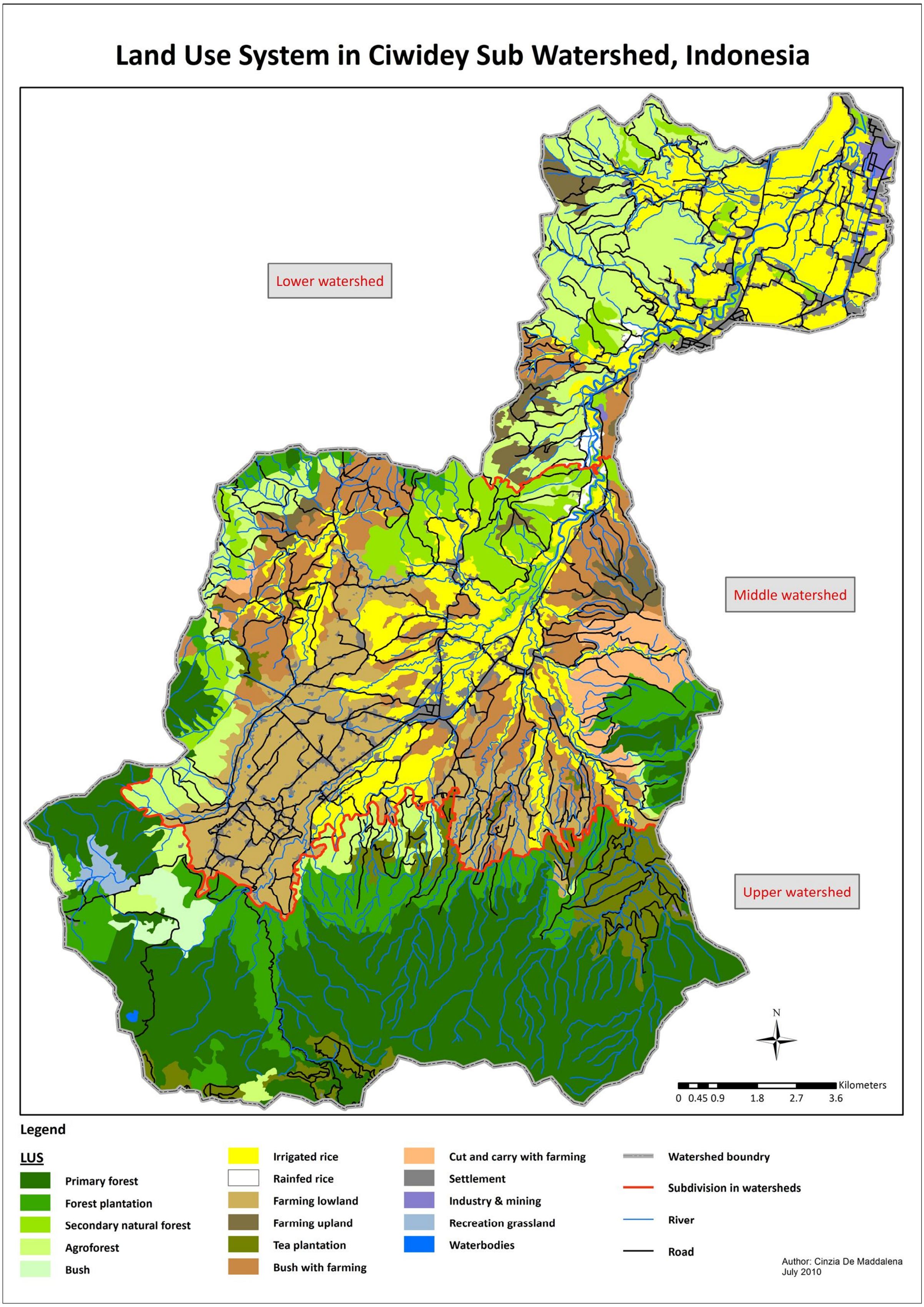

Image 28: Land use system map of Ciwidey sub watershed (De Maddalena 2010)

The LUS map illustrates a complex mosaic of LUS in the Ciwidey sub watershed, in August 2010. Nevertheless, some spatial patterns of land use are recognizable and discussed subsequently.

Upper Watershed

The upper watershed is covered by vast *primary forest*, *forest*- and *tea plantation*. The *primary forest* is recently spread along the highest summits. This *primary forest* belt goes over in *forest plantation* and/or *agroforest* LUS slope downward. Two areas where identified as *grassland* and *bush*. These areas are unique for the upper watershed and do not fit in the natural appearance of the upper watershed. On the contrary the upper watersheds build a suitable environment for *tea plantations* which are often seen in this area.

Middle Watershed

In the middle watershed below the border of the upper watershed (cf. red line in Image 28), *forest plantation* and *agroforest* become *bush and farming*, or *farming lowland* at lower altitude. In this middle watershed area almost all LUS sub categories exist. Their appearance correlates especially with the landform and slope steepness. In other words, the flat areas, west of Ciwidey town which is the center of the watershed are designated as *farming lowland* and *irrigated rice.* This plateau is intensively used for crop production and irrigation channel appear constantly. The rice fields enter the valleys and are located along creeks and commonly stabilized by terraces. On steep slopes the LUS *bush and farming* and *agroforest* are dominant. In contrast to farming lowland, trees / shrubs alternate with farming, whereas f*arming lowland* is treeless. Additionally, there still exists forest such as *secondary natural forest, primary forest,* and *forest plantation*. It is not avoidable that in the forest areas illegal farming and logging occur. However, the forest area remains small and is located on moderate and steep slopes along the summits. In the eastern part of the middle watershed the rotational system *cut and carry with farming* covers a large and unique area for the entire research area. Furthermore, the middle watershed offers the most suitable conditions for *settlement*. Thus, the amount of *settlement* and the density of *settlements* in the plain of the middle watershed are considerably high.

Lower Watershed

In the lower watershed, in the flat areas and along creeks there are predominately cultivated *irrigated rice* paddies and *agroforestry systems* situated on hillslopes. Only a few rice fields are rainfed. Farmers do plant rice along the natural creeks and often upstream in the direction of the springs of the creeks. Irrigation channels make it possible to irrigate a large area of rice cultivation. The majority of rice paddies are located in the flood plain around Soreang. There is only a small area where *farming upland, bush and farming,* and *secondary forest* are identifiable. These LUS(s) are predominately found on ridges or at the edge of the watershed. Furthermore, there are several *settlements* and *textile industries* in the outbound of the Ciwidey watershed which is close to metropolitan Bandung.

The summarized area for the whole LUT is illustrated in **Error! Reference source not found.**. It is surprising that 38%, 8,393 ha can be derived as *forest* area. Thus, forest is the largest LUT in Ciwidey sub watershed. The forest area is even more ample because the *agroforest* has been assigned to mixed system instead of forest land. When including the *agroforest* in forestland the total forestland covers 50% of the whole catchment. Cultivated land designated as cropland amounts to 32% (7,167 ha) and is the second largest LUT. *Farming lowland* and *irrigated rice* contribute the largest area in this LUT. Mixed use contains agricultural activities in an area where shrub and tree cover exists. In total 24% (5,261 ha) belong to this LUT. *Bush and farming* and *agroforest* are the dominant LUS in this category. Unexpectedly, only 6% (1,289 ha) are *settlement* areas or *waterbodies* which belong to the category others. Due to impressions when travelling around the watershed the *settlements* seem to take a bigger proportion.

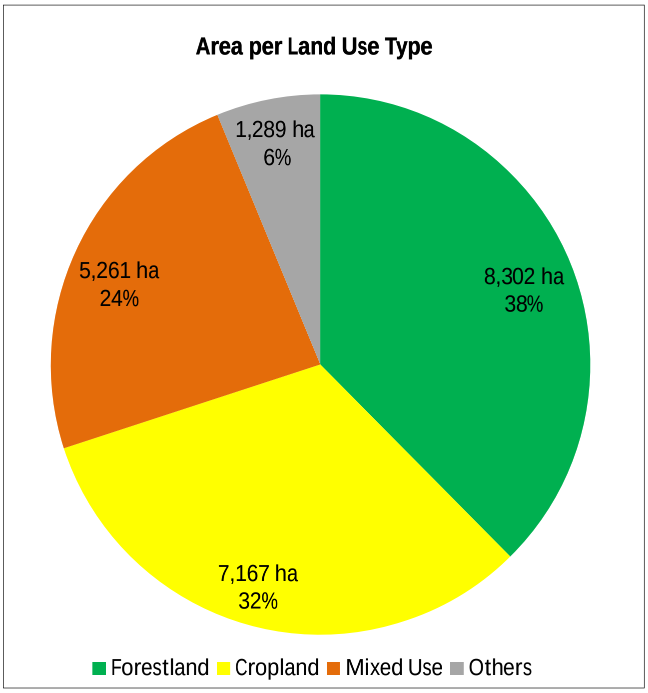

Figure 7: Area per land use type in Ciwidey watershed (De Maddalena 2011)

However, these LUT categorisation allow only an overview of existing LUS, therefore the four broad categories of LUT have be further subdivided into LUS (cf. Figure 8).

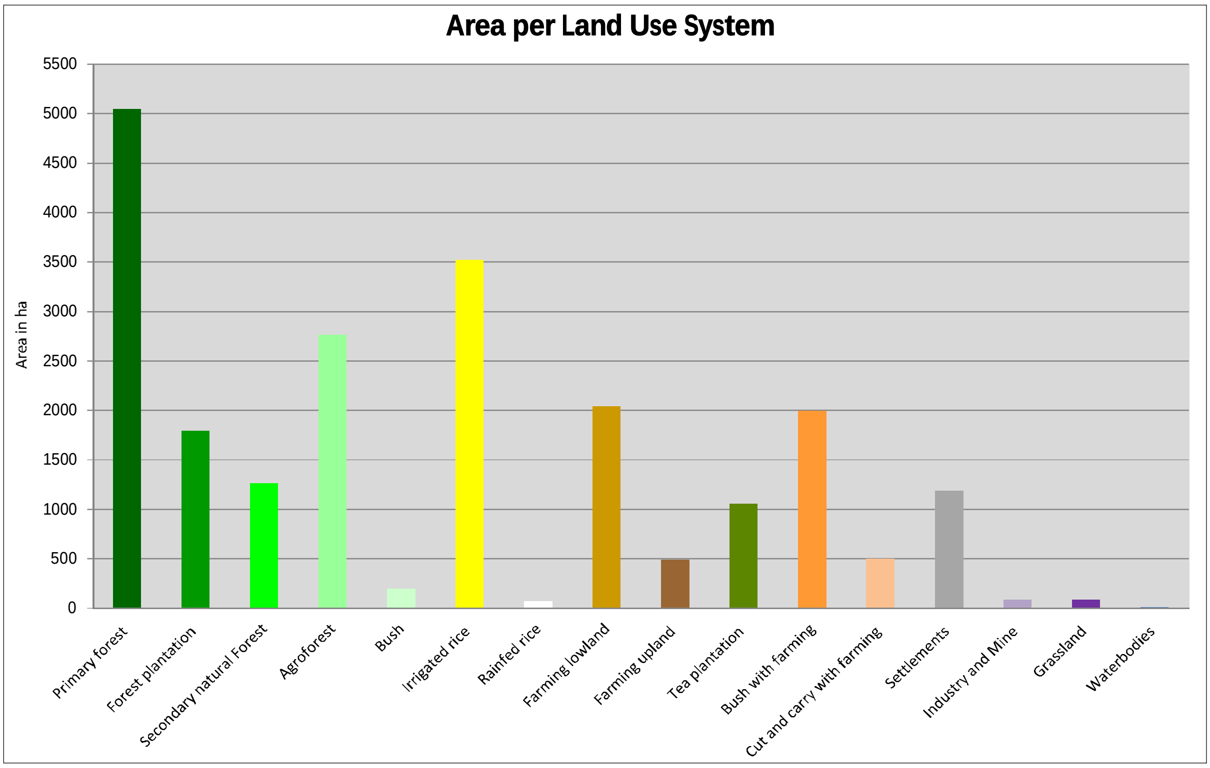

Figure 8: Area per land use system in Ciwidey watershed (De Maddalena 2011)

The largest area is *primary forest* which measures 5,050 ha and covers 23% of the watershed area. This is the remaining *primary forest* and has been partially protected, after the huge deforestation process. But there is, according to the WOCAT mapping questionnaire (cf. Appendix 7), ongoing illegal logging and timber gathering which can hardly be controlled and reduced efficiently.

Irrigated rice is the second largest LUS and a characterizing element of the Ciwidey sub watershed and shows the importance of intensive food production in the watershed. Furthermore, *agroforest* can be assigned as LUS which consists on one hand side crop production and on the other hand side maintains forest's ecosystem and is therefore the third largest area.

The fourth largest area is *lowland farming* which similar to *irrigated rice* lead to valuable food and cash crop production. *Bush and farming* is in a certain manner equal to *agroforest* because farming plots alternate with small trees such as bamboo and bushes but it is not managed by the government and hence it shows a chaotic pattern. It is also crucial that *settlements* perceive the largest number of other LUS.

4.1.3 Area- and Intensity Trend of Land Use System

This sub chapter analyzes the area- and intensity-trend of each mapped LUS for the last decade. The analysis shows trends in upper, middle and lower watershed and gives the opportunity to investigate the reasons. Definitions regarding the area- and intensity-trend categories -2,-1, 0, 1, 2 are listed in the former methodology chapter in Table 4. All the information is derived from the WOCAT mapping questionnaire (cf. Appendix 7).

<u>Upper Watershed</u>

All the LUS in the upper watershed remained stable in the last decade. If the enormous loss of forest in the past is considered, stable or increasing forest area is nowadays a positive development. This trend can be explained through the provision of a new law pertaining to the forest use. According to the experts before 2003 the use of the forest land in Ciwidey was not restricted as nowadays. It was a kind of small scale production forest and the farmers planted trees and harvested. The activities were allowed since the forest was not protected.

After 2003, the Perhutani launched a new law that restricted vegetable farming. Since then the farmers are just allowed to plant coffee, "terong kori" (eggplant), trees, and elephant grass in the *agroforest* (cf. WOCAT mapping questionnaire in Appendix 7). The farmers are part of a program called "empowerment of rural communities" in which agroforestry is a relevant issue. It has to be emphasized that only a few farmers do conform to the restrictions on production mix in these areas. But it is a positive trend compared to former considerable deforestation activities and it implies that land degradation through logging and soil erosion is reduced.

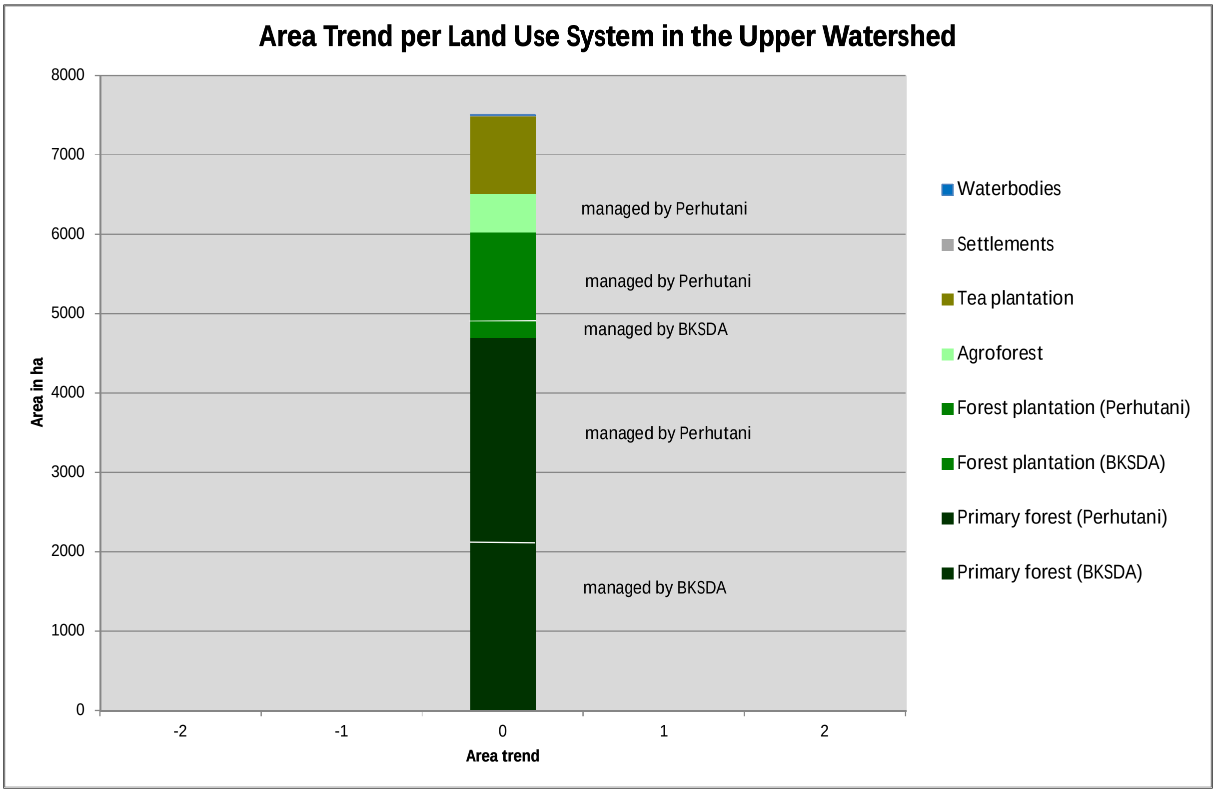

Figure 9: Area trend per land use system in the upper watershed (WOCAT mapping questionnaire 2010)

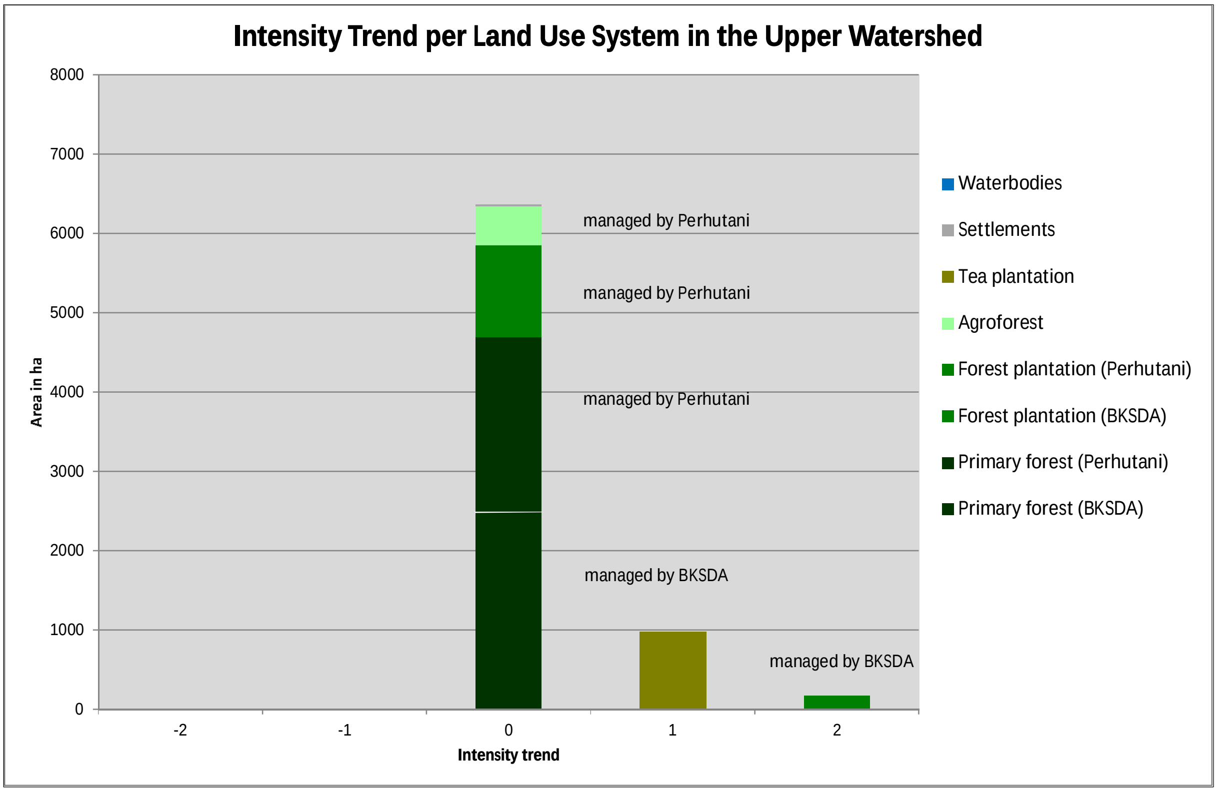

Figure 10: Intensity trend per land use system in the upper watershed (WOCAT mapping questionnaire 2010)

It is obvious that the intensity in *forest plantation* managed by BKSDA increased. In other words the forest plantation which is used as recreational area, namely Cimanggu hot springs, suffers from considerable growth in tourism. Impacts of raising numbers of visitors are vandalism and littering.

According to the experts the visitor number in 2008 amounted to 91,000 and in 2009 it raised up to 156,150 tourists. This rapid increase in visitors combined with the restricted area coverage of this recreational area (there was no increase in the LUS's area), is alarming and lead to degradation of the ecosystem.

The area for *tea plantation* remained stable as well but there were changes in the processing of tea in the state-owned plantation of Gambung. Due to problems regarding energy supply the energy production changed from fossil fuel oil to wood fuel because it is cheaper, and the quality of tea is better. Tea production is driven by an increasing demand for good quality tea which enables the Gambung tea factory to produce wood-based energy. This increases the pressure on the forests. Thus, it counteracts the sustainable use of the natural resources.

It is to be expected that *settlements* are boosted by the population pressure. However, this LUS did not increase in the past decade in the upper watershed. Reasonable explanations are that settlements and infrastructure development particularly take place in the middle and lower watershed where access to market and labor is higher. Furthermore, unsuitable hilly and steep terrain which is not buildable and higher landslide potential hinder the people to build houses in the upper watershed.

Middle Watershed

The area coverage trend in the middle watershed differs from the upper watershed because some LUS slowly decreases or increases and even strongly increases (cf. Figure 11). All of the forest LUS remain the same as in the upper watershed. Farmers are not any more interested in the forest as production source; they tend to assign more importance to crop land from which they gain higher benefits.

LUS which decrease are commonly converted into other LUS and lead to their expansion. Characteristic for this watershed is the decrease of *irrigated rice* fields which is driven by enforced settlement, infrastructure, hotel, and restaurant construction. Hence, *settlements* rapidly increased in the last decade. Also the increase of *farming lowland* is on the expense of *irrigated rice*. *Farming upland* slightly increased due to *bush and farming* that converts to *farming upland.*

A slow decrease in the size of the *bush and farming is reported*. This can be either explained trough the conversion to *farming lowland* or *upland*. In other words bush and small tree cover of *bush and farming* has been cleared and additional agricultural land created.
There has been a slow decrease in the *waterbodies*. Due to population increase, infrastructure, hotel development and more intensively used irrigation channels the area of *waterbodies* diminished (cf. WOCAT mapping questionnaire in Appendix 7).

Farming upland and *lowland* grew slowly. According the WOCAT mapping questionnaire (cf. in Appendix 7) the causes for the increase in *farming upland* are moderately steep slopes on the ridges, and fertile soils. Obviously, *farming lowland* became more commercial and market-oriented which results in an expansion of this LUS. Consequently, former *rainfed rice* plots or *irrigated rice* paddies have been converted to farming field which produce valuable cash crops.

Cut and carry with farming, which is an adequate LUS for densely populated areas, reported a considerably rapid growth, as well. The growth of population leads to a rapid increase of *settlements* in the middle watershed. According to the experts particularly along the main road and in the plain around Ciwidey town, on-going house, hotel and restaurant construction could be observed.

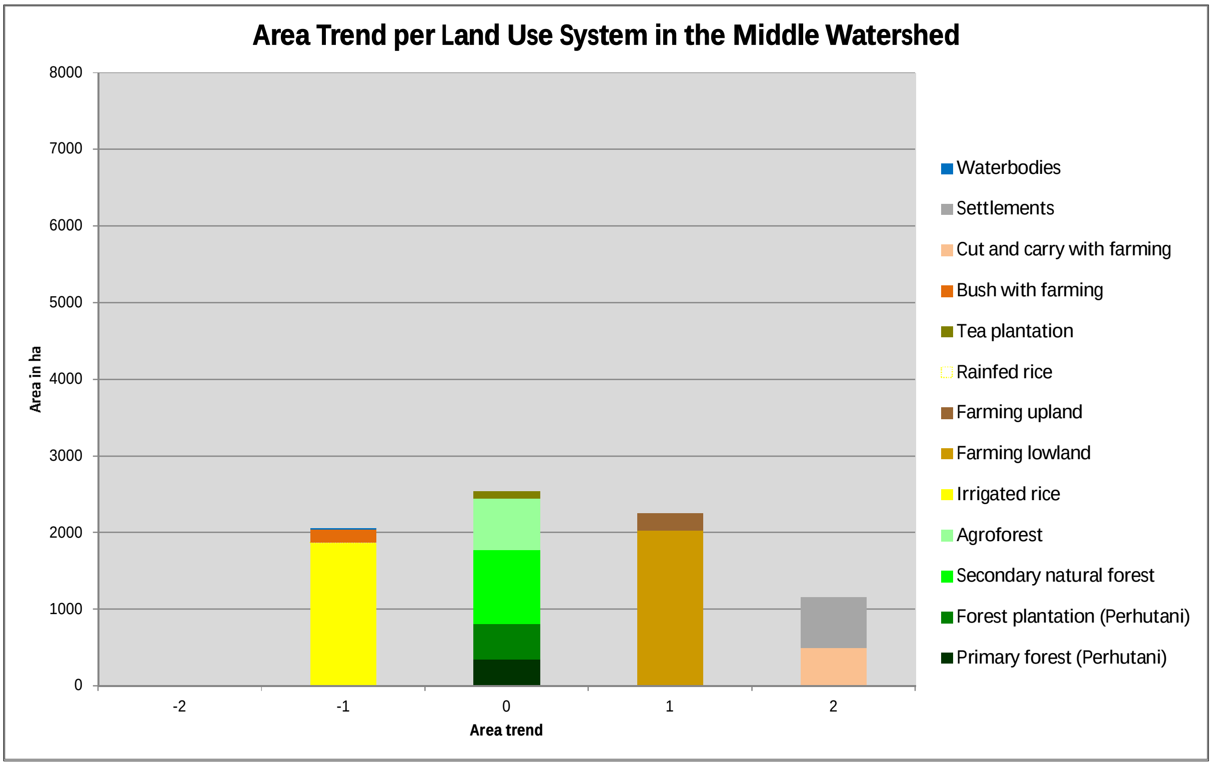

Figure 11: Area trend per land use system in the middle watershed (WOCAT mapping questionnaire 2010)

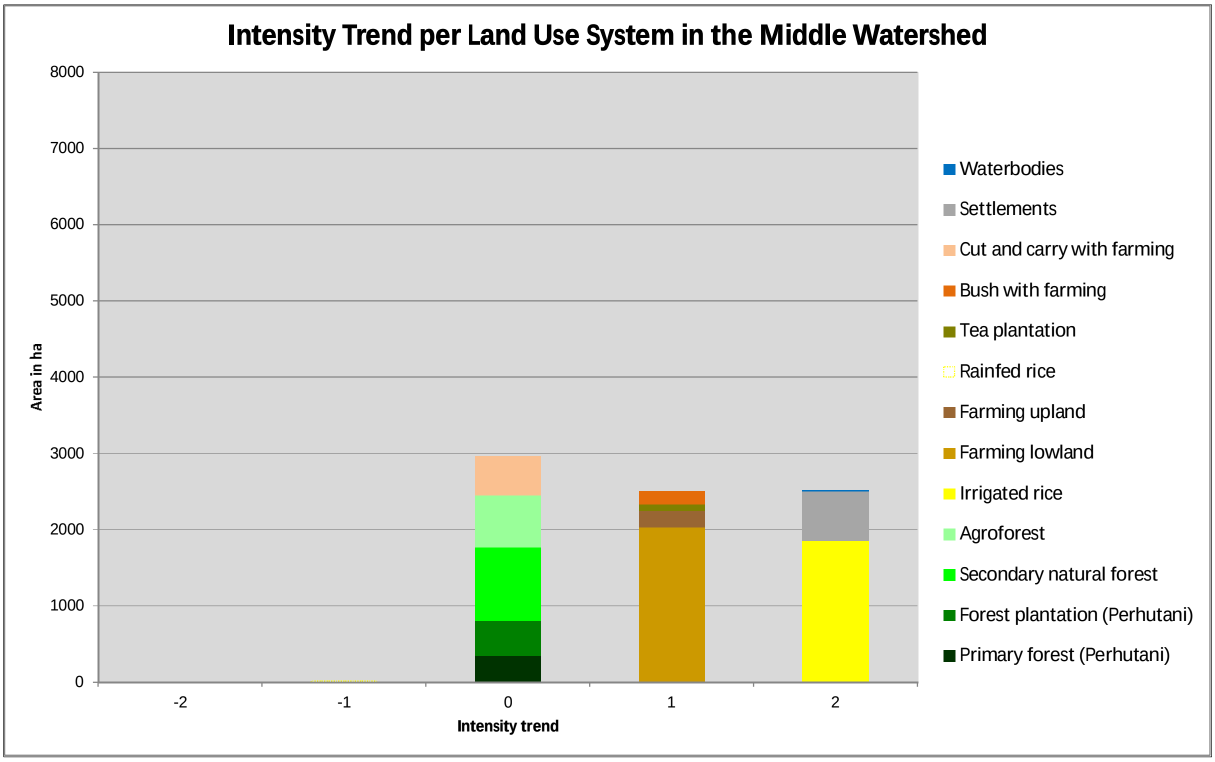

Figure 12: Intensity trend per land use system in the middle watershed (WOCAT mapping questionnaire 2010)

Figure 12 illustrates whether the LUS got intensification or not. Not a single LUS reports a negative trend which implies that in most of the LUS the intensity of management or external inputs increased remained the same. The intensity in forestland such as *forest plantation, protected forest*, and *secondary natural forest* remained stable over the last decade. According to the experts this is due to the management restrictions of BKSDA and Perhutani. Thus a slight increase of external inputs such as organic fertilizer or the change of manual labor to animal traction in the cropland such as *farming lowland* and *upland, bush and farming* occurred.

A major increase of intensity took place in *irrigated rice* due to growing use of organic fertilizer (cf. WOCAT mapping questionnaire in Appendix 7). The observed construction of new settlement and pavement of roads is a sign of major increase of the intensity in *settlements*.

<u>Lower Watershed</u>

The LUS area trend in the lower watershed differs again from upper and middle watershed. The majority of LUS is decreasing either slowly or rapidly in the lower watershed (cf. Figure 13).

There is a worrying negative trend in the LUS of *irrigated rice* which results in a rapid decrease of *irrigated rice* fields. According to the experts rice fields convert in general to settlements or infrastructure buildings. This conversion process is triggered by urbanization of Bandung (cf. WOCAT mapping questionnaire in Appendix 7).

The area coverage of *agroforest* diminished slowly in the lower watershed. The *agroforest* belongs mostly to people in the city. Farmers are logging, burning the fields in order to get a full conversion to agricultural activities. This can be for instance orange trees, cassava, banana, or grass for fodder production. According to the WOCAT mapping questionnaire (cf. Appendix 7) *agroforest* which is the common LUS in the hilly area of the lower watershed converts to typical *farming upland* fields with low vegetation cover. This for instance, results in farming on steep slopes. There is a significant negative impact which intensifies soil erosion.

Bush and farming which is a dominant LUS in the lower watershed, has a slowly declining trend regarding its area coverage. Explanations for this trend are the expanding *settlements* and infrastructure areas. Consequently, *settlements* increase rapidly and suppress agriculture. In addition, *textile industries* replace particularly irrigated paddy fields. The effects of urbanization impact dramatically on water resources. There is an increase of people that use water for irrigation and household. Furthermore industries purchase also a lot of water. All water user increase the use of water which can lead to water scarcity.

Since 2009 there is a legal andesite mining pit in the lower watershed reported in the WOCAT mapping questionnaire (cf. Appendix 7). There are small illegal mining pits in the Cibodas area. In general, the mining area remained stable.

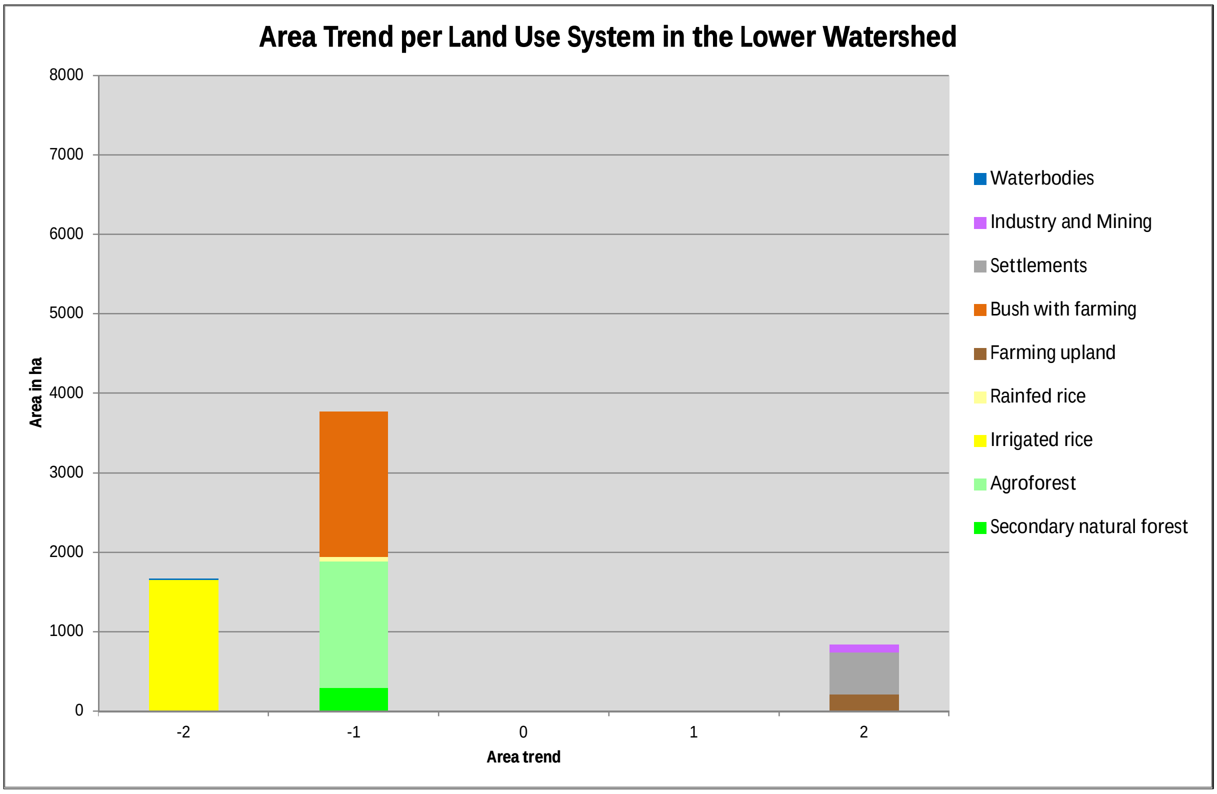

Figure 13: Area trend per land use system in the lower watershed (WOCAT mapping questionnaire 2010)

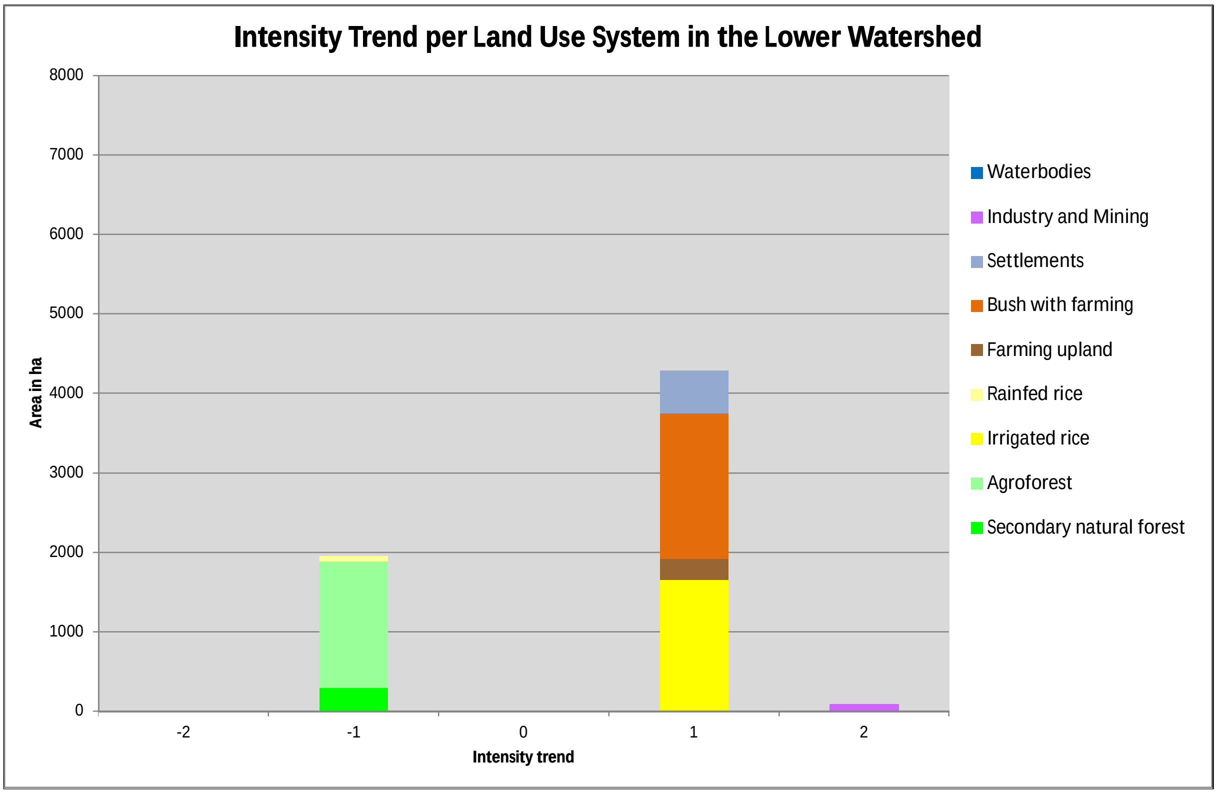

Figure 14: Intensity trend per land use system in the lower watershed (WOCAT mapping questionnaire 2010)

Regarding the intensity trend per LUS it is reasonable that the intensive use of forest is slightly decreasing (cf. Figure 14). Farmers have reduced interest in forest because arable land is limited.

Therefore the intensity in the *agroforest* decreases and the function of land changed to *settlement* area or entire agricultural plots.

In contrast, the intensity of *farming upland*, *bush with farming* and *irrigated rice* increased particularly due to the major inputs such as organic and chemical fertilizer reported by the experts. Two LUS undergo a rapid change in the intensity level. On one hand there are *industries* such as textile factories which accelerate their production process by changing the electricity supply from oil to coal and on the other side there is a growth of water needs (cf. Appendix 7). Increasing population, increased irrigation and textile *industries* are reasons for the intensity change in *waterbodies*. The intensity increase linked with the number of growing water user leads to lack of water in the dry season.

It can be summarized that there is concerning land conversion happening in the middle and lower watershed which has several negative impacts on degradation and the function of ES. Flood and drought potential increased dramatically due to this LUS change. Particularly the conversion of *irrigated rice* to *settlement* in the middle and lower watershed influences the buffering capacity of water in the rainy season. Furthermore the increased water use in cropland and *settlement* can produce water scarcity in the dry season.

However, the increase of farming areas which replace forest or *agroforestry* systems cannot be interpreted easily. In addition to the enlargement of farming area the intensity within has grown as well. Land conversion and its impacts may put more pressure on land degradation which will be explored in the next chapter.

4.1.4 Land Degradation in Land Use System

The analysis concerning land degradation per LUS focuses on land degradation types, their extent, degree and rate. It is more comprehensive to discuss the three parameters together regarding their interaction and dependency per LUS. In order to understand recent land degradation phenomena the most crucial causes are going to be highlighted in addition. All the information on degradation and the direct causes refers to the WOCAT mapping questionnaire which is accessible in Appendix 7. The causes listed in detail can be accessed in Appendix 4.

However, before the valuation of the interview data displayed in the subsequent charts, the most commonly observed land degradation types will be illustrated (cf. Image 29 - Image 35). Land degradation phenomena such as loss of habitat, biomass decline, soil pollution, decline of surface water quality and quantity are not displayed in images although they exist in Ciwidey sub watershed.

Land Degradation Types

Topsoil and sheet erosion

Image 29: Vulnerable bare fields in the *farming upland* (De Maddalena 2010)

It is the most common observed soil erosion type and encountered in several LUS. Particularly bare fields without sufficient vegetation cover, and burned or logged areas are vulnerable by this process. Even in the dry season strong rainfall triggers and steep terrain accelerates topsoil erosion.

Gully erosion

Image 30: Gully erosion in *cut and carry with farming* (Andonie 2010)

Gullies are a more advanced, on-going soil erosion phenomenon (Liniger et al. 2008). Gullies results usually from inappropriate cropland management or deforestation and occur in places where runoff concentrates its flow. Image 30 is a case of an old gully that has been formed when the forest cover was less dense. In general they deepen in every wet season and transport the eroded material in rivers or accumulate it on fields or roads.

Mass movements

Image 31: Landslide in bush and farming (De Maddalena 2010)

Shallow landslides occur often because of oversaturated soils during heavy rainfalls and often in the rainy season. Moreover, the possibility of landslides triggered by earthquakes exists constantly. Inadequate soil treatment in bush and farming and cut and carry system, and

River bank erosion

Image 32: Riverbank erosion (De Maddalena 2010)

At the time of observation river bank erosion was common in river bends and resulted from a considerable runoff process. Predominately the vegetation-less border is vulnerable to this degradation process. Strong or persistent rainfall often induces river bank erosion. In the clearing of vegetation lead to human induced landslides.

upper and middle watershed this erosion process is commonly identified.

Fertility decline

Image 33: Farmer is using fertiliser to encounter the soil's fertility decline (De Maddalena 2010)

The intensification of farming activities with the support of fertilizer induced a fertility decline in soils. Intensification of rice production without replacing nutrients leads to soil fertility decline

Reduction of vegetation cover

Image 34: Reduction of vegetation cover through logging in the secondary natural forest (De Maddalena 2010)

Clearing of trees is due to land conversion to agriculture or the extraction of bamboo for construction or cooking purpose. This processes induce the reduction of the vegetation cover all over the watershed

Aridification

Image 35: Surface crusting in farming upland (De Maddalena 2010)

There are some areas without direct access to irrigation water. Therefore in the dry season when the rainfall declines it can lead to aridification. Surface crusting implies aridification. Aridification happens because water does not infiltrate or too much water evaporates from the soil surface.

Subsequently, the *extent* of land degradation types has been assessed in the different LUS and their aggregated *degree* and *rate was defined*. In order to structure this analysis more adequately the data of land degradation per LUS is always compiled according to their LUT, the extent, degree, and rate which are discussed together for each LUS. Therefore also degree and rate are displayed together in similarly structured figures as the extent of land degradation types.

Regarding the appropriate interpretation of the data concerning the extent of land degradation it has to be considered that land degradation types in LUS either occur in combinations or separately.

Figure 15, Figure 17, and Figure 19 and predominately aim at showing which land degradation exists per LUS and if they are a major or minor problem for the LUS.

The Figure 16, Figure 18, and Figure 20 which illustrate degree and rate of land degradation will analyze the aggregated land degradation per LUS. The corresponding legend illustrates categorized rate and degree of land degradation and is explained in Table 5.

Forestland

The most extended land degradation in forest land happens in *forest plantation of BKSDA* and covers 50% of the LUS. This area is the forest area of Cimanggu hot springs. Thus, mass tourism causes land degradation which amounts to 50% of **decline in groundwater quality** and **soil pollution**. According to the WOCAT mapping questionnaire (cf. Appendix 7) the tourists are not aware of the need to conserve the natural beauty of the forest and to avoid litter. Since there is strong infrastructure development regarding the recreation sector, the impacts of tourism on the forest ecosystem will even increase in future.

In the *secondary natural forest*, in the lower watershed, considerable **loss of topsoil** and **mass movements** (each 20%), and **gully erosion** (10%) can be ascertained. This is caused by deforestation triggered by the conversion to agriculture reported by the experts (cf. Appendix 7). Logged or burned fields are less capable to infiltrate all the water loads. Furthermore, changes of seasonal rainfall which results in wetter dry seasons are a significant cause in this area. To combat the natural impacts this LUS would request appropriate soil management but this does not happen. In contrast, soil management is a further direct cause of degradation because the soils conservation and tillage practice do not exist or are inappropriate (cf. Appendix 7).

The remaining *primary forest* area of BKSDA, namely nature reserve, is affected 10% by biological degradation which is **biomass decline**, **reduction of vegetation cover** and **loss of habitat**. Due to small scale illegal logging of commercial tree and farming, excessive gathering of timber for cooking, heating and construction of houses, deforestation is still an ongoing process according to the WOCAT mapping questionnaire (cf. Appendix 7). Consequently, the reduced vegetation cover causes **surface erosion** and **mass movement** in steep areas which extent 10%.

The forest areas of Perhutani such as *primary forest* and *forest plantation* particularly report 10 % **loss of topsoil** and **fertility decline**. The considerable fertility decline was caused by intensive vegetable farming in the era before 2003, before a new restriction for these areas became effective (cf. Appendix 7). The loss of topsoil in the *secondary natural forest*, and *agroforest* of Perhutani occurs commonly in places where farmers have no contract with PHBM. Hence their crop and soil management is lacking. Furthermore deforestation steered through the pressure of conversion to agriculture is a significant cause of the biological and soil erosion in this area (cf. Appendix 7).

According to the experts indirect causes which have consequences on every forest land are primarily population pressure and politics, and subsidiary education and poverty.

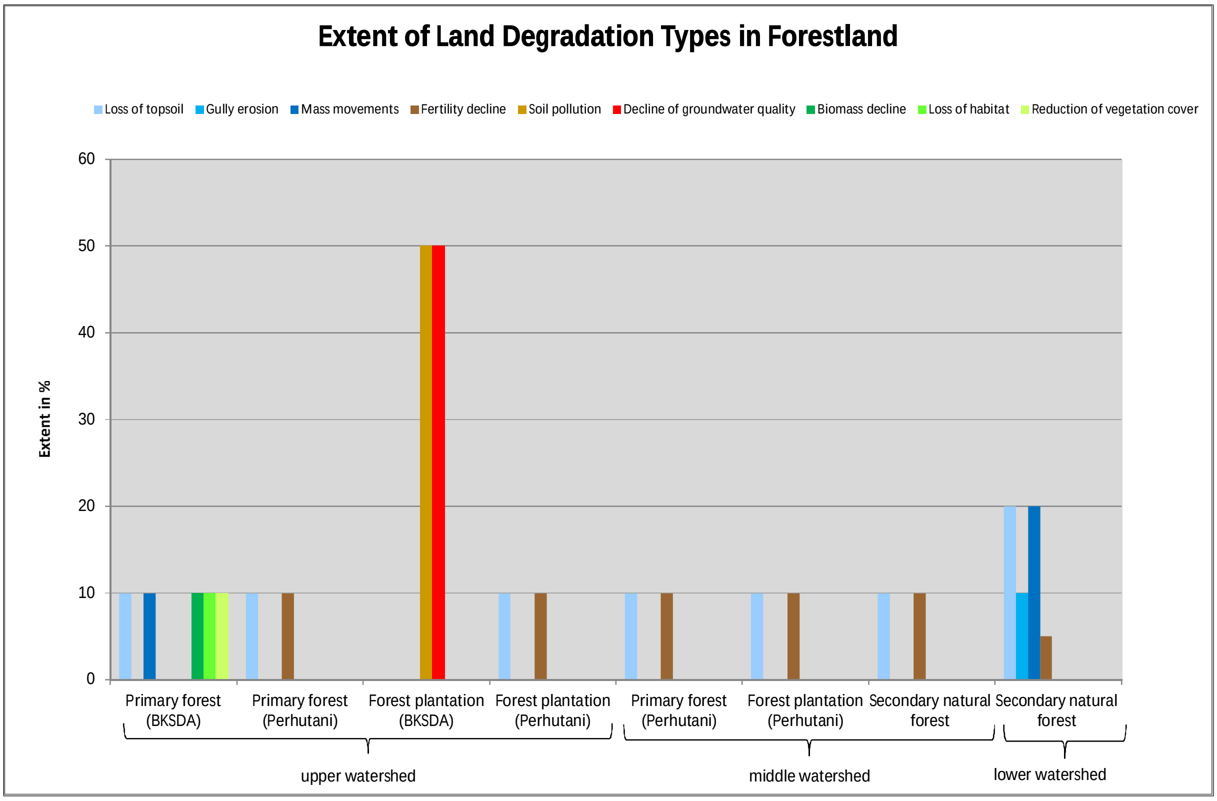

Figure 15: Extent of land degradation types in forest land (WOCAT mapping questionnaire 2010)

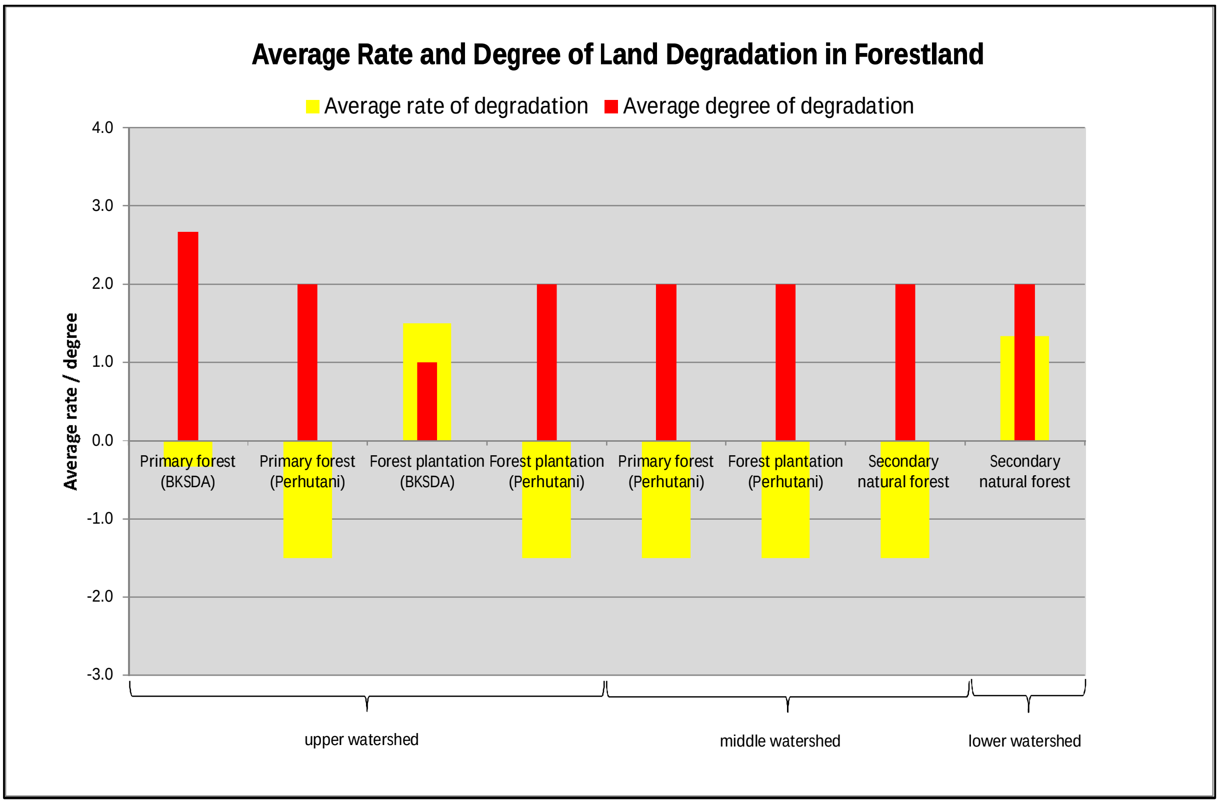

Figure 16: Average rate and degree of land degradation in forestland (WOCAT mapping questionnaire 2010)

According to Figure 16 the major part of LUS have moderate (2) or light (1) land degradation at the time of implementation. Land degradation in *primary forest* from BKSDA reaches almost a degree of (3) which signifies a strong degree with serious signs of degradation. But the extent of land degradation in primary forest (extent of 50%) is not significant what leads to reduce this statement.

In contrast, LUS with a high extent of land degradation such a as *forest plantation of BKSDA* (extent of 100%)and *secondary natural forest* (extent of 55%)in the lower watershed do both show a positive trend between slowly and moderately increasing degradation. This trend towards further degradation in combination with the current degree of land degradation which is defined as light for *forest plantation* of BKSDA, and moderate for *secondary natural forest* in the lower watershed, results in strong degradation of the two LUS.

Moreover, all the forest LUS managed by Perhutani have a moderate erosion degree and moderately decreasing erosion rate which signifies that degradation appears but is under control.

In the authors view a conclusion for forestland is that land which belongs to BKSDA or the people is more affected by land degradation than the area managed by Perhutani.

Cropland

As shown in Figure 17 most *farming lowland* area is affected to 50 % by **fertility decline**. According to the WOCAT mapping questionnaire (cf. Appendix 7) this was caused by intensive farming activities with significant fertilizer inputs and inappropriate application of pesticide, herbicide, and manure. Even if there are many bench terraces in this farming system vegetation cover is low what results in unprotected non conserved soils vulnerable to heavy rainfalls. A consequence of missing conservation, runoff, and erosion control is **topsoil erosion** which covers 5 % of *farming lowland.* Beside the inappropriate cropland and soil management the farming lowland LUS undergoes the impacts of disturbed water cycle in terms of lower infiltration rate and increased surface runoff (cf. Appendix 7).

Further *faming upland* areas along the ridges have much more **top soil erosion** because they are located in steeper terrain with just a few rudimentary terraces. Therefore 40% of the area can be assigned with top soil erosion. In addition to the problem of topsoil erosion **aridification** is a secondary land degradation type. According to the experts the microclimate is much drier compared to the places along the highest peaks and farmers do not have access to springs or creeks. Therefore it is possible that during dry season aridification destroys yields. Topsoil erosion is, on one hand side, caused by the lack of adequate SLM technologies, such as permanent vegetation cover or agroforestry, and on the other hand, due to lower infiltration rate which results from deforestation.

In the LUS *irrigated rice* the degradation types in the middle and lower watershed are different. Rice paddies in the middle watershed undergo a **fertility decline** with an extent of 30% and there is no fertility decline in the lower watershed. In the lower watershed the **change in quantity of surface water** – runoff increased – extends over 25% and is the recent degradation problem. This is caused by the heavy conversion of buffering areas such as *irrigated* and *rainfed rice* paddies or forest land into settlements, hotels, and restaurants. Consequently, less water for rice paddies is available during the dry season.

According to the experts *rainfed rice* areas tend to suffer from drought during the dry season what causes **crusting and cracking** of soil and make the LUS more vulnerable to soil erosion. Especially in steep areas with inadequate soil structure and composition **mass movements** are frequently observed. Regarding the interview’s assertion both mass movements and **gully erosion** amounts each to 10% of *rainfed rice*’s degradation.

Tea plantations in general are well conserved and do only exhibit sparse land degradation. According to the field observation land degradation, in particular **mass movements** such as shallow landslides, happen in areas where tea is uprooted and replaced. This minor land degradation type amounts to 5%. More concerning with an extent of 10 % is the rainfall pattern which alters due to **climate change**. The quality of tea is decreasing because of too much rain and warm temperature reported by the experts

According to Appendix 4 indirect causes for the land degradation in cropland in the middle and lower watersheds are mainly education, population pressure and infrastructure development. Moreover, poverty is a relevant factor in *farming lowland*, whereas climate change and the change in rainfall pattern are indirect causes for *tea plantation, rainfed*-, and *irrigated rice.*

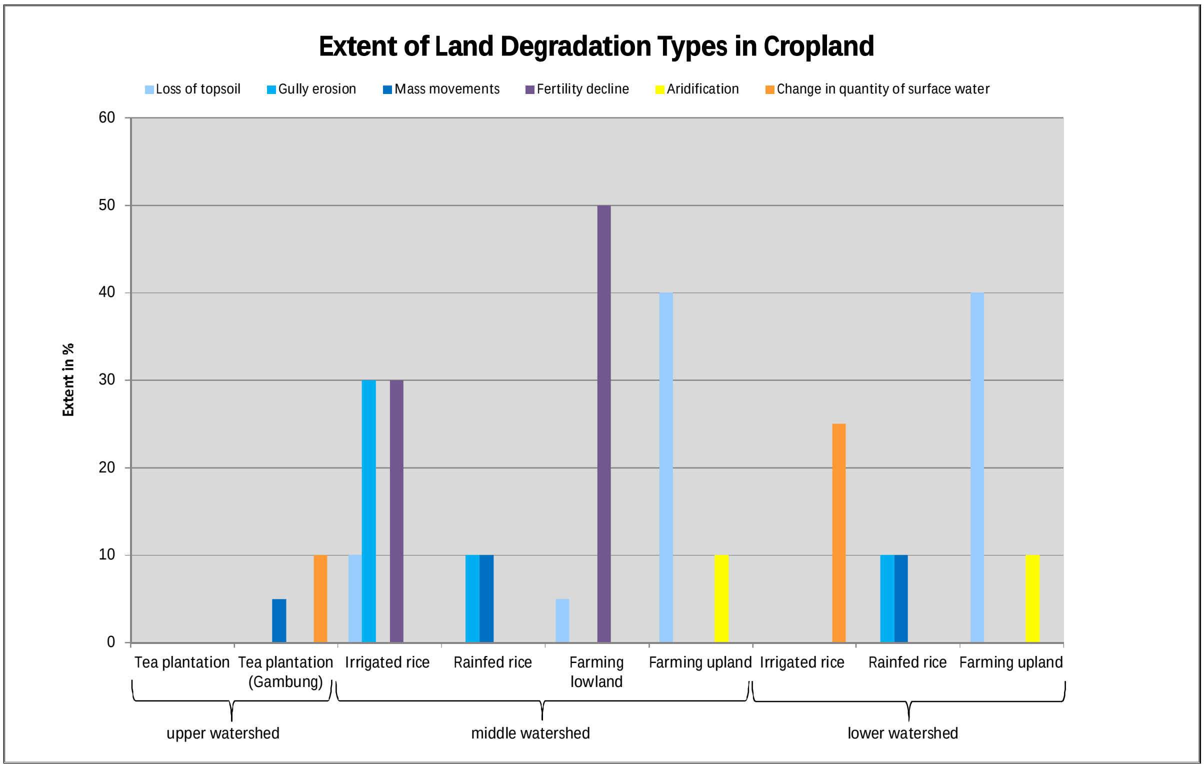

Figure 17: Extent of land degradation types in cropland (WOCAT mapping questionnaire 2010)

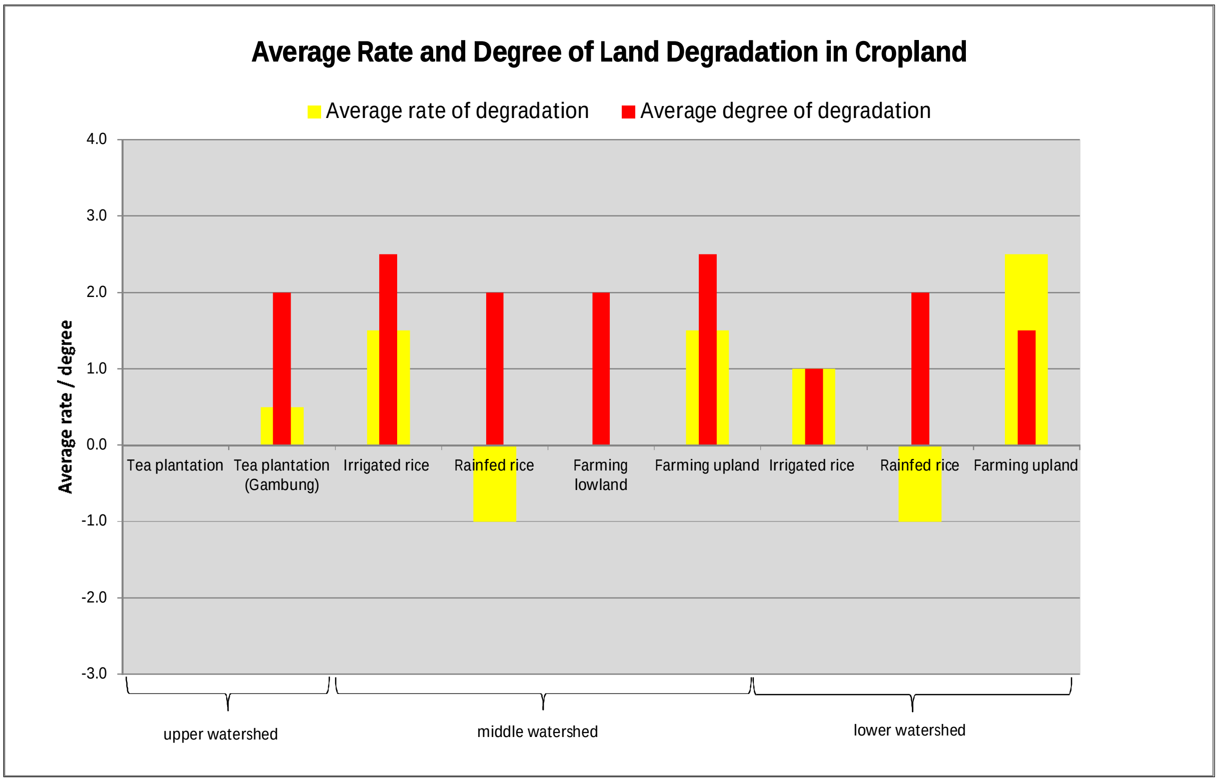

Figure 18: Average rate and degree of land degradation in cropland (WOCAT mapping questionnaire 2010)

In contrast to forestland, cropland exhibits in average a higher degradation degree and rate. Almost all LUS, except *irrigated rice* (1) and *farming upland* (1.5), both in the lower watershed, are affected with a moderate degradation degree. A moderate degradation degree means that there is degradation observable but it can be combated with appropriate approaches or technologies.

This result from the interviews with specialists can be verified by the observed degradation in the field research. But the trend which is illustrated as rate for the irrigated rice in the lower watershed shows with an average of (1) slowly increasing degradation, and for *farming upland* in the lower watershed with (2.5), moderate to an almost rapid increase of land degradation. Due to this trend and high land degradation extent, *farming upland* in the lower watershed is a degrading LUS.

Deduced from Figure 18 a degree between moderate and strong implies evident signs of degradation and is relevant for *irrigated rice* and *farming upland* in the middle watershed. Since the extent of land degradation types in these LUS in considerably high, the degree and rate of land degradation strengthen the inadequate state of the LUS even more. The population driven demand for rice is very high in this region and rice paddies are decreasing in area, therefore *irrigated rice* production was intensified which accelerates the degradation rate. Recently the degradation rate (1.5) is slowly and moderately increasing. The same rate of degradation can be deduced for *farming upland* in the middle watershed. These farming plots are located on ridges and developed through logging of forest. The result from the pressure for land reclamation originated from population growth. Additionally, there is *farming lowland* in the middle watershed which took a considerable extent of land degradation in terms of fertility decline. This LUS has a moderate degradation degree but the rate is stable. Therefore the author judges this LUS as less degrading, in contrast to degrading LUS such as *irrigated rice, farming upland* in the middle and lower watershed. Concluding the results for cropland it is obvious that there is a considerable degradation problem in most of them. Only *tea plantation* and *rainfed rice* while still showing some degradation in these results), are considered better off, because only few erosion was observable in the field.

<u>Mixed Use and Others</u>

According to Figure 19, the highest land degradation extent appears in the *cut and* carry. 60% of this LUS is affected by **topsoil erosion**. Where the field consists of a sparse vegetation cover, surface erosion is already a considerable problem and thereby landslide occurrence increases (cf. Appendix 7). The extent of **mass movements** currently amounts to 40%. The interview partner Ande Supriatna reported an enormous landslide disaster in this region which happened in the beginning of June 2010. Subsequently, there is remarkable water erosion. Land degradation according to a decline in quantity in surface water comes up to total 60%. Both **soil erosion** and decline of surface water quantity are serious and seem to be connected to each other. There are various components which are causes or accelerators for land degradation. According to Appendix 4 the most obvious cause is deforestation in order to gain areas for cropland production. Farmers are not aware of the impacts of clearing vegetation (cf. Appendix 7). This reduction of the vegetation cover leads to a decrease in infiltration and to an unprotected soil surface, if it is not adequately conserved. Indeed, inappropriate conservation efforts are a source of soil erosion in the farming plots. All these factors in combination with the increase of heavy rainfall due to climate change (WWF Indonesia 2007: 27), make this area very affected by land degradation.

Varied results regarding land degradation in the a*groforest* LUS are shown in Figure 19. The *agroforest* managed by Perum Perhutani is located in the upper and middle watershed. In contrast, the *agroforest* in the lower watershed belongs to the people. However, the upper and middle watershed's *agroforests* are degraded with 10 % of **top soil erosion** and 10 % of **soil pollution**. Deforestation in order to enlarge arable land and inadequate management of *agroforestry* areas were indicated as the causes of soil erosion. The soil pollution which is only subsidiary can in the authors point of view either be explained trough littering or the bad air quality from traffic or burned waste. The major source of **soil erosion** in the lower watershed is coming from the *agroforest* on extreme steep slopes where farmers do not use terraces or only apply poorly stabilized terraces. The hillside plugging which impacts soil structure generates easily erodible land. This initial situation together with rainfall events or earthquake implies top soil erosion and **mass movement**. These two types which describe soil erosion by water have an extent of 20%. Furthermore there is **gully erosion** which has an extent of 10% in the lower watershed. The same causes as mentioned for the *agroforest* in middle and upper watershed are valid for the lower watershed. According Appendix 4 these are deforestation processes spurred by expansion and intensification of the recent framing area and the appropriate SLM technologies which should retain runoff and combat soil erosion are missing or insufficient.

The majority of *settlements* is located along roads and exposed to **air pollution** from motorbike, car, truck emission, and burning of waste. According to Memet's statement in the WOCAT mapping questionnaire (cf. Appendix 7) there is a lack of awareness and few responsible thinking regarding the conservation of nature. People are not aware of what they are doing to the nature. The polluted air affects also the home gardens of *settlements* and leads to their **soil pollution** which extends to 30% in the upper and also middle watershed. In the lower watershed this soil pollution is with an extent of 5% considerably low. An explanation for this difference could not be found.

Additionally, **change in water quality** could be identified with an extent of 20% in the upper and middle watershed. Reasons indicated in Appendix 4 were population increase and the expanding *settlement* areas that negatively impacts on the water quality and moreover on the **quantity** that remains for households. It is surprising that in the lower watershed the extent of these two degradation types for water resources is smaller. This outcome is questionable because the water in the lower watershed (see *waterbodies*) is more polluted and the quantity due to the increased demand in the middle watershed, lower.

In the lower watershed *waterbodies* are significantly affected by sedimentation coming from **topsoil**, **gully** and **riverbank erosion** which each of them contributes 35%. This is mainly caused trough deforestation in order to expand settlement and farming areas. The change in **quality of surface water** extents only over an area of 10 % but is higher in reality. Waste water and rubbish from households and sedimentation impairs the **quality of stream water**.
In contrast in the middle and lower watershed the interview partner reveal **reduction of vegetation cover** as a degradation type. With this statement he addresses the vegetation of the river border. Hence, strong runoff drags the vegetation away which seemed to protect the river bank. Therefore vegetation decline results. It is not very serious because it only affects to some places.

For the LUS *settlement a*nd *waterbodies* indirect causes are the same. Particularly, the consumption pattern and individual demand, and population pressure are the indirect drivers. In contrast to the *settlement* and *waterbodies,* education, poverty, climate change and volcanism are stated as indirect causes in the mixed LUT (cf. Appendix 4).

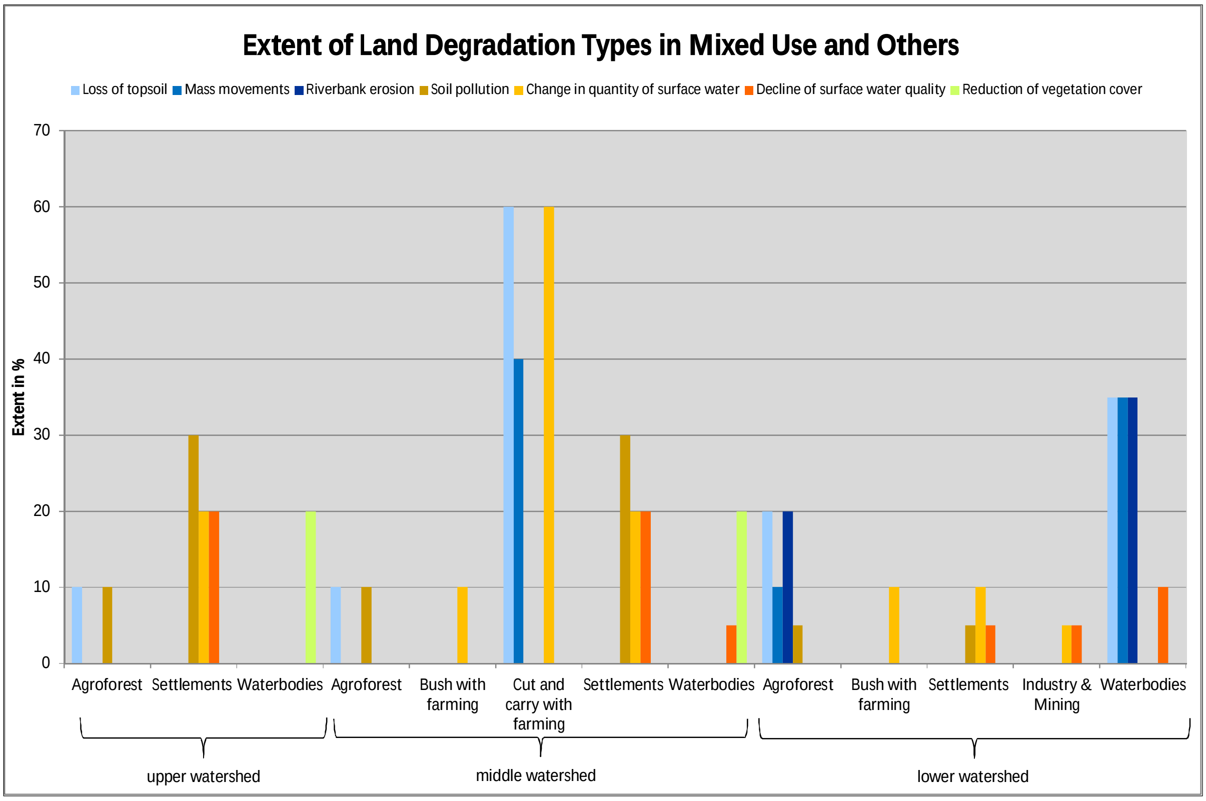

Figure 19: Extent of land degradation types in mixed use and others (WOCAT mapping questionnaire 2010)

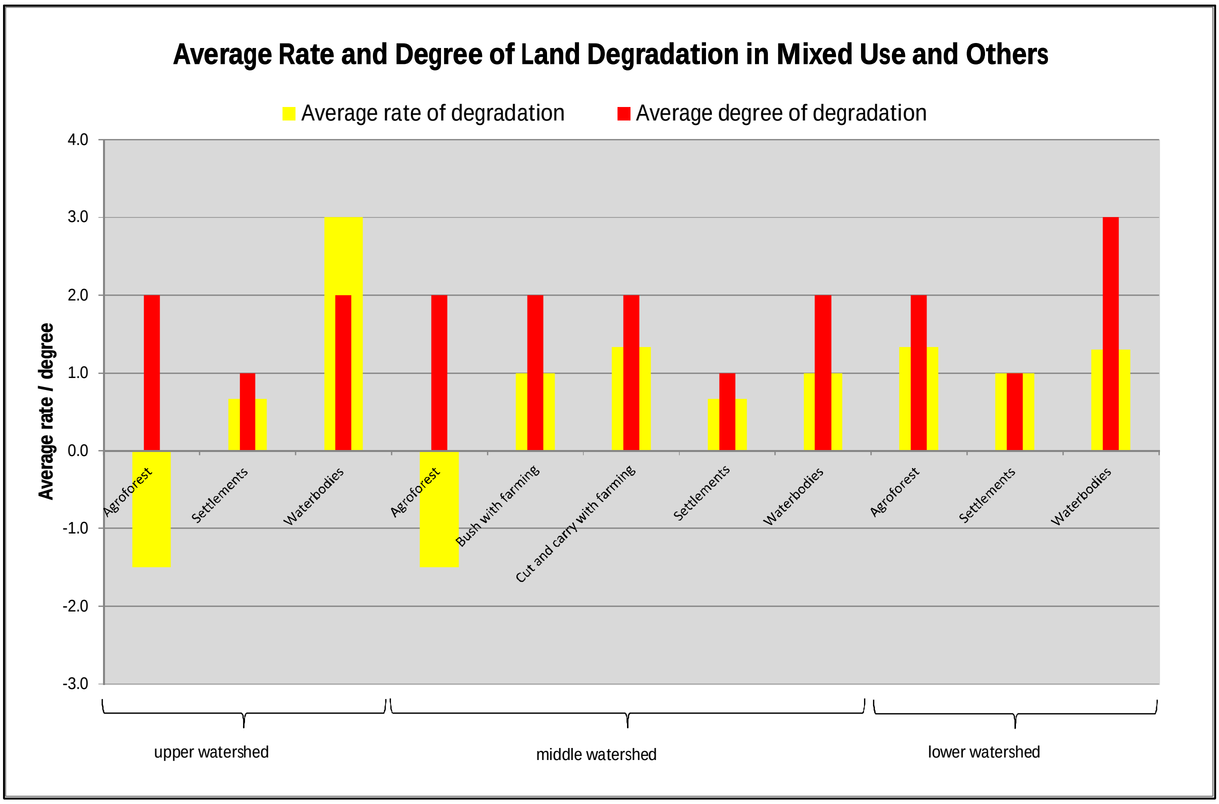

Figure 20: Average rate and degree of land degradation in mixed use and others (WOCAT mapping questionnaire 2010)

The following Figure 20 which shows the rate and degree of aggregated land degradation will allow supplementing the previous information on the extent. Similar to cropland in mixed use the degree of land degradation is moderate except for settlement area where it is only light. This is due to fewer degradation potential of settlement areas which is concentrated on home gardens. However, considerable land degradation occurs in *cut and carry with farming* because in addition to the already high extent and moderate degree, the rate amounts to 1.3. This values lies in between slowly and moderately increasing land degradation.

The land degradation types in *agroforest* LUS have the second highest extent of land degradation and are valuated as moderate regarding the land degradation degree. Although the extent is high, and the degree moderate the overall trend is moderately decreasing which is notable positive. Thanks to improved agroforestry system and the restricting law which allows only to plant coffee this positive trend emerged.

Bush and farming had only a small extent but its degradation degree is moderate and slightly increasing. Therefore this LUS and in particular cut and carry with farming are the most degrading LUS of the mixed use.

In the category other LUS *settlements* display a high extent of land degradation types but it concerns home gardens and not only the building itself. The rate and degree of the aggregated land degradation in *settlements* is only light which means that there are some indicators and the rate is very slowly increasing. Therefore this LUS itself is not really degraded but increased settlements and infrastructure building is a trigger of land degradation process which affects the entire watershed area.

Predominately *waterbodies* suffer from pollution caused by housing and traffic. Although the extent of degradation in *waterbodies* is in the upper and middle watershed is rather insignificant it is much higher in the lower watershed because all soil erosion pollution particles etc. convene and are accumulated in the lower watershed. This fact can also be emphasized by the rate and degree displayed in Figure 20. Hence, the recent rate is strong and this means considerable efforts and time are necessary to combat this enormous water degradation. An adequate trend for the rate did not appear and thereby there is no evidence showing an improvement.

The selected land degradation type of soil erosion which was observed and mapped in the field is displayed in chapter 4.2. Hence, due to this additional information on the spatial localization, areas in LUS with soil erosion can be drawn as conclusion. Image 48 shows the observed soil erosion polygons.

4.1.5 Sustainable Land Management in Land Use System

This chapter is about SLM and targets on SLM technologies and the LUS of their implementation. At the beginning, different major “conservation groups”, will be illustrated, briefly described, and discussed. The extent of conservation groups per LUS will subsequently be highlighted. In order to value the assertions of the interview about the extent of conservation it is crucial to take their effectiveness into account. This chapter focuses on the effectiveness trend and effectiveness of conservation technologies. Extent, effectiveness- and trend will be balanced and discussed for each LUS and in order to designate well conserved LUS. The aim is to identify LUS which follow sustainable land management principles and present a positive effectiveness trend. All the information on sustainable land management is either from the expert interviews (cf. Appendix 1) or the WOCAT mapping questionnaire (cf. Appendix 7).

Conservation groups

Oranic fertilizer

Image 36: Organic fertilizer (De Maddalena 2010)

The goal of the use of organic fertilizer is to increase the soil fertility and furthermore to improve the soil structure. According to Andonie (2011), the main function of this technology is to replace the nutrients of the remaining organic matter to the soils, increase the soil fertility, getting a neutral pH and improve the soil structure.
Organic fertilizer is produced in a digged hole, (lubang buta). This hole is filled with manure, plant residues, and humus. Through chemical decomposition the production of organic manure can be achieved. The mixture of the organic dung with water and methane results in organic fertilicer (Andonie 2011). The farmer on Image 36 carries a bin where he stores the fertilizer. In *agroforest, farming lowland* and *tea plantation* this technology is widely spread. Often the farmers apply organic and chemical fertilizer together.

Inter-cropping

Image 37: Inter-cropping (De Maddalena 2010)

Inter-cropping is an adequate technology in areas where climate seasonality can have a negative impact on the yield in monocultures. In general farmers using intercropping plant either a tall crop with a shorter crop or a deep-rooted crop with a shallow-rooted crop. It is crucial that the crops do not compete each other. By planting two species the risk of crop failure is distributed on two crops instead of one in monocultures (cf. Van Wolfswinkel n.d.). This can secure the income of farming households or even increase it. The technology is only used by small scale farmers or in home gardens. Therefore *farming upland* and *bush and farming* are LUS with several inter-cropping opportunities. In addition to Image 37 where maize is combined with cabbage, chillies with beans or tomatoes, and strawberries with onion grass are the most common combinations.

Mulching

Image 38: Mulching (De Maddalena 2010)

Mulching is an economical technology which only requires few labour investments. Mulch consists of organic residues such as leafs or hay which form a soil cover of dry material (plant residues) in order to protect it from erosive rainfall and evaporation. The technology of mulching decreases the runoff, soil erosion, and increases soil moisture. In Ciwidey sub watershed this technology was identified in *farming upland, bush and farming,* and *cut and carry with farming*. But it is not widespread at the time of the field survey.

Teras kredit (forward sloping terrace)

Image 39: Teras kredit (De Maddalena 2010)

Poorly stabilized forward sloping terraces which aim to cut slope length and to level the fields. Soil bunds are stabilized with fruit or legume trees such as cassava (cf.
Image 39) or vegetative grass strips The construction of "teras kredit" happens gradually. Sometimes it needs more than 10 years until the final terrace size can be reached (cf. Sinukaban (2010) in Appendix 1). This SWC technology is predominately applied in *farming upland* systems. Actually "teras kredit" functions excellently in slopes from 3-10%, but farmers use them in much steeper areas which lead to soil erosion. (cf. Sinukaban (2010) in Appendix 1)

Teras bangku (bench terrace)

Image 40: Level bench terraces (De Maddalena 2010)

According to Sinukaban (2010) in Appendix 1, this kind of terrace is applied predominately in steep slopes with angles of 30-90%. It is used

Teras gulud / drainage channel

Image 41: Teras gulud with soil bund and drainage channel (De Maddalena 2010)

Teras gulud is an irrigated terrace with equiped guludan (soil bund) and suitable on slopes between 10-40%. The surface runoff is particularly for rice production but sometimes also for crops. Irrigation channels convert the runoff and bring the water controlled into the fields. In the fields drainage channels allow to regulate the water amount. The horizontal terrace bench and flooding lead to waterlogging which is crucial for rice production. Farmers remove the topsoil in order to flatten the ground and construct with the soil the bund of the upper terrace. Some farmers plant cassava on the soil bunds which separate the paddy rice but through cassava harvesting the roots can destroy the edges of the terrace. Apart of the *irrigated rice*, this SLM could also be observed in *farming lowland* and *upland*, and in *tea plantation*. Only in *farming lowland* the fields are ripped and there is cultivation of vegetables, where in the other LUS the bench terraces are used for rice production. (cf. Sinukaban (2010) in Appendix 1).

converted in ditches and then infiltrates into the soil. There is no permanent waterflow in the channel since it can be controlled manually. According to Sinukaban (2010) (cf. Appendix 1) contour lines are created along a vertical interval and the drainage channel starts above the slopes and contines to the bottom. In many cases the soil bunds are protected with grass or shallow rooted fruit trees. The darinage channels are usally built at the lowest part of each terrace. Some farmers ditch a second drainage in the highest part in order to drain surplus water. The drainage channel below each terrace is not useful for the efficient function of the terrace. This terrace is found in faming lowland with vegetables and rice. (cf. Sinukaban (2010) in Appendix 1).

Teras bentang lahan (irrigated- and stone enforeced level bench terrace)

Image 42: Teras bentang lahan (De Maddalena 2010)

These terrace type is a sub category of bench terraces and is built in flat to moderate areas along the contour. The main function of the terrace is to prevent soil erosion, cut the slope and flatten the fields to a certain extent, which allows adequate irrigation. Furthermore arable land can be gained and working conditions are less exhausting for farmers. The slope is cut and the topsoil material is removed and fixed on uphill. This forms a soil bund that is either stabilized by a stone or bamboo wall, or vegetation strips with grasses or fruit trees. According to Andonie (2011), the water canals in the plot are 20 cm and the beds are 80 cm wide.

Water harvesting

Image 43: Pond and irrigation channel (De Maddalena 2010)

The overall aim of this conservation group is to collect and concentrate rainfall and runoff. Both are structural measures which can either be consolidated artificialy with concrete or be natural. Ponds (c.f. Image 43) have additional socio economic benefits as the opportunity of fish farming. Sweetwater fishes are a common dish in Sudanese restaurants and therefore in demand. The water is also used for other purposes such as cooking, washing etc. Almost every house in the middle watershed, particularly in the farming lowland area, holds such a pond. It is important to use the water stored in ponds before the wet season starts so

The beds are elevated approximately 7 cm so the water cannot flood the plants but flows round the ribbed beds and waters the roots. The terraces are especially found in the LUS *farming lowland*, where intensive crop production needs irrigation. The products planted in these terraces are vegetables such as cabbage, onion leaves, celery, "pecay", "sawi" and potatoes.

that it can offer storage capacity in flood events.

The irrigation channel network in the Ciwidey watershed is very long and interconnected. Several creeks are connected to the irrigation network which provides water for *irrigated rice farming* all over the watershed and intensive vegetable farming in the middle watershed. There are equipped main channels, and smaller naturally outgoing channels regulated by gates, which irrigate the fields directly.

River bank protection

Image 44: Gabions and palm tree planting (De Maddalena 2010)

Four different kinds of river bank protection were identified in Ciwidey sub watershed mainly along Ciwidey river. First, as shown in Image 44, gabions are stones fixed with wire that stabilize the river bank in critical sections. On the right picture the governement planted palm trees that aim to hold together the soil with their roots. The third river bank protection construction is similar to the gabion. Thus, the river bank is fixed with a concrete / stone mixture.

Runoff control

Image 45: Gate and barrier (De Maddalena 2010)

Run off control is a considerable issue for the water management in Ciwidey sub watershed. Gates and barriers (cf. Image 45) are crucial in order to control the water flow during high rainfall events, or extreme events such as droughts and floods. On the left hand side of the rise there is a gate which regulates the water flow from the above situated rice paddies. Small gates are found along several irrigation channels in the watershed. Other larger constructions such as barriers and gates are located only along the main streams.

Agroforestry

Image 46: Agroforestry **(De Maddalena 2010)**

Agroforestry is a convenient system which allows on one hand the maintenance, stabilization and protection of soil resources, and on the other hand valuable crop production which generates income. Degradation types such topsoil erosion, deforestation, removal of natural resources and decreased infiltration rate are addressed with this SLM technology. The existence of farming plots in forest land is pervasive but not everywhere it is adequately managed. In the agroforestry system where Perhutani coordinate the cultivation of crops the most often seen combination is pine and coffee or eucalyptus and coffee. In other areas, not belonging to the government, the crop and or tree composition differ much more. For instance coffee and "terong kori" (eggplant), cassava, banana, and papaya are common trees, and potatoes, chillies and carrots cash crops which can appear together or separately. It depends on the LUS. In general, agroforestry is used in *cut and carry with farming*, *farming upland* and in the *agroforest* area. Very common vegetative strips which is a conservation group itself, is combined with agroforestry.

Afforestation

Image 47: Afforestation (De Maddalena 2010)

There are various afforestation programs either from the government or non-governmental organizations such as PHBM in Ciwidey sub watershed. Eucalyptus and pines, mahogany, albasia and native trees are planted in order to improve forest cover. These tree species are mostly planted in steep areas which are prone to soil erosion or replant logged fields in the forest. Along the rivers the government plants palm trees to stabilize the river border. Afforestation can also be the initial investment for further agroforestry. Thus, afforestation is common in *bush with farming*, *upland farming*, *forest plantation* and *agroforest* in the lower watershed.

This description of SLM technologies only gives a broad view on the most common SLM practices. Since the purpose of this chapter is to analyze the best conserved LUS, additional information regarding the extent and the effectivness of SLM per LUS, must be evaluated.

For an adeqaute analysis of the data it has to be stressed that conservation groups can appear in combinations or individually. Therefore the summaized extent of conservation can be more than 100% per LUS. However, the following figures show the extent of land conservation groups per LUS which can be interpreted with bearing in mind mentioned problem of combined or single appearance. They illustrate which land conservation is applied in which LUS and where it is most effective.

<u>Forestland</u>

The entire *primary forest* of BKSDA, with a extent of 100%, has the status of **strict conservation** and thus its **conservation of natural biodiversity** prohibits any activities (cf. Figure 21). In addition, forest protection in particular **patrolling** extends also over the entire forest area. There are also small areas where the BKSDA **replanted grass** that serves as fodder for deers. This only comes up to 1% in the *forest plantation* which belongs to BKSDA. In the recreation forest (*forest plantation* of BKSDA) **conservation of natural biodiversity** extends to 50%. This is mainly ascribed to Pam Swakarsa, which is a small organization and gathers the tourist’s waste. Forest protection can be assigned with 100% and is predominately measured in order to raise the **awareness of visitors** regarding the conservation of the forest. For instance, many signs (indicating “leave your footprint not the rubbish”) are situated along the walking paths

In the *primary forest* and *forest plantation which* belongs to Perhutani it does not matter which forest sub type it is because all apply the same conservation groups with the identical extent. The major extent (50%) is the group **afforestation** in particular with pine and eucalyptus species. **Vegetative strips** occupy 40% and are in particular elephant grass strips of strips of tress which lead to increase the infiltration rate. Similar to vegetative strips, **agroforestry** covers 40%. According to the interview with an employer of Perhutani eucalyptus and coffee is a better combination than coffee and pine because pines give too much shadow.

In the *secondary natural forest* in the lower watershed the variablity of SLM is high. There are vegetative measures such as **agroforestry** and **vegetative strips** which appear also in combination and amounts to 45-50%. Some areas belong to a program with demo plots which aims to plant trees and to build terraces. Furthermore all the farmes who have small plots or agroforestry fields apply **organic fertilizer** (extent of 100%). **Water harvesting** is only rarley seen only in steep slopes and consists of check dams in particular. The idea is that the water does not flow directly to the field. The benefits of check dams are less topsoil erosion and better productivity.

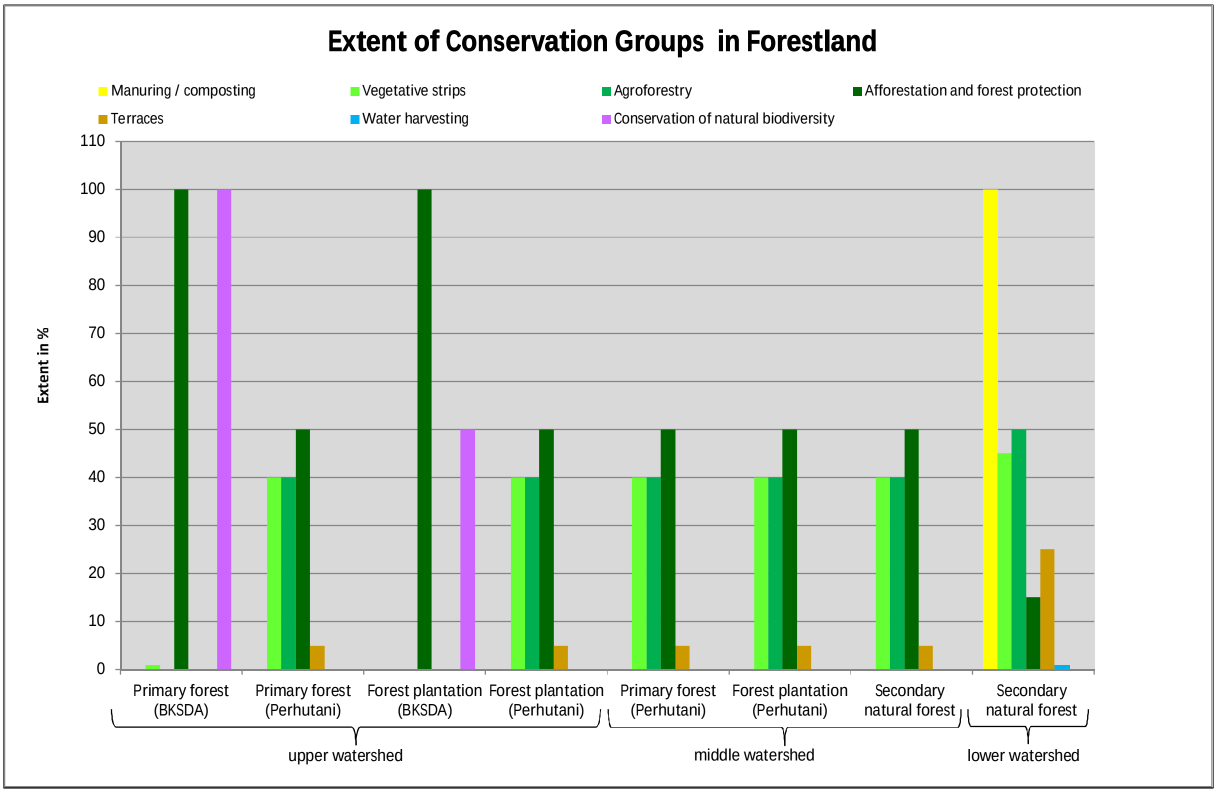

Figure 21: Extent of conservation groups in forestland (WOCAT mapping questionnaire 2010)

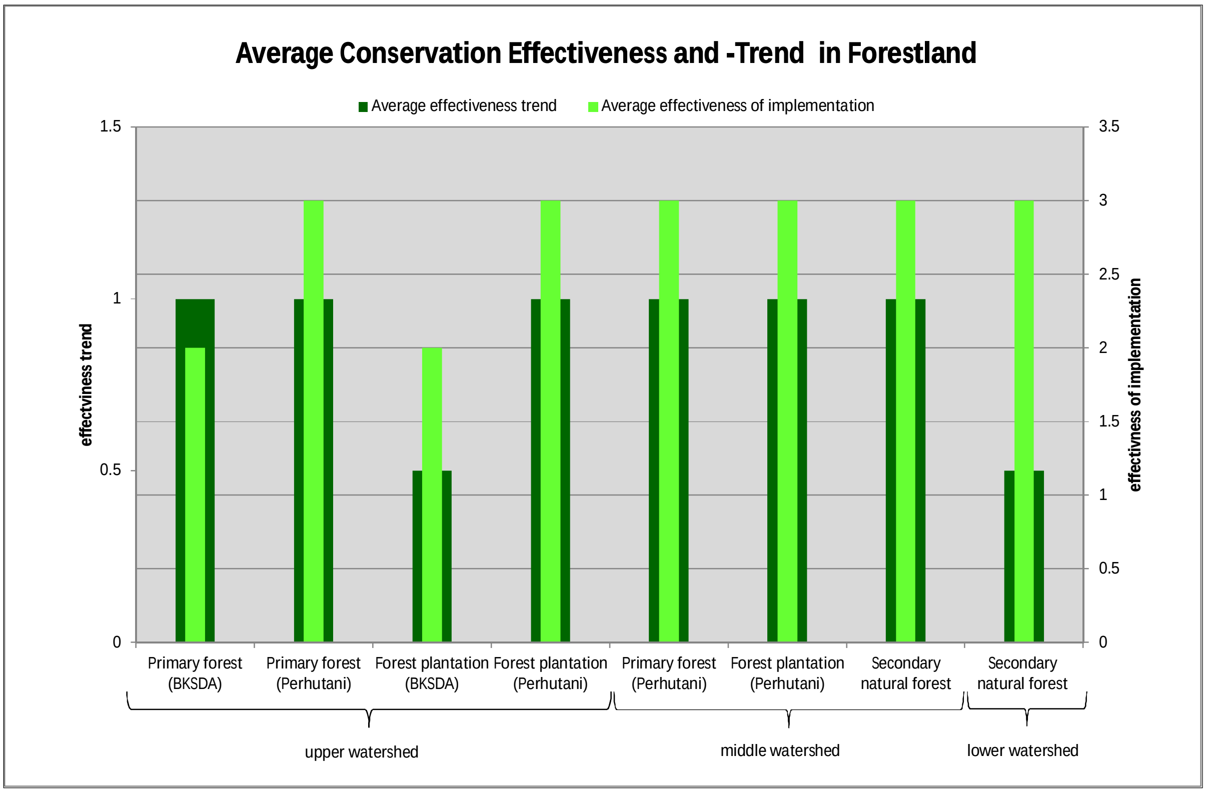

Figure 22: Average conservation effectiveness and -trend in forestland (WOCAT mapping questionnaire 2010)

In order to determine conserving LUS in forestland it is crucial to evaluate the effectiveness of the implemented conservation groups in the LUS. The reason is that a large extent of conservation does not mean automatically that this LUS is well conserved. Lack of maintenance for instance can result in a negative trend of conservation and thereby not combating degradation enough. According to Figure 22, the effectiveness of all conservation measures per LUS lies between 2 and 3 which is moderate to high (cf. Table 6). Especially the area of BKSDA has a moderate conservation effectiveness which is acceptable but not optimal. There is still degradation happening which lead to this moderate effectiveness. A reason therefore is that for **patrolling** in the *primary forest*, only a number of six rangers are responsible for this forest area of 100%, which measures aproximately 8,000 ha and farmers do sometimes know when they patrol and thus. Furthermore the conservation in BKSDA's *forest plantation* is also only moderate. The **awareness rising of the tourist** is not very successful. Tourists ignore the signs which should animate them to keep their waste.

The other forest LUS managed by Perhutani or the *secondary forest* belonging to the people, have high effectiveness which mean that the measures control the degradation problems appropriately. The trend of effectiveness is between 0.5 and 1 which signifies that effectiveness is increasing. It is a decent result for the implementation of conservation technologies that no trend is negative.

<u>Cropland</u>

In cropland several conservation technologies are combined and applied. Thus, the extent of conservation per LUS is considerably high (cf. Figure 23).

Tea plantation which are not state-owned and cultivated by farmers are 100% conserved because **LUS tea** is very sustainable and appropriate in order to combat several aspects of land degradation. It contributes a permanent vegetation cover which is a protection for soil erosion, especially during heavy rainfall. Furthermore, the farmers use approximately 20% "**nitro basileus**" which is a fertilizer and complicated to apply. The main conservation technology in the Gambung estate is with an extent of 70% "**lubang buta**" (dig hole) which offers various conserving functions. On one hand side it can produce organic fertilizer by adding manure, plant residues etc. into the hole, and on the other hand it improves the soil / water and achieves higher soil moisture. 30% of the *tea plantation* area is planted on **bench terraces** because of steep slopes.

Irrigated bench terraces, extending 90% of *irrigated rice* in the middle watershed, are traditional structural measures which have various socio-economic and bio-physical benefits (cf. Image 40). A much smaller extent has gully plugs with 15% and the "**legowo system**" with 10%. "Legowo" is a new planting system in *irrigated rice* paddies which allow fish farming at the same time. According to FFTC (2001), two strips are planted with rice and two strips remain empty. Hence, fish are introduced in the watered rice fields and contribute to better aeration. In the lower watershed this technology with an extent of 25% is even larger.

In the intensively used *farming lowland* system a broad number of conservation groups are applied by the farmers. General changes happened in 2005 which are for instance the shift of chemical to **organic fertilizer** that has nowadays an extent of 85% and the invention of more **productive seedlings** extending 50%. Terraces are either stone or bamboo enforced "**teras banteng lahan**" or more simple "teras **gulud**" (cf. Image 42 or Image 41). **Intercropping** is an additional technology and is described in Image 37.

In contrast *farming upland* has different technologies except **intercropping** and the use of terraces. "**teras gulud**" the more simple one, not stone- or bamboo-enforced has an extent of only 10%. By considering the terrain of *farming upland* this number should be much higher. The general technology in this area is **agroforestry** (40%) and **social forestry** (30%). The difference between these two SLM technologies is small and concerns only the kind of plant or crop species. In **agroforestry** based on *upland farming* there is particularly the tree albasia mixed with chilli, beans, and corn. These are the favourite food crops for farmers but have negative impacts on soil erosion. It is more convenient to use **social forestry** which is mainly horticulture, coffee and “terong kori”.

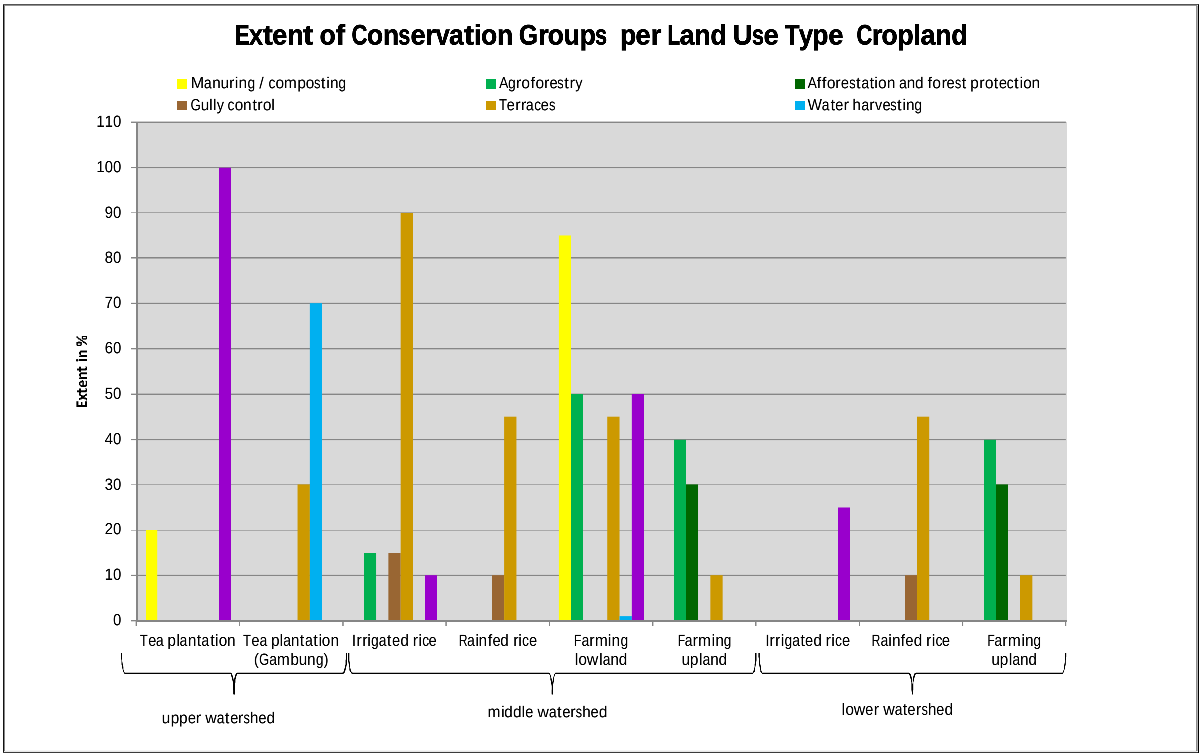

Figure 23: Extent of conservation groups in cropland (WOCAT mapping questionnaire 2010

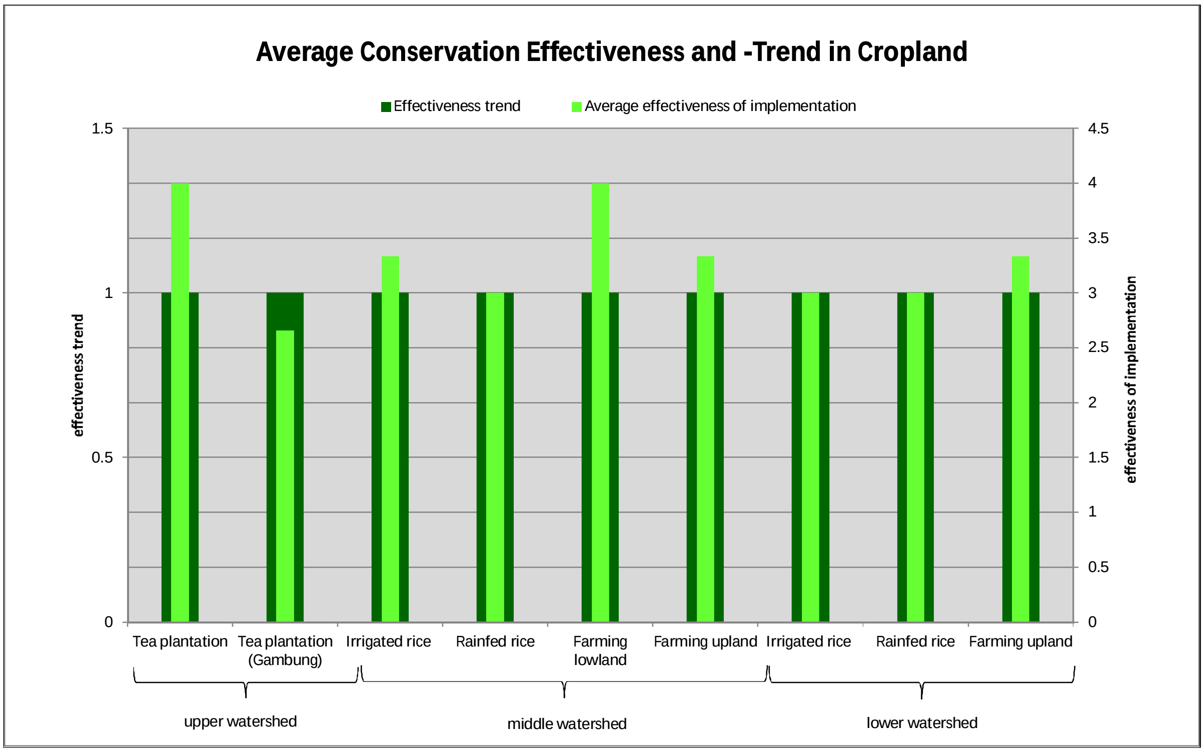

Figure 24: Average conservation effectiveness and -trend in cropland (WOCAT mapping questionnaire 2010).

Subsequently, Figure 24 shows the effectiveness of the summarized SLM technologies in cropland. It is obvious that conservation effectiveness of the implemented technologies was valued considerably high. In *tea plantation* and *farming lowland* it amounts to an effectiveness of 4 which signifies high where the rest is around 3 which means good effectiveness. A certain scope could be verified with the observed data, in particular for tea plantation and *farming lowland*. Anyway in the author's point of view the result is overrated, because *farming upland* terraces were sometimes in a bad state. The trend of the effectiveness is also positive for all the cropland LUS and amounts to 1. As summary for cropland it can be concluded that tea plantation, irrigated rice, and farming upland are the most conserving LUS. By considering the field observations, and further data concerning degradation, *farming lowland* is not as well conserved as displayed in the evaluation of the mapping questionnaire.

<u>Mixed use and others</u>

In contrast to forestland and cropland, there is a lower extent of conservation groups in the mixed use and other LUS.

In the *agroforest* LUS in the upper and middle watershed 50% of the area is covered by **afforestation** activities. Moreover 40% are **vegetative strips** consisting of elephant grass or tree strips, and 40% are appropriate **agroforestry** system with mainly a combination with coffee or "terong kori" with eucalyptus or pine (cf. Image 46).In the lower watershed, the extent of **afforestation** is with 15% smaller but the area with **vegetative strips** (45%), **agroforestry system** (50%), and **gully plugs** is larger. Further mixed use system such as *bush and farming* in the middle and lower watershed only apply a few technologies even if they have considerable degradation problems. On 20% **elephant grass** is planted and on 30% **afforestation** is a related issue. In this part, farmers use perennial plants such as Mahogany, Eucalyptus, but not pines. *Cut and carry with farming* is the third mixed use LUS with only a few technologies, mainly **drainage channels**, which extends 50% are most commonly seen in this area.

In *settlements* in the upper and middle watershed an area of 20% belongs to **water harvesting** conservation groups. These are either ponds which store water or sluices along the neighbouring rivers which slow down the runoff. In order to get purified drinking water some settlements, approximately 20%, are **connected to a source**. For the lower watershed no data exists for *settlements* but for *industry*. There is **waste water treatment** of the textile *industry* factories which extents only 10%. Not all factories have waste water treatment. Factories are very profit-oriented and investors care little about the pollution. In *mining* which is only one andesite pit, every three months a meeting which addresses development, observation and management issues: Additionally there is a **restriction** in the use of machinery for mining above 1,000 m a.s.l. Therefore the mining is located only in the lower watershed. In the LUS *waterbodies* much more direct or indirect conservation activities exist. Indirect activities are for instance **agroforestry** in the upper watershed which should imply less soil erosion and thus less sediment particles in rivers. In order to stabilize the border of rivers, palm trees are planted as **riverbank protection.** In general, the extent of conservation groups related to *waterbodies* increases from the upper to the lower watershed. In the middle and lower watershed, **agroforestry** (100%) should predominately conserve the quality and quantity of rivers. Furthermore there is **afforestation** and **gully control** in the middle watershed which extends 30% and 19%. In the lower watershed **water harvesting** amount 40%, and **drip irrigation** and the installation of **waste water treatment** 50%.

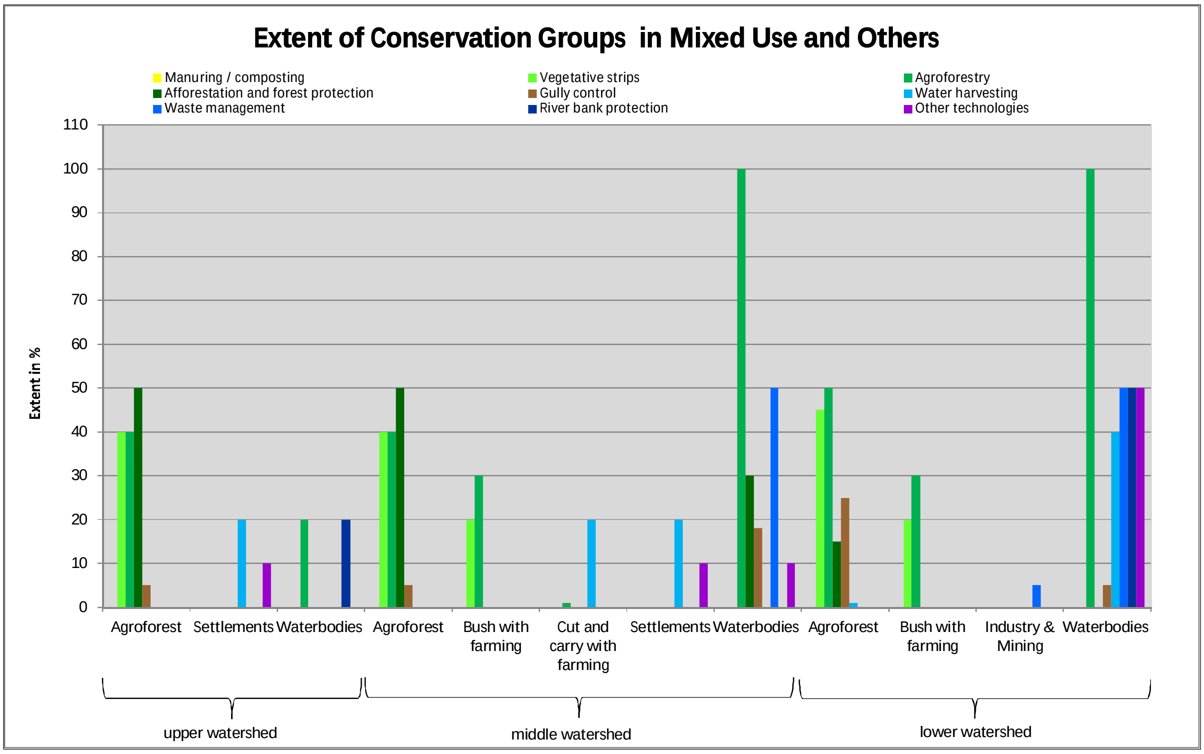

Figure 25: Extent of conservation groups in mixed use and others (WOCAT mapping questionnaire 2010)

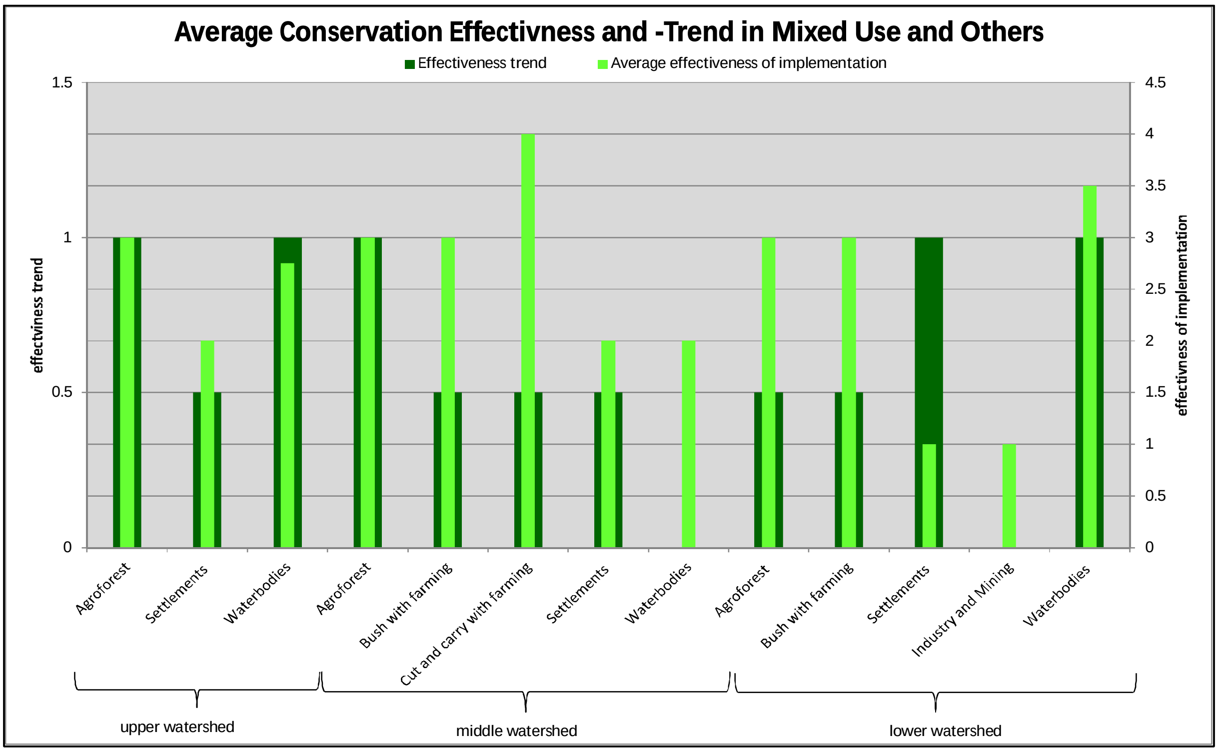

Figure 26: Average conservation effectiveness- and trend in mixed use and other (WOCAT mapping questionnaire 2010)

The effectiveness of conservation differs more in forest land and cropland. *Agroforest* in the upper watershed has the larger extent and is also more effective than in the middle watershed and much more than in the lower watershed. Because some farmers do not have a contract with PHBM, and are not involved in governmental based projects, they have not enough funds and support to conserve their land more appropriately. In their point of view the conservation of their land is not really evident (cf. WOCAT mapping questionnaire in Appendix 7.)

Furthermore, the trend of effectiveness in the upper and middle watershed is 1 which means increasing and in the lower 0.5. The conservation groups in *bush and farming* which has high effectiveness are very effective but since the extent of conservation is small it is not the best conserved system of mixed use. It can be deduced from Figure 26 that in *cut and carry with farming* the effectiveness is even higher than in *bush and farming* and amounts 4. There was an effort to introduce **agroforestry** in *cut and carry* but without success because according to the farmer's calculations they would have fewer yields with agroforestry.

This result relates only to the drainage channels in *cut and carry*, which covers only 20% or the LUS. Therefore this LUS in this category is not the best conserved. Concluding the effectiveness and extent of conservation groups for the mixed use it is crucial that in the LUS *agroforestry* best conservation can be identified.

For the category other *waterbodies* in the lower watershed can be highlighted as the LUS with a vast extent of conservation groups and a high effectiveness (3.5). In the upper watershed the effectiveness is a little bit smaller whereas in the middle it is only moderate.

Settlements are at least conserved regarding their extent and their effectiveness of implementation. Thus they would need some improvements regarding their waste management which is a major problem which leads to pollution of drinking water.

4.2 Degradation and Conservation Map

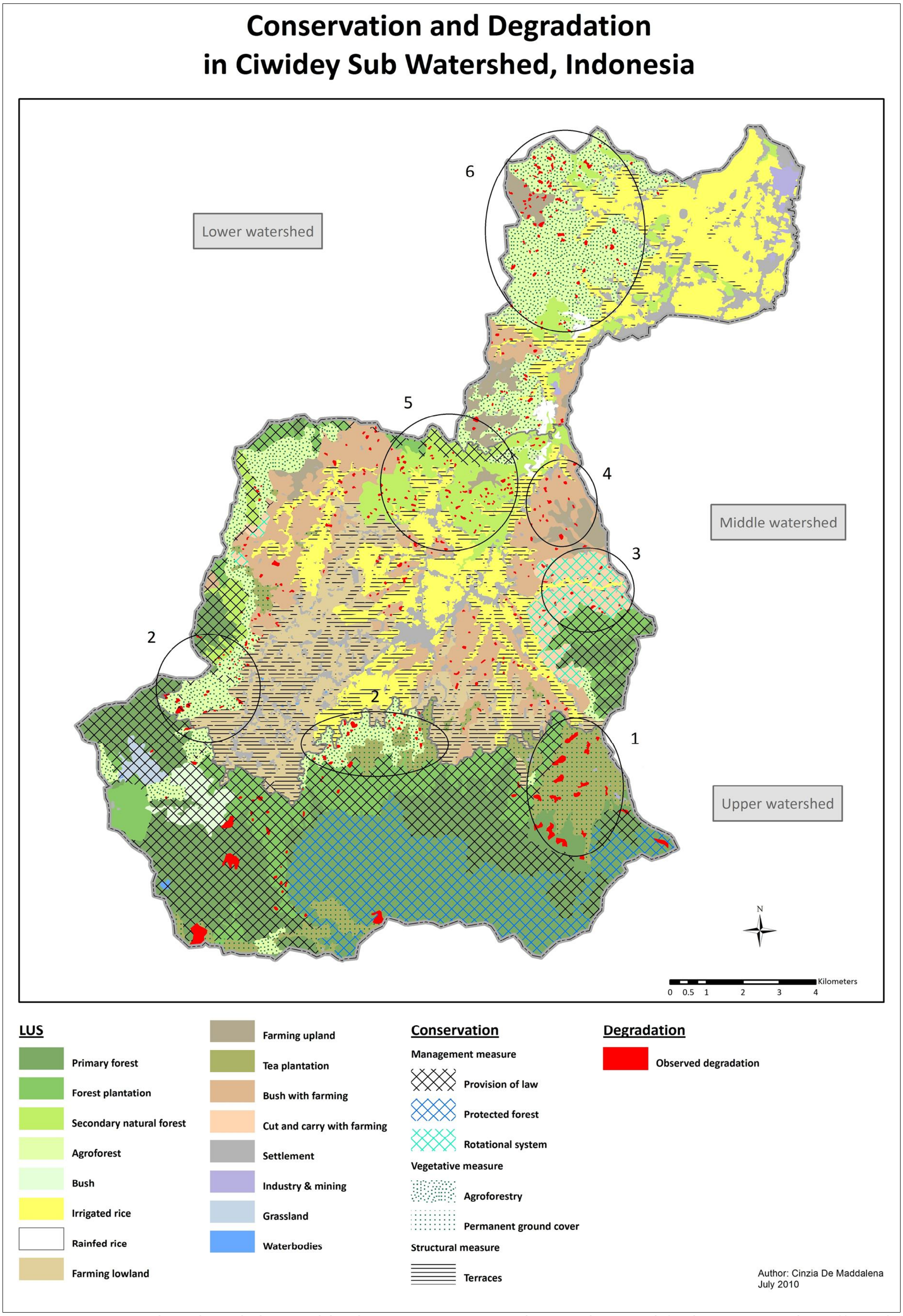

Image 48: Conservation, degradation, and land use system map and areas that need further conservation efforts (De Maddalena 2011)

This chapter aims to display and discuss degradation and conservation on a map in order to complement the results from the previous sub chapter 4.1.4 and 4.1.5. Image 48 illustrates a conservation and degradation map.

The observed degradation pertain observable soil degradation such as **soil erosion** indicated by rill development, logged fields, landslides, and bare / unprotected plots. Anyway the mapped degradations in upper, middle, and lower watershed differ on a certain manner. Numerous degradations occur particularly all over in the middle watershed, while in the lower watershed it still happens more concentrately. In the upper watershed only a few degradations could be detected. However, degradation could be identified in slope steepness from 5% and above (cf. Appendix 5).

The observable degradation phenomena are apparent in several LUS. In total six spots could be identified as critical or concerning, due to the high number of degradation occurrence and density. These are *tea plantation* (1), *agroforestry* (2), *cut and carry with farming* (3), *bush with farming* (4), *secondary natural forest* (5), *agroforest / farming upland* (6). Subsequently, their main degradation and conservation characteristic will be highlighted:

(1) In the *tea plantation* of Gambung soil erosion and landslides are the major problems because the plantation is situated in a hilly and seismic-active terrain. Tea harvesting implies a reduction of vegetation cover and accelerates soil erosion. In addition it has to be emphasized that during the period of uprooting of old tea plant, the soil is bare and mostly prone to soil erosion. However, this area is generally adequately conserved. Tea is appropriate for steep terrain and owing to the almost permanent vegetation cover. Furthermore it is widely believed that tea grows excellently in acid soils which is a feature of the soil characteristics of this area.

(2) In the *agroforest* in the middle watershed incorrect crop selection and soil management lead to topsoil erosion. The most adequate crop is coffee, but farmers instead plant various vegetables which negatively impacts the soil structure. The provision of law should restrict them to only plant the most appropriate vegetable crops in general coffee and “terong kori”. But this is not effective at the moment. There are too many farmers which do not follow the regulation. In order to cut the slopes farmers apply terrace construction, but their maintenance is poor and hence soil erosion occurs. Another problem is that farmers keep the field too long bare. This leads to soil erosion during heavy rainfall.

(3) The LUS of *cut and carry with farming* has several soil erosions on the farming fields. Nevertheless the area is well conserved in some extent, especially where grass covers the soil in order to provide fodder for livestock. In this area crops rotate depending on the season. Thus, in the rainy season *rainfed rice* is cultivated on terraces and in the dry season there is a change to vegetable farming. It is an adequate system which is well adapted to climate pattern and the hilly terrain. Furthermore it allows fodder for livestock.

(4) In *bush and farming*, bush areas are not affected by soil erosion, whereas in farming plots with lacking conservation technologies topsoil erosion exists. Moreover, logging activities could also be identified accelerated by insufficient land availability in order to gain farming

land, or using wood for construction. There is a sparse use of terraces and mulching. Therefore on Image 48 no conservation in indicated.

(5) In contrast to *bush and farming,* there is logging in the *secondary natural forest*, in particular bamboo logging. The demand is high for bamboo because it serves as basic construction material for houses. In addition, logged fields sometimes are burned in order to convert them to cultivable plots. Conservation of this region is almost not existing. There is actually prohibition of logging but it happens anyway. Further conservation activities could not be identified.

(6) The area in the lower watershed implies *agroforestry* that is also called community forest, and on the peaks of the hills farming upland activities. Soil degradation which was indicated in bare fields, gullies, and landslides is very frequent and numerous. Moreover, illegal mining and logging can be located. This area, especially the non-forested, looks to some extent considerably degraded. Although there is reforestation in some parts, the soil and crop management of farming fields is inaccurate. There is no restriction of law which could restrict logging and farming activities in this area, thus soil erosion will not decrease in future.

Concluding this chapter is can be stated that areas with conservation are not automatically without degradation. This can be explained by the bad maintenance or inadequately applied conservation technologies. For instance, since the provision of law was rarely accepted by farmers, it is not a really efficient approach. In contrast, restriction to stop any activities such as in protection of forest is more successful. Nevertheless, an adequate solution for an area where the demand on farming land is enormous should be found without wasting the nature. These can be a well maintained, farmers adapted *agroforestry* system, a larger focus on permanent vegetation cover and the support of poor terraces. This would be an adequate conservation package for the most degraded LUS such as *bush and farming, agroforest, farming upland,* and *secondary natural forest.*

4.3 Impacts on Ecosystem Services

Chapter 4.3.1 shows the assessment of degradation and conservation impacts on productive, ecological, and socio-economic ecosystem services per LUS area. The focus in section 4.3.2 lies more on the most crucial impacts on ecosystem services. Both results refer to the WOCAT mapping questionnaire (cf. Appendix 7) that was filled out with experts during the field research.

4.3.1 Impacts of Degradation and Conservation on Productive, Ecological, and Socio-economic Ecosystem Services

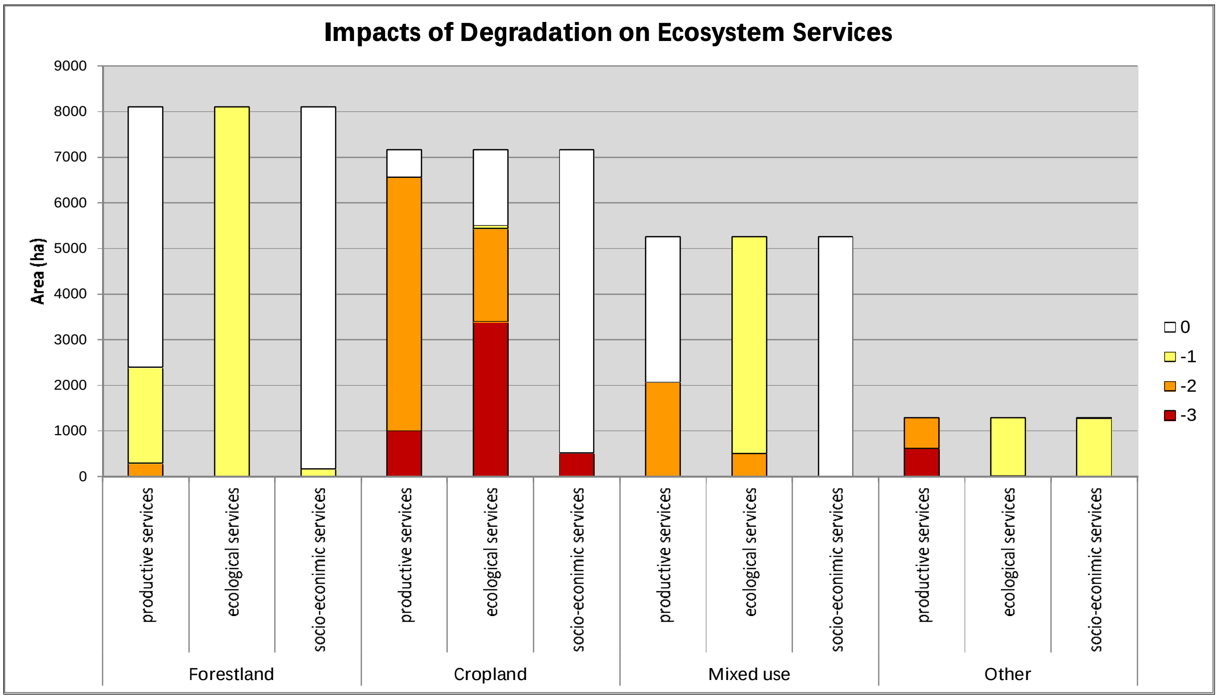

Figure 27: Impacts of degradation on ecosystem services (WOCAT mapping questionnaire 2010)

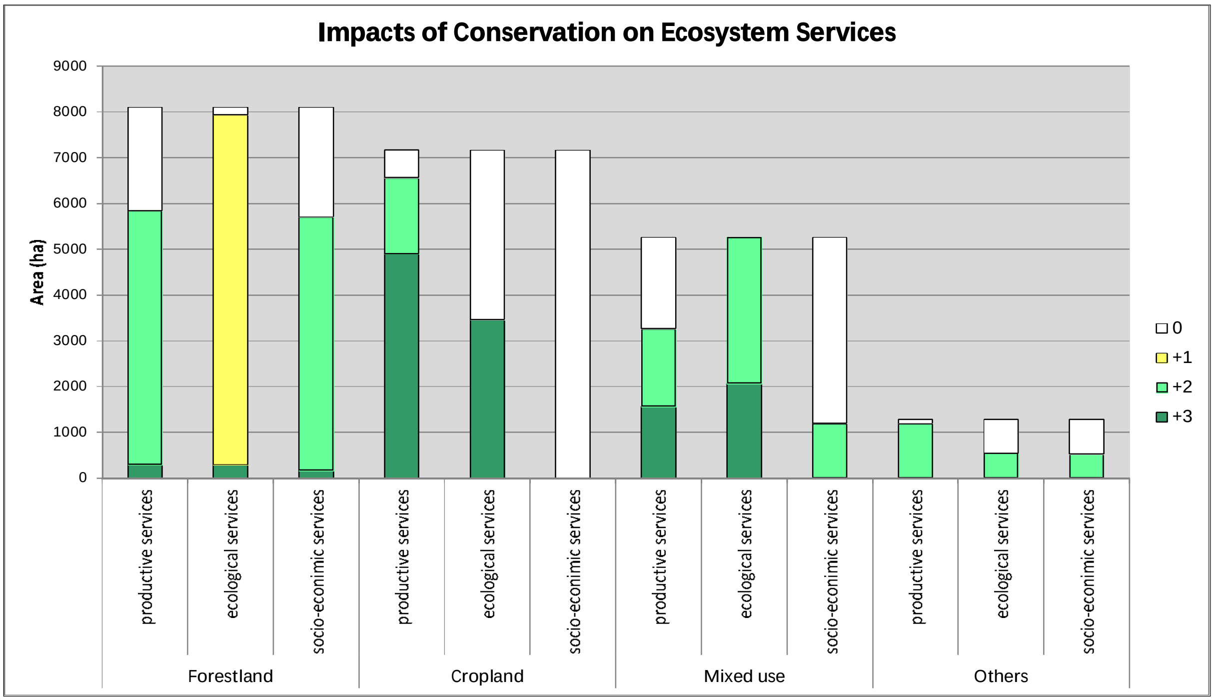

Figure 28: Impacts of conservation on ecosystem services (WOCAT mapping questionnaire 2010)

Impacts of Degradation on Ecosystem Services

The highest negative impacts of degradation on ecosystem services originate from **cropland** (cf. Figure 27). Predominately endangered are the ecological services where approximately half of the cropland LUS have high negative impact (-3). In the definition of Liniger et al. (2008) the value of -3 signifies that degradation impairs the ecological services to over 50%. The second highest impacts are in **mixed use** where 40% of the LUS have negative impacts (-2) on the productive services. This means that the change in ecosystem service is between 10-50 % (Liniger et al. 2008). And the remaining 60% of the LUS area have no impact on the productive services. It is also noticeable that in the **other** uses the impacts of degradation on productive services are high (-3) for settlements and industries in the lower watershed and amount to -2 in the middle and upper watershed. **Forestland** has despite its large area the smallest impact on productive services. However, ecological services of forestland have a low negative impact (-1).

The comparison of the impacts of degradation on productive, ecological, and socio-economic services shows that for the productive services at least one LUS has the value (-2). This can be seen for forestland, mixed use and other land in Figure 27. But it has to be mentioned that forestland and mixed use have areas which do not influence the ES. In short the productive services are the most severely affected by degradation.

Impacts of Conservation on Ecosystem Services

Most conservation measures have positive impacts (+2) or even highly positive impacts (+3) (cf. Figure 28). All the LUT have the best impacts on productive ES. It is remarkable that the impacts of conservation on ecological services are rather low (+1) in **forestland** but cover almost the entire area (see yellow column, Figure 28). All the experts assessed the soil cover as low positive impact. A reason in the author’s view is that all the forest areas except primary forest are regenerating from deforestation and the original vegetation cover is not attained, yet. The highest positive impacts (+3) can be seen in **cropland** on productive services and amounts to 68% of the total LUS area. This means that in a large area effective conservation technologies are found. There is also high positive impact on ecological services in cropland covering 48%. But the remaining area has no impact (0). The second best impacts are in **mixed use.** The amount of high positive impacts is 30% for the productive and 39% for the ecological services. This is an encouraging result that shows an intensive investment of SLM technologies for cropland in order to combat the degradation impacts.

In the category **others** the highest value (+3) is missing and the whole picture is not very differentiated possibly due to some marginalization in the interviews.

Comparison of Degradation and Conservation impacts

The comparison of degradation and conservation impacts per land use type shows that forestland has more conservation impacts than degradation. This is a good result since forest covers the largest area in Ciwidey. In cropland it is astonishing that the ecological services with the highest negative impact of degradation do not get the highest positive impact of conservation: big damages should cause strong interventions. A reason could be that according to the experts productive services are seen as more important than the ecological services and are therefore prioritized. Thus conservation has favored productive services over ecological services

Another aspect arises with the value "0" (standing for No Impact) in both Figure 27 and 28. It is obvious that the impacts on socio-economic issues with few exceptions are valued with "0". In the authors opinion it is first possible that degradation and conservation of certain LUT have no impacts on socio-economic issues. Secondly, agricultural or forest experts rarely evaluate the impacts of LUS on socio-economic ES because it does not match in their scope of work. A third explanation is that measurements of socio-economic effects are very difficult.

4.3.2 Selected Impacts of Degradation and Conservation per Land Use Type on Ecosystem Services

Forestland

Forestland has the lowest negative impacts on ES. However, the *secondary natural forest* in the middle watershed there are negative impacts on the **regulation of excessive water**. Due to the reduction of forest area in this LUS and increase of farming plots, soils have a lower infiltration rate, and surface runoff increases. This triggers soil erosion processes and thereby soil deposition slopes downwards and in rivers.

In the *forest plantation* of BKSDA, the Cimanggu hot spring area, **education and knowledge** is negatively affected. According to the experts the reason is lacking environmental awareness. Furthermore the *forest plantation* of BKSDA, negatively rated before, has a high positive effect regarding income from **tourism**.

The positive aspects in forestland are much higher than the negative ones. High positive impacts regarding **soil cover, organic matter status, land availability, production and risk**, occur in the *secondary natural forest* in the lower watershed. In the middle watershed these impacts are less positive. The *primary forest* of BKSDA is entirely conserved and abundant **biodiversity** is a positive consequence.

Cropland

The negative effects of LUS in cropland are higher than in forestland. *Irrigated rice* in the middle watershed, for instance, negatively impacts the **soil cover**. In order to combat salinity effects there is the aim of correct irrigation practice. Well managed rice paddies influence the harvest and lead to higher yield. Consequently, there is a high positive impact on **production and risk**.

Farming upland which is situated in the driest part of the watershed affects **water for consumption** highly negatively. In addition to this high negative impact there is a similar strong impact on **greenhouse gas emission**. This can be explained due to the logging of trees in order to gain farming fields. Furthermore there is the aim of SLM to achieve high positive impact on **production and risk**, and sufficient **water for consumption**.

In the *tea plantation* of Gambung various highly negative impacts are identified. There is for instance the **regulation of scarce water** or the decreasing ***organic matter status***, which is addressed by the use of organic fertilizer, an adequate conservation technology that **regulates excessive water** (cf. Image 36). It is a necessity to store or increase the soil infiltration of excessive water in order to provide water storage for dry periods. Further negative impacts concern the **net income** of tea pickers which is very low for such an exhausting and labor-intensive work. In general the *tea plantations* offer adequate LUS and have a high positive impact on **production and risk** and diminish soil erosion.

<u>Mixed Use and Other</u>

There are high negative impacts of degradation which amounts (-3) in the two LUS of *Industry and mining* and *settlements* in the lower watershed. In both the **regulation of excessive water** is a considerable negative issue which can have alarming consequences during the rainy season. The main problem is that the decrease of *irrigated rice* and simultaneously forest land imply expansion of *settlements* and *industries* which do not buffer excessive water adequately. In order to cope with this high negative impact, settlements try to store water in ponds. But this conservation impact is only valued with a (+2) and signifies a positive impact. In addition there is low negative impact of *settlements* and *industries* on the **health** of the residents. Recently there is no aim to combat the impacts on *health*. Anyway, for *industry and mining* no positive impacts exist. However, *waterbodies* have negative impacts on several ES such as **micro climate, biodiversity and again the regulation of excessive water.**

Cut and carry with farming and *agroforest* have both due to degradation a negative effect on ES. **Regulation of excessive runoff** due to the change of land cover or insufficient soil protection is the most common impact. In addition to this, *cut and carry with farming* negatively effects the **soil cover** and **greenhouse gases** due to the same reason as mentioned before. For *cut and carry with farming* replanting of trees was a project which has not been successful yet. Anyway, there is high positive impact on ***greenhouse gas emission*** which cannot be argued and thus could be an error in the database. *Agroforest*, especially in the lower watershed, impacts very positively with a level of (+3) on **production and risk, soil cover, organic matters status and land availability**. Why the positive impact is smaller in the middle watershed could not be found. *Bush and farming* show only a small negative impact, which in contrast to the previous evaluation, is rather unlikely. However, the positive impacts relating on *soil structure* and *soil cover* are reasonable since bushes still exist, and mulching is applied in some extent in this LUS.

5 Methodological Reflexions

5.1 Modified WOCAT Mapping Methodology

The modified WOCAT methodology shows some shortcomings in its application. It is crucial that they have to be considered and highlighted.

LUS polygons could be mapped in adequate detail, land degradation only for obvious soil erosion case, and conservation due to expert interviews or observation. It hindered that some area couldn't be accessed because of too steep terrain or the lack of roads. Anyway it was possible with the Google Earth map and its coordinates to define the LUS from broader distance.

Moreover there are some issues related to the WOCAT questionnaire. The extent of degradation and conservation was estimated but not located in the field. Thus the questionnaire showed for instance that terraces cover an area of 20% in farming lowland. But it was not possible to locate this area in the LUS on the map because the interview was hold in an office. Due to this lack of data the LUS, degradation and conservation maps are rather superficial than detailed but the information obtained through the WOCAT questionnaire considerably useful. Anyway, it was possible to show which LUS has what percentage of area covered by degradation or conservation and to locate potentials and threats. A further issue concerns the evaluation of impacts on ES. Actually the idea was to use the extent of degradation and conservation per LUS, but this was not possible for lack of information. It remained unclear if degradation or conservation phenomena appear overlapped or not.

The mapping was actually intended for larger areas than this research area. In this master thesis it gives a good overview regarding LUS, degraded and conserved areas on a scale of a watershed. The author suggests that if higher accuracy wishes to be achieved some critical or good areas can be picked out for deeper studies.

In addition it is important to adjust and discuss mapping categories with local experts before entering the field, in order to achieve a common understanding. This was particularly difficult and time intensive for forest classifications, because of the language barriers, different definitions. For instance in Switzerland, the term protected forest means a forest area where any human activities are prohibited. In Indonesia it signifies a forest area in which restricted activities are still allowed.

Other issues regarding the WOCAT questionnaire arose because the place of interview was in an office and not in the field, in the relevant LUS. The extent of degradation and conservation is an issue which was difficult to valuate and is therefore rather an estimation. The remaining topic of the questionnaire could be investigated with much higher validity.

The reliability of the answers in the mapping questionnaire differs depending on the expert's background (employing organization, institute, personal interests etc.). The Perum Perhutani, for instance, acted as organization very prudently when providing information about their forest area. Thus, their answer that their forest cover remained stable in the last decade was problematic, since possibly biased towards preserving their reputation.

5.2 Important Topics for Research in Indonesia

Research permission, culture, traffic and language can be considered as the most important issues for the implementation of a research project in Indonesia.

Since research without a research visa is forbidden and can be punished a long process for visa application has to be accepted. This process starts already in the home country where several documents such as medical attachment, letter of application and motivation, proposal, and funding must be handed in at the Indonesian embassy. It is advisable to present these documents at least six months before the field research starts. The beginning of this research project was delayed one month because visa application was handed in three months before the start of the project which was a too short time for the proceedings. It resulted in problems with Miriam Andonie's project which would have needed the LUS map as a base to start. Anyway the pilot project with Miriam Andonie could be conducted with some adjustment. The visa application process continued in Jakarta and took one week because several institutions such as the institute for research, office for immigration, and the police department were visited in order to provide letters and payments. This time intensive process must be taken into account and needs a patient researcher.

The culture which is strongly influenced by the religion (Islam) and colonial past of the country (occupation by Dutch) has to be considered. It is crucial for a foreign researcher to not act dominantly. In other words, Indonesian research partners and the foreign researcher are on the same level and researching together. It is wrong if a researcher has an arrogant attitude when judging the Indonesian research manner or concepts of land degradation in question. During the workshop there was for instance a discussion if a mentioned plot was eroded or not. In Indonesians view "this field was free of erosion" while from the researcher perspective "sheet erosion" was visible. The advice for such situations is to behave properly and not to dominate the discussion. Moreover, a further cultural aspect is that some Indonesian people, no matter if they are employed by the government or not, do not trust foreign researchers. This experience was made when the author entered a region which showed some illegal mining activities. Thus, she was asked, even after showing research permission, to leave the area otherwise "an accident will happen" Whatever this means it seemed to be a serious threat. In addition to this cultural aspect, the lifestyle of Indonesians which is more relaxed and less focused on punctuality has to be considered, as well. The researcher, thus must patience and always calculate more time for interviews, workshops etc. than in the home country. This is the Indonesian lifestyle and has not to be changed by foreigner researchers but seriously taken into account when planning the research project.

A further time factor is the traffic which in West Java, especially in the area of Jakarta, Bogor and Bandung is extremely high. This implies long journeys from one city to the other. It is daily life to get stuck in traffic jams. Even in Ciwidey sub watershed traffic which consists predominately of motorbikes and lorries can be dangerous for someone who is not familiar with such unorganized traffic. Therefore to be on the road during rush hours has to be avoided.

6 Synthesis

The synthesis reveals the most important aspects that resulted from the previous chapter 4 from the WOCAT mapping questionnaire (cf. Appendix 7). It shows on one side LUS with considerable land degradation extent, degree and rate, and negative impacts on ES. On the other side it synthesizes LUS with high conservation extent and effectiveness, and positive impacts on ES. However, it allows identifying areas which have to be addressed in the integrated watershed management plan.

The LUS are ranked separately according the highest extent, degree / rate, area coverage and impacts on ES in Table 11. Subsequently the average of the four ranks a, b, c, d will show the most degrading LUS. The same procedure regarding the ranking is done for well conserved LUS in Table 12. In order to locate the degrading and conserved areas a hot and bright spot map (cf. Image 49) can be consulted.

Land use system	Extent of degradation types (a)	Degree / rate (b)	Ha (c)	Ecosystem services and level of impact (d)	Rank (a)	Rank (b)	Rank (c)	Rank (d)	Rank (AVG a+b+c+d)	Final rank
Cut and carry with farming (m)	60/60/40	++/+	502	productive s. (-2), ecological s. (-2)	1	2	4	2	2.25	**1**
Waterbodies (l)	30/30/30/10	++/++	12	productive s. (-2), ecological s. (-2)	2	1	7	2	3	**(2)**
Agroforest (l)	20/20/10/5	++/+	1596	productive s. (-2), ecological s. (-1)	5	2	2	4	3.25	**3**
Farming lowland (m)	50/5	++/z	2037	productive s. (-2), ecological l s. (-2)	5	3	1	2	3.25	**3**
Farming upland (m/l)	40/10	+/++	486	productive s. (-3), ecological s. (-3)	4	4	5	1	3.5	**4**
Settlement (m/l)	30/20/20	+/+	1186	productive s. (-2), ecological s. (-1), socio-economic (-1)	3	5	3	3	3.5	**4**
Forest plantation BKSDA (u)	50/50	+/+	166	ecological s. (-1), socio-economic (-2)	2	5	6	4	4.25	**5**

Table 11: Synthesis of degrading land use systems. + =1; ++ =2; - =-1; -- =-2; z=0 / u=upper; m=middle; l=lower (De Maddalena 2011)

According Table 11 the highest degrading area is ***cut and carry with farming***. This statement can be verified by the observed soil erosion phenomena in the farming parts of this LUS. Farmer's motivation of combating soil erosion is rather small because they refuse to regreening programs, for instance. This results in negative effects regarding erosion and leads to several impacts on soil cover, greenhouse gas, excessive runoff. Actually, the *cut and carry,* which is a rotation system, is very efficient, feeds the livestock and produces crops. But, particularly grass cutting and carrying is very labor-intensive. The farming plots consequently are not well maintained due to lack of time. Farmers should learn that permanent soil cover is crucial in order to increase the water infiltration rate and reduce soil erosion. The problem is that they are not convinced of the benefits of tree planting and the financial burden is still high. Without any financial support they are reluctant to plant trees.

Waterbodies are no shaded in red because of their small area compared to the other LUS. However, the state of *waterbodies* shows the effects of inappropriate land management or land conversion. These effects are driven by upland-lowland dependences. In other words, the upper and middle watershed produce water pollution and sediment yield in the rivers and creeks which flow downstream. The losers of inadequate soil management in the upper and middle parts are the *waterbodies* in the lower watershed in the district of Soreang. Soil erosion accumulates in the lower and flatter part of the watershed, and leads to siltation of Saguling dam. In order to achieve benefits for these *waterbodies* less soil erosion and pollution must be produced upwards. Furthermore, the *waterbodies* in the lower watershed are overwhelmed during the rainy season because less water can be stored due to the land use change from forest to cropland or from cropland to settlements. Because runoff moves forwards considerably fast in the upper and middle watershed due to higher slope gradient and reduced infiltration capacity of the LUS, the entire amount of water cannot be captured in the lower flatter parts, and flooding happens. In almost every rainy season Soreang district is flooded. The flood's severity even increased in the last years in the lower watershed because of the reduction of forest areas or rice paddies which under normal circumstances buffer large amounts of water. However, field observation show that the irrigation channels and rivers transport high amounts of soil particles. Indicator thereby is the color and turbidity of water. Along the river, various locations suffer from riverbank erosion which probably has been caused during the rainy season (winter 2010). Predominately, during la Niña years the area is threatened by considerable amounts of rainfall, also in the dry season. This leads to noticeable land degradation.

When excluding the ranking of *waterbodies,* ***agroforest*** is the second most degrading LUS. It is designated as forest not belonging to the government but to local community organizations. Logging activities in order to gain more farming fields are commonly observed. Soil erosion and landslides are impacts of the farming activities in predominately steep slopes. Compared to the *agroforest* of Perum Perhutani various crop species are cultivated because farmers do not have to follow law restrictions. These LUS is decreasing but converting to farming upland with reduced soil and tree cover which have even more land degradation.

Farming lowland which is also the second most degrading LUS, suffers from the shift to intensive agriculture and stronger market orientation. The decrease of crops which need irrigation in the dry season leads to slight decline of water resources. Predominately the availability of water for consumption is diminishing. Simultaneously, the economic pressure on the former fertile plateau in the middle watershed will cause its destruction. There is already a fertility decline. Farmers try to tackle it with the application of organic fertilizer. Moreover, the well terraced *farming lowland* suffers from topsoil erosion which also contributes to fertility decline. The problem is that weeds in fields are cleared and the average vegetation cover is low. Predominately, unexpected rainfall periods during the dry season and heavy rainfall in the wet season cause considerable soil erosion on not well protected land. An advantage of the flat to rolling farming lowland areas is that the slope gradient does not have considerable influence on the state of the LUS. The reason is that terraces are stone enforced and well maintained; steep areas without terraces do not exist. It is contrary to *farming upland* and *bush and farming* where terraces are poorly stabilized or not existing. The reason why *farming lowland* is rated as more degrading despite its terrace coverage is that the extent and degree of degradation is higher than in the *farming upland*.

However ***farming upland*** has a considerable extent of land degradation, a moderate degree, but an increasing trend. This comes up to rank four (without the rank for *waterbodies* to rank three) in the ranking of degrading system. It is not surprising that this area is degrading since farming plots are located on hilly ridges and would require considerable soil and water conservation measures. Terrace constructions for instance, are not affordable by farmers in this region because of their lack of funds. Furthermore this area is disconnected from irrigation network because no creek flows down the ridges. This can lead to aridification during the dry season. Bad access and road condition is also an issue which hinders the farmers to produce for markets. Most of the farmers produce for self-consumption or sell their goods at the daily market in Ciwidey town. Anyway, since climate change scenarios anticipate drier dry seasons this area will have a degradation increase if practices of cultivation are not adopted. It is difficult to convince poor farmer to invest in soil conservation practices. The trend is that more and more farming fields on such areas are converted to intensive farming plots, because the convenient areas are already occupied by more export oriented farming activities. The trend that poor farmers are forced to expand in hilly, badly connected, and drier areas have further negative impacts on vegetation cover and greenhouse gas emission.

In contrast to the most severely degrading areas which were discussed in the first part of this chapter, conserving LUS are subsequently enlisted in Table 12.

Land use system	Extent of conservation groups(a)	Effectiveness / trend(b)	Ha (c)	Ecosystem services and level (d)	Rank (a)	Rank (b)	Rank (c)	Rank (d)	Rank (AVG a+b+c+d)	Final rank
Tea plantation(u)	20/100/30/70	++/++	1055	ecological s. (3)	1	1	3	2	1.75	**1**
Irrigated rice (m/l)	15/15/90/10	++/++	3521	productive s. (3), ecological s. (3)	3	1	2	1	1.75	**1**
Primary forest (u)	100/100	++/++	5050	ecological s. (1)	2	1	1	4	2	**2**
Agroforest (m)	50/40/40/5	++/++	680	Productive s. (2), ecological s. (2), socio-economic s (2)	4	1	4	3	3	**3**

Table 12: Synthesis of conserving land use systems. + =1; ++ =2; - =-1; -- =-2; z=0 / u=upper; m=middle; l=lower (De Maddalena 2011)

Tea plantation is a very sustainable LUS, in particular for the predominant climate in the upper watershed. Several advantages can be derived such as the (almost) permanent vegetation cover which slows down the runoff, increases infiltration and strengthens the soils structure. Moreover, positive impacts on production and risk and organic matter status are prevalent. It is surprising that the area of tea plantation is very small in contrast to crop farming. A reason is that farmers who are predominately self-sufficient do not have benefits from tea planting; nevertheless they have contracts with tea factories. There is one large area in Gambung which is state owned and employees several tea pickers. The connection between other farmers and commercial tea estates is unknown.

Although tea is considerably conserving, some soil erosion or landslides occur in harvested tea fields, as well.

Irrigated rice is a well conserved LUS and adapted to the wet tropical climate. It buffers high amounts of runoff and can hinder floods. The innovative “legowo” system offers additional benefits for farmers. They have the opportunity to grow fishes and sell them on the market. This generates a decent income and secures their livelihoods. Rice cultivation offers a positive impact on nutrient cycle. Moreover, *irrigated rice* paddies are also suitable for steep areas since the bench terraces reduce the slope and thus runoff and soil erosion. The actual trend that indicates a decline of *irrigated rice* fields in the watershed is alarming. At the same time population and hence the demand of rice increases. This contradictory development leads to enormous environmental and economic threats.

The best conserved forest is the full protected ***primary forest*** area of BKSDA. This management protects the forest provisioning, regulating and socio cultural services. It is important to maintain the remaining biodiversity which can also be seen as positive contribution. Particularly, in Ciwidey watershed the forest area serves as watershed protection, provides genetic resources, and controls erosion (cf. Wardojo and Masripatin 2002:78). Therefore the main aim of the ministry of forestry is to invest in afforestation programs and soil and water conservation technologies where it is not possible to gain the status of full protection.

A further conserving LUS is ***agroforest*** in the middle watershed. The area which is located at the edges of the watershed, in a predominately steep terrain, allows the use of forest land without overexploitation of its resources. Since the remaining arable land is small or belongs to commercial employments farmers moved into forest areas. At these times, the cultivation was not controlled and the farmers planted any vegetable crops without investigation of their influence on soil and water resources. Due to this inadequate development only the most suitable crops are now cultivated in the *agroforest*. It makes sense to plant coffee, “terong kori”, cassava, and fruit trees. Since farmers are self-sufficient, in particular coffee leads to income increase but does not provide daily food. Therefore some farmers still cultivate illegal vegetables in the forest. However, there are positive effects on marketing opportunities, production and risk, soil cover, and regulation of excessive runoff.

Image 49 shows the most degraded and the most conserved areas summarized in Table 11 and Table 12. The thick red circles signify the most degrading areas and the green thick circles the best conserve areas. Circle that are smaller are the second or third best conserving or respectively degrading LUS.

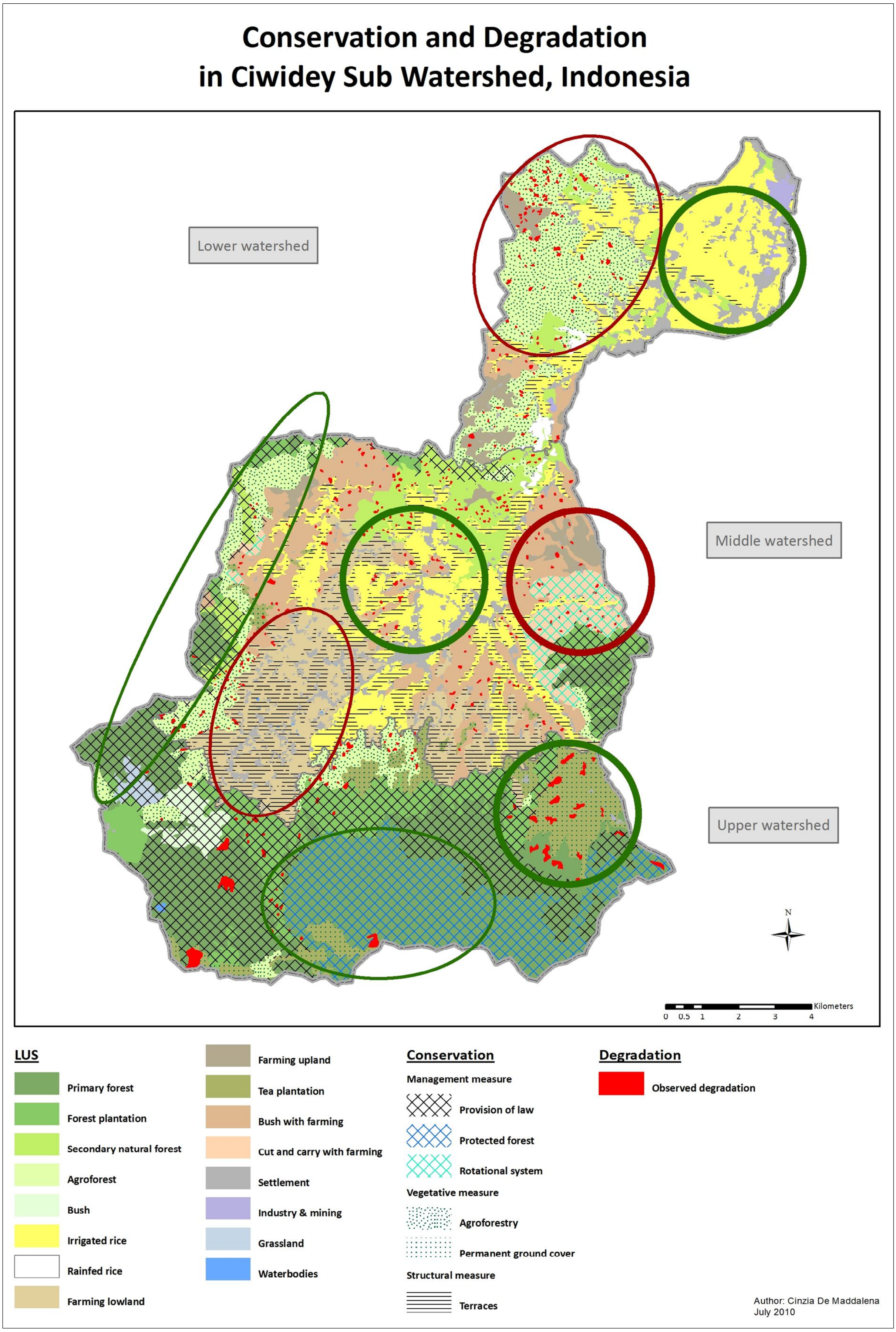

Image 49: Hot and bright spots in Ciwidey (De Maddalena 2010

By using only the information on land degradation SLM and impacts on ES from the WOCAT mapping questionnaire it is difficult to define the most conserved bright and the most degraded hot spot areas. It is necessary to refer also to the area- and intensity-trend of the LUS (cf. chapter 4.1.3) and to the field observations (slope steepness) in order to define a single priority area.

According to the expert the LUS in the upper watershed remained stable. It is obvious that in the middle watershed the most area changes on LUS occurred. Most pressures are on the *irrigated rice* fields which were converted to *settlements* or *farming lowland* in the past decade. *Farming lowland* is a degrading LUS. Furthermore, it is also worrying that *bush and farming* decreased and *farming upland* increased instead. Also, the LUS *cut and carry with farming* grew strongly in the past decade. These shifts in the middle watershed may incorporate on one side a decline in rainfall buffer capacity and, on the other side, a reduction of vegetation cover. Hence soil erosion may increase in the future. ***Cut and carry with farming*** and the adjacent LUS ***farming upland*** are the most critical areas. *Farming lowland* is less critical because it is applied in flatter terrain (cf. Appendix 5).

The best conserved LUS is **tea plantation** because it remained stable and is well conserved and has high positive influence on ES. The second best conserved LUS ***irrigated rice*** produces basic rice supply and has buffering capacity to prevent or mitigate flood events.

7 Conclusion and Recommendation

The previous synthesis revealed degrading and best conserved LUS which now allow making some conclusions and recommendations for the management of Ciwidey sub watershed. It is a proper assessment of the LUS in the whole watershed. More specifically this chapter concludes the discussion of areas with potential or endangerment. The mapping and assessment of different LUS revealed the following:

Upper Watershed

The best conserved LUS in the upper watershed is ***tea plantation*** because its area does not have severe soil erosion. Tea planting is multifunctional and addresses many land degradation types due to the permanent vegetation cover. It is well conserved and has high positive impacts on productive and ecological ecosystem services. Tea plantation is a LUS which can expand but cannot replace the indispensable vegetable cropping of a self-sufficient farmer.

The most degrading area is the ***forest plantation*** of BKSDA. The trend is concerning that more forest areas are used by tourists and nature reserves attract crowds of visitors. Tourists are not enough aware of their damaging potential. In touristic areas littering is an alarming problem. There are already information boards against littering. Unfortunately this measure is not very effective up to now. Therefore the management of these areas should introduce fines for every littering person.

Middle Watershed

Agroforest in the middle watershed belongs to Perum Perhutani and is well conserved. It is a system protecting the forest resources and allowing restricted farming activities. There are considerable benefits regarding the crop production and soil erosion reduction and, as well, benefits in the regulation of excessive water. Moreover *agroforest* can substitute conversion of forest to agricultural fields. Therefore further expansion of agroforestry technologies particularly in the rolling to steep areas in the middle and lower watershed is recommended. There is one aspect that could improve this LUS in order to optimize its sustainability. In the *agroforest* in the middle watershed farmers are obligated to follow restrictions on crop selection, but not all of them follow the rules. It is crucial to provide different sustainable agroforestry systems to the farmers so that they are not forced to cultivate exclusively coffee, for instance. Not every farmer is familiar with coffee production or willing to change his habits. If farmers had the possibility to adopt their system to agroforestry system without a fundamental change they would follow the rules more consequently. New policies such as the restriction for the state owned land by Perum Perhutani must be negotiated in a transdisciplinary dialog between local authorities, the government, scientists, and farmers. If the policies are negotiated appropriately, farmers will follow the rules.

The most degrading LUS is ***cut and carry with farming***. Actually it is a sustainable system adapted to the monsoon seasons. The crop rotation and the integration of livestock make this system innovative and sustainable. But the clearing of vegetation can be observed due to farmer's perception that clean fields symbolize good farming. This causes considerable soil erosion and additional conservation is recommended such as vegetation strips, tree and shrub planting, mulch, and financing for “teras kredit”. The only obstacle is that the farmers, fearing financial loss, do not want to replant trees assisting the water storage capacity and reducing soil erosion. It would be helpful to run trainings with focus on adequate SLM practices and to teach the farmers that vegetation cover should be integrated. The rotational system *cut and carry with farming* could be enriched by agroforestry.

Lower Watershed

The best conserved LUS of the middle and lower watershed is ***irrigated rice.*** It produces basic food supply and has buffering capacity to prevent or mitigate flood events. It is an important and very sustainable LUS with many terrace constructions. *Irrigated rice* fields decrease due to settlement, or the conversion to commercial farming plots. This is a critical development. Therefore damage trough extreme events are likely to become more common. Vegetable cropping and settlements cannot replace the rice cultivation’s function of buffering excessive runoff. It is crucial to take action to stop the reduction of rice fields. The “legowo” system has high potential and produces, due to fish farming, an additional income enriching many households. This makes the cultivation of *irrigated rice* more rewarding. Therefore the knowledge about “legowo” should be spread more broadly among farmers.

Agroforest is the most degrading LUS in the lower watershed. It is designated as forest not belonging to the government but to local community organizations. Logging activities in order to gain more farming fields are commonly observed. Soil erosion and landslides are subsequent damages of the farming activities, predominately in steep terrain. Contrary to the *agroforest* of Perum Perhutani various crop species are cultivated because there are no law restrictions. The size of this LUS is decreasing and converts to *farming upland* with reduced soil and tree cover. In *farming upland* top soil erosion is even worse. Here again sustainable agroforestry systems is recommendable. Consultation and education of agroforestry is important and must highlight the benefits for farmers.

Cropland

Cropland which covers a considerably large area is still expanding and tends to become more intensified. Top soil or sheet erosion is an issue in the *farming upland* and *lowland*. Predominately, in the rainfed *farming upland*, the soil management is inappropriate and conservation lacking. Intercropping occurs in *farming upland* where self-sufficient farmers prevail. This system is recommended to maintain and a conversion to monoculture such as in *farming lowland* must be avoided. Mulch can be used as convenient SLM technology in rainfed farming areas because it is not expensive (the farmer has it anyway from the last harvest) and it protects the soil cover. In the author’s view every area must be addressed directly and needs different support by local initiatives or the government. Financial support for terraces and the consulting of intercropping and mulch technologies is very important.
In the irrigated and terraced *farming lowland* the central problems are topsoil erosion and fertility decline. There are in general bare fields which are especially vulnerable to heavy rainfall. Thus, in such events runoff washes the soil away, transports it in *waterbodies*, and the soil particles end in the worst case, as sedimentation in the dam. In *farming lowland* it is advisable to have permanent vegetation cover and to apply biological and non-chemical fertilizer, in order to reduce the decline of soil fertility. A mix of manure and plant residues positively affects the soil fertility.

Mixed use

The mixed LUT has some positive aspects on SLM due to the mixture of cropland with trees / bushes such as in the *agroforest*. Anyway in *bush and farming* topsoil erosion happens. The clearing of vegetation due to different reasons can be observed. One motivation is that in the farmer's perception clean fields symbolize good farming. Another motivation is to make the land more profitable in order to achieve additional reclamation of farming fields. The trend is that *bush and farming* converts to *farming lowland* and will become more profitable and commercially used. In general SLM exists in *bush and farming* but it is in a poor state. *Bush and farming* require further inputs of conservation technologies such as vegetation strips or tree and shrub planting, and financing for terraces.

Forestland

The forest area remained stable in the last decade. Nevertheless logging and burning of cleaned areas occur and farmers start cultivating crops. There is the aim at reducing these activities. Unfortunately it was not achieved until now. Farmers are clever and when the rangers patrol the forest they hide. In general it can be said that since the forest management became decentralized the local governments are more autonomous and the control of people's activities in the forest is difficult nowadays. The control of biological degradation has to be strengthened. One possibility is to augment the number of rangers which will only combat the symptom. It would be more convenient to focus on the cause which addresses land tenure in this region. If a farmer has to sell his land or needs new and more fertile land he shifts his food production into the forest. Before this happens farmers should receive, support for soil and water conservation. This would hopefully prevent further forest destruction.

Water

Water as a resource and the LUS *waterbodies* is the most severely degraded category. It is also the LUS which shows the environmental problems at its best. On one hand sediment yields and water pollution are observable in the field but were not measured yet. Anyway the major part of soil material (not all, because not every soil particle end up in the water system) flows into the irrigation channels and rivers. This raises enormous costs for the cleaning and causes the destruction of *waterbodies*. Furthermore inadequate water management and industry activities lead to pollution of drinking water. On the other hand the water quantity is another issue which has an upland-lowland gradient (from upper to lower watershed). The LUS in the upper and middle watershed have negative impacts on the water availability downstream. Due to land conversion (from forest to farming or from farming to settlements) the capacity of water storage of the entire watershed is reduced. This fact is reflected in floods or water scarcity in the lower watershed.

There are two recommendations. The first addresses the soil and water conservation in cropland and the second the river system as such. It is crucial to apply the already mentioned SLM technologies (mulch, intercropping, vegetative strips, terraces) in cropland and mixed use predominately in the middle watershed which directly impacts soil loss and thereby the condition of rivers. The technologies predominately focus on soil and water conservation. Regarding the river as such, well established gates and barriers were observed. They function well and need constant maintenance. The author anticipates a considerable potential in the stabilization of river banks through gabions or through the replanting of trees. But it is more crucial to focus on the LUS in order to reduce soil loss. Furthermore, efficient and environmentally friendly waste management can tackle pollution of rivers. It has to be recognized that these problems will even increase with the population growth and the expansion of settlement areas. Alternative waste deposition must be created instead of burning the waste or depositing it in rivers. Waste management is expensive. If the government cannot provide it, many residents will refuse to apply it because they are not willing to spend money, if they can do it on a cheaper way. In order to achieve a better waste management people who recycle their waste should receive compensation such as fresh vegetables or tea bags. This would positively enhance their motivation.

Climate change

Climate change and monsoon based seasonality is a challenge for the future of the Ciwidey sub watershed. According to 1.3.1 the monsoon will be delayed and the rainfall in the rainy season is predicted to be stronger. This will severely influence the land use and its vulnerability. Heavy rainfall as the accelerator of soil erosion pressures farmers to adapt their soil and crop management. The increase of rainfall can seriously impact the tea's quality and lead to a decline of its market value. Furthermore flooding, particularly in the lower watershed, happens more often and causes damage. In contrast in the dry season, regions that have restricted access to water resources and/or where of dryland farming is standard will encounter water scarcity and thus reduced harvest. These developments and scenarios have considerable negative effects on livelihood.

Farmers should be advised to reduce water losses, in the dry season. Today farmers plant chilies, but the harvest can be destroyed during wet la Niña years. Therefore it is important to inform the farmers in advance which climate regime or which forecasts will be prevalent in the coming year. Thus, they can better plan the timing of their farming activities and the crop selection. This information could be accessed on a website in the internet since in Ciwidey town several internet cafes exist. Further research and experiments are needed regarding the most adequate approach to cope with climate change and changing seasonality.

Socio-economic issues

The alarming increase of West Java's population density is the cause of the persistent environmental problems. As observable in Ciwidey sub watershed settlement and infrastructure construction is ongoing and prevalent in the middle and lower watershed. It is a challenge to deal with the increase of settlement areas and residents who need daily food whereas the fertile and cultivable land declines. The trend lies in the intensification of crop production. It is challenging to find solutions for socio-economic issues since it is not possible to stop population increase in West Java. The large cities in West Java offer too much opportunities such as education and jobs compared with the other Indonesian islands. To move universities or international companies to Sumatra for instance, is an unfeasible illusion. Hence, West Java, such as the Ciwidey sub watershed must cope with this threat on a different way. The most reliable idea is that forestland is cultivated again, but with restrictions. Land reclamation in a sustainable way by applying agroforestry systems can contribute positively.

Hence, food availability might be secured. This has to be handled and managed carefully with the appropriate soil and water conserving technologies.

Along with the increase of population and a shift of lifestyle among the younger generation traffic increased dramatically. Residents of Ciwidey watershed commute into metropolitan Bandung and are no more not interested anymore in farming. The availability of jobs in textile factories, entertainment, shopping malls etc. is higher than in the countryside. This change of lifestyle is caused by globalization and the orientation to western lifestyle. This is a threat for rural communities such as in Ciwidey sub watershed. If more people work in the cities for off-farm income less labor is available for SLM.

However traffic and air pollution are considerably high but most of the people are not aware of their impacts on the land use and climate change. Thus the environmental consciousness is partially low. This is also observable in the behavior of tourists. In general, weekend tourism increased. Residents from Bandung, Bogor, or Jakarta seek to go to the mountains. Then Ciwidey sub watershed gets almost overrun by tourists who like to explore tea plantation, strawberry fields, hot springs, rain forests, or the volcano crater. This leads to littering and traffic density during the weekends and affects soil pollution.

In order to sensitize the residents of Ciwidey sub watershed to conserve all LUS, education is the first step. The universities in Bandung have launched initiatives where all the students from different faculties can participate. They plant trees or talk to younger students aiming at the improvement of their environmental consciousness. But this education should already start in the primary school. Moreover, the media which have considerable influence on an individum's thought and movement patterns should draw people's attention on environmentally issues.

<u>Watershed management</u>

According to this study, the mapping of LUS, degradation, and conservation revealed that agroforestry and terracing are the most efficient practices in order to achieve SLM in Ciwidey watershed. Owing to this master thesis it is possible for the responsible authorities of the watershed management to invest in the most degraded or problematic area such as *cut and carry with farming* and *farming lowland* in the middle watershed, and *agroforest* in the lower watershed. Nevertheless the author would suggest investing further into impacts of different LUS and conservation practices such as productivity, soil erosion, and sediment yields to investigate the source of soil loss in an actor based approach.

In view of the integrated watershed management plan of Citarum watershed this thesis revealed predominately, from a bio- physical perspective, the prevalent state of LUS and ES, areas of degrading or conserving LUS (cf. chapter 5) and recommend best practices for LUS affected by degradation. Although there is no focus on the social dimension, it is crucial for an integrated watershed management plan to take socio-economic aspects into account. For instance, education, tradition, religion, and institutional embedment, have considerable impacts on the farmers perception and their attitude regarding SLM practices. The result of this master thesis shows that the cause of degradation, in most cases, is inadequate crop and soil management which roots in poor education or lack of funds which are social aspects. A possibility for farmers is to build a center of knowledge sharing and information access in Ciwidey town. The center could contribute to great benefit if farmer learn from each other. Furthermore, the center for knowledge sharing could support places with degrading LUS. An additional benefit is that farmers who risk new investments, such as the planting of trees in order to convert to *agroforest*, can be convinced by farmers who had already long term benefits with this technology. It is important that recommendations are sustainably harmonized with the three spheres of environment, economy, and society/policy.

By summarizing all the mentioned conclusions and recommendations, the most important recommendation for land users and the integrated watershed management plan in Ciwidey sub watershed is the application of SLM technologies and approaches in degrading areas. This master thesis was successful in the assessment land degradation, and conservation and can contribute to decision making and planning in the Ciwidey sub watershed in order to achieve a sustainable development.

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9 Appendices

Appendix 1: Semi – Structured Expert Interviews

Interview with Syaiful Anwar, Ministry of Forestry, Jakarta, 18 July 2010

Topic: Integrated Watershed Management Plan Section Upper Citarum Watershed

1. **CD: What is the background of the Integrated Watershed Management Plan Section Upper Citarum Watershed?**

   SA: Citarum watershed provides water resources for irrigation, energy and for domestic use. The goal is to enhance the life of Saguling dam. The Saguling dam existence with an installed capacity of 700 MWH is a barn that is cheap and clean energy, but the condition of sedimentation and erosion in the upstream area is very alarming. This is due to the sedimentation rate that reached more than 4 million tons / year. In addition flooding often occurs in this region. There are efforts to tackle the water catchment area (DTA) Saguling. This area has first priority in preparing the Citarum river basin management.

2. **CD: What goals does the action plan of the upper Citarum watershed aim to achieve?**

   SA: We should be able to extend the useful life of existing reservoirs in Citarum with the aim of controlling pollution and maintaining the water quality in the Citarum basin. A goal is to improve the level of social welfare in both the upstream and downstream area. Furthermore, we achieve to make a planning document that directs Citarum watershed development.

3. **CD: What results do you expect from the management plan?**

   SA: The existence of directives and guidelines for the Citarum river basin management is important to establish coherence of cooperation between stakeholders in the management of the Citarum watershed to improve the welfare of society.

4. **CD: Which SWC technologies exist in the upper Citarum watershed?**

   SA: There are structural and vegetative technologies. Structural technologies are *teras bangku* and *gulud*, stream bank erosion control, gully plug, drainage channel, check dam, control dam, and small reservoirs. The vegetative technologies consists of grass strips, permanent vegetation cover, regreening, agroforestry, green tree belts, rehabilitation along the river.

5. **CD: Which sub watersheds are part of the upper Citarum watershed and how can they be described?**

   SA: The upper Citarum watershed is divided into eight sub watersheds. Ciwidey makes part of 1 in 8. The total upper Citarum watershed has a size of 227,446 ha where Ciwidey measures 22,169 ha. It can be derived that the number of forest area remained in some watersheds more than in others. In Ciwidey for instance, 40% of the areas is forest and 60% non-forest land use. Compared with Ciwidey, Cikeruh sub watershed's forest area is rather small with 15% .

There is also a high rate of erosion in Ciwdey. 39.8% of the entire watershed area suffers and displays very bad erosion index. Ciwidey can be derived as the watershed with the highest erosion rate in the upper Citarum watershed.

6. **CD: Do you have already any conclusions for the integrated management plan of the Upper Citarum watershed?**

SA: We do not have real conclusions, rather more measures that support the necessity of a well-developed and sustainable management plan for the upper Citarum watershed:
For instance, the potential water runoff that enters the Saguling is 4001.2 million m^3 per year. The number of priority areas for runoff in the DTA Saguling reservoir is 141 ,146 ha (61.6%). On average in the DTA Saguling has a deficit of 85 mm / year.
Compared to other sub-watershed, sub watershed Cisangkuy and Ciwidey have a net value of water in a state surplus of about 38-50 mm / year. There are very bad erosion amounts which perceive 35% in the Saguling reservoir. This high rate is due to the contributed rates from some of the adjacent sub watersheds. For instance, Ciwidey has 39.8%, Cisangkuy 35.3% and Cirasea 38.6% of soil erosion.
Due to the Saguiling DTA region which is characterized by a large area of land rehabilitation issues the Sedimentation amount that goes in total into Saguling is more than 8.4 million tons/year. The number of landing sites in DTA Saguling from DAM Controller (DPI) include 280 points that can hold or control erosion as much as 23.8 million tons / year.DPI may decrease the availability of sediments and results in each sub-watershed outlets on average up to 21.4% and lower. Most DPI are in Sub Ciwidey (51 units), Ciminyak (47 units) and Cirasea (49 units).
The number of referrals to the location of the DAM holder (DPN) in the DTA Saguling much as 2292 points with a total catchment area of about 40,143 ha and is able to control erosion as much as 20.4 million tons / year. DPN may decrease the availability of sediments in each sub-watershed outlets in average 18.3%. Location DPN most are in the sub watershed of Ciwidey exists (341) whereas in Ciminyak were built 481 and in Cirasea 367.Both DPI and DPN can reduce erosion by 67 million tons / year. Hence sediments in Saguling water bodies can be reduced to 39.6% and sediments that arrive at the outlet Saguling can be reduced to 39.4%.The costs required to manage DTA Saguling for 5 years amount to USD. 397.47 billion. On the basis of this PRA management plan we try to find solutions for the ideal land use in the villages. It has been agreed to reduce runoff and erosion that harmed the dam, by all parties. Openness, coordination, collaboration and synergy are the key words in conducting land management activities on watershed scale.

Interview with Ruddy Fadilah, BKSDA, Bandung, 24 August 2010

Topic: General Information about forest conservation in Ciwidey.

1. **CD: Which part of the forest belongs to your institution?**

WS: We manage forest conservation which is split into four forest sections with a distinguishing conservation effort:
-Nature reserve (strict protection, no activities allowed)

-Recreation forest (for tourists, since 1972)
-Forest for hunting
-Wild forest sanctuary

2. **CD: How did it come that such a large number of forest have been destroyed?**

WS: Due to Gus Dur, the fourth president of Indonesia who reigned from 1999 zo 2001 the period of mass crime of the forest had its starting point. Gus Dur told its population "the forest belongs to the people. It is empty land and has to be used!" Because of the destruction of the ecosystem in Soreang floods and drought are very frequent.

3. **CD: What kind of conservation efforts do you make in your management area?**

WS: There are rangers patrolling and trying to stop the activities. There are still farming activities and sometimes in very steep hills without the use of terrace. We have 8000 ha of land which we try to protect and with six rangers. Therefore the rangers cannot make successful controls. Another problem is that when the rangers are patrolling the farmers are often not in the field.

4. **CD: What do you think about waste pollution?**

WS: In the recreation area which suffers from mass tourism and with it vandalism. Half of the visitors run after they entered the recreation area directly in the forest. Hence, there is garbage spread around the forest everywhere which results in negative impacts for the ecosystem. We display a board that indicated with the sentence "Leave your footprint, not your garbage!" that people should take more care to the nature.
However the garbage problem in Bandung is even worse because the attitude of the people is very bad. An new program should solve this problem. It's called 3R (stand for recycle,..,..). It aims to split the garbage and recycle it.
Some people in Ciwidey make fires and hence burn their waste. This has two reasons. The first is that they can warm their hands at the fire. The second is that with the fire all garbage can be burned. This results in air pollution.

<u>Interview with Naik Sinukaban, Agricultural University, Bogor, 27 August 2010</u>

1. **CD: What is the annual crop circle in farming areas?**

NS: In the wet period the major part of the farmers cultivate rice. Rice can be harvested twice a year. In a good year even a third time. Farmers plant corn, tomato, chilli, beans, banana and so on particularly in the dry season. A cassava needs sometimes longer than a year or at least nine months until it can be harvested. The bananas are often planted on borders of terraces and plots. As opposed to this tomato, chilli, corn and beans need three to four months. This dry season is very wet therefore they didn't planted chilli and beans, yet. Chilli doesn't like to much rain. Usually, after the wet season farmers plant crops and achieve higher productivity through crop rotation.

2. **CD: What cultivation system and technologies do farmers apply in irrigated rice paddies?**

NS: In the lower parts of the watersheds irrigated rice is the dominant land use system. The growing process of irrigated rice is supported by fertilizer (Nitrogen, Phosphor and Potassium). The average harvest is 2.5t/ha. Water logging is rarely a degradation process in irrigated rice. We invented a new technology which aims not maintain water logging because the aeration is very important for the root system. To achieve optimal aerobic condition the rice seeds are already planted directly in the paddy fields with a distance of 30cm between the hills. Afterwards the seed grow to seedlings in 7 days. In the old technology the seeds were planted on seed belts instead of the paddy fields and growing process lasted about 21 days. It is a considerable advantage to shorten this growing period. Additionally the amount of harvest in the new technology is 3t/ha higher than with the old technology. Summarizing this, harvest amounts 8t/ha, today.

Since the green revolution 1963 we are improving our land use systems every year with different innovations and approaches. There was the approach of high yield variety, irrigation systems, innovations in integrated chemical pest management and sustainable soil management to prevent soil compactions.
I trained farmers in biological pest management, but still use chemical pest management because it is more secure. They are afraid and don’t take risk because in one night a famer can loose everything!

3. **CD: How do the commodities in upland farming compared with lowland farming differ?**

NS: There are more monocultures in the lowland. This is especially for commercial production. As a result of markets gains farmers have more capital and invest in monoculture. Monoculture is more profitable than mixed farming systems.
In upland farming the existence of mixed farming plots is more frequently applied. The use of mixed farming reduced the risk of failure. If one crop fails, there is a second one that can be harvested, probably. The farmers, for instance plant one row of corn and three rows of cassava.
In the past the people made channels for irrigating 2-3 ha of rice in certain upland farming areas. Ciwidey is owned by many farmers.

4. **CD: What can be described as community forest?**

NS: The community forest established by the government prevents people from going in the national park, The village development program assists the farmers. Logging is prohibited in the community forest but happens illegally.
Large scale mining can also be a problem because it destroys the ecosystem but doesn’t exist in the sub watershed of Ciwidey. We should keep a ecosystem that can feed our people.

5. **CD: What kind of SWC Technologies exist and are applied?**

NS: There are different measure for Soil conservation such as vegetative, agronomic, structural and management.
Vegetative:
-In Tea plantation mulching and Africa trees (Mysobis) are applied.
Agronomic:
-The already mentioned change of planting distance in irrigated rice to 30 cm.
-Crop rotation not in strips (Multiple cropping). One year rice next year something else.
-Change of planting time/season
Structural:
-To stop gully erosion we plant bamboo sticks or make barriers with cement.
-Sheet erosion is very difficult to combat. Sometimes we cover the fields with plastic which also prevents soil bone disease, evapotranspirtation and splash erosion.

6. **CD: What is the difference among agro forestry and social forestry?**

   NS: Agro forestry is a system with consists of a mix of farming plots and trees. A type of agro forestry is agriculture forestry.
   Social forestry is a project of the government that aims to support farmers in technical advice consulted through extension workers and seeds for free. The forest area where this project has been conducted is owned by people.

7. **CD: A large part of the forest area belongs to the institution Perum Perhutani. What is their task?**

   NS: Perum Perhutani gives a license to the people for planting and selling tobacco, corn, bean, coffee, cabbage and so on. The people should look after their trees. After three years the license is expired and the farmer cannot plant any more crops. Coffee is a premium crop. In some parts annual crops are cultivated. The area which is owned by Perhum Perhutani is composed of Andosols and considerably fertile.

8. **CD: Can you tell me about politics that influenced the handling of the people with the natural resources?**

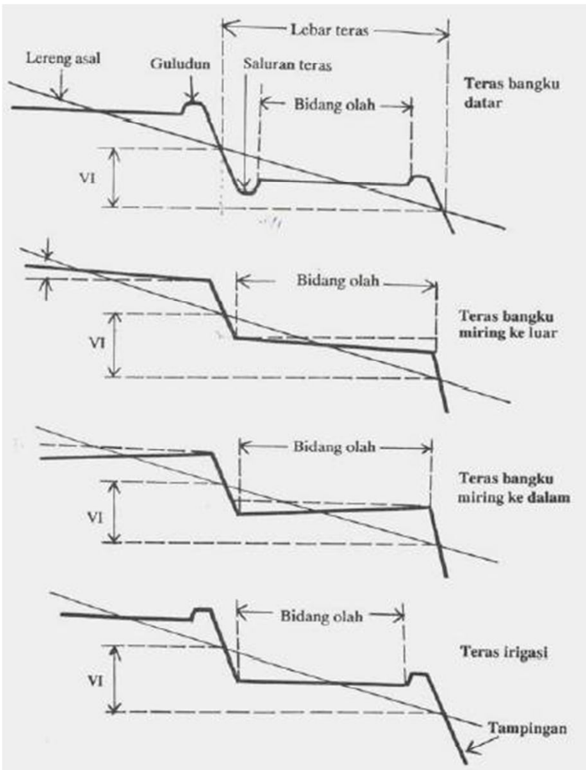
   NS: In 1969, Suharto was president of Indonesia. With his politics and interests the increasing export of timber from the forests of Sumatra and Kalimantan arose. The demand after Indonesian logging companies increased. The government therefore gave them money and the possibility to establish. The same development happened with mines.
   In 1997 we opened 1 Mio pit soils and 1 Mio rice fields. Land which is not sustainable for rice production was used.
   1999 There was a reformation with a high number of demonstrating students who went to the government. The government was very fundamental. The democracy which we have today is better but was bad at the beginning.

9. **CD: What kind of pollution exists in water bodies?**

NS: Rivers suffer from garbage deposition and sanitary waste. High soil erosion rates with it high sedimentation rate have negative Impacts on the Saguling dam. The alarming erosion rates results particularly from the community forest.

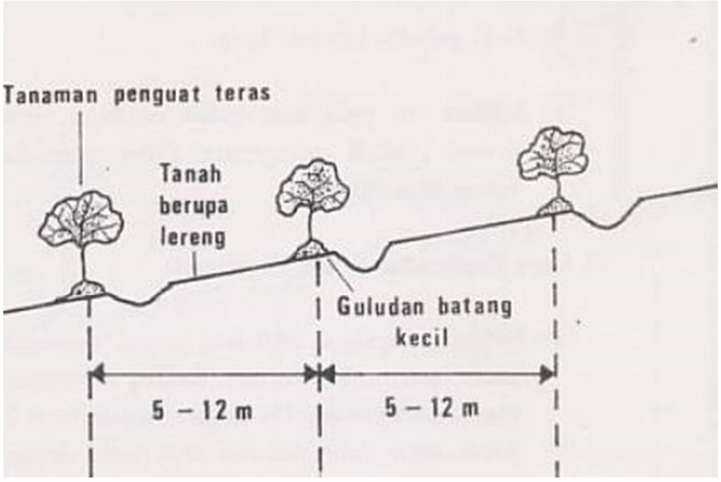
10. **CD: Different terraces types can be identified In the sub watershed of Ciwidey. Can you explain each one?**

NS: Teras banku: is applied in step slopes with angles of 30-90%. This terrace type is used particularly for rice production but sometimes also crops. Farmers remove the topsoil and construct with it the soil bund of the upper terrace. This leads to water logging. After the removal of the fertile topsoil the remaining subsoil on the lower terrace in Ulitsols area commonly contains a high number of aluminum and iron and is therefore toxic for crops. My advice for farmers is that they shouldn't build terraces if they have Ultisols. Sometimes farmers plant cassava on the soil bunds which separate the paddy rice but through cassava harvesting the roots can destroy the edges of the terrace.



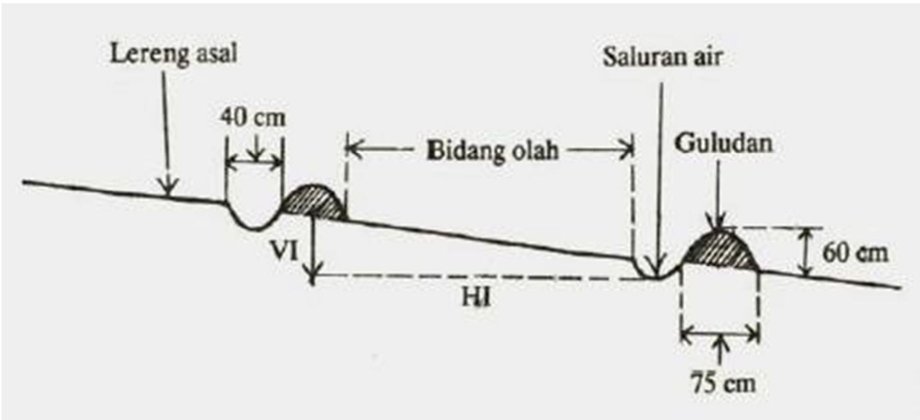
Source: Bebas Banjiir 2015

Teras kredit: The building of Teras kredit happens gradually. Sometimes it needs more than 10 years until the final terrace size could be reached. This SWC technology is predominately applied in upland farming systems.



Source: Bebas Banjiir 2015

Teras gulud: In this terrace type farmers often plant legume trees. The farmers are ditching a second drainage channel bellow each terrace that is not useful for the efficient function of the terrace. The upper channel is sufficient to drain surplus water and hence maintain the terrace.



Source: Bebas Banjiir 2015

Reverse back slope bench terrace: These terraces are not horizontal and applied in upland farming where upland rice is cultivated. The bench is fixed with stones and bamboo branches.

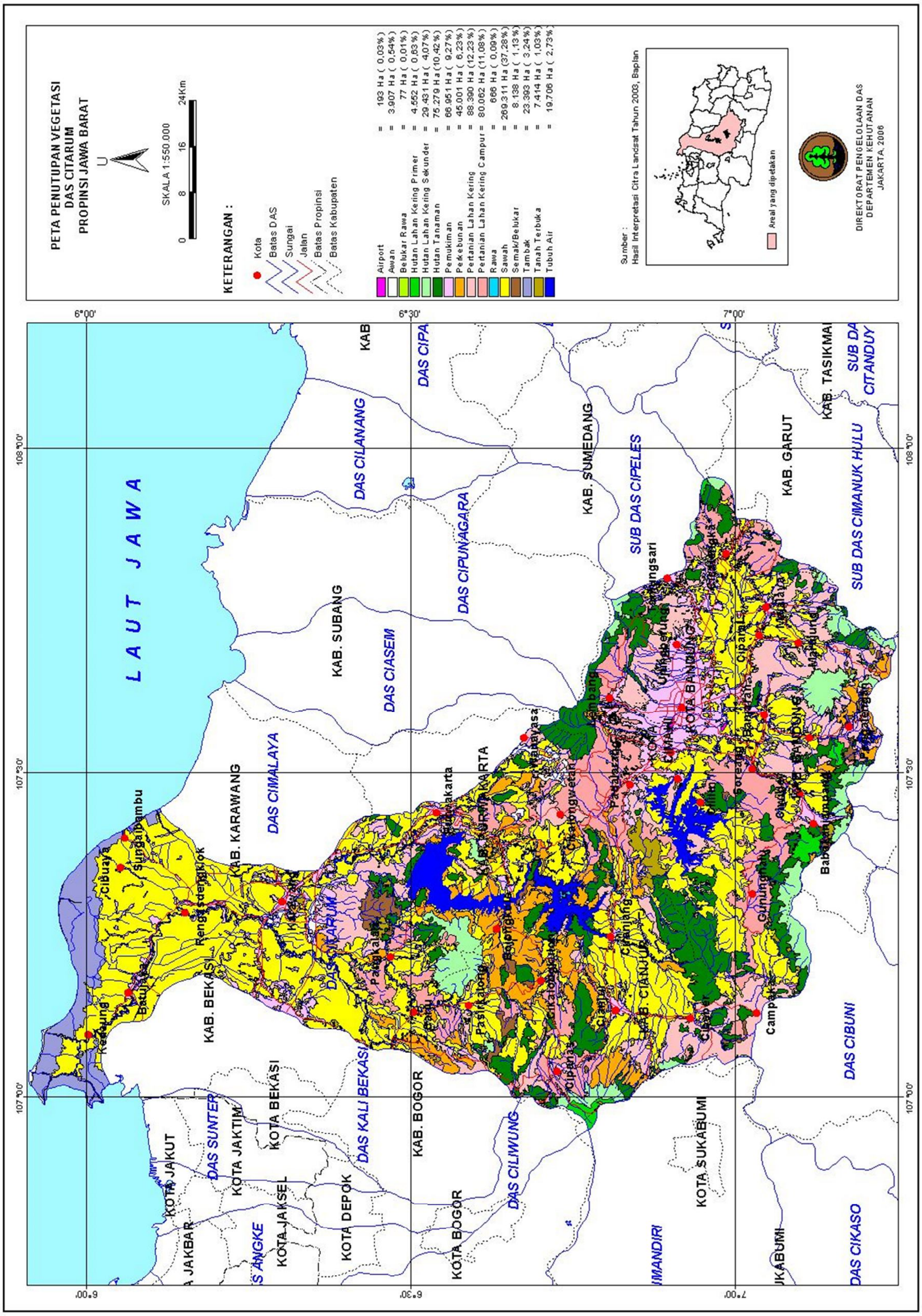
11. CD: How does a "Lubang Buta" works?

NS: "Lubang Buta" is a dig hole that is filled with runoff from the drainage channels. The farmers put some small fish in the dig hole and let them grow. Rice doesn't need waterlogging all the time. Due to the dig hole with fish the aerobic system's function can be obtained. This process leads to intensification of rice production. The fish which is sold on the market is called Ikan gurami. The fish species are valuable and therefore strong-selling.

12. CD: What do you think about organic fertilizer used in the sub watersheds of Ciwidey?

NS: Organic fertilizer is a decent market product that improves the growth of healthy fruits and vegetables. In Indonesia a biological label such as the one in Australia does not exist. Organic fertilizers are often mixed witch chemical substances. Farmers who do not use pure organic fertilizer are not been punished, yet. In Bangalengan for instance the application of pesticide is high but still under the critical threshold.

Appendix 2: Land Use System Map of Citarum Watershed by the Ministry of Forestry



Appendix 3: Land Use Type Subcategory Categorisation

Cropland: Land used for cultivation of crops (field crops, orchards)

Ca: Annual cropping: land under temporary / annual crops usually harvested within one, maximally within two years (eg maize, paddy rice, wheat, vegetables, fodder crops)
Cp: Perennial (non-woody) cropping: land under permanent (not woody) crops that may be harvested after 2 or more years, or only part of the plants are harvested (e.g.sugar cane, banana, sisal, pineapple)
Ct: Tree and shrub cropping: permanent woody plants with crops harvested more than once after planting and usually lasting for more than 5 years (eg orchards / fruit trees, coffee, tea, grapevines, oil palm, cacao, coconut, fodder trees)

Grazing land: Land used for animal production

Ge: Extensive grazing land: grazing on natural or semi-natural grasslands, grasslands with trees / shrubs (savannah vegetation) or open woodlands for livestock and wildlife
Gi: Intensive grazing/ fodder production: improved or planted pastures for grazing/production of fodder (for cutting and carrying: hay, leguminous species, silage etc) not including fodder crops such as maize, cereals. These are classified as annual crops (see above)

Forests / woodlands**:** land used mainly for wood production, other forest products, recreation, protection.

Fn: Natural: forests composed of indigenous trees, not planted by man
Fp: Plantations, afforestations: forest stands established by planting or/and seeding in the process of afforestation or reforestation
Fo: Other: eg selective cutting of natural forests and incorporating planted species

Mixed: mixture of land use types within the same land unit.

Mf: Agroforestry: cropland and trees
Mp: Agro-pastoralism: cropland and grazing land (including seasonal change between crops and livestock)
Ma: Agro-silvopastoralism: cropland, grazing land and trees (including seasonal change between crops and livestock)
Ms: Silvo-pastoralism: forest and grazing land
Mo: Other: other mixed land

Other:

Oi: Mines and extractive industries
Os: Settlements, infrastructure networks: roads, railways, pipelines, power lines
Ow: Waterways, drainage lines, ponds, dams
Oo: Other: wastelands, deserts, glaciers, swamps, recreation areas, etc

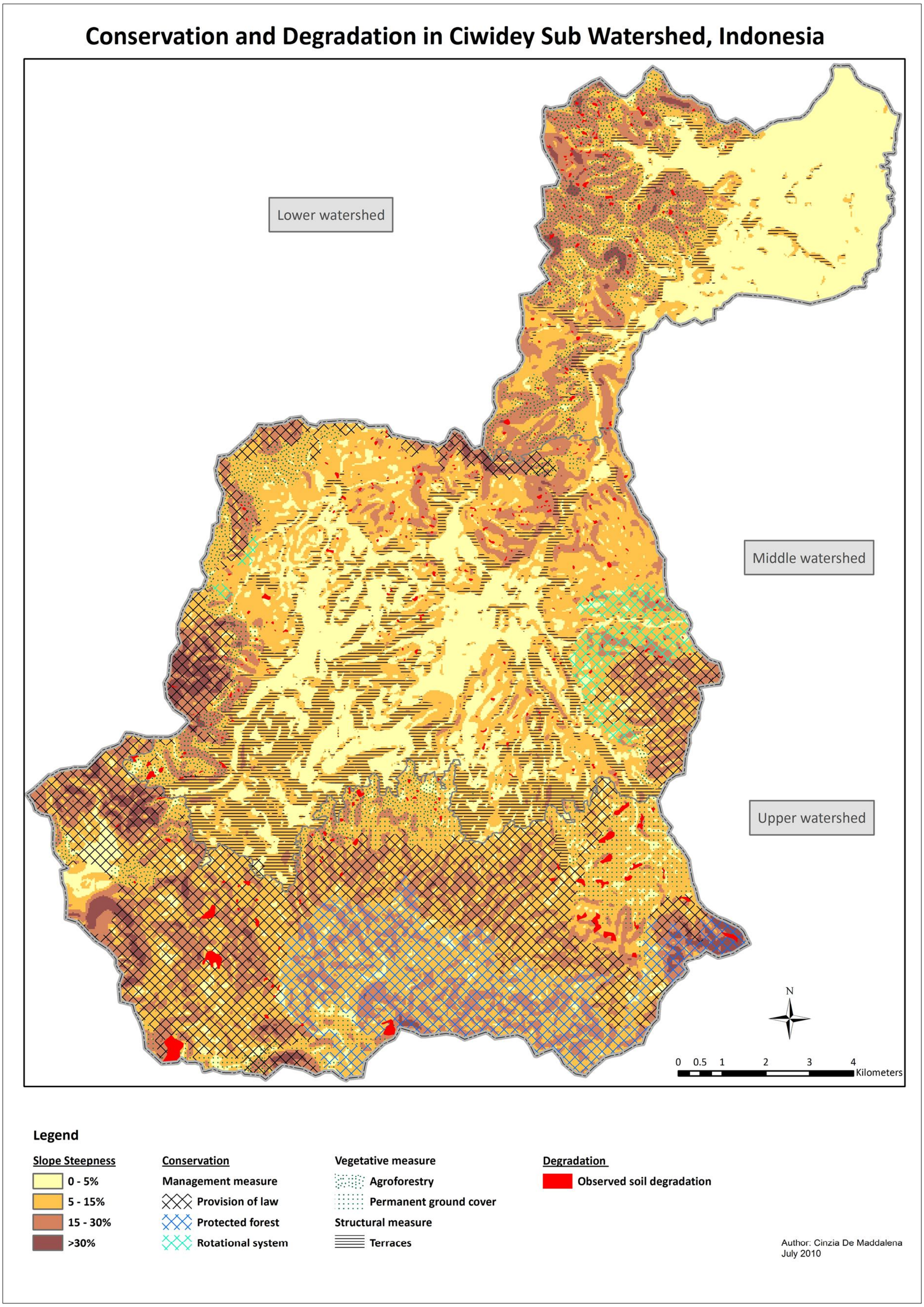
Source: WOCAT c

Appendix 4: Direct and Indirect Causes of Degradation per Land Use Type

Land use system	Watershed	Direct causes	Indirect causes
primary forest (BKSDA)	Upper	deforestation (large scale commercial forestry + conversion to agriculture, excessive gathering of timber)	politics, poverty
primary forest (Perhutani)	upper / middle	deforestation (conversion to agriculture), soil management (insufficient soil conservation)	population pressure, politics
forest plantation (BKSDA)	Upper	infrastructure development (recreation)	Infrastructure , education
forest plantation (Perhutani)	upper / middle	deforestation (conversion to agriculture), soil management (insufficient soil conservation)	population pressure, politics
secondary natural forest (middle w.)	middle	deforestation (conversion to agriculture), soil management (insufficient soil conservation)	population pressure, politics
secondary natural forest (lower w.)	lower	soil management (insufficient soil conservation + tillage practice), deforestation (conversion to agriculture), changes of seasonal rainfall	population pressure, politics, education
irrigated rice	middle	deforestation (expansion of settlement areas , hotels, restaurants), cropland management (inappropriate application of manure, fertilizer, herbicide, pesticides)	population pressure, infrastructure
irrigated rice	lower	deforestation (expansion of settlement areas , hotels, restaurants), cropland management (inappropriate application of manure, fertilizer, herbicide, pesticides)	infrastructure
rainfed rice	middle/lower	Soil management (cultivation of high unsuitable / vulnerable soils)	change in rainfall pattern
farming lowland	middle	cropland management (inappropriate application of manure, fertilizer, herbicide, pesticides Soil management (missing or insufficient soil conservation / runoff and erosion control measures), disturbance of water cycle (lower infiltration rate / increased surface runoff)	education
farming upland	middle/lower	soil management (missing or insufficient soil conservation / runoff and erosion control measures), disturbance of water cycle (lower infiltration rate / increased surface runoff), deforestation (conversion to agriculture)	education, poverty, population pressure
tea plantation	upper	no degradation	no degradation
tea plantation	upper (Gambung)	heavy and extreme rainfall, earthquake	climate change, earthquake region
agroforest	middle	deforestation (conversion to agriculture), soil management (missing of insufficient soil conservation and runoff measures)	population pressure, poverty
agroforest	lower	soil management (missing of insufficient soil conservation and runoff measures, tillage practice), deforestation (conversion to agriculture)	population pressure, aducation
bush with farming	middle/ lower	cropland management (inappropriate application of manure, fertilizer, herbicides, pesticides)	education
cut and carry with farming	middle	cropland management (reduction of plant cover and residues), heavy extreme rainfall, deforestation (conversion to agriculture), soil management (missing of insufficient soil conservation and runoff measures)	education
settements	middle	urbanization (settlements and roads ,Discharges (sanitary sewage disposal +waste water +poor infrastructure to deal with urban waste), Release of airborne pollutants leading to contamination of vegetation, crops and soil disturbance of water cycle (lower	consumption pattern and individual demand, population pressure , education

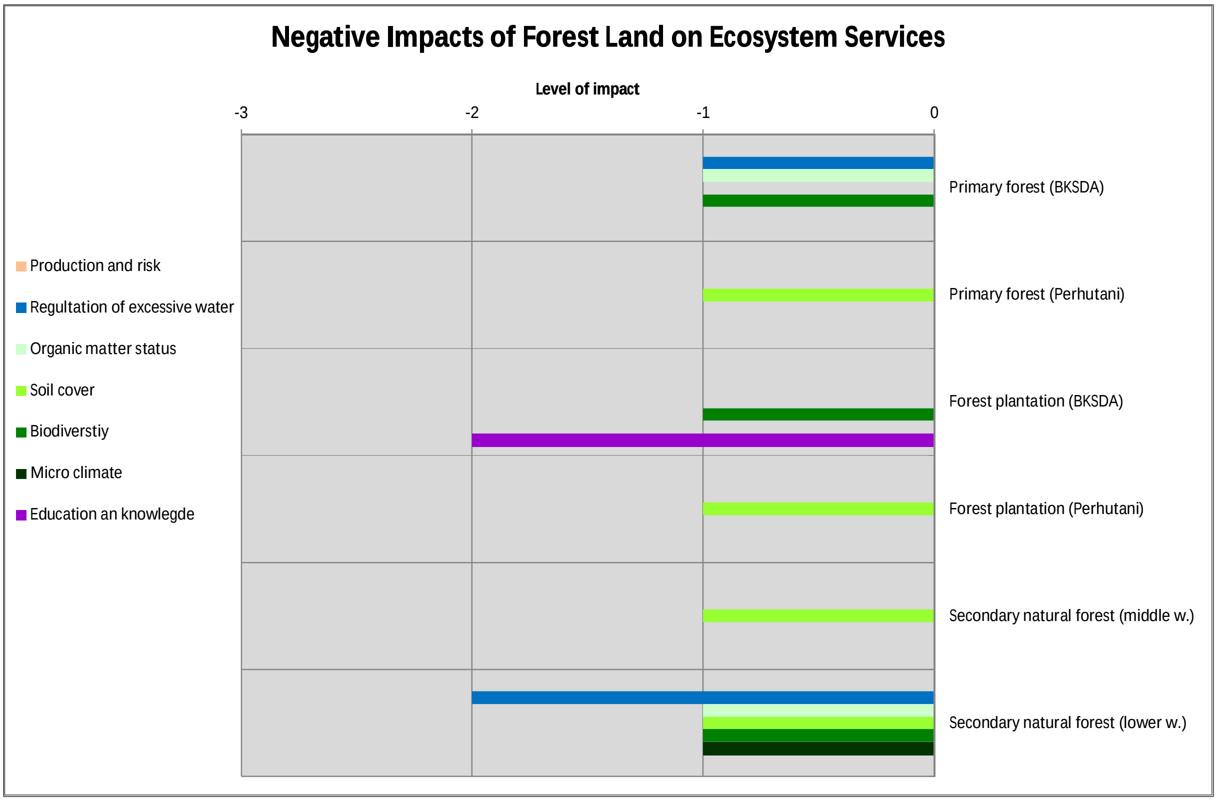
		infiltration rates / increased surface runoff) deforestation (expansion of urban areas)	
settements	lower	urbanization (settlements and roads +recreation, Discharges (sanitary sewage disposal +waste water +poor infrastructure to deal with urban waste, release of airborne pollutants leading to contamination of vegetation, crops and soil	consumption pattern and individual demand, population pressure , education
industry and mining	lower	industrial activities and mining, waste water discharge Release of airborne pollutants from industrial activities (contamination of surface and groundwater resources, disturbance of water cycle (lower infiltration rate / increased runoff)	consumption pattern and individual demand, population pressure
Waterbodies	upper	Deforestation (expansion of settlement areas and industry + forest fires)	consumption pattern and individual demand
Waterbodies	middle	Deforestation (expansion of settlement areas and industry + forest fires)	consumption pattern and individual demand
Waterbodies	lower	soil management(missing of insufficient soil conservation and runoff measures), industrial activities and mining, change of seasonal rainfall, topography,u1discharges (wast water, excessive runoff), Urbanisation (settlement + roads)	consumption pattern and individual demand , population pressure, land tenure, poverty,inputs and infrastrcture, education,

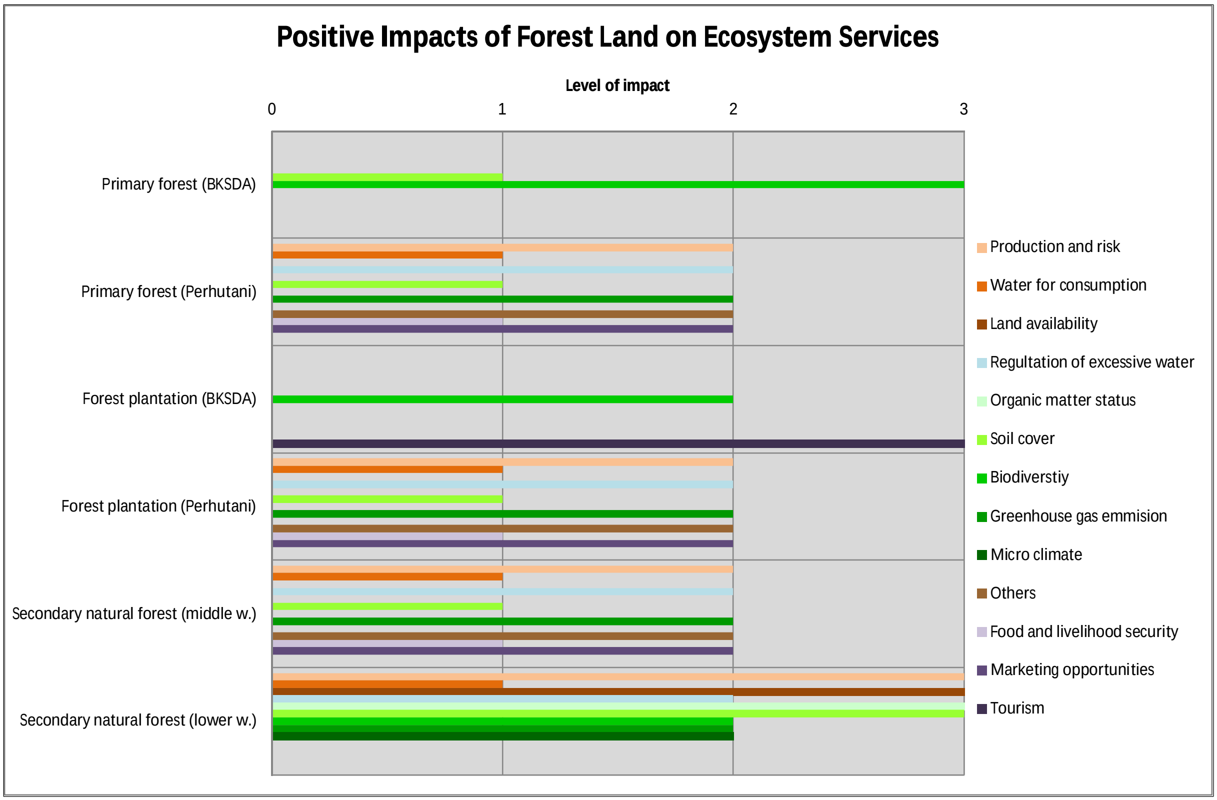
Appendix 5: Conservation, Degradation and Slope Steepness Map



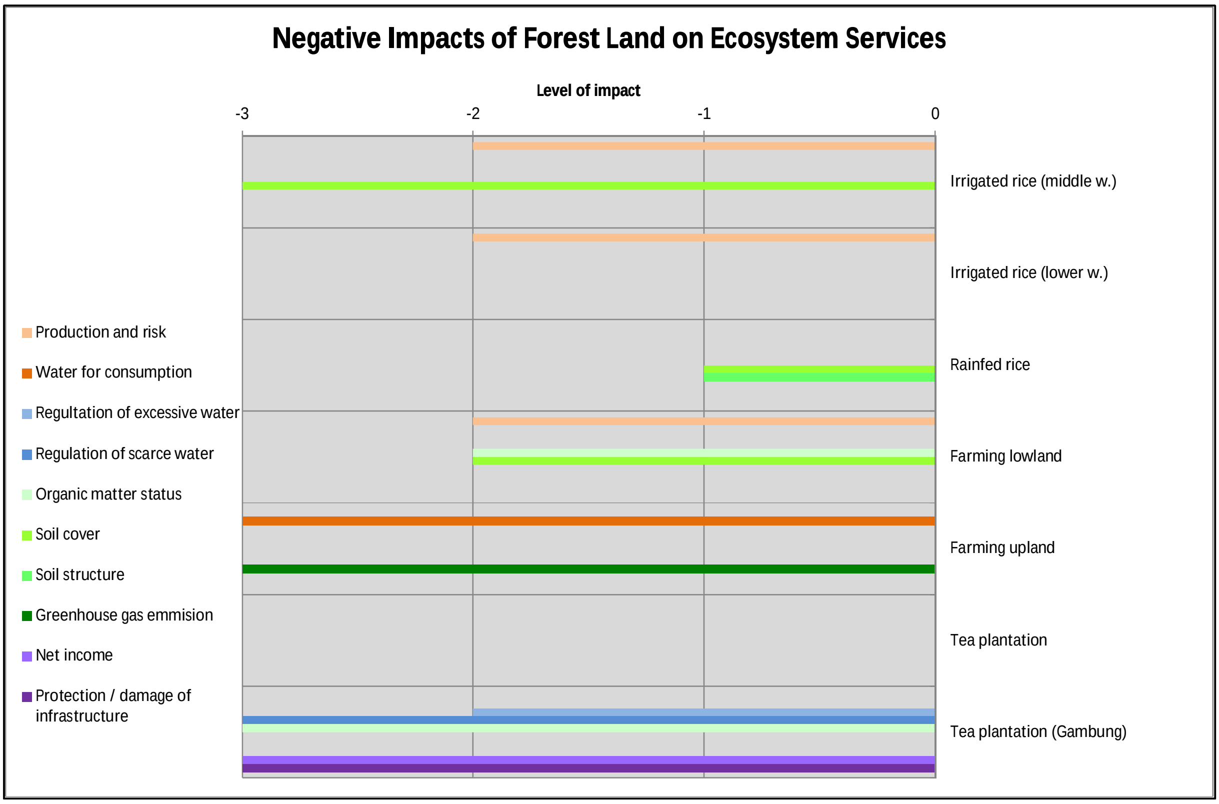
Appendix 6: All Impacts of Degradation and Conservation on Ecosystem Services

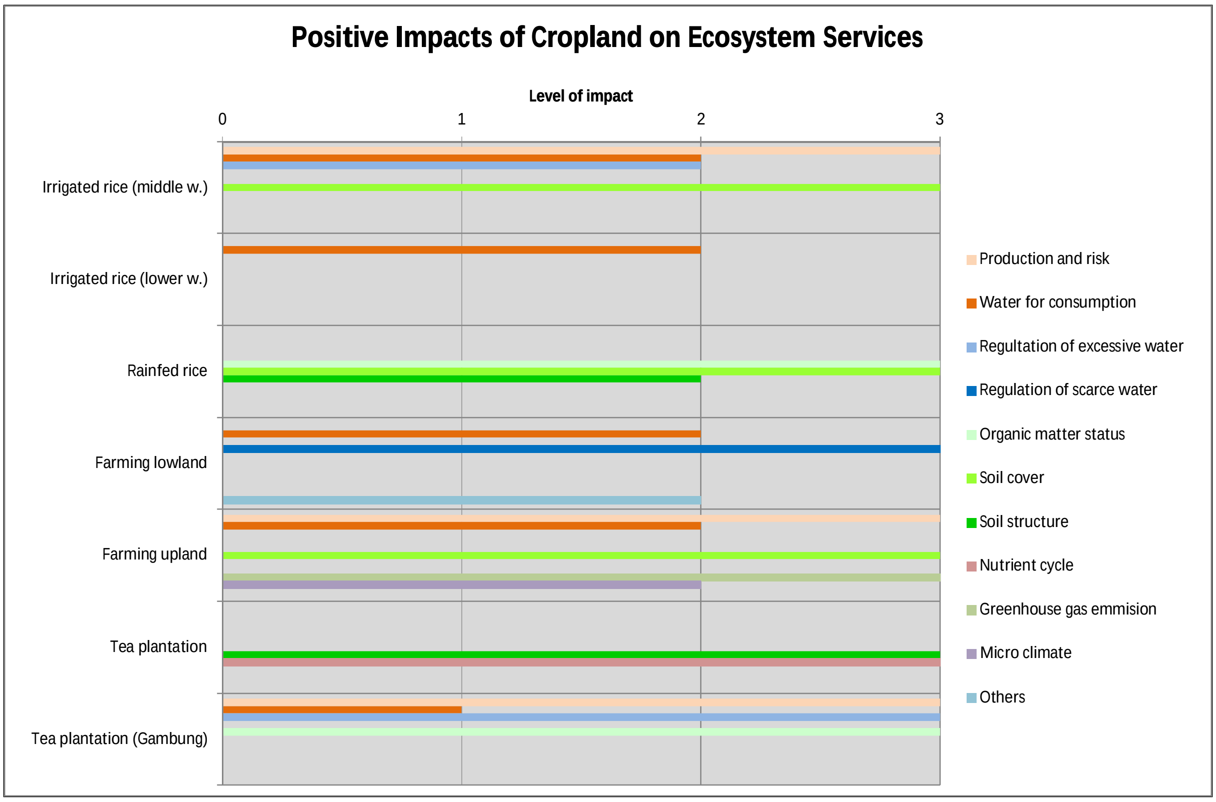
Forestland



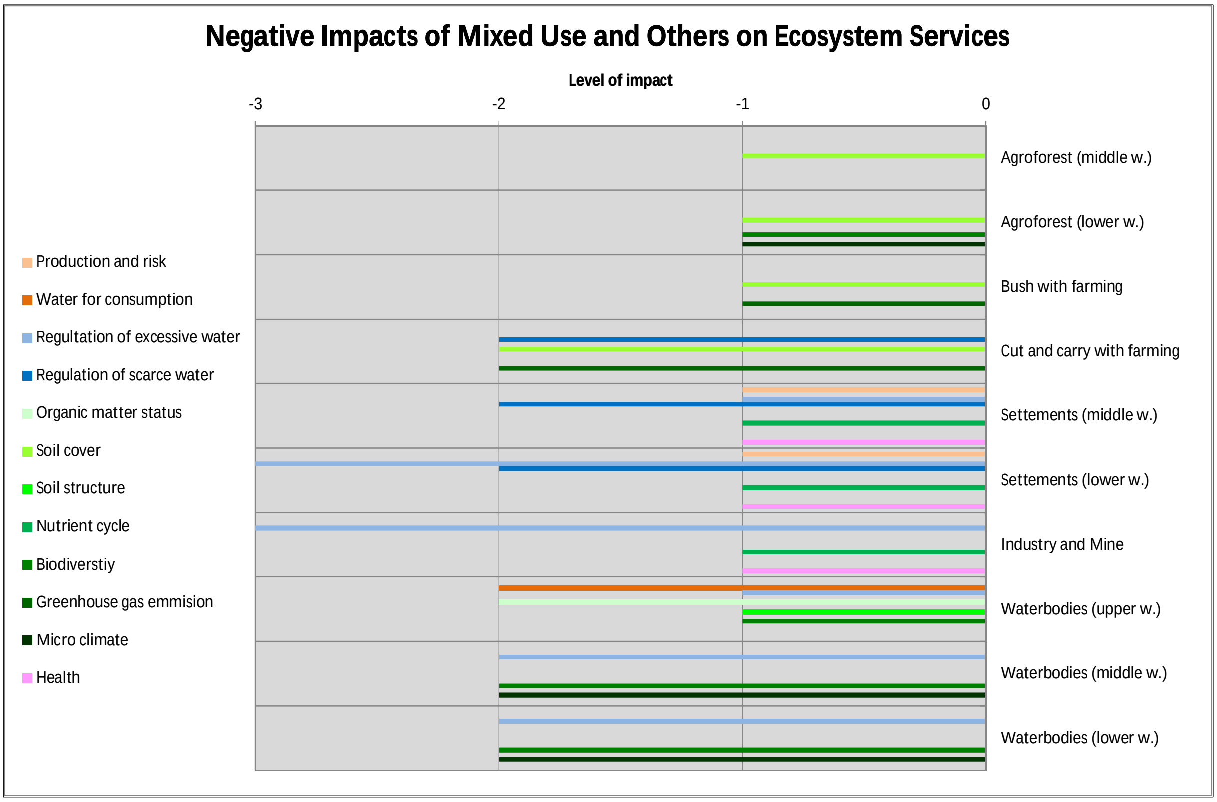


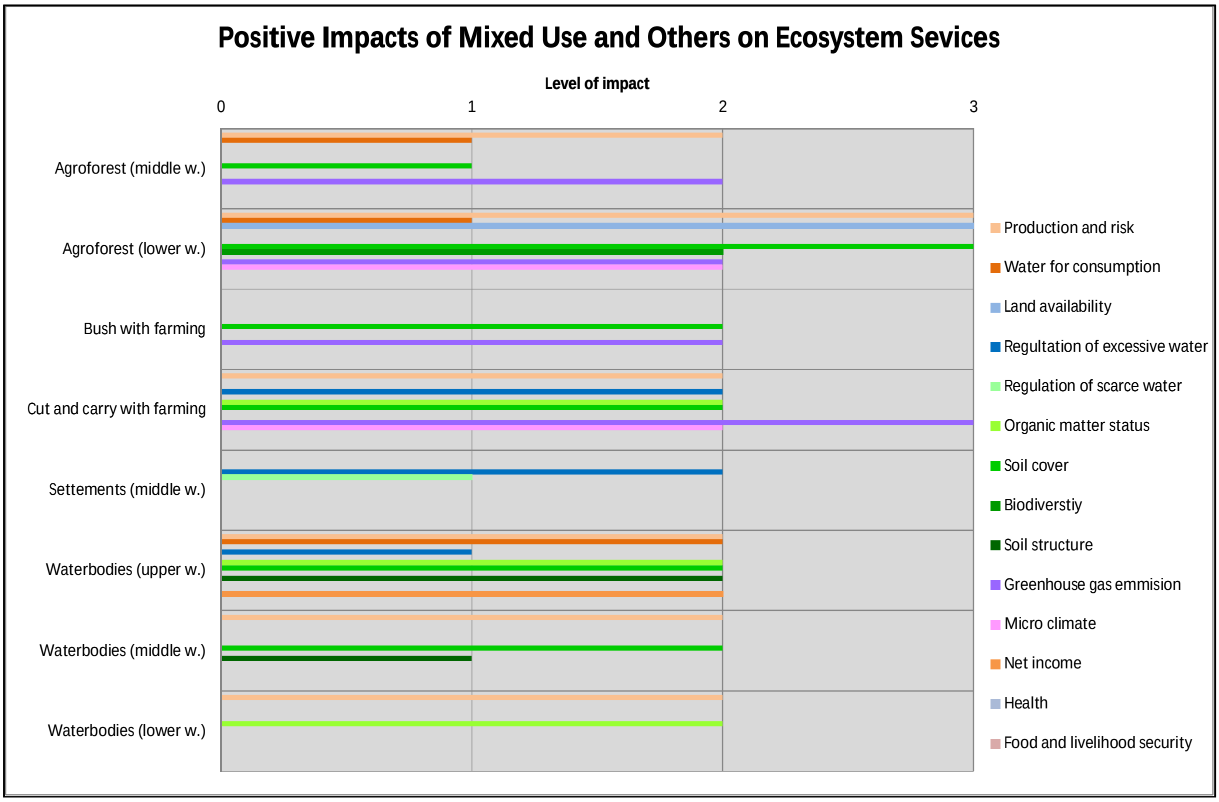
Cropland


Negative Impacts of Forest Land on Ecosystem Services
Level of impact
-3
-2
-1
0
Irrigated rice (middle w.)
Irrigated rice (lower w.)
Rainfed rice
Farming lowland
Farming upland
Tea plantation
Tea plantation (Gambung)
Production and risk
Water for consumption
Regultation of excessive water
Regulation of scarce water
Organic matter status
Soil cover
Soil structure
Greenhouse gas emmision
Net income
Protection / damage of infrastructure


Positive Impacts of Cropland on Ecosystem Services
Level of impact
0
1
2
3
Irrigated rice (middle w.)
Irrigated rice (lower w.)
Rainfed rice
Farming lowland
Farming upland
Tea plantation
Tea plantation (Gambung)
Production and risk
Water for consumption
Regultation of excessive water
Regulation of scarce water
Organic matter status
Soil cover
Soil structure
Nutrient cycle
Greenhouse gas emmision
Micro climate
Others

Mixed Use and Others





Appendix 7: WOCAT mapping questionnaire

An explanation of the used abbreviations can be found in Liniger et al. (2008).

Mr. Ruddy, Mr Wawan														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Primary forest BKSDA (1) in the upper watershed	Mr. Ruddy, Mr Wawan	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	BKSDA Jabar, Jl. Rayagedebage No. 117, Bandung, Indonesia	0	0	nothing, is stable	*i*	*ii*	*iii*							
	rrfadilah@gmail.com, Tel: 0227567715				bq	*bc*		*10*	*2*	*-1*	f1,e1,f3	g,h	e8(-1)	e) small scale illegal logging of commercial three and farming, wood for cocking, heating and house construction
					wm			*10*	*3*	*0*	f1,e1,f3	g,h	e1(-1),e3(-1)	e) small scale logging of commercial tree, wood for cocking, house construction, heating
					wt			*10*	*3*	*0*	f1,e1,f3	g,h	e1(-1),e3(-1)	e) farming activities from farmers that have no contract with PHBM

Sustainable land management (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Rehabilitation of habitat	VS	v2		R	1	bq	bc	wm/wt	1	0	e8(1)e4(1)	2007	a) planting grass for deers
Patrolling by BKSDA	OT	none		R	100	wm	wt		1	0	s9(2)	long time ago	g) just 6 rangers are responsible for 8000 ha. When the rangers are patrolling no farmers are working in their fields. They hide or stay at home
Strict conservation	CO	none		P	100	bq	bc	wm/wt	4	1	e8(3)	1927	a) the law doesn't allow any activities

Mr. Ruddy, Mr Wawan														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Forest plantation BKSDA (3) in the upper watershed	Mr. Ruddy, Mr Wawan	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	BKSDA Jabar, Jl. Rayagedebage No. 117, Bandung, Indonesia	0	2	b) land acces, parawisata, transport service, many hotel, restaurant, promotion. It results in mass tourism and vandalism	*i*	*ii*	*iii*							
	rrfadilah@gmail.com, Tel: 0227567715			b) cimnaggu hot springs, visitor number: 2008 (91000), 2009 (156150), 2010 until july (110840)	garbagge from tourist snacks			*50*	*2*	*3*	u2	r,e	e8(-1),s1(-2)	the tourists are no aware to conserve the natural beauty of the forests.
				b) Situ patengan, visitor number 2008 (118226), 2009 (73979), 2010 until july (75571)										

Sustainable lamd management (Step4)										
a) Name	b) Group	c) Measure	d) Purpose	e) % of area	f) Degradation addressed	g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Pam Swakarsa (participation security)	OT		R	50		3	1	e8(2),s1(3)	2008	a) little organisation that is gathering the rubbish
board/sign	OT		P	100		1	0	e8(1),s1(1)	2008	a) Moto: "leave your footprint not the rubbish!" g) people are just ignoring that sign

Mr. Avid Rollick Septiana														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
	Mr. Avid Rollick Septiana	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
primary forest (2), forest plantation (4), secondary natural forest (5), and agroforest (7) managed by Perhutani upper and middle watershed.	Perum Perhutani, Jl Cilengkrang, Bandung, Indonesia	0	0	b) due to government rules, use of organic fertilizer since a). Before 2003 this Ares was not protected and a huge number of farmers were cultivating vegetables. It was a kind of small scale production forest with just a few timber production and some illegal logging. After 2003, the perhutani launched a new law that restricted the use of vegetable farming. Since then the farmers are just allowed to plant coffee, annual trees and elephant grass for fodder production. The farmers are part of a program that's labeled "empowerment of rural communities"	*i*	*ii*	*iii*							
	rollickseptiana@gmail.com, Tel: 628112293253				wt.			*10*	*2*	*-2*	f3,s2	p,h	e4(-1)	
					cn			*10*	*2*	*-1*	f3,s2	p,h	p1(-1)	a) fertility decline due to much of farming with vegetables before 2003

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
teras gulud)	TR	v2		P	5	wt	wm		3	1	e4(1),e1(1)	long time ago	
change of crops	AF	m5	v1	M	40	wt	wm		2	1	p1(2),s4(1),s8(2),e1(1)	2003	a) eukalypthus and caffe is better for production. Pinus too much shadow
elefant gras	VS	v2		M	40	wt	hs	wm	3	1	s4(1)e1(2)e11(2)	2000	i) e11= fodder for goat and cow
planting tree	AP	v1		R	50	hs	wt	wm	4	1	e9(2),p2(1),e1(2)	long time ago	a) pinus and eukalyptus

Mr Memet Ahmad Surahman														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Secondary natural forest (6) and Agroforet lower watershed (8)	STAR, PKSAM, 6P4LH: Pasir Jamb des Cibodas, Bandung , Indonesia	-1	-1	land belongs to people in city, 52ha of bare land in Cibodas (Pasir Jambu)	*i*	*ii*	*iii*	b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	eyang-kautsar@yahoo.com, 08122255329				wg			10	2	*1*	s2,s4,f3	p,e	p1(-1),e1(-2)	
					wt	*wm*		30	3	*1*	f3,s2	p,e	e1-2	
					pu			1	1	*0*	i2,f3	p,e	e8-1,e3-2	illegal mining/logging, conversion agricuöture
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Teras Kredit	TR	s2	v1	M	25		wt	wg	hs	3	0	p1(-3), e1(-2)	long time ago	
Regreening	AP	a1	v1	R	15		bc	bq	wt	2	1	e1-2,e8-2, p1-2	1990	

Ms Nilda, Mr Has Agus, Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Agroforest lower watershed (8)	Ms Nilda, Mr Has Agus	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	BPDAS Citarum-Ciliwung, Jl. Rasamala Kav. 39-40 Tamanyasmin, Bogor, Indonesia	-2	0	logging, burning of the field and then conversion to full agricultureal activities for instance orange trees, cassava, banana, grass for animals. Farmer is no interested in forest. b)The farmers has been useing organic and chemical fertilizer since many years	*i*	*ii*	*iii*							
	Nilda: ine1391@yahoo.com Agus Has: hasagoes@gmail.com				wt	wm		*10*	*1*	*2*	s2,n2,n3	h,e	p1(-1)	e) the farmers are ploughing hillside in extrem slopes and don't use terasse f) the farmers think that the use of SWC technologies is not nessesaire e) rainfall increased, dry season is shorter but more humid f) climate change
					cn			*5*	*1*	*2*	f3,s2	e	p1(-1),e3(-1)	f) the farmers think that the use of swc technologies is not nessesaire.
Agroforest lower watershed (8)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricukture, Horticulture and Forestry, Soreang, Bandung, indonesia	-1	-1	because of limited land and switch of land use function to settlement, agriculture, etc.	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				Wt	*Wm*		*23%*	*2*	*1*	c2,e2,i1,	p,h,e	e4(-1),e8(-1),e10(-1)	

Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks	
Check dam	WH	s4		M	1	wt	wm	hs	1	0	p1(1)e1(3)	1981	a) the idea is that the water doesn't flow directly to the field. But it is very rarely seen! e) just in very step slopes i) less topsoil erosion so more productivity	
Oranic fertlizer	NM	a2		P	100	cn			4	0	p1(3)e3(3)	1981	a) cow, goat, chicken, maybe earlier.	
Agroforestry	AF	v1	v2	R	50	wt	hs	bf	4	1	e4(3)e1(2)	2000	a) progra to make terraces and planting trees, but just in demo plots	
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ESS	j) Period	l) Remarks	
Vegetation Strips	VS	V1		R	45	Wm	Wt	Hp	4	1	p3(2)	2003		
Agroforestry	AF	A1	v1	R	50	Wt	Wm	Bf	4	1	p3,e10(2)	2000		

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Irrigated rice middle watershed (10)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-1	2	a) settlement, infrastructure, population pressure, hotel b) organic fertilizer	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				Cn			40	2	2	c2	p	p1(-2)	
					Wt			40	1	3	f2,f6	p,r	e4(-3)	3) f6:infrastructure such as hotels, restaurants

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effect-ivenes s	h) Effect. Trend	i) Impact on on ecosystem services	j) Period	l) Remarks
Teras banku	TR	s1, s4	v2	P	90	Wt			4	1	p1(3)p2(2),e 4(3)	long time ago	
Gully plug	RH	s8		P	15	Wr			3	1	e1(2)	1990	
Legowo	OT	m2	m4	P	10	Hs	Pw	hp	3	1	p2(2)	2000	

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Irrigated rice lower watershed (11)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-2	1	infrastructure, settlements, urbanisation	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				Hs			25	2	2	f6,f2	r	p1(-2)	e) infrastructure such as hotels, restaurants
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Legowo	OT	m2	m4	P	25		Hp	Hs	Pw	3	1	p2(2)	2000	

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	Land Use System (Step 2)			Land degradation (Step 3)									
Rainfed rice middle watershed (12)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-1	-1	the use of rainfed lowland (sawah tadah hujan) is decreasing because of rainfed lowland more reliable to the rainfall, so most of farmer switch it to 'sawah irigasi' (irrigation ricefield)	i	ii	iii							
	ande_supriatna@yahoo.com Tel: 0225091703				wg			<10%	2	-1	s1	o	e5	rainfed lowland areas tend to F22 in drought season there are many crack, so it has potential for erotion occurs in those area. Besides, the degradation also depend on the structure/ characteristic of the soil.
						wm		<10%	2	-1	s1	o	e5,e4	

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effectiv-veness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Gully control with bamboo sticks (Kerucuk bamboo)	RH	a1, a3	s6	P	10%	wg			3	1	e5(2)	1995-present	
Teras bangku	TR	m2		P	40-50%	Wt			3	1	e3,e4(3)	long time ago-present	

Mr Ande Supriatna

Mapping Unit	Contributing Specialist (Step 1)	Land Use System (Step 2)			Land degradation (Step 3)									
farming lowland middle watershed (13)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	1	1		*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				Cn			*50*	*2*	*-1*	c2, s2	e	p1(-2)	d)compost, organic fertilizer, shit of goat,cow e) wrong farming system because no swc technologies f) quality of human ressources is bad. The farmers went just to high school.
					Wt			*5*	*2*	*1*	s2, w1	e	e3(-2), e4(-2)	e) deforestation on uppland leads to floods in plain

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Organic fertilizer	NM	a1, a2	m2	M	85	Cn			4	1	p1(3), e11(2)	2005	change of chemical to organic fertilizer i) better and healthier food quality
New seedling	OT	m5		M	50	increase prductivity of coffee			3	1	p1(2)	2005	quality of seedling (coffe was from Aceh before. Now from Seelind. It is expensive, difficult to get and still in research
Teras gulud/benteng lahan	TR	s4	s3	P	45	Hs			3	1	p2(2)	long time ago	
Dig hole	WH	s6		M	5house,1	Hs	Hg		4	1	e2(3)	long time ago	

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
Farming upland middle and lower watershed (14)		2	1	fertile soils and moderate slope stepness	*i*	*ii*	*iii*							
					Wt			*40*	*2*	*2*	s2,f3	e,h	e9(-3)	e)lack of knowledge to manage lus system g)bare land no longer to absorb carbon
					Ha			*7*	*1*	*3*	f3,w1	p,e	p2(-3)	e)no forest for infiltration of water

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Teras banku	TR	s1	v2	P/M	10	Wt			4	1	p1(3),p2(2),e4(3)	long time ago	
Agroforestry	AF	v1, v2	a1	M	40	Wt	Wm		3	1	p1(2),e10(2),e9(3),e4(2)	2000	a) albasia, chilli, beans,corn (favorite food but not good)
Social forestry	AF	v1, v2	a1	M	30	Wt	Wm		3	1	p1(2),e10(2),e9(3),e4(2)	1995	a) horticulture, coffe and terong kori

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Tea plantation middle watershed	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	0	1	increase of demand for tea	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				o									
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effect-iveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
LUS Tea	OT	m7		P	100					4	1			tea planting is multifunctional and adresses many land degrdation types
Nitrobaselus	NM	m2		P	20		higher productivity			4	1	e6(3),e5(3)	still in research	application is very complicated

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Tea plantation middle watershed (15)	Mr Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	0	1	increase of demand for tea	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				o									
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
LUS Tea	OT	m7		P	100					4	1			tea planting is multifunctional and adresses many land degrdation types
Nitrobaselus	NM	m2		P	20		higher productivity			4	1	e6(3),e5(3)	still in research	application is very complicated

Mr Memet Ahmad Surahman														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Tea plantation Gambung (16)	Mr Memet Ahmad Surahman	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	STAR, PKSAM, 6P4LH: Pasir Jamb des Cibodas, Bandung , Indonesia	0	1	problem with teaplantation: problem with energy they change from oil to wood because is cheaper and quality is better. First manual than machine. Now manual again. Different companys have different technologies	i	ii	iii							
	eyang-kautsar@yahoo.com, 08122255329				Hs			10	1	1	n3	o	s6(-3)	a)quality of tea is decreasing because of to much rain and warm temperature. f)climate change from western people
					Wm			1	4	0	n3,n8	o	e4(-3),e3(-3),e1(-2),s7(-3)	a)hillslide with 15 victimes,e)n8=earthquake f)location is in a earthquake-region

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact onecosystem services	j) Period	l) Remarks
Dig hole	WH	s6		M	70	soil moisture	ca		4	1	p2(1)e3(2)	long time ago	to make organic fertilizer and soil /watercycle.more humidity for the soil
Teras banku	TR	s1	v2	P	30	wt	hg		3	1	e1(3)p1(3)	long time ago	

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Bush with farming in the middle and lower watershed (17)	Mr. Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-1	0	the land use is slowly decreasing because of the switch function of land and also the farmer tend to sell their livestock than keep them to breed.	i	ii	iii							
	ande_supriatna@yahoo.com Tel: 0225091703				Wm	Hs		<10%	2	1	c2, g3	e	E4,E9(-1)	
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Perennial gras strips	VS	V1	M1	R	<20%		Wm	Hs		3	0	E4,E9(2)	1995-present	a)elephant gras and others
Afforestation	AF	V1	M1	R	30%		Wm			3	1	e9,e4(2)	2003-present	a) In this part, they use perennials plants such as Mahogany, Eucalyptus, but not use pines.

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
	Mr. Ande Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
Cut and Carry with farming in the middle watershed (18)	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	2	0	use oof a rotational system, cultivation is based onseason. In the rainy season farmers plant potato,chilli, and hisrticulture olants. In the dry season they plant gras.This land before was used for fodder production for livestock and forest plants. The farmers changed the system because lack of funds. Several grasses grow naturaly others are planted.	*i*	*ii*	*iii*							
	ande_supriatna@yahoo.com Tel: 0225091703				Wm			*40*	*2*	*2*	c1,n3	e	E4(-2)	a)one month ago there was a huge landslide that leaded to enormous disaster f)The farmers are not aware of the impacts of land clearing
					Wt			*60*	*2*	*1*	s2	e	E4(-3)	f)The farmers are not aware of the impacts of land clearing
					Hs			*60*	*2*	*1*	f3	e	E9(-2) E2(-2)	a) Huge evapotranspiration rate and less infiltration, They should plant threes and mix them with gras- and cropland

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effectiveness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
SPA (drainna-ge channel)	WH	s4		M	20	Wt	Wg	Hs	4	1	E1(2)E3(2),E4(2)	2005	
Agroforestry	AF	v1	v2	M	0	Wt	Wm		none	none	P1(2),E10(humiditiy2), E9(3) E4(2)	The farmers didn't accept the technologie 2 years ago	They calculated that the profit will be less high than before

Mr Memet Ahmad Surahman														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Settlements middle watershed (19)	Mr Memet Ahmad Surahman	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	STAR, PKSAM, 6P4LH: Pasir Jamb des Cibodas, Bandung , Indonesia	2	2	conversion to hotel, restaurant, specialy for tourism	*i*	*ii*	*iii*							
	eyang-kautsar@yahoo.com, 08122255329				cp			*1*	*1*	*1*	u1,q1	p,e	p1(-1)e6(-1), s5(-1)	air pollution due to motorbike, car, truck emission, and burining of waste, people are not aware what they are doing to the nature
					hs			*1*	*1*	*1*	f2,u1	p	e2(-2)e1(-1)	
					hp			*1*	*1*	*0*	u1,p1,p2,p4,w	c,p,e	s5(-1)	waterquality is better than in soreang

Conservation (Step 4)													
a) Name	b) Group	c) Measure		d) Purpose	e) % of area	f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
pintu air	WH			M	20	hg	hs		3	1	e1(2),e2(1)	1990	regulating the runoff
use of a source in the region	WQ			M	10	hq	hp		1		s5(1)	long time ago	therefore waterquality is not that bad like in Soreang

Mr Memet Ahmad Surahman														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Settlements lower watershed (20)	Mr Memet Ahmad Surahman	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	STAR, PKSAM, 6P4LH: Pasir Jamb des Cibodas, Bandung , Indonesia	2	1	conversion from agriculture to settlement,industrie and livestock	*i*	*ii*	*iii*							
	eyang-kautsar@yahoo.com, 08122255329				hp			*5*	*1*	*1*	u1,p2,p4,p1,	c,p,e	s5(-1)e6(-1)e1(-3)	
					cp			*1*	*1*	*1*	u1,q1	p,e	p1(-1)e6(-1), s5(-1)	air pollution due to motorbike, car, truck emission, and burining of waste, people are not aware what they are doing to the nature
					hs			*10*	*1*	*1*	u2,u1,	p	e2(-1)e1(-3)	g)before more water,specialy rice fields are affected and have less water in dry season

Conservation (Step 4)										
a) Name	b) Group	c) Measure	d) Purpose	e) % of area	f) Degradation addressed	g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
	WM	water treatme nt		just for the factory		-1				rules of governement are good. But the implimentation bad. Selltement to much profit oriented.lot investor from foreign countries

Mr Memet Ahmad Surahman														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Textile industries lower watershed (21)	Mr Memet Ahmad Surahman	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	STAR, PKSAM, 6P4LH: Pasir Jamb des Cibodas, Bandung , Indonesia	2	2	conversion from agriculture to industrie. The factories change from electricity produced with oil to coal	*i*	*ii*	*iii*							
	eyang-kautsar@yahoo.com, 08122255329				hp			5	2	2	i1,p2,q2	c,p	s5(-1)e6(-1)	
					hs			5	3	2	w1	c,p	e6(-1)e1(-3)	
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Waste water treatment	WM			M	5					-1				Factories are too much profit oriented. Lot of investors from foreign countries. They don't care about the poluttion.

Ms Desi Aprilliana Dewi														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Mine in Pasir Jambu (22)	Ms Desi Aprilliana Dewi at the mining departement	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
					i	*ii*	*iii*							
		0	0	Mining pit is used since 28 December 2009. Andesit mining										
	dsmileyy@gmail.com													

Conservation (Step 4)										
a) Name	b) Group	c) Measure	d) Purpose	e) % of area	f) Degradation addressed	g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
BINWASDAL	OT		P	100%					every three months	a) Development, observation, and management
Restraint below 1000 m.a.s.			R							mining below 1000m needs the permisson of the subdistrict chief, and they are not alllowed to use mechanical equipement

Mr Ande Supriatna														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Waterbodies upper watershed (23)	MrAnde Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	0	1	because of the switch function of land and the dense of population.	i	ii	iii							
	ande_supriatna@yahoo.com Tel: 0225091703				Bc			<20%	2	1	f4,f2	c	E1,E8,E10(-2)	f2: because of forest encroachment.
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Agrofoerstry with coffee	AF	a1	v1	R	20%		bc			4	1	P1,e4(2)	2000-present	
Planting trees on the riverbank	AP	v1		R	20%		bc			3	1	P1,e4(2)	2000-present	a)palm trees, sundanese: pohon kawun

Ms Nilda, Mr Has Agus, Ms Nilda, Mr Has Agus														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Waterbodies middle watershed (24)	Ms Nilda, Mr Has Agus	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	BPDAS Citarum-Ciliwung, Jl. Rasamala Kav. 39-40 Tamanyasmin, Bogor, Indonesia	0	2	strong increase of people that use water für irrigation and household, in middle watershed are more irrigation channels than in the lower	i	ii	iii							
	Nilda: ine1391@yahoo.com Agus Has: hasagoes@gmail.com				hp			5	3	2	u1,p2,p3	p,e,o	none	e)waste water and rubbish from houeholds and sedimentation,f)soil erosion leads to sedimentatiom
Waterbodies middle watershed (24)	MrAnde Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-1	1	land use area decreasing because there are switch of function become settlements, tourism places, and the dense of population makes the intensity of land use moderate increase.	i	ii	iii							
	ande_supriatna@yahoo.com Tel: 0225091703				Bc			<20%	2	1	f4,f2	c	E1,E8,E10(-2)	f2: because of forest encroachment.
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Programm Agroforestry and teras	AF	v1	v2	M	100		wt	hp	hs	3	1	P1(2)s6(2)e3/e4(2)	long time ago	a) planting trees, they cut again. short time (vegetables, middle time fruit).On long time he can use wood. it's free for farmer. The governement buy the seedlings but just demoplot area (10-25ha). For other areas they have to pay
Consulting from extensionworker to people	OT			M	10		wt			3	0	P1(2)s2(3)e3/ea(2)	long time ago	b) consulting h) farmers are always waiting a long time for extension worker. They are not many available
Gully plug	RH	s8		M	5		wt	wg		1	-1	e1(1)	long time ago	h)not working any more. It's full, lacj of maintenance
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Gully Control	Rh	S4		M	30%		Hs	Hp		3	1	e5(1)	2000-present	
Eukalyptus with ist leaves for fodder	Ca	M2		P	30%		Bl			2	1	p1,e5(2)	2001-present	

Mr Ande Supriatna, Ms Nilda, Mr Has Agus														
Mapping Unit	**Contributing Specialist** (Step 1)	**Land Use System** (Step 2)			**Land degradation** (Step 3)									
Waterbodies lower watershed (25)	MrAnde Supriatna	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	Depatement of Agricuklture, Horticulture and Forestry, Soreang, Bandung, indonesia	-2	2	because there are switch function of land become industry area, settlements, and population pressure that increase.	i	ii	iii							
	ande_supriatna@yahoo.com Tel: 0225091703				Wm			30-40%	3	1	s2,i1	c,p,t,h,r,e	E1,E5,E8,(-1)	because of the needs for industry, settlements, and irrigation system.
						Wg		30-40%	3	1	n2,n7,	e	E5(-1)	
							Wr	30%	2	2	i1,u1,n2,n7	r,p,o	P2,E3, (-2)	because of the nature characteristic: the soil structure is easy to cause runoff.
Waterbodies lower watershed (25)	Ms Nilda, Mr Has Agus	a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)	a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
	BPDAS Citarum-Ciliwung, Jl. Rasamala Kav. 39-40 Tamanyasmin, Bogor, Indonesia	0	1	moderate increase of people that use water for irrigationand household	i	ii	iii							
	Nilda: ine1391@yahoo.com Agus Has: hasagoes@gmail.com				hp			10	4	3	u1,p2,p3	p,e,o	none	e)waste water and rubbish from houeholds and sedimentation,f)soil erosion leads to sedimentatiom
Conservation (Step 4)														
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Water storage	WH	M2		P	40%		Wm			2	0	p2	2000-present	
Drip irrigation	SA	M2		M	50%		Wr			2	0	e1	2005-present	
Instalation of waste water management (IPAL)	WM	M2		P	50%		Wr	Wg		2	0	e5,	2000-present	
a) Name	b) Group	c) Measure		d) Purpose	e) % of area		f) Degradation addressed			g) Effective-ness	h) Effect. Trend	i) Impact on ecosystem services	j) Period	l) Remarks
Programm Agroforestry and teras	AF	v1	v2	M	100		wt	hp	hs	3	1	P1(2)s6(2)e3 /e4(2)	long time ago	a) planting trees, they cut again.Short time(vegetables, middle time fruit).on long time he can use wood. It's free for farmer. The governement buy the seedlings but just for demo plot area (10-25ha). For other area they have to pay.
Consulting from extensionworker to people	OT			M	10		wt			3	0	P1(2)s2(3)e3 /ea(2)	long time ago	b) consulting h) farmers are always waiting a long time for extensionworker. They are not many available
Gully control	RH	s8		M	5		wt	wg		1	-1	e1(1)	long time ago	h) not working any more. It's full, lack of maintenance

Appendix 8: Appendix on an enclosed CD

1) LUS photos, categorization
2) WOCAT QM questionnaire and evaluation
3) Maps with attribute table
4) Data from Indonesian institutions
5) Presentations

Erklärung

Gemäss Art. 28 Abs. 2 RSL 05

Name/Vorname:	De Maddalena Cinzia
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Studiengang:	Master of Geography, Universität Bern

Bachelor ☐ Master ☑ Dissertation ☐

Titel der Arbeit:	Mapping of Land Use System, Soil Degradation, Sustainable Land Management, and Assessing Impacts on Ecosystem Services in Ciwidey Sub Watershed in West Java
Leiter/-in der Arbeit:	Prof. Hans Hurni

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Ich erkläre hiermit, dass ich diese Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen benutzt habe. Alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Mir ist bekannt, dass andernfalls der Senat gemäss Artikel 36 Absatz 1 Buchstabe o des Gesetzes vom 5. September 1996 über die Universität zum Entzug des auf Grund dieser Arbeit verliehenen Titels berechtigt ist.

Wabern, 28.11.2011

Ort/Datum

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Unterschrift