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Sustainable Agricultural Systems Upstream of the Citarum Watershed: Social, Economic and Environmental Implications

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Abstract.
The Citarum watershed is Indonesia's most degraded watershed. This is due to upstream agricultural practices that are harmful to the environment, such as the expansion of vegetable crops into steep areas and the destruction of forest areas. The upstream watershed's management is critical to the overall watershed's long-term viability. The purpose of this paper was to examine the characteristics of agriculture upstream of the Citarum watershed, as well as its social, economic, and environmental consequences. The participants in this study were 500 farmers from 22 villages in 14 sub-districts in the administrative areas of Bandung and West Bandung Regencies in Indonesia's West Java Province. The following were the findings of a quantitative data analysis supplemented with qualitative data: 1. Farmers are typically productive adults with a low level of education (graduated from elementary school) who cultivate the main vegetable commodity using a combination of monoculture and intercropping techniques. 2. Due to financial constraints and a scarcity of land, farmers have been forced to cultivate state-owned forests and plantations using less environmentally friendly agricultural methods. 3. Farmers' actions have an impact on critical land, river pollution, landslides that cause silting, and the Saguling reservoir's lifespan. The key to implementing environmentally friendly agricultural practices in the short term is to structure agricultural practices with environmentally friendly technology. Furthermore, long-term sustainable solutions such as increasing human resource capacity, optimizing natural resource management, and utilizing social capital need to be addressed in the future.

Keywords: scarcity of land, Citarum watershed, sustainable agriculture

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1. Introduction

The Citarum watershed is the main watershed in West Java with an area of 6,080 km2. The Citarum River is the main river that includes 36 tributaries with a total length of 873 km. The Citarum watershed is used for agriculture and covers an area of 170.832

ha (27.5%), plantation 59,657 ha (9.6%), settlements 76,777 ha (12.3%), forest 88,271 ha (14.2%), fisheries 35,892 ha (5.8%), and others 190,418 ha (30.6%) [1].

The upstream part of the Citarum river is a source of water flow that flows into the river downstream and is used for various functions, such as a source of fresh water, irrigation, fishing, water supply for industrial activities, and a source of hydroelectric power [2]. The Citarum River stretches from a spring at Mount Wayang to Tanjung Karawang by passing through 12 regencies/cities and flows into the three large reservoirs of Saguling, Cirata, and Jatiluhur. The role of rivers is very important for people's lives in West Java and DKI Jakarta, namely as a source of fresh water, irrigation, fishing, water provider for industrial activities, and a source of hydroelectric power [2].

The upstream Citarum watershed covers Subang, Bandung and West Bandung Regencies. These three districts are areas with a high level of economic development and a relatively well-established and complex agricultural system. Agricultural practices that are not environmentally friendly have caused the upstream area of the Citarum watershed to become one of the most degraded watersheds in Indonesia. Farmers expand vegetable crops in steep and hilly areas, cultivating forest land, which results in the destruction of forest areas.

During the period 1990-2017, the land cover of the Citarum watershed was rice fields, but the trend tends to decrease (-9.23). Furthermore, the second largest area is dry land agriculture, with a rapidly increasing trend of 11.29. The third largest is the settlement, which rose by an average of 3.27 [1]. In the last two decades, environmental damage in the upstream has been at an alarming level. The reduction in land conservation areas, densely populated settlements, and river pollution from domestic and industrial waste cause floods, droughts, and landslides in the downstream part of the river. This condition is very dangerous for the agricultural sector as a food provider sector for the community who work and live in the region.

Given the important role of the upstream area in supporting the community's lives and the environment along the Citarum watershed, the management of the upstream area has become necessary to be observed for the sustainability of the watershed function as a whole [3]. An interesting question that needs to be answered is how to manage existing agriculture in the upstream Citarum watershed, especially the management of dry land agriculture, which continues to increase very rapidly.

This paper aims to analyze the characteristics of agriculture applied by farmers in the upstream area of the Citarum watershed and the social, economic, and environmental impacts of dry land farming practices. The discussion of the agricultural system and its

development is inseparable from the policies carried out by the government in an effort to overcome the threat of environmental sustainability and its challenges.

2. Methodology

This study is a part of a broader research project entitled ”Policy Research to Support Natural Resource Management in Indonesia’s Upland Landscapes”. The analysis is based on household survey data collected in June-August 2019 in Bandung and West Bandung Districts, West Java Province, Indonesia.

The stages before the survey to build a sampling frame are: (1) Conducting a review and collecting secondary data. (2) Register all sub-districts and villages in the research area. Bandung Regency: 27 sub-districts and 224 villages; West Bandung Regency: 14 sub-districts and 140 villages. (3) Then the villages are grouped based on agricultural intensity, elevation and topography. Villages that fall into the kelurahan category are excluded from the list. (4) Finally obtained 142 underdeveloped villages in Bandung, and 76 villages in West Bandung. This study randomly selected 10% of villages. Selected 14 villages in Bandung and 7 villages in West Bandung.

The total sample is 500 farmer households. Further scrutiny resulted in one sample not meeting the requirements so that the analysis was only carried out on 499 households. The data was processed using statistics and analyzed descriptively. The analysis is enriched by the results of a review of similar research conducted previously.

3. Result and discussion

3.1. Agriculture Characteristics

Farmers in the Upper Citarum watershed area are originally from ethnic Sundanese, with more than 50% of the head of the family being in the productive adult age group (40-60 years), followed by the older group (over 60 years) at 23.65% and the young adult group (15-39 years) at 21.04% (Table 1). The largest group is elementary school and non-elementary school graduates. If there was no effort to make millennials interested in agriculture, this proportion has the potential to become an aging farmer [4-5].

From 1,286 plots of land managed by households, the average area per plot is 0.25 hectares. The average area of agricultural land in Bandung is 0.29 hectares, larger than in West Bandung, which is 0.19 hectares. The share of government-owned land (Perhutani) is the largest in the sample (Figure 1), but most plots are private land located

within villages and are accessible by motorbike or on foot. One household manages between 1 and 3 plots of land, so that the average land area per household is 0.65 hectares. There is a fairly large land tenure gap between the largest having more than 7 hectares and the smallest having around 0.006 hectares. Based on the number of plots studied, 1,182 plots were managed by the households themselves, while the rest were leased/loaned.

TABLE 1: Household head age distribution.

Age (year)	**Respondent**	
	Household Head	Percentage
15-39	105	21.04
40-60	276	55.31
Lebih 60	118	23.65
Total	499	100.00

Resource: Primary data

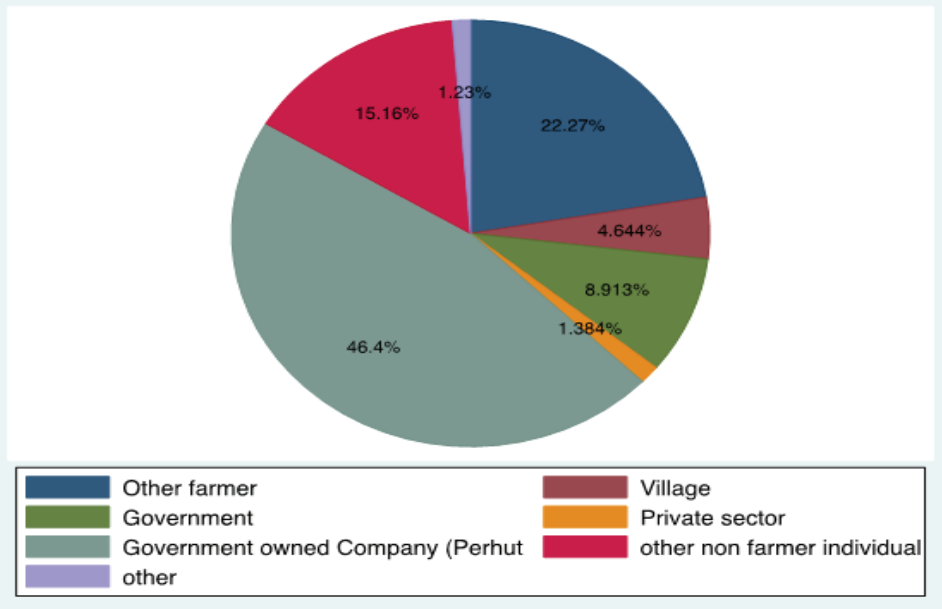

Figure 1: Percentage distribution of plot owner7.

Agriculture in the upstream area of the Citarum watershed includes staple crops, horticulture and estate crops. Out of the total agricultural plots surveyed, 42% of the plots are horticultural farms with a total area of 132 hectares, followed by rice fields with 31% of plots with a total area of 50 hectares, and coffee with 14% of plots with a total area of 99 hectares. Horticultural planting adheres to a combination of monoculture and intercropping with intensive use of fertilizers and pesticides. Both inputs compose a large cost composition in vegetable farming [6-8]. When it rains, the position of the

upstream area causes some of the chemical waste to flow into the Citarum rivers and tributaries, and poses a risk to the lives of fish and humans who use the river water.

Agricultural practices are considered an established category, complex and tend to be less environmentally friendly [1]. A land contour with various slope types is used as vegetable farming land, while the rice fields are located at the lower part of the hills which are arranged in the form of a terrace. Population growth causes land resources to become increasingly scarce. The urgent need for land encourages people to use land that is steep and hilly. Many state forest lands have been cultivated for generations. Many land transactions take place in informal transactions without proof of ownership. Agricultural practices and changes in land use cause damage to the function of the forest as a catchment area and are harmful to the environment.

Based on observation of land conservation practices, there are at least 8 (eight) types of practiced by farmers, namely terrace systems, beds, roak/wind holes, drainage channels, mulch, elephant grass, water reservoirs, and tree planting. Beds, terrace systems and drainage canals are the most widely adopted. Meanwhile, planting elephant grass is the least applied with the excuse of absorbing fertilizers and plant nutrients.

During the last 5 years, there were 41 households that sold or purchased/leased land and 84% of them were agricultural land. The total number of transactions is 49 plots with a total land area of 9.8 hectares (the average plot area is 0.2 hectares). In the same period, there was a slight increase in the number of plots and the area of horticultural farming. The bigger increase applies to coffee farming, which reached more than 30 percent. On the other hand, paddy fields decreased in both the number of plots and the total land area.

The increase in the number and area of horticultural commodities is influenced by the experience of growers of the relevant commodity and the market attractiveness. The characteristics of high-cost farming commodities due to the concentration of chemical elements (pesticides and the like) are not an obstacle to the increase in horticultural farming plots. The shortness of the business cycle generates income quicker and can be planted several times a year is a positive factor for farmers, although from an environmental perspective, this farming implies conservation.

In the last year, a total of 448 out of 499 farmer households cultivated seasonal crops. Vegetable crops occupied the highest share, which is 613 plots with a total area of 172 hectares. In terms of planting frequency, rice is the most dominant crop, with as many as 754 planting times in 3 seasons with an area of 95 hectares. Meanwhile, annual timber, plantation and fruit crops are crops that have experienced a significant increase in the last 12 years. Of the 198 plots planted, 157 plots (86 hectares) were coffee

plots. Coffee is the most dominant annual crop grown on agricultural plots. Some of the coffee plantations in the plots are monocultures and some are mixed with woods such as pine, or fruit trees such as avocados, bananas, oranges, and so on. Coffee farming has developed very rapidly in the last 7 years after the government intensively moved reforestation in the context of controlling and restoring the Citarum watershed environment through several programs involving related institutions.

Coffee productivity in the area has not yet reached the optimal level. One of the reasons is that many coffee plantations are grown on state-owned land, so that the handling of farming is not optimal. The coffee harvest season begins in March and reaches its highest peak in May and June. So far, farmers have not implemented a red fruit picking harvesting system because they consider it time-consuming and slow to generate money. The mixed harvest system and selling in fresh form causes farmers to not receive added value. The price level of coffee received is lower and the agricultural system implemented does not consider the sustainability of coffee production.

Dryland and vulnerability agriculture in the Upper Citarum watershed

Dry land, which is the largest farming area in the upstream Citarum watershed, is a farm that has not been flooded for a long time. Its irrigation is highly dependent on rainwater, and its soil contours are unstable and prone to erosion. The land can be used as a water catchment area by planting annual crops. It is located relatively far from water sources, near residential areas, so that there is a struggle for water between human and plant needs, at an altitude of 500-1500 meters above sea level [9-11]. Generally, dry land in the highlands is less fertile due to erosion [12]. However, agricultural developments and the demand for agricultural land show that the use of dry land agroecosystems for seasonal crop farming is almost equally distributed in West Java, including in hilly areas and upstream areas of the Citarum watershed, which have suffered heavy damage [2]. Planting of annual plants as intercrops, shade as well as water retention have not been done much.

The damage to ALK not only complicates the lives of local rural communities, but has brought social, economic, and environmental losses for all upstream, middle, and downstream communities. For years, this loss is estimated to continue to increase due to changes in land cover, primary waste that changes hydrological characteristics, conflicts over water struggles, floods, siltation, landslides, increased environmental costs in the form of reservoir maintenance and decreased production of electrical energy. So far, efforts to improve the management of the upstream watershed have been carried out by the government, but due to the low support from the community as the main actor in the field, the results are still far from what is expected. This is reminiscent of the

past 2-3 centuries. The destruction of ALK has become part of the ”blurred history” of the management of sedentary agricultural systems in rural Java [13-15]. The damage is not only because of the weak ability of farmers or rural communities to manage ALK, but also because of the inaccuracy of government policies in building a model for empowering local rural communities.

There are four characteristics of degradation in the Citarum watershed. The first is the decrease in carrying capacity. The decrease in the carrying capacity of the Citarum watershed manifests itself in the form of land clearing, erosion, sedimentation, and pollution due to industrial waste that is not managed according to environmental safety standards. Especially for industry, from 176 corrected industrial data, the total volume of B3 waste generated is 119,685.03 tons per month, containing fly & bottom ash, mud, B3 waste packaging, used oil, TL lamps, cotton waste, and others. In the upstream area, changes in land use and function occur so that they affect water resources, considering that the watershed/sub-watershed is an independent hydrological unit. Changes in land cover in the upstream cause severe erosion and sedimentation rates, such as the decline in the function of natural resource facilities and infrastructure in the form of river silting in the downstream, middle and upstream watersheds. As a result, the high peak discharge exceeds the capacity of the existing channel capacity. If there is no environmentally friendly technology used to overcome, it will be bad for the sustainability of Citarum [16-18]. Second, the high pollution of domestic waste in the form of waste from settlements, agriculture, animal husbandry, and industry. Third, threats to forest resource ecosystems. Some protected forest areas with unique high-value biodiversity have been turned into residential, agricultural, livestock and industrial areas. Currently, the Citarum watershed is one of the 15 Super Priority watersheds in Indonesia that needs to be addressed for recovery. Fourth, soil erosion in the upstream area causes high sedimentation rates in the middle and downstream areas. As a result, river siltation occurs because the cross-sectional area is smaller, so that river water overflows beyond its capacity and causes flooding with a higher frequency. The four degradations above have a high risk to economic, social and environmental life.

3.2. Government Policies Toward Citarum Watershed

At least seven programs have been implemented in order to control pollution and damage to the Citarum watershed, starting from the Rehabilitation of Soil Conservation Land (RLKT) initiated in 1976, the Integrated Citarum Water Resources Management Investment Program (ICWRMIP) in 2010, Citarum Bestari in 2013, Citarum Harum in 2017,

Governance of the Citarum Watershed PPK in 2019, the management of the Integrated Citarum Watershed, and Clean Citarum.

The RLKT, which has been initiated since 1976, became a concern for the Citarum-Ciliwung Watershed Management Center (BPDAS) in the 2000s. The basis for establishing the implementing organization is the Decree of the Minister of Forestry No. 665/Kpts-II/2002. The program objectives for the development of watershed management towards the realization of the effectiveness and efficiency of watershed management are based on the principles of coordination, integration, and synchronization. The program is closely related to soil conservation, land and watershed development. In the long term, it is expected to restore the condition of critical land so that it can function as a productive land that supports living systems. The program is translated into development projects in the forestry sector which are funded by the Reforestation Fund and the State Revenue and Expenditure Budget Fund, as well as other funds. The existence of Regional Autonomy has also changed the RLKT institution from the province to the district [19].

In 2010, the ICWRMIP program was imposed, which aimed to restore and improve integrated water resource management in the Citarum River area. This program involves all parties working together in a participatory manner. The program was initiated by the Government of Indonesia together with the Asian Development Bank (ADB) and other stakeholders, which are academicians, NGOs, the private sector, and the community. Implementing organizations involve Bappenas, the Ministry of Public Works, the Ministry of Agriculture, the Ministry of Forestry and the Ministry of Environment. Through this program, it is expected that by 2023, poverty, health and living standards in the Citarum area will be improved through GDP growth without causing a decline in environmental conditions and a significant improvement in water quality in the river area. This program is designed to meet the needs of various stakeholders in the Citarum watershed and to assist upstream and downstream communities in carrying out water and soil management efforts. The results of the evaluation by the Independent Monitoring and Evaluation (IME) showed that the program was slow and weakly coordinated due to poor communication between stakeholders [20].

Furthermore, there is the Citarum Bestari Movement Program, which was initiated by the West Java Regional Government on the basis of the West Java Governor Regulation No. 75 of 2015. The main focus of the program is to improve the condition of the Citarum River, which has experienced a decline in water quality and an increased volume of waste along the river. The local government intends to change the mindset and behavior

of the community so that they have a sense of care for the cleanliness, beauty, and sustainability of the Citarum River.

Worriness about the condition of Citarum, which concerns the sustainability of the lives of many people. On the initiative of President Jokowi, the Central Government, in collaboration with the Regional Government, created a program known as Citarum Harum. Through the support of Presidential Regulation No. 15 of 2018 concerning the Acceleration of Control, Pollution and Damage to the Citarum Watershed, 13 action programs were carried out aimed at restoring the Citarum watershed [21]. This program is implemented synergistically by involving the Central Government, Ministry of Environment and Forestry, Regional Government, Military Regional Command (KODAM) Siliwangi, and other relevant stakeholders. Citarum Harum has taken steps to restore the Citarum with several steps and methods, including modernization of waste management, forest encroachment upstream of the Citarum river, floating net cages, as well as efforts to provide clean water and regulate river discharge. The main program achievements are flood-free and water quality improvement. The concept of integration and command is expected to give measurable results with clear stages of development [22].

At the micro level, the local government then follows up with the Citarum Watershed PPK Governance program, which principally carries out activities in the form of preventing and overcoming watershed pollution/damage and restoring its functions. Watershed pollution is controlled by its pollutant sources, both from industrial, livestock, and fishery waste, as well as domestic waste and solid waste. Damage in the Citarum watershed is controlled through efforts to reduce erosion and water resources management by reducing sedimentation and reducing erosion through handling of critical land, monitoring and enforcing laws and land use management, improving water resource management, and conducting education and outreach to industry, educational institutions, and communities in the Citarum watershed. The implementation of the program is based on local government policies, West Java Governor Regulation No. 5 of 2019 concerning the Management of Pollution and Damage Control in the Citarum Watershed.

4. Conclusion

The majority of farmers in the upper Citarum watershed are productive adults with low education , who mainly farm vegetables through monoculture and intercropping farming systems. Agricultural practices develop through the insistence of community needs in

terms of limited land resources and knowledge of a sustainable environment. Intensive farming systems are production-oriented, highly dependent on commercial chemical inputs (fertilizers, pesticides) but do not take into account the environment.

Agricultural practices are not yet oriented towards sustainable agriculture. Behavior has an impact on increasing critical land, river pollution, and landslides, followed by silting and shortening the life of the reservoir. The impact has caused economic losses in the form of a decrease in the quality and quantity of agricultural production and clean water. Social losses are in the form of conflicts over land and water among farmers, sectors and sub-sectors, upstream and downstream, as well as among administrative areas. As well as environmental losses in the form of erosion, flooding, and water pollution.

Sustainable government policies still face obstacles to coordinating program implementation, which is expected to have synergy between stakeholders. Nevertheless, evolutionarily, it has built public awareness about the risks of environmental costs by shifting and adding to commercial annual crop commodities as well as functioning as conservation. Structuring agricultural practices with environmentally friendly technology is an urgent key to be implemented in the short term. Furthermore, increasing the capacity of human resources, limiting the management of natural resources by creating other alternative livelihoods, and utilizing social capital are sustainable long-term solutions to be addressed in the future.

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