

# Predicting The Depletion Level of Cultivation Area on Dry-Land Agriculture Ecosystem Along The watershed Of Serayu River Central Java (A case study along the sub Logawa river bank)

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**Abstract.** Current study was aimed to explore the depletion levels in agricultural areas due to erosion as well as the appearance of critical soil along the sub watershed of Logawa river by applying a descriptive study using tabulations and SEM-LPS analysis. For these purposes, some physical variables including length and slant of the slope; chemicals: soil acidity; and biotic such as microorganisms; social-cultural: local people knowledge and habits. Research was done at the end of dry season or prior to rainy. sampling was done following to a stratified random sampling technique, but sampling of microorganisms was done differently i.e.: by taking from the soil at the depth of 15 cm according to altitude. Samples of the farmers, however, were determined by a purposive random sampling i.e.: as workers only and Not the owners. Total number of farmers selected were 10% of the total respondents in a group. Soil samples, were taken from different altitude and mentioned as stratum 1 (0-150m alt at 109° 13' 4" EL and 7° 29' 45" SL); stratum 2 (150-300 m alt, 109° 11' 20" EL, and 7° 23' 7" SL) while stratum 3 (300-450 m alt, 109° 10' 58", and 7° 20' 41" SL). Soil samples were analysed in the laboratory, but the soil depletion levels were calculated according to  $R \times K \times LS \times C \times P$ . Samples in term of farmers were analysed based on a Forum Group Discussion data, including knowledge, habits and behaviour applying a scheduled questionnaire and interview guide. In order to know the relationship between knowledge, habits and behaviour and the soil depletion levels data were score and analysed using s Partial least Square Structural Equation Modelling (PLS-SEM). the study showed that the erosion level in the upstream was categorised as severe i.e.: 158.79 tons/ha/year, middle 280.88 tons/ha/year was strongly severe; and downstream 107.38 tons/ha/year as severe. The main factor of this depletion was human activities as well as high rain falls.

**Keywords :** critical land, agriculture ecosystem, Logawa watershed

## 1 Introduction

The sub Logawa watershed is part of the Serayu river watershed ecosystem lies from upstream in Wonosobo, Banjarnegara, Purbalingga, Banyumas and down stream of Cilacap Central Java Province. In National level, this province has a strategic position as supporting food production areas.

The sub Logawa watershed has a total area of 35,515.2 hectare [1], with the riverbed width varies between 1 meter and 20 meter, and the length of 25 km. this watershed lies between Mengaji watershed and Banjarnegara in Serayu river with its outlet in Indian ocean. The sub Logawa watershed has an inlet on Baseh village of Kedung Banteng district, which also provide water to the areas of Kedungbanteng, Cilongok, Karanglewas districts and finishes in Notog village of Patikraja district. This watershed is characterised with different altitude from 0 m to 600 m altitude and slant of 0 to 40 % [2].

According to land utilities, the sub Logawa watershed is utilised for rainfed rice field, farmyard, garden, forest and horticulture field. Some vegetation are planted along this area, including rice, corns, bananas, lemon grasses, pineapples, coffee, coconuts, and alabasia woods. Increase of land uses along this area are potential to degrade the land.

Human activities including sand mining, cows farms, rocks excavation, land dredging, logging, and horticulture which is done in an environmental unfriendly way surround the sub Logawa watershed imply an ecological unbalance in that area. Unfortunately, the activities are done almost in all areas along the sub Logawa watershed starting from the up stream to the down stream areas, and causes an ecological unbalance in the area. Those activities may cause land degradation like soil and water pollution and water run off, leads to critical soil condition. [1] suggested the increasing land productivity along the sub Logawa watershed. Increase, however, needs a preliminary studies of factors causing the land depletion such as erosion. [3] and [4], stated that shifting on the land use of the peripheral area may cause significant increase of river's water flow and run off water.

Moreover, [5] in their study for 12 years in China stated that land-use shifting lead to increase erosion and soil characteristic. A similar study in Thailand done by [6] that erosion of the forest area was smaller than that of come from farm yard. Infrastructures development like shelter and other buildings are parts of human activities which cause land depletion [7].

According to [8] and [9], when the land yard are cleared from their vegetations and humic soil, they face some serious erosions. Indicating if the land-use in an unfriendly way will end to land degradation.

According to [10], as much as 12,269 hectare land area along this watershed are categorised as critical land and of those 1,390 ha have been being managed well. Increasing the land-use shift in an unfriendly ways, increases also land depletion in the area. Current study was aimed to know the main cause of land depletion as well as how much is the erosion.

## 2 Research Method

Current study was done on the critical land which spreaded along the sub Logawa watershed. Samples of the critical land divided into three different categories representing high land area in Kedungbanteng district with 300-450 m altitude, middle area of Karanglewas district with 150-300 m altitude and low land of Patikraja district with 0-150 m altitude. Determining these categories was based on the Governmental decree of Number: 150 year 2000 Chapter III Verse 6. Study was done at the end of dry season/prior to rainy season.

Land degradation due to erosion was determined by RUSLE [11] method. The RUSLE is a method which was developed from USLE method with similar formats with USLE [12], with some revisions on the determination of R, K, LS, C and P [13] factors and the formula is:  $R \times K \times LS \times C \times P$ .

Whereas, depletion levels were determined according to classification done by [4], as follows:

**Table 1.** Classification of land depletion due to erosion

| Class of land depletion | Erosion (t/ha/year) |
|-------------------------|---------------------|
| No-light erosion        | 0 – 20              |
| Mediocre                | 20 – 50             |
| Heavy                   | 50 – 200            |
| Severe                  | >200                |

In order to understand levels of land depletion, current study set up a Focus Group Discussion (FGD) by scoring and weighting. Research was done in a descriptive study to describe the facts and their relationships systematically [14]. Data were then analysed using a *Partial Least Square Structural Equation Modeling (PLS-SEM)* to reflect the relationship between knowledge, habits and behavioural and land depletion.

Research variables are:

- Physical variable, land physiology (levels of slope and altitude)
- Chemical variable, soil acidity pH
- Biological variables, soil microorganisms. berupa mikroorganisme tanah. Microbial spreading was determined as governmental decree of PP 150 year 2000.
- Social culture variables, farmers' habits on agronomical practices. Total number of samples were determined by [15], as follows :

$$N = \frac{N}{1 + N \cdot e^2}$$

Remarks:

n = Number of samples

N = Total population

e = Error tolerance (signifacant level of 0.05)

### 3. RESULTS

Observations and measurement results of land depletion/degradation due to erosion on the sub Logawa watershed varied from upstream to downstream areas. The following data were reflecting erosion levels in the upstream, middle and downstream; as well as human activities which potent cause ecosystem problems.

**Table 2.** Prediction of the erosion levels along the sub Logawa Watershed

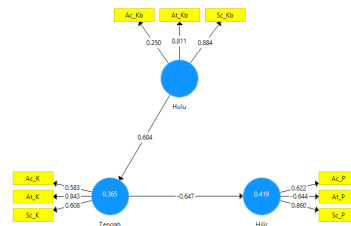
| Location   | Slope/% | Rain erosivity /R | Soil erodibility /K | Length of the slope /L | Angle of the slope /S | Cover Crops/C | Land management /P | Erosion ton/ha/year |
|------------|---------|-------------------|---------------------|------------------------|-----------------------|---------------|--------------------|---------------------|
| Upstream   | 25-40   | 263.48            | 0.23                | 25                     | 1.75                  | 0.2           | 0.3                | <b>158.79</b>       |
| Middle     | 8-25    | 263.48            | 0.26                | 21                     | 1.63                  | 0.4           | 0.3                | <b>280.88</b>       |
| Downstream | 0-8     | 263.48            | 0.21                | 18                     | 0.9                   | 0.4           | 0.3                | <b>107.37</b>       |

**Table 3.** Types and numbers of human activities potent to cause land degradation

| Location                 | Agriculture | Mining | Industry | Electricity, gas and water | Construction | Traditional market |
|--------------------------|-------------|--------|----------|----------------------------|--------------|--------------------|
| Upstream (Kedungbanteng) | 879         | 20     | 274      | 36                         | 241          | 1                  |
| Middle (Karanglewas)     | 661         | 66     | 459      | 56                         | 286          | 1                  |
| Downstream (Patikraja)   | 707         | 62     | 316      | 47                         | 303          | 1                  |
| Total                    | 2.247       | 148    | 1.049    | 139                        | 830          | 3                  |

## 4. DISCUSSIONS

### 4.1. Relationship between farmers' knowledge, habits and behaviour toward land degradation



**Figure 1.** Analysis diagram of effect of knowledge, habits and behaviour and land degradation

Data in form of social aspects which related with dry-land ecosystem degradation including knowledge, habits and behaviour in running some agronomic practices done by the farmers. Based on current data analysis, it is shown that those three social aspects were significantly caused the land degradation on the upstream, middle and downstream areas of the sub Logawa watershed.

The PLS-SEM analysis, showed that the knowledge (Sc\_Kb) and behaviour variable (At\_Kb) of the respondents/farmers had highly significance to land degradation on the upstream at the value of 0.811 and 0.884, whereas habits variable (Ac\_Kb) with the value of 0.250 did not significantly caused land degradation on the up stream. These data indicating if the level of knowledge of the respondents was not implemented on their farming activities maximally and so caused light degradation. This might due to 50% of the respondents in the upstream had a minimum of secondary high school (SMA) but do not have a comprehensive knowledge in a friendly agricultural activities.

In the middle area, the habits variable (At\_K) with score of 0.843 had significant effect on land degradation, whereas others like knowledge and behaviour variables (Sc\_K) and (Ac\_K) were not significantly affected the land degradation. Indicating if the respondents behaviour did not implemented in the correct agricultural practices leads to mediocre level of land degradation. This was mainly due to 57% of the respondents were only having elementary education level, to cause very low perception in taking a friendly agricultural practices.

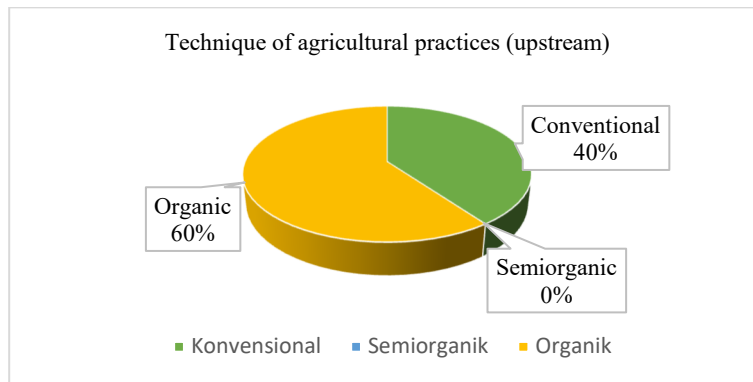
In the downstream, however, knowledge had significant effect to the land degradation as shown by its score of 0.860, but habits and behaviour performed differently. Indicating if the respondent's knowledge were not implemented in the correct agricultural practices and caused land degradation at mediocre level. This situation was mainly due to only 64% of the respondents had secondary school level and so they were not able to apply friendly agricultural activities comprehensively.

Based on the track coefficient from upstream to middle area was scored as 0.604 means that the behaviour and knowledge variables of the respondents on the upstream area were significantly affected land degradation on the middle area. Apart from those variables, the land-slope of 40% - 25% on the upstream was also causing land degradation. Meanwhile, the track coefficient of the middle to downstream with score of -0.647 was not significantly affect land degradation. Apart from that, the slope-slant of 25% - 0% on the middle area to downstream were not affect land degradation.

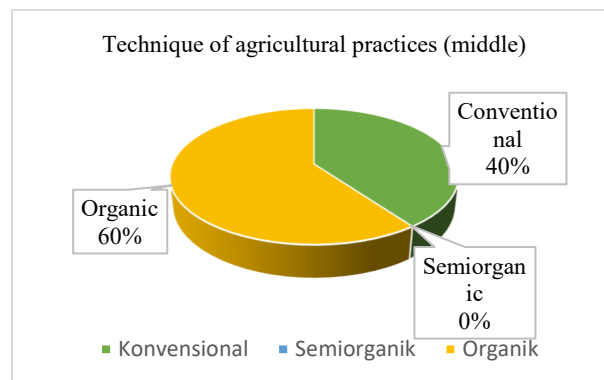
Variables of habits, knowledge, and behaviour of the respondents 36-40% of them applied a conventional agricultural practices and so caused land degradation (Figure 2). On this conventional practices, the farmers focus their agricultural practices on the use of chemical compounds for both fertilizing the crop as well as countering plant pests and diseases. These applications of course, will lead to land degradation.

Some of agricultural practices in all area from upstream, middle and downstream are similar but varied in their intensity. Among those conventional practices was the utilization of inorganic fertilizer in form of urea, TSP, and ZA; while pests were controlled by inorganic pesticides.

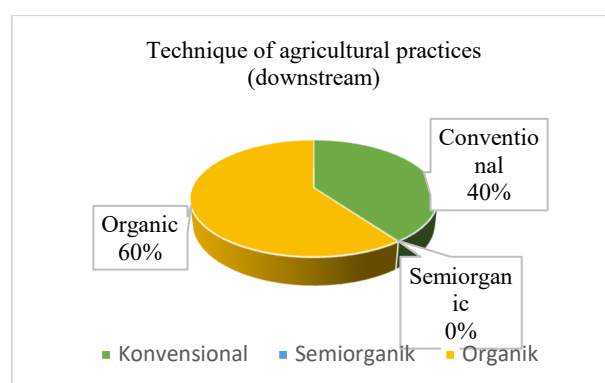
Apart from the farmers' way of agricultural practices, land degradation was also caused by land use by local people along the sub Logawa watershed. Figure 2 shows land distribution along the sub Logawa watershed which is strongly varies, including housing/shelter of 9% - 28%, this of course affect the total *catchment area* and lead to *run off*.



**Figure 2.** Land use along the Sub Logawa watershed (upstream)



**Figure 3.** Land use along the Sub Logawa watershed (middle)

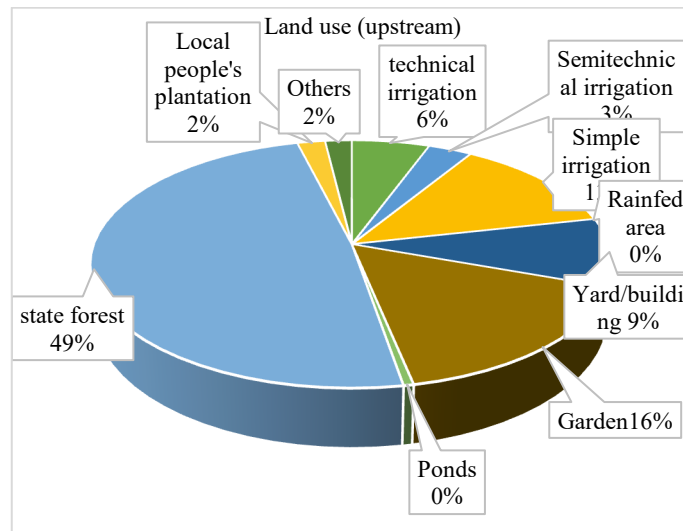


**Figure 4.** Land use along the Sub Logawa watershed (downstream)

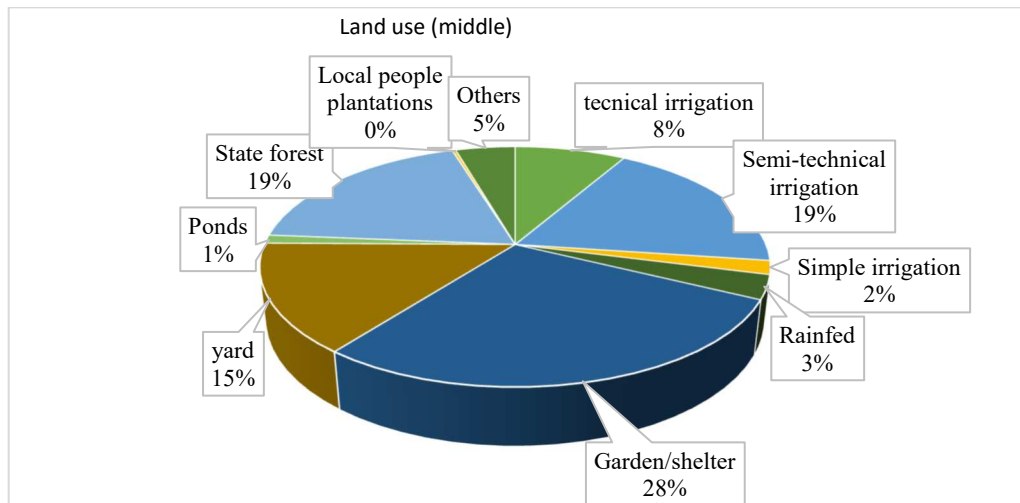
#### 4.2. Levels of land degradation due to erosion

Besides due to unfriendly agricultural practices, other human activities along the watershed might also triggered in land degradation. For examples: sand and rocks mining, soil digging of 148 spopts, chicken farms 2,247, logging nd log sewing 139, soy bean tofu industries amd metal industries 1.049 and tradtional markets 4.

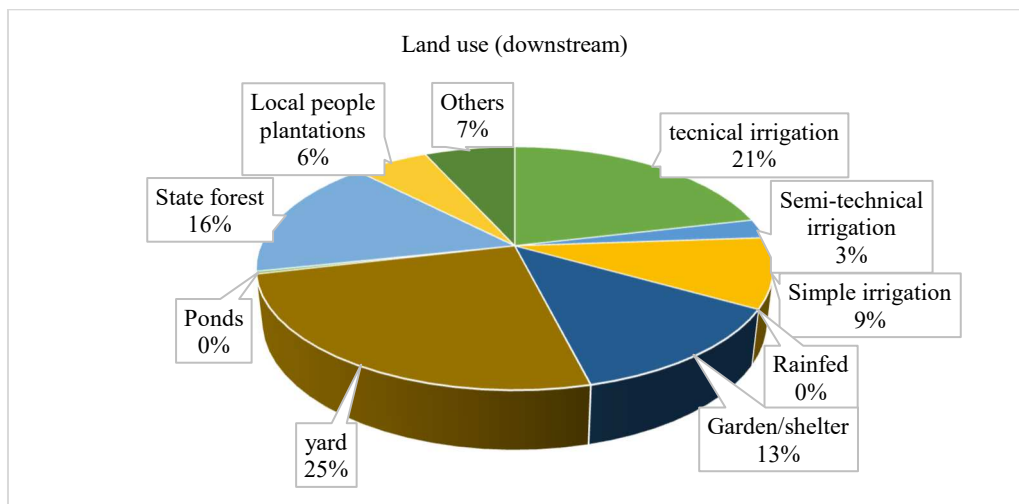
In order to determine land degradation levels, it is important to understand physical, chemical and biological processes within. According to [16], soil encrustation and compaction structure are the two physical processes, erossions and shift from aerobic to an aerobic conditions also pollution, and utilization of natural sources in non sustainable ways. Chemical processes, however, including acidification, bleaching, salinisation, decreasement of soil fertility. Whereas biological processes including decreasement in biomass, decreasement in natural biodiversities due to eutrophycation, ground water and gaseous emission due to the glass house effect.



**Figure 5.** Farmers' behaviour on agricultural practices in upstream



**Figure 6.** Farmers' behaviour on agricultural practices in middle



**Figure 7.** Farmers' behaviour on agricultural practices in downstream

Physical processes, however, was the main cause of land degradation as well as erosion. Some of them are logging, and log sawing, farming, tofu industry, soil digging, sand and rocks mining, restaurants. Land degradation, happens start from upstream to downstream with light to heavy categories. Whereas the top soil runoff was the main cause of soil fertility decrease and so-called as chemical processes. While decrease of soil microorganisms including total number of earthworms belong to the biological processes. These might be happened due to increase of open space/land area due to land clearing, earthworms live in a humid soil, whereas the open land area increases soil temperature thus uncomfortable for them to live there.



According to the RUSLE, current study noted some erosion levels on the up stream, middle and down stream area of each 158.79 ton/ha/year, 280.88 ton/ha/year and 107.37 ton/ha/year. According to the [4], the current erosion level noted in the upstream area could be classified as heavy since it shows erosion of 50-200 ton/ha/year, meanwhile in the middle the erosion is heavier since the data show erosion level of >200 ton/ha/year. But the erosion level in the downstream is heavy. According to [11], some factors may take roles in erosion as follows: rain erosivity, soil erodibility, length and slant of the slope, plantation management, and some efforts to handle erosion which causing erosion might be simplified into land and plantation managements.

The RUSLE formula shows also that rain erosivity was the main cause of land degradation in tropical areas [13]. Identification which based on secondary data of the last five years observations, shows if the rain falls along the sub Logawa watershed is 4,824 mm/year [10]. This high rain fall of course increase the severity of land degradation in this area. According to [17], the high rain falls may also affect to the photosynthesis process of the plants, since the rain falls protect sun light which is important in photosynthesis processes.

Current study also noted if the erosion more related with soil and plantation managements which were run in an unfriendly ways to its environment. Both factors are included as agricultural practices. Current survey to the respondents shows that 40% of the agricultural practices in the upstream area was done in a conventional method and 60% applied an organic ways. In the middle, only 36% run a conventional practices and, 57% semi organic and 7% organic. On the downstream, 37% are conventional, 36% organic and 27% semi organic. Agricultural practices in a conventional ways was the main contributor of land degradation (erosion).

## **5. CONCLUSIONS**

1. Land degradation levels due to heavily erosion was found in the middle of the sub Logawa watershed i.e 280.88 ton/ha/year, followed by upstream and downstream which are 158.79 ton/ha/year and 107.37 ton/ha/year consecutively.
2. The heavily land degradation along the sub Logawa watershed was predicted due to some agricultural practices applied by the local farmers. i.e.: in a conventional way, as well as some unfriendly activities to environment and highly rain falls level of 4.824 mm/year in this area.

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