Analysis of soil and water conservation practices by community throughout the Upper Citarum River Watershed: motivational, technical and institutional aspects

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Abstract. Forest degradation in the Upper Citarum Watershed requires an approach to changing farming patterns that applies techniques of soil and water conservation. The objective of the paper is to examine the extent to which the community in the Upper Citarum Watershed has practiced soil and water conservation techniques in its farming practices, as well as institutional support and community motivation in the application of the conservation practices. This study used a survey of 499 farmers to collect data in Bandung and West Bandung districts. Data were analyzed using descriptive statistic analysis. Results of the study indicate that the soil and water conservation practices have been implemented by 45% of the farm household. The households practicing conservation techniques have higher revenue compared to those who not practicing. The sources of information that households learned come from fellow local farmers, while the most reasons motivating households to practice soil and water conservations are to prevent erosion and improve water supply. The local Agriculture and Forestry Service Offices and Watershed Agency are the dominant sources of assistance with the form of assistance are either materials or training. This study recommends improving spatial planning, providing market incentives and assistance, and supporting the agroforestry system.

1. Introduction

The Citarum watershed is one of the strategic watersheds in Indonesia. Saguling, Cirata, and Jatiluhur are the three large reservoirs built along the Citarum watershed that play a strategic role in supporting food security through irrigation, source of water supply, and energy security for electricity generation. The area of the Citarum watershed is 682,227 hectares, divided into Upper, Central, and Lower Citarum Watershed areas. At this moment, Citarum Watershed is one of the restoration priority watersheds because it is considered to be in a critical stage [4]. The area of very critical land in the Citarum Watershed reaches 133,274.07 hectares, while the area of critical land reaches 66,240.07 hectares. Meanwhile, the critical land area in the upstream Citarum watershed is 62,653 hectares, and the critical land area is 14,384 hectares. Bandung Regency and West Bandung Regency are districts that have the largest critical land area in the Upper Citarum Watershed, which contribute 56% and 34% of the total...
critical land area in the Upper Citarum Watershed. Meanwhile, land cover in the Citarum Watershed is dominated by rice fields (23.44%), dryland agriculture (24.23%), and settlement (12.53%) [4].

Several problems that have been identified in the Citarum Watershed are: i) critical land mainly occur in vegetable plots where they have steep slopes and without any adequate soil nor water conservation practices; ii) bench terraces practice on steep slopes considered to damage vegetable crops and reduce planting area; iii) river pollution; iv) reduction in water catchment areas due to land degradation from infrastructures development; and v) high level of sedimentation [4]. One of the challenges is the presence of critical land, mostly vegetable fields that reside on steep slopes without any soil and water conservation practices. Based on these conditions, the practice of land use in upstream areas dominated by steep slopes needs to be carefully examined to be consistent with soil and water conservation. According to the interpretation of [19], the upstream area of Citarum includes the upstream Citarum Watershed area within the administrative areas of Bandung District, West Bandung District, Cimahi City, Bandung City, Garut District, and Sumedang District with an area of 231,991 hectares. The interpretation shows that the Upper Citarum Watershed is still dominated by rice fields, settlements, and annual crops. Therefore, it is crucial to examine the level of soil and water conservation techniques by farmers in the area to maintain land use according to their carrying capacity and ability to avoid floods, landslides, and erosion.

This paper aims to examine the extent to which the community in the Upper Citarum Watershed has practiced soil and water conservation techniques in land-use practices and institutional support and community motivation in the application of the conservation practices. The information obtained from this study is expected to contribute to the formulation of policy recommendations that encourage conservation practices by the community in the Upper Citarum Watershed, especially in the areas with steep slopes.

2. Research methodology
2.1. Conceptual framework
This study is conducted using stages of screening to obtain selected sample villages. The stages are as follows [15]:

1. Upstream Citarum Watershed consists of 8 sub-watersheds: (1) Citarik, (2) Cirasea, (3) Cisangkuy, (4) Ciminyak, (5) Cihaur, (6) Cikapundung, (7) Cikeruh, dan (8) Ciwidey
2. Only six sub-watersheds with dominant farming (rural) activities were selected: (1) Ciminyak, (2) Ciwidey, (3) Cisangkuy, (4) Cirasea dan (5) Citarik, (6) Cihaur.
3. Two districts which cover 85.5% of Upper Citarum Watershed were selected, namely: Bandung (56.2%) and West Bandung (29.3%)
4. all villages in stage 2 were considered a population, namely 224 villages in Bandung district and 140 villages in West Bandung.
5. Only 221 "rural" villages out of 224 villages in Bandung and 103 "rural" villages out of 140 villages in West Bandung were selected as village population ("urban" villages are excluded)
6. Only "rural" villages with >15% slopes were selected as target village population → Bandung: 142 villages, West Bandung: 76 villages
7. Take a 10% random sample of villages → Bandung: 14 villages, West Bandung: 8 villages
8. Get an updated list of farm household (FHH) populations in each of 22 sample villages (farm households) who work as farm owner-operator, operator, and shared-cropper.
9. Take 23 FHHs, randomly (plus five reserves), in each sample village → total of 500 HH samples.
10. Make the list of FHH samples, consisting of name and address, for each sample village.
11. Check/verify the presence of FHH samples before starting an interview in each sample village

2.2. Time and location of study
The study is conducted using household survey techniques which were carried out in a total of 2 districts; 14 sub-districts; and 22 villages that distributed as follows: 9 sub-districts with 14 villages in Bandung
District and five sub-districts with eight villages in West Bandung District. Detailed research locations are presented in Table 1.

| District     | Sub District | Village         |
|--------------|--------------|-----------------|
| West Bandung | Cilikin      | Mukapayung      |
|              |              | Nanggerang      |
|              | Cipongkor    | Citalem         |
|              |              | Sarinangen      |
|              | Cisarua      | Pasirhalang     |
|              | Gununghalu   | Sirmajaya       |
|              |              | Wargasaluyu     |
|              | Sindangkerta | Mekarwangi      |
| Bandung      | Arjasari     | Baros           |
|              |              | Mekarjaya       |
|              | Cicalengka   | Dampit          |
|              |              | Tanjung Wangi   |
|              | Cikancung    | Mandalasari     |
|              |              | Mekarlaksana    |
|              | Ciwidey      | Lebakmuncang    |
|              | Ibun         | Dukuh           |
|              |              | Neglasari       |
|              | Kertasari    | Cihawuk         |
|              |              | Cikembang       |
|              | Pacet        | Cikitu          |
|              | Pangalengan  | Pulosari        |
|              | Soreang      | Sukaneagar      |

Primary data and secondary data are both collected in this paper. Primary data are collected from interviews with 499 farmers who were randomly selected in the sample villages above (Table 1). Some of the Information gathered through interviews includes community land use characteristic patterns in the Upper Citarum Watershed, soil and water conservation practices, community motivation in implementing soil and water conservation practices, and institutional support for soil and water conservation practices. Data then were analyzed using descriptive statistic analysis to obtain shares and average of the variables sought in applying conservation practices.

3. Results and discussions

3.1. Community's land cover characteristic patterns in Upstream Citarum Watershed

Using spatial analysis, [19] have identified land uses in Upstream Citarum Watershed. The research shows that in 2018, the Upper Citarum Watershed was still dominated by rice fields (17.5%), settlement (17.5%), and seasonal crops (21.2%). Figure 1 provides detailed information on land-use changes in Upper Citarum Watershed during periods 2012, 2015, and 2018.
Spatial analysis of land use conducted by [19] uses 18 different land cover classes. From the above Figure, from 2012 to 2018, there have been more than 1300 hectares of primary forests lost and only less than 2 percent left in 2018 compared to the 2012 total area. On the contrary, agroforestry plantation such as coffee has expanded by 703 hectares (37%) during the period. This expansion indicates that the need for agricultural purposes land has pushed a significant conversion of primary forest into agricultural land such as coffee agroforestry. This conversion is consistent with the Power government’s program to develop agroforestry with coffee plantations, especially forest areas, through social forestry programs. Ricefields and settlements also increased by 21% and 19.8%, respectively, from 2012 to 2018. This increase indicates the impact of high population pressure resulting in a significant expansion of land use for ricefields and settlements and a reduction in the primary forest area.

3.2. The practice of soil and water conservation techniques

According to [3], the upstream physiology condition of the Citarum Watershed is like a giant basin, or better known as the Bandung basin. The upstream Citarum watershed is surrounded by mountainous terrain and hills where the northern part is Mt. Tangkuban Perahu; to the east are Mt. Munggang and Mt. Mandalawangi; to the south is Mt. Malabar, Puncak Besar, Puntang, Haruman, Mt. Tilu, Mt. Tikukur, Mt. Guha and irregular mountain ridges in the West. Generally, the watershed area has various slope classes from moderate to very steep, with the upstream Citarum watershed elevation ranging from 625 - 2,600 m asl. Therefore, this land condition requires land management techniques following soil and water conservation principles to avoid the danger of landslides, erosion, and flooding. Soil and water conservation techniques in general, aim to achieve an improved quality of human life that can benefit...
future generations, and to be specific, the purpose of soil and water conservation is to increase land productivity and reduce the negative impacts of land management such as erosion, sedimentation, and flooding [7].

According to the Ministry of Environment and Forestry Regulation (PermenLHK) No. 105 of 2018 regarding Procedures, Supporting Activities, Incentives Provision, Fostering and Controlling of Forest and Land Rehabilitation Activities is an effort to use each parcel of land by the land capabilities and treat it according to the required conditions to prevent soil degradation so that it can be sustainable. Meanwhile, in principle, water conservation uses rainwater that falls to the ground for agriculture as efficiently as possible and controls the water flow to prevent destructive flooding and keep enough water during the dry season [2]. These are the principles that are referred to for the application of soil and water conservation techniques in land management.

There are two ways of soil and water conservation techniques according to [7]:

1. Engineering or mechanical conservation practice (mechanical methods): this includes all mechanical, physical treatments given to the land and construction of conservation buildings (technical civil structures), aiming to reduce surface runoff and erosion and increase the level of land capability.

2. Vegetative conservation practice (vegetative method): this includes all conservation practices that use plants (vegetation), both spreading legumes, bushes or shrubs, as well as trees or grasses and other plants, which are intended to control erosion and flow surface

Selection to use mechanical and vegetative land conservation techniques within one location that are based on the level of land slope, soil erosion, and solum depth is regulated in "Regulation of The Minister of Agriculture No. 47/Permentan/OT.140/10/2006 regarding General Guidelines In Mountain Land Agriculture. Based on the regulation, vegetative techniques should be applied in any agricultural lands that are potentially subject to soil erosion. Once the lands have been widely exposed to agriculture activities, they should then be combined with mechanical conservation techniques to reduce the risk. This suggested that in upper agriculture areas, farmers should apply soil and water conservation techniques.

Table 2 below shows some of the most commonly used soil and water conservation techniques described in Ministry of Environment and Forestry Regulation No. 105 of 2018, which is also described in Technical Guidelines for Soil and Water Conservation issued by the [7]. Some of these conservation such as retaining dam, controlling dam, gully plug, etc. are village level infrastructures funded by the village or through local/central government supports.

| No | Type      | Detail                                                                 | Source                                      | Picture |
|----|-----------|------------------------------------------------------------------------|---------------------------------------------|---------|
| A  | Mechanical| Retaining Dam Small dams that let water through with stone gabions or bamboo/wood trays construction built-in river channels/gorges with a maximum height of 4 (four) meters that serve to control/precipitate sedimentation/erosion of soil and runoff. | Ministerial regulation of Environmental and Forestry No 105/2018 |         |
|   | 2 Controlling Dam | Semi-permanent small dam that can hold water (does not let water through) with homogeneous earth fill construction, waterproof concrete layer (arc type) to control soil erosion, sedimentation, and surface runoff built-in river/tributaries with a maximum dam height of 8 (eight) meters. | Ministerial regulation of Environmental and Forestry No 105/2018 |
|---|---|---|---|
|   | 3 Gully Plug | Small dams that let water through are made in trenches, across the grooves, with stone, wood, or bamboo constructions. | Ministerial regulation of Environmental and Forestry No 105/2018 |
|   | 4 Waterfall construction | Buildings made at any given distance in the Water Dump (depending on the slope of the land) made of stone, wood, or bamboo are intended to reduce the speed of the water. | Ministerial regulation of Environmental and Forestry No 105/2018 |
|   | 5 Trunches | The dead-end channel functions as a temporary reservoir of water from the surface flow to be absorbed into the ground. | Ministerial regulation of Environmental and Forestry No 105/2018 |
|   | 6 Drainage | Water drainage that is made to cut contours can be strengthened by waterfall buildings and/or grass thickness. | Ministerial regulation of Environmental and Forestry No 105/2018 |
|   | 7 Water reservoir | One form of engineering water conservation techniques forms as a building that is made in such a way that resembles the shape of a dug well with a certain depth that serves as a reservoir for rainwater that falls on the roof of the house or waterproof and absorbs it back into the ground | Ministerial regulation of Environmental and Forestry No 105/2018 |
### Technical guidelines for soil and water conservation (2018)

| terrace type | Description | Reference |
|--------------|-------------|-----------|
| Terracing    | Cutting slope and leveling ground at the bottom so that a row of stairs or stairs are made. This type of terrace can be flat or tilted inward. | Technical guidelines for soil and water conservation (2018) |
| Beds         | Terraces forming the mounds are made across the slopes and are usually made on land with a gradient of 10-15%. Along the inner mounds, gently sloping water channels are formed so that they can accommodate eroded sediments. The channel also serves to flow the surface flow from the field to the sewerage channel. | Technical guidelines for soil and water conservation (2018) |
| Channel terrace | Soil and water conservation techniques in the form of making dead-end holes made to absorb water into the soil and collect sediments from cultivated parts of the land. | Technical guidelines for soil and water conservation (2018) |

#### B. Vegetative

1. **Intercropping**
   - Method of mixed cropping (polyculture) in the form of mixing two or more types of plants in one planting area at the same time.

2. **Alley cropping**
   - A method of erosion control plants forms rows of plants planted closely following contour lines to create alleyways, and seasonal crops are between the hedges.

3. **Grass strip**
   - This method is almost the same as the alley planting system, but the fence plants consist of fodder grass plants. Strips are made following contours with strip widths of 0.5 m or more.

#### 3.3. Survey results: adoption of soil and water conservation practices

Adopting conservation practices requires several factors for farmers to consider. Instead of merely being based only on environmental benefits, farmers also financially calculate these factors and expected monetary benefits from the practices. Several works of literature have shown such vital elements that may influence farmers to adopt such practices. [8] stated that farmers tend to adopt technologies and conservation techniques as long as they realize an increase in expected profitability. In addition to such monetary motivation, in farming activities, soil and water conservation practices depend upon resources.
and capital that, if possessed, might ease farmers to follow such practices. A study by [17] indicated that both natural and social capital are important factors in increasing the likelihood of adoption.

However, market incentives are not always available for farmers to generate profits from soil and water conservation practices. Maximizing production is still the only visible incentive for farmers to maximize their incomes from agriculture. According to [20], current incentives favor increased agricultural production at the expense of ecosystem services. This situation raises the attention of whether conservation practices might be feasible only for large farmers and smallholders as the majority case in many developing countries in Asia such as Indonesia. With only big farmers with abundant land and large capital who could afford the practices, we expect that agriculture in developed countries has already in line with conservation practices. However, this also might not always be the case. According to [16], despite the attractive alternatives that sustainable agriculture represents for many farmers, widespread adoption of sustainable agriculture practices has not occurred, even in a country like the United States, conservation tillage as the most commonly used sustainable practice in the country, its adoption has remained slow and low due to an economic environment that generally favors conventional agriculture.

On the contrary, several studies pointed out some possibilities for smallholders' motivation to conduct conservation practice even with small and non-owned lands. Uncertain land rights can even enhance tree planting and the adoption of erosion control measures if farmers believe that these investments will increase long-term tenure security [13]. Other policy-driven external factors may promote adoption. According to [11], credit, farm size, and proximity to an input store positively influence the adoption of soil and water conservation techniques by smallholders in Ghana.

Based on the literature's discussion above, many factors could promote adoption and no adoption of the soil and water conservation practices, and they may be unique and differ among regions/countries. Thus, a description of soil and water practices in Upper Citarum and farmers' background and capacity toward the practices is necessary to understand the unique characteristics the area has and how to approach them to promote soil and water conservation practices.

This section of the paper describes the survey results on the adoption of soil and water conservation practices by farm households in the Upper Citarum. The household survey in specific explored the practices of soil and water conservation from two aspects: Current practices within agriculture plots owned/managed by the households; Households' knowledge and experience in the practices and information and support obtained. During the household survey and interviews with farmers, detailed land use and characteristics are listed. Farmers were then presented with some conservation practices (both mechanic and vegetative practices) and asked whether they are currently adopting them in their agriculture plots.

3.4. Plot utility
There were 499 farm households surveyed in this study, and among them, there are more than 1200 agriculture plots owned and/or managed during the survey period. Most of the plots are private lands located within the village, with the size of the plots on average being 0.25 hectares. On average, a household own/manage agricultural land with a total size of 0.62 hectare that consists of between 2 to 3 plots. Even with almost half of the total plots being privately owned by the households. Still, only 21 percent of that number is supported with a legal document that should be sufficient as collateral to access the loan. Outside managing their agriculture plots, farmers also manage other party's agriculture plots through formal or informal arrangements such as renting/ borrowing or sharecropping. A significant contributor of agricultural land for lease is The State-Owned Enterprise of Forestry (Perhutani). Through Community Joint Forest Management (PHBM) arrangement, farmers could manage land that belonged to Perhutani for agriculture purposes. During the survey, such an arrangement with Perhutani covers 96 hectares or 31 percent.
The most common commodity farmed in the plots is horticulture, which is the most planted crop and acquires the largest land area with 43 percent of the total area. The most dominant type of horticulture commodity grown is vegetables that mostly are potato, cabbage, chili, and green onions. Although paddy fields are many in terms of number and even more than vegetable crops, their average plot size is only half of the horticulture plots.

In contrast, even with the number of annual crop plots being much less than horticulture and paddy, they have a much larger average size per plot. Contrary to seasonal crops planted in private lands, annual crops are primarily planted in large plot areas belonging to Perhutani through arrangements such as community-based forest management (PHBM) granted to several farmers in the area. Coffee is the leading annual commodity planted in the plots, followed by timbers and fruit trees.
Figure 3. Commodity planted and land area.

3.5. Current conservation practices in the survey area

The household survey finds that there are 450 plots currently practicing any soil and water conservation practices. This number is only a third of the total plots surveyed. Out of the total 499 farmers, only 226 of them or less than a half are practicing conservation in their plots. These data show that the adoption rate is still low in the study area; most plots and farmers in the area are still not adopting any practices.

Figure 4. Type of soil and water conservation techniques used.

Almost all conservation practices performed are a mechanical type of conservation. The most common mechanical conservation practices used are beds, terracing, and water reservoir. Mechanical conservation practices are used by farmers mostly to serve specific farming reasons such as to prevent soil erosion or improve water supplies, which in many cases farmers consider mechanical conservation are far more effective. Based on observation during the survey, on average it would take 20 to 30 man-days (IDR 50–80 thousand per day wage rate) for a hectare of a plot to build a terrace, beds, or water reservoir. A minimal number of farmers conduct vegetative conservation practices. There are 16 plots (4%) by nine households that use only vegetative conservation. From the total number of plots, concerning significant conservation practices that usually involved mechanical practices such as
terracing, building beds, ditch, drainage, and mulch, there are only 33% of them practiced any of these five practices, and that involved only 206 households or 41 percent of the total household sample.

In general, the adoption of soil and water conservation is low in all plot use categories, with seasonal plots slightly higher proportion (34%) compared to annual plots (29%). The difference between conservation practices in yearly and seasonal plots is in the most used practices. Unlike in annual plots where all conservation practices are evenly distributed, seasonal plots show different rice fields and horticulture plots. In terms of those plots that practice conservation techniques, terracing and drainage are the most common practices in rice fields. Terracing is used especially within steep rice fields to avoid erosion and improve irrigation purposes by using gravity.

Meanwhile, beds are the most common practice in horticulture plots. It indicates that for seasonal plots, which practice to apply merely depends on the type of crops and which practices are heavily in favor of the crop's maintenance. In annual crops, making ditches between trees in the plot is the most common practice to keep puddles out from the plot after heavy rain and to contain organic materials used for soil fertilizer.

![Figure 5](image_url)

**Figure 5.** The most common conservation techniques in seasonal and annual crops plots.

The fact that soil and conservation practices are primarily conducted in private agriculture plots shows that these practices are treated as a private investment by the farmers in which they expect a long-term benefit. Investing such practices for plots that have uncertain land rights might demotivate farmers to do so. However, the survey result shows no clear indication of the relationship between the ratio of owned land size to total land size managed to affect households' decision to practice conservation, nor did this indicate different practices and non-practices. On the other hand, there is a slight indication that big farmers with large and abundant land tend to practice conservation, and the non-practices are concentrated in the small landholders' farmers.
Figure 6. Scatter plots of total land area with a ratio of land owned.

Financially, there is an indication of higher average revenue for plots that practice conservation practices than those not particularly for seasonal crop plots. On the contrary annual crop, plots show lower revenue for those plots that are practicing. Both profits in yearly and seasonal crops at the household level show a higher profit for conservation practices. At the household level, households who do conservation practices in any of their plots receive total higher revenue from all the plots than those who do not. However, this might be significantly influenced by performance in other plots. There is also no clear indication that the existing market provides incentives for products from plots that practice conservation.

Table 3. Profit Comparison of annual and seasonal crops.

| PROFITABILITY IN THE LAST 12 MONTHS (For all available crops in the plot) | IDR / Hectare |
|--------------------------------|----------------|
| Annual Crops Plots | Seasonal Crops Plots |
| Observation | Mean | Observation | Mean |
| Profit per plot/ hectare | 286 | 8,620,040 | 889 | 13,400,000 |
| Non - Practicing | 203 | 9,815,279 | 594 | 12,400,000 |
| Practicing | 83 | 5,696,745 | 295 | 15,400,000 |
| Profit per household/ hectare | 190 | 13,000,000 | 447 | 26,600,000 |
| Non - Practicing | 128 | 12,100,000 | 275 | 24,700,000 |
| Practicing | 62 | 14,800,000 | 172 | 29,600,000 |

Table 3 indicates a low rate of adopting soil and water conservation practices; several key findings might be considered. Farmers’ mindset is still under the impression that conservation practices are mechanical practices that require infrastructures and should be applied within the adequate size of lands. Conservation practices with direct monetary impacts (as in seasonal crops) or directly affect maintenance efforts would likely be adopted by farmers. Also, the investment of such practices is preferable to be applied within privately owned lands to secure the investment. Even with several findings above, the adoption of soil and water conservation in the Upper Citarum is still low. Several farmers/households are still reluctant to adopt to avoid extra works and investment, arguing that monetary benefits are not adequate nor specific. This reluctance shows that factors beyond individual plots or individual household farms might influence the adoption. The fluctuating nature of individual
conditions might cause the adoption to be temporary. A better adoption requires communal efforts and local customs and policies to promote such conservation practices to grow.

3.6. Knowledge and experience in conservation practices
In addition to the current application of conservation practices by farm households, the household survey also explores farmers’ knowledge and experience in conservation practices. Furthermore, the survey included sources of information, difficulty levels, and parties who support farmers in implementing soil and water conservation practices. In terms of experience, farmers generally have adequate experience in carrying out the practices. More than 40% of farmers have experience in raised and drainage practices. For beds that are merely a terrace, only beds have a wider size and usually consist of two rows of plants that are different from mounds that have only one row of plants. This practice (beds) is the most popular among farmers; more than half of the total respondents have experienced adopting it. It is reasonable as many farmers in Bandung and West Bandung Sub-districts are vegetable farmers who mostly require beds for cultivation.

Although only around 16% of the households currently apply soil and water conservation practices on their plots, in general, most households have sufficient knowledge and experience regarding soil and water conservation techniques. This suggests that farmers with knowledge or skill in conservation practices do not certainly practice them most of the time. There are factors such as investment cost, land tenure, or expected commodity price, and others that might influence farmers’ decisions in adopting conservation practices at a certain time. Figure 1 shows the households’ level of expertise and experience in practicing soil and water conservation techniques, where they have applied the conservation practices both vegetatively and mechanically. The figure also indicates the most common practices that are ever applied by the households: beds (297 or 60% of the total household), terracing (219 or 44% of the total household), and drainage channels (210 or 42% of the total household). Beds are the most common technique applied by households, especially for vegetable farmers. A bed is a terrace that forms a ridge made across the slope and is usually applied on land with a 10-15% slope. Along the inner part of the beds formed a flat-water channel to accommodate eroded sediments.

Other techniques that have been applied are water reservoirs (183 FHH or 37% of the total household), tree planting on agriculture crops (163 FHH or 33% of the total household), and trenches (152 FHH or 30% of the total household). Conservation practices that are applied by only less than a third of households are mulch (108 KK or 22% of the total household), grass planting (64 FHH or 13% of the total household). Besides the above mechanical and vegetative conservation practices, households also use both manure and chemical fertilizers to improve soil fertility.

At the village level, soil and water conservation infrastructures have been built in several villages, which the central or regional governments fund. These infrastructures are retaining dams, controlling dams, and gully plugs.

The household survey also explored reasons that motivate households to practice soil and water conservations. Respondents were asked several reasons to choose from for each conservation practice where farmers can answer more than one reason. The result, as shown in Table 4, indicates that some reasons surpass others. Prevent erosion is the most common reason for households to apply conservation practices, especially for plots with a steeper slope. These steep plots are mostly used for horticulture farming and only a quarter of them are located in the West Bandung District which is relatively more rural between the two districts. Most farmers learned the techniques from fellow local farmers (more than 70%) with average land holding 0.75 hectares. Vegetative conservation practices such as planting grass and trees are also mostly used to prevent erosion. Some of the most common conservation practices applied by farmers, such as beds and mulch, are, on the other hand, mostly done for maintenance purposes. The reason for these practices is because they make plant care much easier. The same opinion also applies to village-level conservation infrastructures. Households view these infrastructures such as retaining or controlling dams and gully plugs to be mostly built to prevent erosion. Some other reasons for applying conservation practices are for the effectiveness of farming daily maintaining activities such as to keep fertilizer from eroded by water and improving water supply.
Table 4. Reasons for conservation practice.

| Type of Practice | Prevent erosion | To improve water supply | To maintain improve fertility | To maintain climate | To ease plant care | Other |
|------------------|-----------------|-------------------------|------------------------------|--------------------|-------------------|-------|
| Terracing        | 54%             | 10%                     | 6%                           | 0%                 | 18%               | 10%   |
| Beds             | 9%              | 14%                     | 14%                          | 0%                 | 52%               | 11%   |
| Trunches         | 8%              | 26%                     | 24%                          | 0%                 | 24%               | 18%   |
| Drainage         | 22%             | 18%                     | 9%                           | 0%                 | 19%               | 32%   |
| Mulch            | 5%              | 3%                      | 10%                          | 0%                 | 58%               | 25%   |
| Grass            | 39%             | 1%                      | 6%                           | 3%                 | 0%                | 51%   |
| Water reservoir  | 0%              | 82%                     | 2%                           | 0%                 | 14%               | 1%    |
| Trees planting   | 49%             | 7%                      | 6%                           | 12%                | 2%                | 24%   |
| Water infiltration| 10%             | 42%                     | 16%                          | 16%                | 0%                | 16%   |
| Retaining dam    | 77%             | 17%                     | 1%                           | 0%                 | 0%                | 5%    |
| Controlling dam  | 82%             | 18%                     | 0%                           | 0%                 | 0%                | 0%    |
| Gully Plug       | 59%             | 30%                     | 2%                           | 0%                 | 0%                | 10%   |

The other important aspect discussed above regarding conservation practices by households is supporting that received by households in both forms of information and direct assistance. This information and assistance are essential for policy intervention to promote soil and water conservation practices among farmers. Which channels of information are effective to farmers, and what types of assistance have been distributed to farmers for these conservation practices. The figure below shows the sources of information that households learned at the first time of how to do conservation practices.

Figure 7. Sources of information of households to learn conservation practice.

Soil and water conservation practices required information and learning from external parties. Exposure to information was the most critical variable [5]. However, farmers have already possessed local wisdom in their farming practices, such as making beds or other common conservation practices.
The above figures show that for almost all the soil and water conservation practices except for water infiltration wells, households learned how to do the practices from fellow local farmers who are mostly their neighbors, friends within the same village, or outside the village. The statistic is high on average, 69% of conservation practices information came from local farmers. In the case of water infiltration wells, the highest source of information is from the government extensions, making sense as this practice is more technically engineered. The only other source of information for soil and water conservation practices is government extension, and no other sources show any significant number. This result concludes that for soil and water conservation practices, there are only two channels that effectively inform and train farmers through fellow local farmers and government extensions. This conclusion is confirmed by [1] that the information sources about soil and water conservation techniques used by farmers in the Upper Citarum Watershed are very diverse, but family and cultural assets seem to be the most important sources. Further, the farmer organizations are important in terms of information dissemination, which describes the willingness of the farmers to learn more about soil and water conservation techniques as high [1].

For assistance in soil and water conservation practices, households would need supports from relevant institutions for continuous applications and improvements. In identifying this support, the household survey explores through questions on any institution or other parties who provide assistance and the form of assistance (cash, material, training, equipment, maintenance, etc.). A well-designed system of environmentally determined subsidies can compensate for otherwise substantial differences in owners' and tenants' attitudes towards soil conservation [18]. The household survey indicated by the figures below shows that the local agriculture office is the dominant source of farmers' assistance in conservation practices. Forestry Office is another government institution that provides such assistance, especially in tree planting. The other institution which also offers reasonable service in conservation practices is watershed agencies. However, the watershed agencies focus more on village-level conservation infrastructures such as retaining or controlling dams and gully plugs.

Figure 8. Sources of assistance for soil and water conservation.
Various government programs have been implemented to support Soil and Water Conservation Practices in the Upper Citarum Sub-watershed area. As explained in the previous section, the Bandung District Agriculture Service has facilitated plant nurseries such as coffee, agarwood, macadamia, eucalyptus, and cloves [22]. This assistance program develops soil and water conservation practices in a vegetative technique, namely intercropping planting activities. [12] indicated that the adoption depends on several farm and farmer characteristics, and the relative importance of these factors differs across sites. According to [9], a program that pays farmers to plant grasslands over-rides the effect of insecure land tenure and creates incentives for owner-operators and tenant farmers alike to use crop management that protects soil fertility in the long term. To improve land cover in the Upper Citarum watershed, the Bandung district government has implemented a Kampung Kopi development program through a Bandung District Regulation since 2016 in the Pangalengan District agroforestry system. Meanwhile, the Ministry of Environment and Forestry, through the Management of Watershed and Protection Forest Office in the Citarum Ciliwung watershed, has carried out a series of activity programs such as the construction of technical civil buildings for soil and water conservation, namely gully plugs, control dams, retaining dams, water reservoirs, and ditches. For vegetative conservation activities, the Management of Watershed and Protection Forest Office in Citarum Ciliwung Watershed has helped provide community nurseries for woody plants [4].

The forms of assistance received by farmers can be varied; thus, the household survey also explores the types of assistance received by respondents. The survey shows that the most dominant forms of assistance toward conservation practices are either materials or training. For vegetative conservation techniques such as planting trees and grass or technical engineered techniques such as water infiltration wells, the form of assistance is dominated by material support. Meanwhile, the most common conservation practices such as terracing, beds, ditch, and drainage are mostly through training. This reason is based on observation during the survey is that farmers, in general, have independently initiated to apply the practices.

Figure 9. Forms of assistance given to households for soil and water conservation practices.
3.7. Challenges for succeeding in soil and water conservation practices in Upstream Citarum Watershed

Several studies have shown that good soil and water conservation practices will help reduce land degradation, as the results of research by [21] state that conservation technologies of soil and water are efficient in reducing runoff and total sediment yield. However, there are several challenges faced by the community in implementing this soil and water conservation practice. Based on the Citarum Watershed Management Action Plan Report [6], it is concluded that several socioeconomic problems existed in the Citarum Watershed are:

1) Poor law enforcement and legal regulations, primarily to deal with vandalism and exploitation of the Citarum watershed area.
2) Community participation low level in integrated watershed management is due to a lack of discipline and an absence of community culture that upholds watershed functions.
3) Conflicts over the natural resources use in both community and State and between the community and the private sector.
4) Energy security is weak within communities surrounding Citarum Watershed.
5) Health-problems cases are high within communities surrounding Citarum Watershed.
6) Resilience and food sovereignty are low within communities surrounding Citarum Watershed.

Some of these problems become issues in the management of the Citarum watershed. From the analysis results, there are several fundamental problems in land use in the Upper Citarum watershed that affect the success rate of implementing this soil and water conservation technique. The first issue is the limited land allocation for farmers. Most of the land in the upper Citarum watershed is forest estate, plantations and only a small part is private land. Meanwhile, the local community's culture is farming. The small amount of farmers’ land encourages them to meet their land needs by encroaching on the plantation and the forestry land for agricultural use [14]. This encroachment has resulted in significant land changes, i.e., a decrease in forest cover from 2012 to 2018 from 1,382 hectares to 26 hectares. Meanwhile, Ricefields and settlements also increased by 21% and 19.8% from 2012 to 2018 [19]. This condition induces the occurrence of critical land in the upper Citarum watershed covering an area of 77,037.36 hectares, which impacts soil erosion, floods, landslides, drought, river sedimentation, and decreased soil fertility, and a further impact on increasing temperatures.

The high population growth is one of the factors in the emergence of limited land for farmers, resulting in the encroachment of forest-covered areas, an increase in rice fields and settlements. It is also confirmed by [21] that rapid changes in upland farming systems in Southeast Asia were generated predominantly by increased population pressure and ‘market forces’ which induce widespread land degradation. The other research showed that the increased demands for water and land in Indonesia due to population growth and economic development had impacted the spatial and temporal variability of human-induced hydrological changes in a river basin that could affect the quality and quantity of water. This condition leads to river sedimentation, particularly due to anthropogenic factors caused by human activities such as uncontrollable deforestation, land degradation, land-use change, and unsustainable agricultural practice [10].

Based on Central Bureau of Statistics data in 2019, the population density of Bandung District is 2,142 people / km², with a population of 3,775,279 people and a growth rate of 1.56% per year. The poverty rate profile in Bandung District in 2019 was 5.94% or 223 thousand people, with the highest concentration in the upstream area of the Citarum watershed. The culture of the local community is farming; therefore, they use the land predominantly for agriculture, particularly for planting vegetables, because it generates relatively fast and continuous income. This condition is the main challenge in implementing soil and water conservation practices in the Upper Citarum watershed. Due to the weak socioeconomic conditions that can be seen from the high poverty rate and the low level of education, the vegetable cultivation practices in the high slope land in the upstream area are dominant. Most of them do not apply soil and water conservation practices. It can be seen from the survey results that only 45% of the respondents applied to soil and water conservation techniques.
Another challenge in the land use in the upstream Citarum watershed is related to land tenure. There is a lot of the land owned by migrants or people outside the village area. Local people are only cultivators. The landowner certainly more controls decisions in land management and land-use practices. If the land is managed for commercial purposes, the owner will prioritize cost efficiency and fast yields.

Meanwhile, soil and water conservation techniques require costs and time-consuming processing, which become an inhibiting factor in implementing conservation techniques. Another problem is the inconsistency of land use with regional spatial patterns. Based on the Upper Citarum spatial pattern regulated by the Regional Regulation of West Java Province, the northern and southern regions of the upstream Citarum are managed with a Protected Area plan, with a percentage of Protected Areas of 48% and Cultivation Areas of 51%. However, in the actual field, there is a lot of encroachment in this protected area. This encroachment causes challenges for the application of soil and water conservation techniques, especially in cultivated areas.

4. Conclusion and recommendations
Based on the household survey data, the study indicated that the soil and water conservation practices in the upper area of the Citarum watershed have been introduced to and implemented by almost half of household respondents (45%). The type of conservation practices mostly used are terracing, beds, and drainage. Nevertheless, from 499 samples, there is less than 50% implemented the soil and water conservation practices in their plots. It suggests that the assistance government program has been less effective in encouraging farmers to practice soil and water conservation in the upper area of the Citarum watershed. Consequently, since rice fields, settlement, and seasonal crops still dominate land use in the upper Citarum watershed, the assistance program still needs to be improved and intensified, mainly to enhance planting trees and annual crops. The roles of government institutions in the assistance programs of soil and water conservation practices must be strengthened. These include the District Agriculture office as the main institution in the assistance program of soil and water conservation practices, the forestry service office related to assistance program of planting trees, and watershed management agencies in facilitating constructing the retain or control dams gully plug. From the household survey data, it is found that the knowledge of soil and water conservation practiced by farmers comes from their environments, such as among farmers in their neighborhood and less from a government institution. It implies that soil and water conservation practices must consider and enhance local community participation. The government must support planting trees and grass to vegetative conservation techniques, material supports for specialized engineered techniques, and thorough training regarding standard conservation practices such as terracing, beds, ditch, and drainage for the farmers.

This study recommends several policy directions include strengthening the direction of incentive policies for farming communities that practice soil and water conservation in the corridor of Spatial Use Control policies through the realization of sustainable food agriculture areas. Incentives that can be given are easy market access and a premium price for farmers who practice soil and water conservation techniques. Also, the provision of assistance for seedlings for planting is directed at woody plants that function as soil protection and have high economic value, such as vetiver, lemongrass so that the farming is sustainable from social, economic, and ecological aspects. It is also important to encourage farmers to transform commodities by replacing vegetables with crops that are economically valuable but good for conservation, including Multi-Purpose Tree Species of avocado, macadamia, palm sugar, etc., as well as types of shrubs or grasses such as coffee, tea, elephant grass, lemongrass. Also, farmers in the upstream area of the Citarum watershed need to be encouraged to practice planting with an agroforestry system. The incentive policy as described earlier must also be able to target farmers who transform commodities and apply this agroforestry system.

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