Rural transformation in the upper Citarum watershed and its implication to soil conservation practices

S H Susilowati¹, T Sudaryanto¹*, H W Perkasa², Sumaryanto¹, and H Tarigan¹

¹Indonesian Center for Agricultural Socio Economic and Policy Studies, Jln. Tentara Pelajar No. 3B, Bogor, West Java, Indonesia
²Global Food Studies, Faculty of Profession, University of Adelaide, 10 Pulteney Street, Adelaide, South Australia

* tahlim@indo.net.id

Abstract. In response to soil and environmental problems in the Citarum river of West Java, the upper Citarum watershed has focused on government policy intervention. The policy framework primarily focuses on encouraging soil conservation practices and promoting an environmentally friendly farming system. However, most empirical research on this subject failed to acknowledge that the conservation practices varied with the stage of rural transformation. This paper aims to assess rural transformation in the upper Citarum watershed and its relation to soil conservation practices. We use Indogreen Farm Household Survey (IFHS) data collected in 2019 from Bandung and West Bandung districts, covering six sub-watersheds, 22 villages, and 500 farm households. The sub-watersheds are divided into two groups based on the degree of rural transformation. Descriptive analysis using graphs and charts presented the data. The results show that the more dominant non-agriculture job characterizes household employment and income structure in the faster regions. Furthermore, farmers in these regions mostly choose higher-value commodities compared to the slower area. Finally, soil conservation practice is more intensive in the faster region in response to more intensive land utilization. The research implies that agricultural development programs, in particular extension services, should put this issue in perspective.

1. Introduction

Citarum watershed is one of the largest watersheds covering six districts in West Java Province. The watershed plays an important role in providing water for domestic, agriculture, and industrial purposes. However, the Citarum reservoir is confronted with severe environmental problems such as sedimentation, pollution from household and industrial wastes, and deforestation in the upstream regions [1].

To maintain its prominent role in supplying water, from an environmental point of view, the upper regions of Citarum should be conserved as a protected region. However, in practice, the area also serves as a source of livelihood for the local population, particularly farmers. Therefore, the challenge is how to improve the welfare of the farmers and at the same time protect the environment by applying soil conservation practices. Land use, soil conditions, and geography all influence sediment's spatial and temporal variations in the watershed [2,3]. The question is to what extent soil conservation problems and the corresponding soil conservation practices differ across the different stages of rural transformation.
As the economy developed, it usually includes structural transformation, characterized by shifting economic sectors from primary to industry and services. This process is also accompanied by increased productivity across sectors, expansion of labor economy, and declining agriculture share [4, 5]. In the process, structural transformation also involves agricultural change, characterized by a shift from subsistence to commercial and more diversified production systems. There is also a shift from grain base production toward high-value commodities. Furthermore, structural transformation may also involve rural transformation, which in addition to agricultural transformation it also includes the existence of income-generating activities in the rural non-farm sectors.

More specifically, rural transformation is defined as follows: "A process of comprehensive societal change whereby rural societies diversify their economies and reduce their reliance on agriculture; become dependent on distant places to trade and to acquire goods, services, and ideas; move from dispersed villages to towns and small and medium cities, and become culturally more similar to large urban agglomerations" [6]. A much more straightforward definition of rural transformation is a process that gradually shifts the structure of agricultural production from grain-based (or low-value agriculture) to more diversified and commercialized high-value agriculture and the rural labor employment from farm to non-farm sectors [7].

Indonesian agriculture, like that of other Asian countries, is dominated by cereal-based cultivation. As a result, transformation is shifting away from cereal production toward high-value commodities and more commercialized and off-farm activities [8]. As an impact of this transformation, labor productivity, household income are expected to increase, whereas the poverty level is expected to decline. Related to sustainability, soil conservation in the upper river basin is one policy issue.

Many factors influence the level of success in the transformation process, such as resource endowment, socio-cultural setting, and amenable factors, such as technology innovation, investment, institution, and government policies. In addition, wage level policies, frameworks, rules, and employment policies, such as subsidies, taxes, insurance, employment contracts, work protection, and other labor market policies, are also important [9,10].

Rural regions in Asia, including Indonesia, have experienced a dynamic transformation [11,7,12]. The transformation directly implies rural household income and poverty reduction [8]. However, minimal studies have explicitly analyzed its implication to the issue of soil conservation. This paper aims to analyze the indicators of rural transformation in the upper Citarum watershed and its linkages to soil conservation practices.

2. Materials and methods
2.1. Data, location, time of research, and sampling method
Analysis in rural transformation in this paper is based on household survey data collected from Bandung and West Bandung District as part of a broader research project entitled "Policy Research to Support Natural Resource Management in Indonesia's Upland Landscape" in September 2019. A total of 499 household samples were collected randomly from 6 sub-watersheds and 22 villages. Disaggregation of the two sub-watersheds was based on the data of Potensi Desa (Village Capacity) [13,14].

2.2. Data analysis
The villages sample was disaggregated into two sub-watersheds based on the level of rural transformation. Disaggregation village used secondary data of Potensi Desa sources from BPS [13, 14], based on the percentage change of agriculture as an indicator in 2011 and 2018. The indicator used is the primary income sources of the village, namely agriculture vs. non-agriculture (manufacture and processing, marketing, restaurant, services, and others). In each sub-watershed, there is a number of villages with agriculture and non-agriculture as primary income sources. Sub-watershed is classified as fast rural transformation villages if the percentage decrease in villages with the main agricultural income during 2011-2018 is greater than the average percentage decrease of all sub-watersheds. Similarly, the sub-watershed is classified as slow rural transformation villages if the percentage decrease in villages with the main agricultural income during 2011-2018 is smaller than the average percentage decrease of
all sub-watersheds. From the calculation, we obtained disaggregation as follows. Group A is a fast rural transformation village, include three sub-watersheds (Cihaur, Citarik, and Ciwidey) with an average of 18.6 percentage point decline. Group B is a slow rural transformation village, include three sub-watersheds (Ciminyak, Cisangkuy, and Cisarea), with an average of 9.2 percentage point decline.

The data were analyzed descriptively. We compare differences in land utilization, employment, and income structure, as indicators of rural transformation, at the household level using graphical presentations. The same comparison was also made on household land area and land status differences with conservation practices between two sub-watershed groups.

The hypothesis to be tested in this study are as follows. Household area with conservation is higher for faster rural transformed villages than slower rural transformed villages. Statistically, the hypothesis is written as follows.

\[ H_0 = A_{cons}^{Fstr} = A_{cons}^{Slw} \]
\[ H_1 = A_{cons}^{Fstr} > A_{cons}^{Slw} \]

\( A_{cons}^{Fstr} \) is an area of farming applying conservation techniques in faster rural transformed villages, and \( A_{cons}^{Slw} \) is the area of farming with conservation techniques in slower rural transformed villages.

With a large sample size (> 30), the Z-test is used to test the hypothesis

\[ Z_{calculated} < Z_{table} \text{ at 5% significance level, } H_0 \text{ accepted.} \]
\[ Z_{calculated} > Z_{table} \text{ 5% significance level, } H_1 \text{ accepted.} \]

3. Results and discussion

In line with the scenario on rural transformation, villages’ number that relies on agriculture as a major source of livelihood had decreased consistently during 2011 and 2018 [13,14]. On the other hand, the number of villages with non-agriculture as primary employment sources had increased significantly. A significant shift was observed in the manufacturing industry, from 89 villages (28.2%) in 2011 to 151 villages (34.5%) in 2018. The number of villages focusing on the marketing and restaurant sector also increased from 13 (3%) in 2011 to 26 (5.9%) in 2018. This observation indicates that at the village level, the concept of rural transformation is progressing.

The transformation, to some extent, is influenced by investment in infrastructure, such as rural roads. The villages that experience shift from agriculture to the non-farm sectors is characterized by better rural roads, i.e., road with asphalt [13,14]. Better road facilitates better connectivity, which ultimately promotes more productive economic activities.

3.1. Structure of employment and income

Village level data provide a more aggregation figure on which sector or sub-sectors the economy is moving over time. To have a more detailed figure on the structures of employment and income as indicators of rural transformation, we need household-level data analysis. Figure 1 indicates that more than 40% of household members work as farmers, and the second field of employment is non-agricultural business, followed by the non-farm laborer and farm labor. The figures for faster rural transformed and slower rural transformed villages are similar; however, in faster rural transformed villages, the non-farm labor is slightly higher than in slower rural transformed villages.

Consistent with the figure on type of occupation, a major source of household income is agriculture (more than 70%), followed by non-agriculture (17-22%) and others (salary and remittance) about 5-7% (Figure 2). This observation indicates that agriculture is still a back bone of the rural economy. If we look more deeply, staple food production (rice and maize) is still dominating agriculture. However, diversification toward high-value crops, in particular, vegetables and coffee, is also observed. Diversification to coffee farming is not only due to higher income but also a consideration on land conservation.
Changes in revenue sources might be considered part of a rural transformation process in various countries [15]. Currently, the contribution of the non-farm sector as a source of income is still relatively low. However, with the development process, we expect that sources of income will steadily shift toward non-farm enterprise and non-farm labor. Several elements influence households seeking jobs other than farming [16]. Access to urban employment possibilities enhanced the likelihood of off-farm work in general [17]. If this stage is achieved in the future, the pressure on land utilization to some extent will be reduced. In other words, the issue of land conservation is decreased as well. Villages in a faster rural transformed area indicate an increased shift towards non-agriculture incomes than slower rural transformed areas. The share of non-agriculture incomes is higher in the faster area.

3.2. Land utilization
Transformation of agriculture from staple food to higher-value crops is driven, among other things, by land consolidation through land market transactions. As may be seen from Table 1 average size of land managed is larger than the average size of land owed in both groups. However, most farmers are small farmers. Therefore, their land holdings will determine whether households will stay in farming or diversify into non-agricultural activities [15]. The differences between land owned and land managed size is made possible by land market transaction, particularly land rent or traditional land tenures such as borrowed from relatives or neighbors. About 22% of land managed is borrowed from the owner, and 18% is rented.

The survey also shows that farmers in the faster rural transformed area are less likely to have their own farming plot (Figure 3). The farmers rely more on land markets for farming activities. Smaller own farming plot farmers in this area have a lower dependency on agriculture.
### Table 1. Average land ownership and land managed per household, 2019.

|                        | Faster rural transformed | Slower rural transformed | Aggregate |
|------------------------|--------------------------|--------------------------|-----------|
| Average land ownership per household (287 out of total 499 samples) | 0.35 ha (69 out of 159) | 0.36 ha (218 out of 340) | 0.35 ha   |
| Average land managed (operated) per household                           | 0.68 ha                  | 0.56 ha                  | 0.6 ha    |

#### Figure 3. Land ownership, 2019.

Land utilization for seasonal crops shows that the most extensive area (39%) of land in slower rural transformed villages is planted to rice followed by vegetables (potato, cabbage, chili, tomato, and others) (Figure 4). In contrast, faster rural transformed villages are more dominant planted to vegetables (48%) than rice (18%). This difference is consistent with what [8] mentioned, which rural transformation process will shift from grain-based or low-value agriculture production to more commercialized high-value agriculture (vegetable). However, due to environmental concerns, particularly its impact on land erosion, the government discourages vegetable farming. It promotes tree crops, particularly coffee, which provides a high return but simultaneously conserves the environment.

#### Figure 4. Major crop categories planted, 2019.

### 3.3. Soil conservation practices

To address the issue of land erosion, farmers implement conservation practices. There are many different types of land conservation practices. The highest frequency of conservation practice is beds, followed by terraces and drainage canals. Other frequent upland vegetable cultivation, land conservation strategies include small canals, mulch, and others [18]. The most important reason for choosing those practices is to avoid erosion for the terrace, make easy crop maintenance for the bed, and prevent erosion.
for the drainage canal. Applying conservation farming in cereal farming provided farmers with various tangible benefits, including lower labor expenses, reduced input costs, higher productivity, and higher profits than conventional farming [19].

The total area of agricultural land in the sample villages is 307.8 ha. Area with land conservation of 108 ha (42%), while the remaining 58% is not conservation (Table 2). For villages with a faster rural transformed category of 111 ha, the conservation area is 60 ha (55%). The 197 ha land in slower rural transformed villages, land with conservation practices of only 68 ha (34%). This figure shows that in faster rural transformed villages, although the agricultural land is smaller than in slower rural transformed villages, conservation land is more significant. Identical to the area, sample households doing land and water conservation in faster rural transformed villages is also higher than in slower rural transformed villages. This result implies that farmer interest in conservation is even higher in villages with more experience transformation from agriculture to the non-farm sectors. The higher interest in land conservation could be driven by better access to information on the importance of land and water conservation for agricultural sustainability.

Table 2. Land area and number of households with conservation, 2019.

| Villages category       | Total area (ha) | Area with conservation (%) | Total HH | HH doing conservation (%) |
|-------------------------|-----------------|----------------------------|----------|---------------------------|
| Faster rural transformed| 110.61          | 55                         | 159      | 51                        |
| Slower rural transformed| 197.20          | 34                         | 340      | 40                        |
| Agregat                 | 307.81          | 42                         | 499      | 44                        |

The difference in household land area with a conservation between faster rural transformed villages vs. slower rural transformed villages was significantly different between the two villages category (Table 3). Z count (2.3009) is greater than the z table (1.96) at the 5% significance level.

Table 3. The results of the Z-test of the differences in the average of household land area with conservation practices of faster and slower rural transformed, 2019.

| Variable         | Obs | Mean     | Std. Err. | Std. Dev. | [95% Conf. Interval] |
|------------------|-----|----------|-----------|-----------|----------------------|
| Faster transform | 72  | .839022  | .1248621  | 1.05949   | .594297 1.083747    |
| Slower transformed | 132 | .512422  | .067517   | .7257109  | .3800911 .6447528   |
| diff             |     | .1419475 | .0483883  | .6048122  |                      |

Diff= Mean (faster transformed) – Mean (lower transformed)  z = 2.3009

Ho: diff = 0
Ha: diff < 0  Ha: diff = 0  Ha: diff > 0
Pr(Z <z) = 0.9893 Pr(Z > z) = 0.0214 Pr(Z > z) = 0.0107

Land conservation strategies will not, in the medium run, increase productivity. However, land conservation will positively influence productivity, production, and farm income [19,20,21]. Therefore, household interest in conservation is generally influenced by land ownership status, which is dynamic across seasons. For example, farmers work on land by renting or sharecropping in one season, and the following season does not necessarily work on the same land. Thus, if the farmers conducted land conservation, not on his land, he would be dis-invested if he no longer cultivates the same land in the long run. Therefore, in general, farmers do not conduct conservation on not their own land.

The survey results in Table 4 show farm households conducting conservation distinguished by land ownership. Of the 218 farm households that do land conservation, 124 households have their land, while 94 households do not own land. The more significant number of farm households with land doing conservation might be because the security in land tenure provides incentive toward farmers’ willingness
for long-term investment in conservation practices. The result also showed the percentage of landowners who do conservation in slower rural transformed villages is more significant than landowner households in faster rural transformed villages.

Table 4. Farmer households conduct conservation according to land ownership, 2019.

| Villages category          | Have own land (%) | Do not have own land (%) |
|---------------------------|-------------------|--------------------------|
| Faster Rural Transform    | 24                | 54                       |
| Slower Rural Transform    | 76                | 46                       |
| Total                     | 100 (124 HH)      | 100 (94 HH)              |

4. Conclusions

Confronted with complex environmental problems, the Citarum upper catchment area of West Java has experienced a common structural and rural transformation process. As might be expected, the observed change is from agriculture toward the manufacturing and processing sector. This transformation process was driven by constructing better infrastructure, a road in particular, and land rental market transactions, which help promote a larger farm size.

In both categories of faster and slower rural transformation, agriculture is still a backbone of the rural economy. The non-farm sector as a source of income is still relatively low. However, in the faster rural transformed villages, there is an increasing shift towards non-agriculture employment more accelerated than the slower rural transformed area. Land utilization also shifts from grain-based or low-value agriculture production toward more commercialized high-value agriculture (vegetable). In addition, land ownership by farmers moved from predominantly owning land to not owning land.

The intensity of soil conservation practices is significantly higher in the faster-transformed villages compared to the slower-transformed regions. However, there are no differences in the type of soil conservation practices between the two categories of villages. This finding suggests that more intensive soil conservation measures have been used to address more severe soil degradation issues in the faster-transformed region.

This analysis implies that the rural transformation process requires more intensive soil conservation practices in response to more intensive land utilization. Therefore, agricultural development initiatives, in particular extension services, should put this issue in perspective.

References

[1] The Diplomat 2018 Indonesia’s Citarum: the world’s most polluted river [cited 3 May [2021] Available at: (https://thediplomat.com/2018/04/indonesias-citarum-the-worlds-most-polluted-river/)
[2] Liu Y, Yang W and Yu Z 2015 Estimating sediment yield from upland and channel erosion at a watershed scale using SWAT Water Resour Manage 29 1399–1412
[3] Woznicki S A and Nejadhashemi A P 2013 Spatial and temporal variabilities of sediment delivery ratio Water Resour Manage 27 2483–2499
[4] IFAD [International Fund for Agriculture Development] 2016 Rural Development Report 2016: fostering inclusive rural transformation (Rome: International Fund for Agricultural Development)
[5] FAO [Food and Agricultural Organization of the United Nations] 2017 The state of food and agriculture 2017: leveraging food systems for inclusive rural transformation (Rome: Food and Agricultural Organization)
[6] Berdeuge J, Rosada T and Bebbington A 2014 The rural transformation in International development ed B Currie-Alder, R Kanbur, D M Malone, and R Medhora (Ideas, Experience, and Prospects, Oxford)
[7] Huang J 2018 Facilitating inclusive rural transformation in the Asian developing countries World Food Policy 4 31-55
[8] Huang J and Shi P 2020 Regional rural and structural transformations and farmer's income in the past four decades in China China Agricultural Economic Review 13 278-301
[9] Donnellan T, Hanrahan K and Hennessy T 2012 Defining an institutional framework for the labour market Factor Market Working Paper 24 1-8
[10] Tocco B, Davidona S and Bailey A 2012 Key issues in agricultural labour markets: a review of major studies and project reports on agriculture and rural labour markets. Factor Markets Working Paper 20 1-41
[11] [IFAD] International Fund for Agricultural Development 2014 Transforming rural areas in Asia and the Pacific: a policy brief (Rome:IFAD)
[12] Susilowati S H, Ashari and Sudaryanto T 2020 Rural transformation in various ecosystem in Indonesia E3S Web of Conferences 232 04002
[13] BPS 2011 Hasil pendataan potensi desa 2011 (Jakarta:Badan Pusat Statistik)
[14] BPS 2018 Hasil pendataan potensi desa 2018 (Jakarta:Badan Pusat Statistik)
[15] Davis B, Winters P, Carletto G, Covarrubias K, Quinones E, Zezza A, Stamoulis K, Bonomi G and Giuseppe D 2010 Assets, activities and rural poverty alleviation: evidence from a multicountry analysis World Development 38 48-63
[16] Susilowati S H 2017 Dinamika diversifikasi sumber pendapatan rumah tangga perdesaan di berbagai agroekosistem J. Agro Ekon. 35 105-26
[17] Nantel S J, Freshwater D and Katchova A L 2011 Agric. Finan.Rev. 7 329-46
[18] Nuraeni, Sugiyanto and Zenaal 2013 Usahatani konservasi di hulu DAS Jeneberang (studi kasus petani sayuran di hulu DAS Jebneberang Sulawesi Selatan) J. Manusia dan Lingkungan 20 173-83
[19] Pokharel D, Jha R K, Tiwari T P, Gathala M K, Shrestha H K and Panday D 2018 Is conservation agriculture a potential option for cereal-based sustainable farming system in the Eastern Indo-Gangetic Plains of Nepal? Cogent Food & Agriculture (4)1-5
[20] Tiwari K R, Sitaula B K and Bajracharya RM 2010 Effects of soil and crop management practices on yields, income and nutrients losses from upland farming systems in the Middle Mountains region of Nepal Nutr Cycl Agroecosyst 86 241–53
[21] Sutrisna N and Oktorie O 2019 Conservation farming system of vegetable crops in upstream areas of Subwatershed Cikapundung Sumatra J.of Disaster, Geography and Geography Education 3 10-17