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Soil Damage Control Techniques Based on Local Wisdom in Sumberbrantas Village, Batu City

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Abstract: Sumberbrantas village faces potential soil damage due to agricultural intensification for biomass production on sloping land with high erosion rates. The importance of soil conservation through the local wisdom approach encourages this research to explore soil damage control techniques the local community applies. This study aims to identify local wisdom-based soil conservation techniques applied in land management for biomass production. The methods used included structured interviews with 90 respondents who work as farmers/gardeners, followed by field observations and documentation to collect primary data on community characteristics, land use, and conservation techniques. The results showed that the community applied conservation techniques in crop rotation, intercropping, and terracing as the primary efforts to reduce soil damage. Organic fertilizers, simple technologies such as hoeing, mechanical methods in the form of rolling terraces, and vegetative methods in the form of ground cover plants are also commonly applied. Most communities have gained this knowledge from generation to generation and through regular counseling. Land management based on community wisdom in Sumberbrantas Village effectively maintains land productivity while preserving the environment. These techniques reflect the community's adaptation to environmental challenges, with the potential to be further developed through modern innovations and local traditions.

Keywords: Biomass Production, Local Wisdom, Soil Damage Control

Introduction

Soil is the most complex and diverse ecosystem in the world; in addition to living space, this natural resource also has a strategic role in people's lives as a producer of biomass, such as food, fiber, wood, and medicinal materials (Suzana, 2019). Biomass has been produced many years ago in various fields to support human needs. The utilization of biomass includes as a source of food, industrial raw materials, and environmental conservation agents (Hidayat et al., 2019). Soil plays a vital role as a medium for biomass production, so its use must be regulated, guarded, and maintained so that its biomass production function is not disturbed. Soil also provides minerals and nutrients for plants; if the soil loses nutrients, plants cannot grow properly. The limited availability of soil resources and the rapid growth of the human population will increase consumption rates, placing unprecedented pressure on soil through the intensification of agricultural production (Kopittke et al., 2019).

Land resources cannot be separated from the soil on the land, and external factors will affect them (Putra et al., 2018). Soil can experience a decrease in productivity, generally caused by land use that exceeds the carrying capacity so that damage occurs (Nurhartanto et al., 2022). Intensive cultivation, improper cultivation methods, and external factors can decrease soil quality (Darmanto et al., 2021). Community behaviour, which can be identified based on the management of cultivated land, referred to as anthropogenic factors, is one factor affecting soil degradation for biomass production (Lias & Syahrul, 2021). This aligns with the research results by Rusdiyana et al. (2021) that local communities in Indonesia play a role in conservation through traditional land management based on local wisdom. The lightness or severity of soil degradation status for biomass production in an area is inseparable from anthropogenic factors that seek soil conservation techniques on cultivated land resources.

Land utilization for biomass production activities in the form of agriculture and plantations in Sumberbrantas Village reaches 512 Ha or around 78.82% of its total area. The village, dominated by agricultural land in moorland, is located on the slopes of Mount Arjuno-Welirang. Hence, the landscape in this area is generally in the form of hills to mountains, with slopes ranging from 25% to > 45%. Agriculture on land with a high slope level has a very high risk of erosion, which can decrease soil fertility (Sumantri, 2011). The rainfall condition of Sumberbrantas Village is relatively high, reaching 2,229 mm/year, which is dominated by the soil orders andisols, inceptisols, and entisols with fertile soil characteristics but easily eroded.

The physical condition of the research area illustrates the high potential for soil damage in Sumberbrantas Village if tillage activities are carried out continuously without any conservation efforts. The diversity of patterns of adaptation to the environment that exist in the community and are passed down from generation to generation eventually become guidelines for controlling soil damage in the form of soil conservation techniques, which are then known as community wisdom-based conservation techniques. The active and conscious role of the community in carrying out conservative land management is one of the functions and implementation of local community wisdom (Teshome et al., 2014). Therefore, soil damage control based on community wisdom must be studied and preserved in a community group to maintain the balance and sustainability of land and soil resource functions. This study aims to determine soil damage control techniques implemented by the Sumberbrantas Village community based on local wisdom in land management for biomass production.

Methods

The research area is in Sumberbrantas Village, Bumiaji Sub-district, Batu City, East Java Province (**Figure 1**). The analysis of soil damage control techniques implemented by the community in the research area went through several stages. It began with preparing a questionnaire as an interview guide with respondents. The substantial components in the interview questionnaire related to community wisdom in land management and soil damage control include respondent characteristics, land ownership and control, and understanding of land management activities and soil damage control.

The population of interview respondents was the total number of people in Sumberbrantas Village who work as farmers/gardeners, namely 1,767 people, which was obtained based on village monographic data. The number of people who work as farmers/gardeners in the study location is relatively large, so a sample of respondents was drawn using the Krejcie and Morgan formula (1970).

Based on calculations using the Krejcie and Morgan formula, a sample size of 90.07 was obtained and rounded up to 90 respondents, which was carried out randomly for people who work as farmers/planters in three hamlets in Sumberbrantas Village, namely Dusun Lemah Putih, Krajan and Jurang Kuali. The criteria for determining the sample focused on people who knew or had competencies by the research objectives; in more detail, the research respondents were limited to a minimum farming experience of 2 years and at least 20 years old.

The interview technique was an open-ended interview with a list of questions prepared in advance. The interview data were then processed and presented in the form of diagrams to show the variation in the answers of the sample respondents and their distribution. Data related to the research was collected through a primary data survey conducted from October 10 to October 20, 2024. This research was also completed with photo documentation to provide an overview of the environmental conditions of the research area.

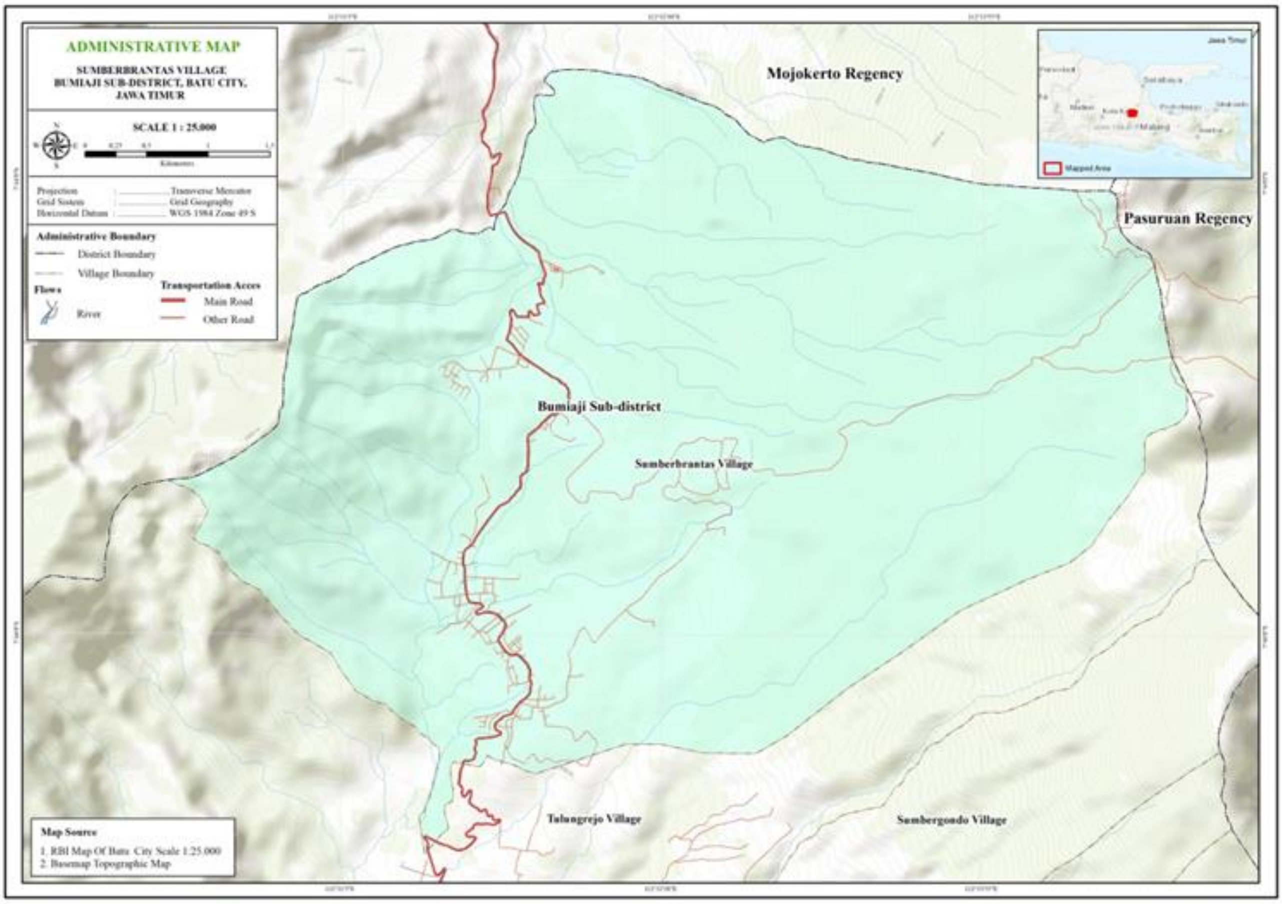

Figure 1. Administrative Map of the Study Site, 2024

Results and Discussion

Land management and soil damage control techniques based on local wisdom applied by the community in Sumberbrantas Village were obtained based on the results of primary data collection through the interview method with several respondents who work as farmers or planters in the research area. The results of the interviews with 90 respondents in the research area are described as follows.

A. Respondent Characteristics

In detail, the characteristics of respondents in the study area include the number of family members, number of family members working as farmers/gardeners, gender, age, farming experience, and latest education, presented in graphical form as in **Figure 2**.

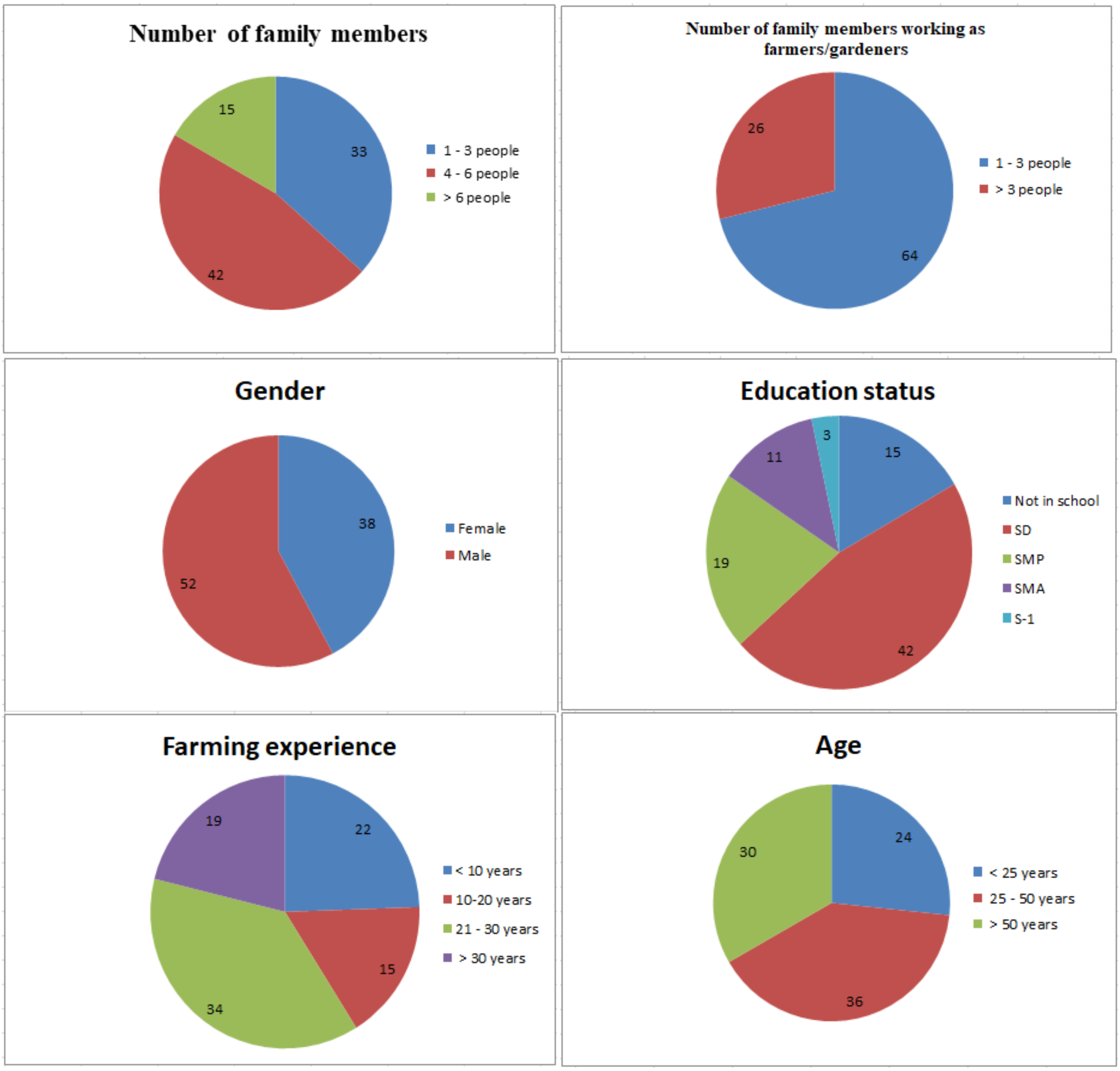

Figure 2. Characteristics of Respondents in Sumberbrantas Village

Generally, in the study area, a family consists of four to six people, including a mother and father and two to four children. A total of 33 respondents have one to three family members, which can occur because some other family members choose to work or continue their education outside the area, so usually, the families who remain in the village are parents and farmers. In addition, 15 other respondents typically have more than six household members living in one house. In more depth, interview data was obtained regarding the number of household members who work as farmers/gardeners. Based on the diagram in Figure 2, 64 respondents with 1 to 3 family members carried out land management and tillage activities or worked as farmers/gardeners. Furthermore, 26 respondents with more than three family members cultivate agricultural activities in the study area.

The research respondents were dominated by men 52 people, and female respondents as many as 38. Based on age, research respondents are divided into three categories: the age under 25 years, as many as 24 people; ages 25 to 50 years, as many as 36 people; and the age category above 50 years, as many as 30 people. The age of farmers is one of the benchmarks for the success of farming activities; Romadhoni (2022) revealed that in the age group of 30 to 50 years, the productivity of farmers looks higher than in the age group < 25 years and the age group > 50 years, it is influenced by the physical ability of farmers in managing their farms. In addition to the age factor, agricultural labour productivity is also influenced by one's farming experience or length of time. In the research area, data was obtained that farmers generally have an average farming experience of 21 to 30 years. As many as 19 respondents explained that they had experience cultivating agricultural land for more than 30 years. This means that the longer a person is engaged in farming, the more experience they will gain in managing land and including efforts to control soil damage due to these agricultural activities.

Based on data collection in the field, information related to the latest education of 90 respondents was obtained, namely no school, elementary school, junior high school, high school, and university degree. One factor that influences people to implement conservation activities is knowledge, which is characterized by the level of education (Yanti, 2018). The higher an individual's education level, the more straightforward information can be received by that individual. Conversely, if an individual's education level is low, the information delivery rate can be lower. Based on the results obtained in the field, the education level of the Sumberbrantas Village community, which worked as the last elementary school education, dominates farmers. Although the people of Sumberbrantas Village generally have a primary school education, they quickly receive information about land conservation techniques and soil damage control by seeing it directly and being taught by their parents. Thus, the community in the research area can also receive information well based on each individual's visual experience and then practice directly.

Figure 3. Interview with Respondents

B. Land Ownership and Tenure

Land, the subject of agriculture, is essential in people's lives as a place for biomass production in the research location. Analysis components related to land include type of land use controlled, land tenure status, land area controlled, and utilization of agricultural products. Detailed data recapitulation results can be seen in **Figure 4.**

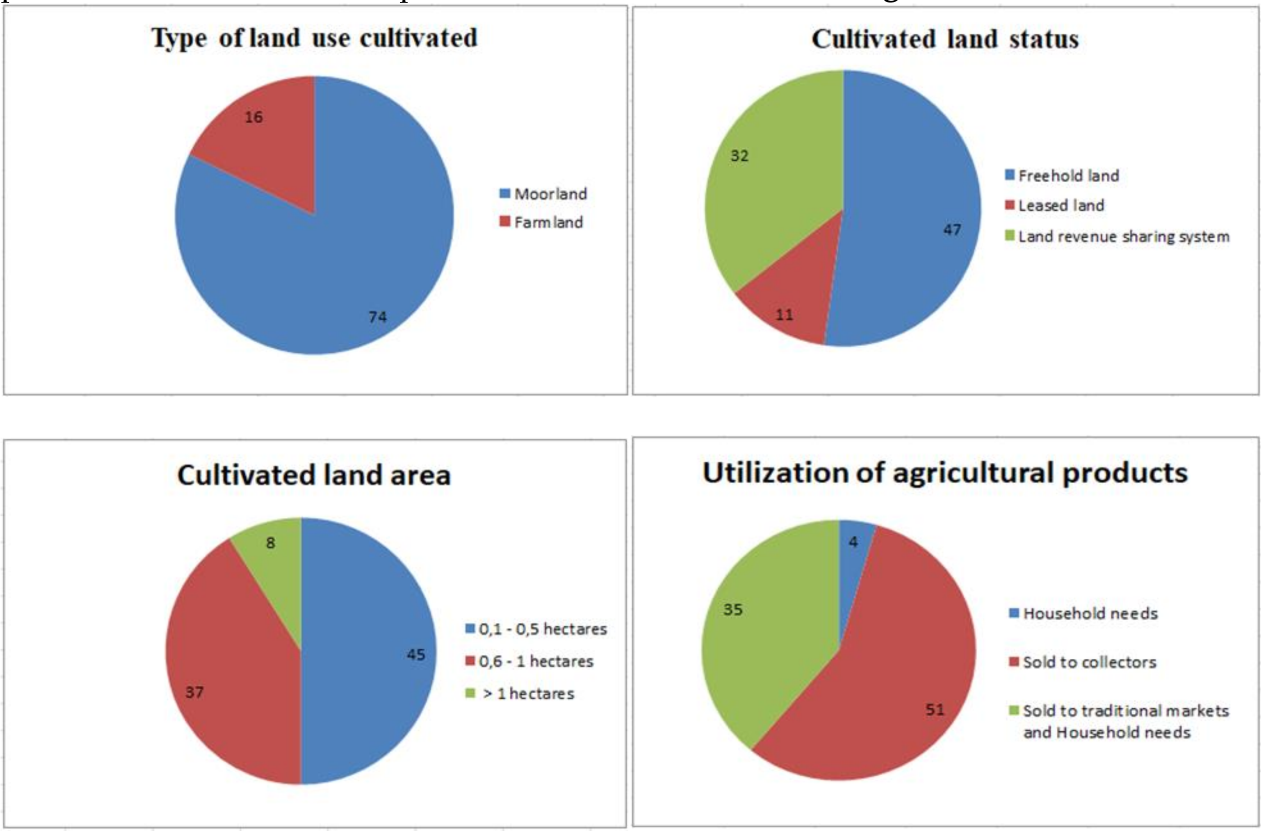

Figure 4. Land Ownership and Tenure in Sumberbrantas Village

Field data collection shows that the type of land used by the community on each piece of land is dominated by moorland and farmland, with a comparison shown in Figure 4. The characteristic of moorland in the research area is dry land in the highlands with a slope reaching more than 45%, which depends on rainwater. The community utilizes its moorland by planting seasonal crops, such as potatoes, carrots, mustard greens, cauliflower, and leeks. Based on field observations, people in the research area generally cultivate different seasonal crops from one land to another in the same period. The type of land use in the form of farmland cultivated by the community in Sumberbrantas Village is an orchard in the form of apples and oranges, where the two types of fruit are superior commodities in the village and are used as one type of ecotourism in Batu City.

The status of agricultural land tenure for biomass production in Sumberbrantas Village, whether in the form of moorland or farmland, is generally privately owned. However, around 11 respondents said that the land they cultivate is rented land with a rent payment system at the end of each year. As for the tenant farmers in the location, they apply a profit-sharing system with the landowner, the tenant farmers who carry out land cultivation activities and comprehensive soil damage control efforts on the cultivated land.

The area of agricultural land owned by the community varies; generally, land with an area of more than one hectare up to three hectares is privately owned and cultivated by themselves. For agricultural land, up to 0.5 hectares are cultivated with rental status and profit sharing, and land with an area of 0.6 to one hectare is generally self-owned or has rental status.

Biomass production in the form of seasonal vegetables and fruits in Sumberbrantas Village is generally sold directly to collectors with a direct selling system on the farm, and the buyer carries out the harvesting process. Usually, the direct selling system to collectors is carried out by people with sizeable agricultural land with the status of their land. In addition, some people use biomass production directly for household needs or daily life fulfillment. Others are sold independently to traditional markets outside Sumberbrantas Village; by selling outside the village, local people usually get a more significant profit when compared to selling directly to collectors.

Figure 5. Types of Land Use include Moorland and Farmland in Sumberbrantas Village

C. Understanding of Tillage Activities and Soil Damage Control

To analyze the techniques implemented by the community in Sumberbrantas Village based on local wisdom in land management and soil damage control, information related to the community's understanding of land or soil management activities in the form of planting patterns, planting techniques or models, technology used in tillage, types of fertilizers used, community activeness in extension activities related to agriculture, and efforts to control soil damage that are cultivated by the community are essential to study. The results of the recapitulation of the interviews with the respondents are presented in **Figure 6.**

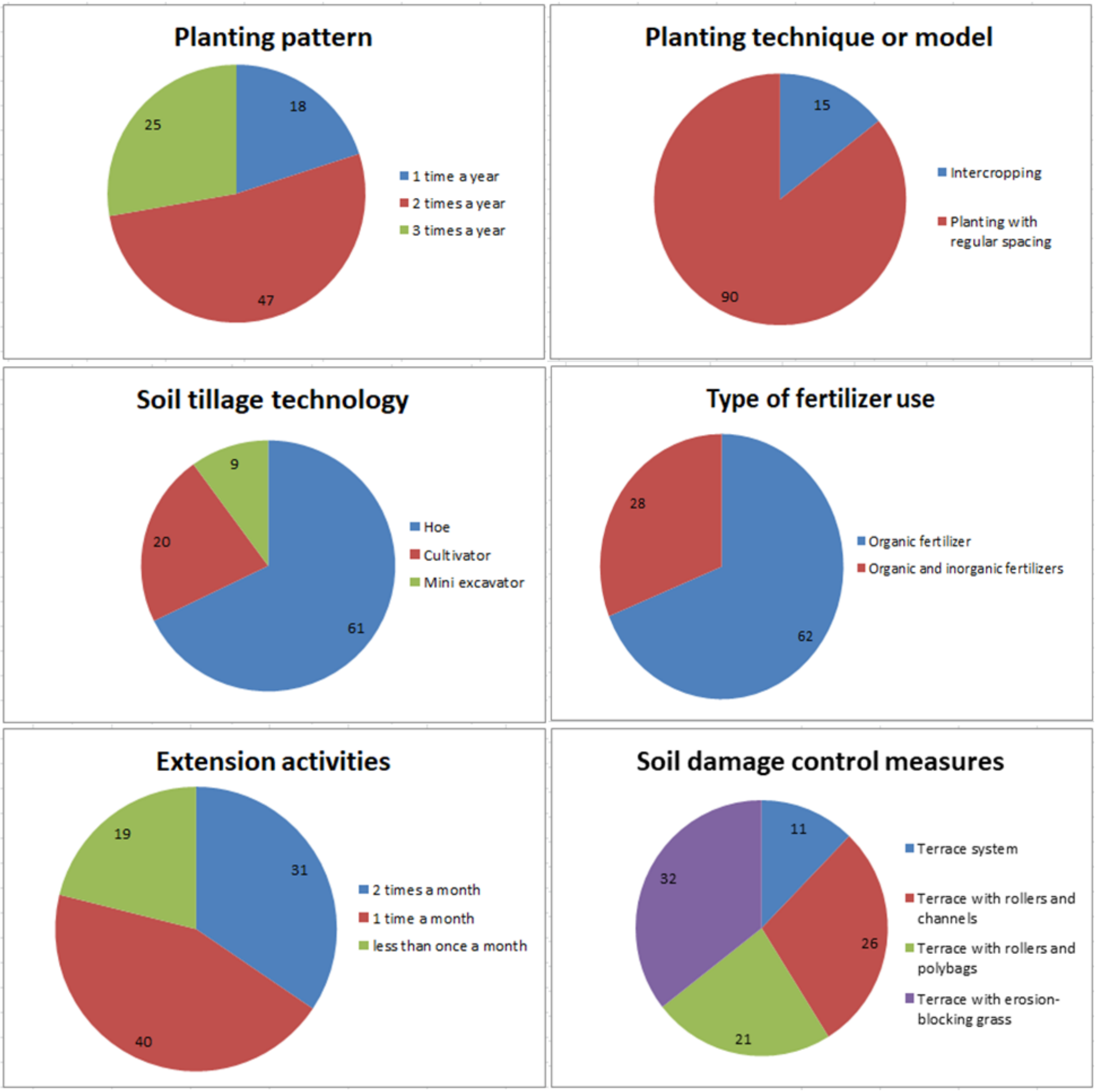

Figure 6. Community Understanding of Land Cultivation Activities and Soil Damage Control in Sumberbrantas Village

The community in the research village applies several cropping patterns or rotations, where the determination of the cropping rotation depends on the type of commodity being cultivated on the land. Generally, the community applies cropping rotations twice a year, especially for moorland with vegetables such as carrots and potatoes. Planting with a 2-time rotation system is usually done at the beginning of the year in the rainy season, around January to March. Furthermore, the community conducts a fallow system or the process of resting agricultural land to provide time for soil fertility recovery, around April to June or mid-year. The second planting begins again during the rainy season at the end of the year, around September or October. As many as 25 respondents said they apply crop rotation three times a year with the type of vegetable commodity in the form of leeks because this type of vegetable has a relatively faster planting period and can be harvested 60 to 90 days after planting, depending on the growth conditions. The application of cropping patterns or rotations once a year is reserved for garden land and crops such as apples and oranges.

The system of resting agricultural land after two crops is land management that aims to restore soil fertility while reducing environmental pressure due to farming activities. The benefit to soil productivity is that the soil has time to recover the nutrient content depleted during the previous cropping cycle by resting the land. The natural organic matter decomposition process can run better without interference from agricultural activities. In addition, during the resting period, the soil's ability to retain water increases due to better soil structure and increased organic matter content. By giving the soil time to "breathe," long-term biomass productivity can be improved while maintaining soil stability. Based on interviews, local communities recognize that limiting the crop rotation system to 2 times a year will positively impact soil fertility and improve yield quality. The research results from Hadriansyah et al. (2017) show that land fallowing is a natural process that aims to restore and enhance soil fertility by leaving land uncultivated for a certain period.

Based on the results of interviews and field observations, the local community applies planting techniques in the form of intercropping models and regular spacing models. Intercropping is simultaneously planting two or more crops on a piece of land. The community applies the intercropping model between apples and vegetables in the form of leeks and between chili peppers and leeks. Intercropping systems can increase agricultural land productivity if the types of plants combined in this system form mutually beneficial interactions (Vandermeer, 1989). Plants grown by intercropping can provide maximum yields and are more profitable than those grown in monoculture (Warman, 2018).

Figure 7. Intercropping Technique in Sumberbrantas Village

The intercropping practice between perennials such as apple trees and vegetables applied by the Sumberbrantas Village community has many benefits; in addition to optimizing land to be more efficient, another important role is as a soil erosion control because the roots of perennials help hold the soil, while vegetables protect the soil surface from erosion due to rainwater. According to the findings of Warman and Kristiana (2018), annual crops planted together with other types of plants produce better productivity because these plants can fix nitrogen used by surrounding plants.

In addition to regularly spaced rows with terrace mounds. Regularly spaced planting using mounds has several essential functions and benefits, especially in agricultural practices. *Guludun* is a technique of creating taller and denser soil beds or dividers, often used in agriculture to regulate drainage, provide crop space, and improve growing efficiency. *Guludan* helps water to flow correctly between crop beds, reducing the risk of waterlogging that can lead to root rot or plant diseases. In addition, it can help reduce soil erosion, especially on sloping land. With higher and neater mounds, rainwater does not easily carry fertile soil down, and the soil becomes more stable. *Guludan*, in the direction of the contour line, serves to shorten the length of the slope and/or minimize the slope by digging and reducing the soil across the hill (Permana, 2017).

Figure 8. Regular Spacing Pattern with Terrace Mounds in Sumberbrantas Village

Applying the regular spacing planting technique with terrace *guludan* in Sumberbrantas Village is very suitable for overcoming the physical conditions of the area with high rainfall and steep topography. Regularly planted crops help slow down the flow of rainwater on the surface of sloping slopes. Furthermore, the *guludan* structure can help stabilize the slope and prevent landslides or soil erosion. This local conservation technique can physically strengthen the slope by providing a natural barrier to soil movement.

Land management activities on agricultural land for biomass production in Sumberbrantas Village include clearing the soil, plowing and loosening it, applying fertilizer (organic matter), planting seeds, and maintaining plants until harvest time. The community uses tillage technologies such as hoes, cultivators, and mini excavators in land clearing and plowing activities. Hoe is a tool used to turn, break, and flatten the soil on agricultural land plots (Sari, 2020). Based on the results of interviews, most people use this manual tool in cultivating the soil because the hoe puts less pressure on the soil so that the soil structure is maintained and does not cause excessive soil compaction. Excessive soil compaction can hinder the movement of water, air, and plant roots, ultimately reducing soil fertility. Tools such as cultivators and mini excavators are also used in cultivating the land by communities in the study area, although not as much as hoes.

Using manual tools, such as hoes, commonly found in the research location, has a good socio-economic impact on the local community. Regarding operational costs, homes are more affordable than modern tillage tools and do not require fuel or engine maintenance.

In addition, hoes are often used in cooperation with the farming community (*GAPOKTAN*) of Sumberbrantas Village, thus strengthening social relations between farmers and increasing the spirit of togetherness.

Figure 9. Utilization of Tillage Technology in Sumberbrantas Village

Farmers use organic and inorganic fertilizers to support soil fertility and crop resilience. Applying organic fertilizer to the land has the highest percentage of use in the study location, in the form of manure from chicken, goat, and cow manure, which is done before planting. Based on information obtained from Mr. Joni, the Head of *Gapoktan* in Sumberbrantas Village, the manure used by the community is obtained either from independent livestock or from buying from outside the area. He continued that a land area of 1,000 m^2 requires about two to three colts. Chicken manure is the manure that farmers often use with a price of around IDR 220,000.00 per colt, and goat manure ranges from IDR 180,000.00 per colt. Inorganic fertilizers in the form of insecticides and pesticides are applied about once every two weeks, along with watering in the afternoon. Several fertilizers fertilize plants and spur fruit growth, including POSKA, ZA, MPK, and Hydro white.

Organic matter increases soil cation exchange capacity, pH, and nutrient content. Compost and organic fertilizer are two organic materials that can be used (Yuniarti et al., 2020). This theory aligns with land fertilization efforts generally pursued by the community in Sumberbrantas Village, which utilizes manure (chicken, cow, and goat manure) as organic material when preparing land for planting. This effort neutralizes the soil pH in the research location and encourages more optimal plant productivity.

Organic fertilizers, such as chicken and goat manure, provide significant economic benefits to the local community. With relatively affordable prices, farmers can reduce their dependence on chemical fertilizers, which tend to be more expensive and fluctuate in price. In addition, the availability of organic fertilizer from independent livestock in the village also reduces additional costs for purchase while creating economic opportunities for other farmers who sell the fertilizer. Using organic fertilizers also improves soil fertility naturally, reducing the long-term need for additional fertilizers and extending the productivity period of the land, ultimately increasing yields and farmers' income.

One aspect of efforts to convey knowledge about soil damage control techniques can be done by counseling the community. Most Sumberbrantas Village community members have participated in extension activities related to soil conservation. The number of meetings of respondents in extension activities can be seen in **Figure 6**. Providing counseling on conservation activities for the community that involves the source of information and the recipient of the information is one of the effective methods (Siswanto et al., 2021).

Soil damage control efforts applied by the Sumberbrantas Village community use mechanical and vegetative methods. People who apply this mechanical method are characterized by making terraces, rolling terraces and channels, rolling terraces and polybags, and rolling terraces with erosion-blocking grass. According to (Zhang et al., 2021), building rolling terraces on sloping land can reduce surface flow, control erosion, and increase crop yields. According to (Yurisinthae, 2024), the construction of water channels aims to facilitate the use of water according to the needs of plants and also become a water source for the land. To further reduce the effects of soil erosion due to the erosivity of rainwater, the community also combines the rolling sloping terrace system with a polybag planting system, which is specialized for leek vegetables. Some other communities have taken the initiative to plant grass on their mounds to prevent dissolved sediments from being washed away.

The application of terracing techniques, including channeled rolling terraces, polybag rolling terraces, and rolling terraces with erosion-blocking grasses, plays a vital role in soil conservation on sloping land. These techniques reduce the speed of rainwater flow on the soil surface, thus preventing erosion and loss of fertile topsoil. Channeled rolling terraces effectively direct water flow to drains, preventing puddles that can damage crops. Polybagged rolling terraces support individualized crop management, improving space-use efficiency and minimizing erosion damage. Meanwhile, using erosion-blocking grasses on rolling terraces helps strengthen soil structure with dense root systems, creating natural barriers to water flow. These techniques maintain land productivity and support environmental sustainability in the high-slope study area.

Research conducted by Diu et al. (2023) revealed that terrace conservation is an effective and efficient solution to utilize sloping land in crop cultivation because this technique plays a fundamental role in supporting growth and increasing crop production yields. In addition, terrace mounds positively impact plant height growth because they can hold water when it rains. Furthermore, the water retained in the terrace canals acts as a solvent that helps plants absorb nutrients from fertilizers more easily.

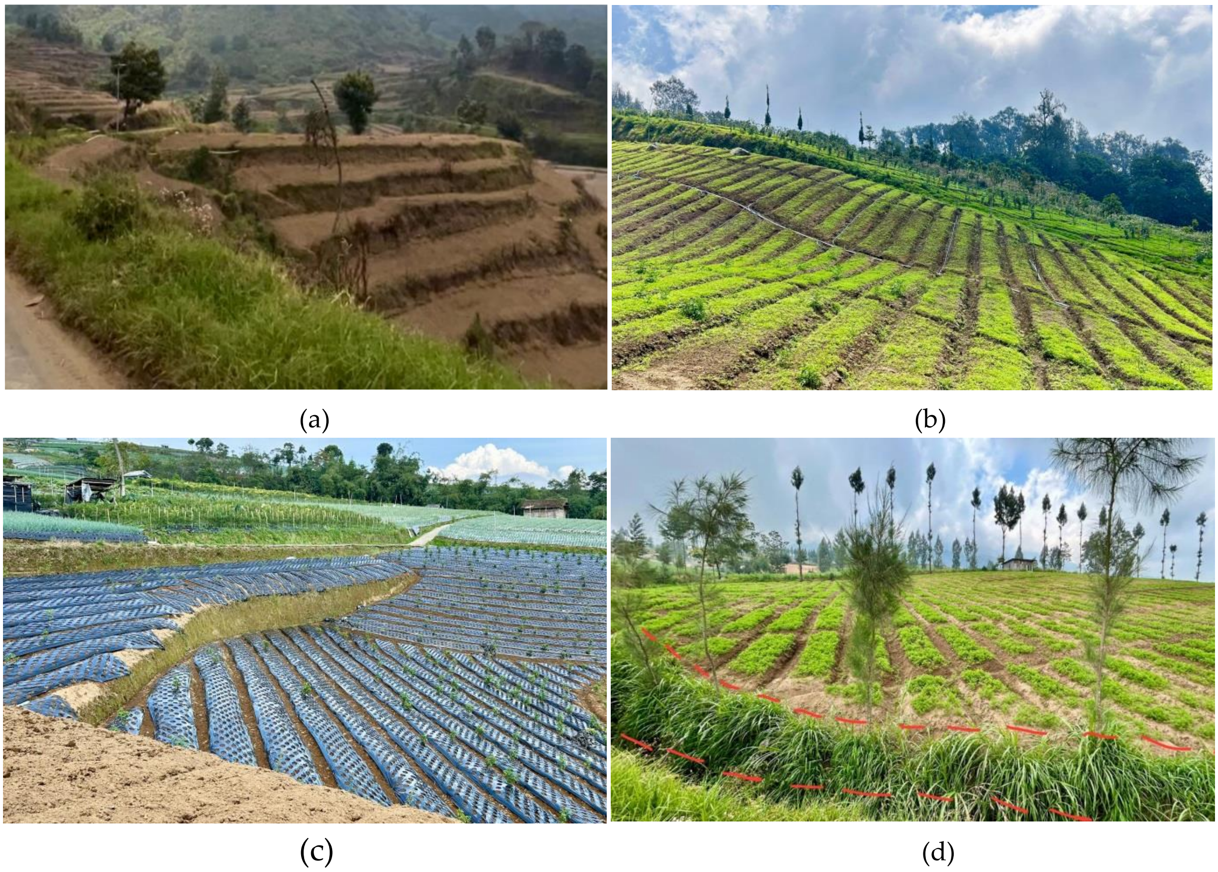

Figure 10. Forms of Community Local Wisdom in Land Cultivation and Soil Damage Control in the form of (A) Terrace System, (B) Terrace with Rollers and Channels, (C) Terrace with Rollers and Polybags, and (D) Terrace with Erosion Control Grass

The farming community controls vegetative soil damage by planting cover crops such as annuals or plants that produce tubers. Apart from being cover crops that function as protective water barriers to not directly hit the soil surface, which can cause topsoil erosion, it also aims to increase farmers' income from their crops. Cover crops are plants planted on dry land covering the entire soil surface (Asbur et al., 2018). The people of Sumberbrantas Village, who apply both vegetative and mechanical soil degradation control efforts, are motivated by the legacy of their parents from generation to generation and the results of directions from extension activities routinely carried out in the village. This hereditary land management knowledge can be known as local wisdom; this local wisdom can be applied by adding innovations developed by subsequent descendants so that knowledge about land management is not lost after being left by previous parents (Afriawan et al., 2024).

Conclusion

Various efforts are applied by the Sumberbrantas Village community in land management to overcome soil damage due to biomass production activities. Based on information obtained from a sample of respondents, most people apply crop rotation as a process of resting agricultural land to restore soil fertility—applying intercropping techniques and various terracing models to improve soil fertility and minimize erosion. Community understanding of conservation is supported by years of farming experience and regular extension activities. Organic fertilizers dominate, with simple tools such as hoes to limited mechanization used for tillage. Local wisdom-based conservation efforts involve mechanical approaches such as creating rolling terraces and vegetative ones through planting ground cover crops. In addition to addressing environmental impacts, these measures also improve the productivity and sustainability of farming. Inherited local traditions are central to creating adaptive soil management patterns supported by modern innovations and technical guidance.

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