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LAND CHARACTERISTICS AND IMPLEMENTATION OF CONSERVATION AGRICULTURE TO SUPPORT DIVERSITY AND SUSTAINABILITY OF BROMO TENGGER TOURISM

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ABSTRACT: Ngadisari Village is located in Bromo Tengger Semeru National Park, Mount Bromo, and has strong natural tourism potential. However, its agricultural practices do not yet follow conservation principles or fully support agro-tourism development. This study has been completed to evaluate the implementation of conservation agriculture in the cultivation of main crops (potatoes, onions, and cabbage) according to conservation agriculture principles. The study was conducted in Ngadisari Village, Sukapura District, Probolinggo, East Java, Indonesia from 2022 to 2023. Located at 1,950 m above sea level, the area has high rainfall (3,577 mm/year), cool temperatures (10–20°C), sloped land, and light-textured soil. Results show that most of the land in Ngadisari is used for agricultural practices that do not fully align with conservation agriculture principles. However, terracing has been implemented, reinforced by annual plants like pine or elephant grass, which has helped reduce soil slope. Land preparation is intensively conducted to a depth of over 30 cm. Most farming is rainfed, leaving fields bare during the dry season. Mixed cropping or two-crop intercropping is more common than monoculture, with potatoes, onions, and cabbage as the most dominant crops.

KEYWORDS: Intercropping, Sustainability, Soil Conservation, Terracing

INTRODUCTION

Conservation agriculture practices refer to efforts aimed at protecting natural resources and promoting environmental sustainability across agricultural landscapes. It focuses on improving soil health, water quality, and biodiversity while ensuring productive and, of course, profitable farming operations. The focused aspects are minimizing soil disturbance through no-till farming, which helps prevent erosion, increases water infiltration, and improves soil health (Busari *et al*., 2015; Pittelkow *et al*., 2014).

Conservation agriculture practices play a crucial role in enhancing welfare of farming communities. These practices have been shown to boost crop production by lowering production costs (both inputs and labor), improving and preserving soil fertility (by maintaining plant nutrients, organic matter, and abundant soil microorganisms, as well as a loose soil structure), increasing soil's water retention capacity, and preventing soil erosion and land degradation (McConnell and Burger, 2011; Capmourteres *et al*., 2018; Burney *et al*., 2010). Agricultural conservation practices are also key to dealing with climate

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change, both by reducing its causes and by helping farms cope with its impacts. base on mitigation side, they help sequester carbon and lower emissions and energy use. When it comes to adaptation, they lead to better water efficiency and greater crop diversity, which makes farms less vulnerable to changing conditions (Jug *et al*., 2018; Manale *et al*., 2016; Su *et al*., 2021;). In 2018/2019, total area of agricultural land implementing conservation agriculture was 205.4 million ha, equivalent to 14.7% of the global agricultural land area and the distribution of conservation agriculture covers Asia, Africa, and Europe (Kassam, *et al*. 2022).

To make conservation agriculture a success, we need to develop simple and effective practices that help farmers sustain their land while also improving their daily lives. For communities in sensitive areas like the Bromo Tengger Semeru mountains, this approach should ultimately lead to greater food security, better nutrition, and stronger incomes. The nature of Bromo Tengger Semeru mountains is very famous for its natural tourism and in 1982 it was designated as Bromo Tengger Semeru National Park of Indonesia with an area of 50,276.3 ha. This is main destination for tourists when visiting East Java. Rising dramatically from the sea of sand in Tengger Caldera, Mount Bromo is one of Indonesia's most captivating active volcanoes. Standing at 2,329 meters above sea level, its smoldering cone offers visitors a breathtaking glimpse into raw power of nature (Zaennudin, 2011). With a population of 1,461 people in 2023, approximately 76.25% of population have their main job as farmers, and around 2.53% work as farm laborers. Some people other than farmers also work as guides or provide tourism services. The agricultural lands are hilly and mountainous (Ngadisari, 2023).

A preliminary survey revealed that while conservation agriculture practices do exist in Ngadisari Village, they haven't yet been fully adopted. Farmers continue to cultivate land intensively, which raises questions about long-term sustainability. This study therefore aims to evaluate how well conservation agriculture principles are being applied to village's main crops potatoes, onions, and cabbage and whether these practices align with the actual suitability of the land.

MATERIALS AND METHODS

Location and Time of research

The research was carried out in Ngadisari Village, part of Sukapura Sub-district in Probolinggo District, East Java, Indonesia (Fig. 1). Covering approximately 1,047.32 hectares, the village is made up of three smaller sub-villages (Wanasari, Ngadisari, and Cemara Lawang). Geographically, research is located at coordinates 112°57′0″E - 112°58′30″E and 7°54′0″S - 7°55′30″S (Fig. 2).

Historically, Ngadisari Village was originally a pine forest located in a highland zone at an altitude of around 1,800 meters above sea level, with an average daily temperature ranging from 10 to 20°C. The research was conducted from September 2023 to 2024. Data analysis was carried out at the

Fig. 1. Research location in agricultural landscapes in three sub-villages (Wanasari, Ngadisari, and Cemara Lawang).

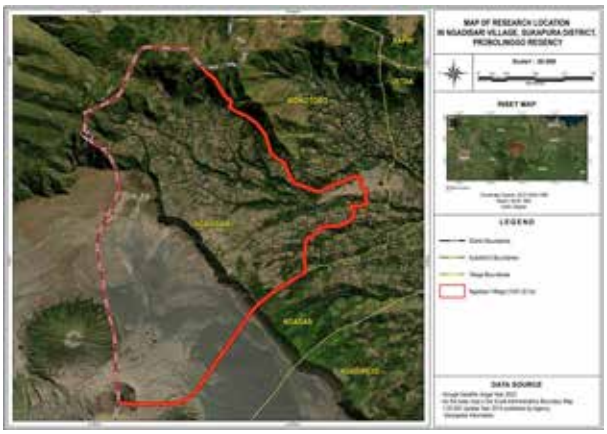

Fig. 2. Research location around the natural tourism of Mount Bromo and the sea of sand as well as some agricultural practices.

Chemistry and Fertility Laboratory of Jember University.

This study was based on three core principles of conservation agriculture: 1) limited soil disturbance (through no-tillage, minimum tillage, or row/ hole planting to reduce erosion), 2) permanent soil cover (using both living and dead mulch), and 3) crop diversification (via crop rotation and intercropping). To assess these principles, map materials were obtained from the Geospatial Information Agency of Indonesia (BIG), and direct field surveys (Table 1) were conducted on agricultural land and with local residents and farmers.

Table 1. Land Quality and Characteristic Parameters

Symbol	Land Quality	Land Characteristics
Tc	Temperature	Average Annual Temperature (°C)
Wa	Water availability	Rainfall (mm) Length of Dry Period (bulan)
Oa	Oxygen availability	Soil Drainage
Rc	Rooting medium	Soil Texture Effective Soil Depth (cm)
Nr	Nutrient	pH (H_20) C-Organic (%) N-Total (%)
Xc	Toxicity Hazard	Salinity ($dS.m^{-1}$)
Eh	Erosion	Lereng (%) Erosion hazard
Fh	Flood Hazard	Flood
Lp	Land preparation	Rocks on the surface (%) Rock Outcrop (%)

Souce: Djaenudin *et al.*, 2003

RESULT AND DISCUSSION

Land Characteristics

Based on the 1:25,000 scale administrative map (BIG) and the 1:50,000 scale soil type map (BBSDLP), soil type in Ngadisari Village is dominated by Typic Hapludands, covering approximately 65.5% of the area. The soil types of research areas are generally Andisols which have a histic epipedon (Soil Survey Staff. 2022). Other types of soil, inceptisol and entisol, distribution and complete area are presented in Figure 3. Land use in Ngadisari

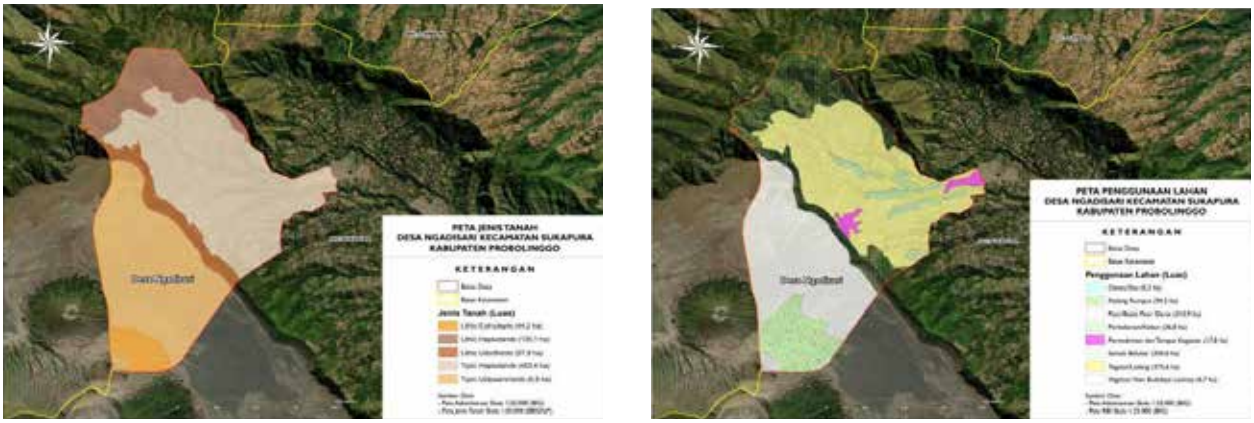

Fig. 3. Soil type and land use map of the research location in Ngadisari Village, Sukapura District, was obtained, covering the area around the Mount Bromo nature tourism site and the sea of sand

village, mostly for fields/dry fields, which is around 456 ha or 58.82% of the total area. Other land uses are bushes, grasslands, plantations, lakes, and settlements.

Agricultural lands in Ngadisari village have slopes with a gradient of more than 15% (slightly steep to steep) as much as 51.8% or 553.7 ha (Fig. 4) and light soil texture and relatively the same between locations, so that it has the potential for landslide hazards. Based on the landslide hazard map on a scale of 1:25,000 (Fig 4) shows that most of the lands in Ngadisari village have high potential (329.2 ha) and medium (204.5 ha) and the rest are low (199.5 ha) and none (314.1 ha). Land management

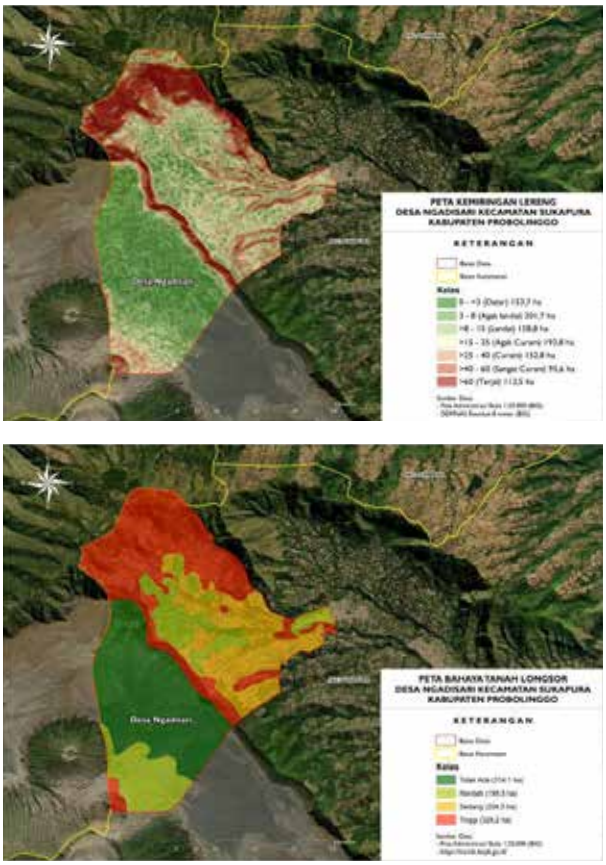

Fig. 4. Map of land slope gradient and landslide hazard at the research location in Ngadisari Village, Sukapura District, around the Mount Bromo nature tourism area and the sea of sand.

practices have transformed the steep terrain through terracing, which lessens the slope within planting areas. The resulting slope gradients range from 0% to 49.73%, and importantly, 60% of the land features slopes under 15% (Fig. 5).

Moreover, based on boxplot, most of the land has a slope of 13%, so that based on a survey of farmers and community in Ngadisari village, landslides have never occurred. In addition, the presence of perennial plants (*Casuarina equisetifolia* or casuarina) between the boundaries of land plots also strengthens land to prevent landslides.

The average land height in Ngadisari village is around 1950 meters above sea level (msl), average annual rainfall is 3577 mm, with an average daily temperature of around 10 – 20°C during the rainy season and 0 – 8°C during dry season. Water availability based on recorded data 2022 – 2023 and the basic data of the Ngadisari village monograph 2023, high rainfall of around 3577 mm, distributed throughout the year as presented in Figure 6.

Based on the picture, it shows that it rains throughout year with a dry period (RF below 60 mm) of only 2 months (August and September). Water conditions based on

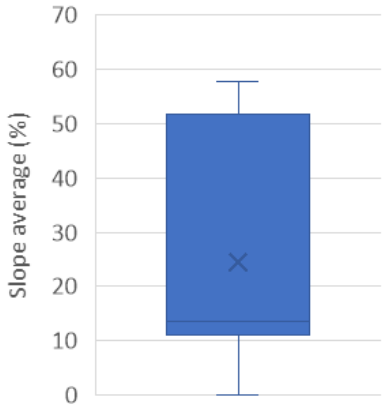

Fig. 5. Diversity of slopes of agricultural land that has been terraced and used for agriculture or vegetable cultivation.

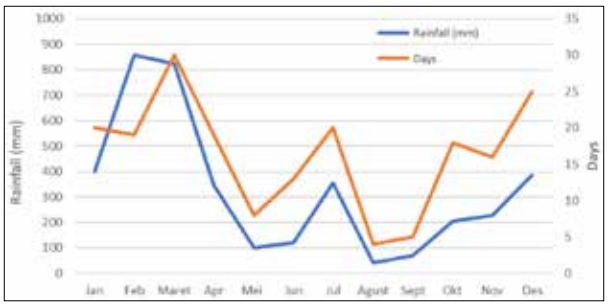

Fig. 6. Number of days and distribution of rainfall in Ngadisari village, Sukapura, Probolinggo in 2023

climate for agriculture are very important, an important factor causing low cropping index. Most of the cropping patterns in Ngadisari village are based on conditions or availability of rainwater during plant growth, so that some land has a cropping index (CI) of 2, it cannot be 3 because there is a time when the land is empty (not planted and open).The availability of oxygen or soil aeration is very good. In addition to light texture, intensive processing, water channels are also made. Most of the water flows as gravity water and also surface water through drainage channels.

The rooting medium is very favorable due to its light texture and intensive cultivation, although organic matter content is generally low to very low (average C-organic 0.99%). This condition contrasts sharply with findings from Nozari and Borůvka (2023) in the Czech Republic, who reported a positive relationship between slope steepness and organic matter content. In their study, soil organic matter ranged from 0.42% to 11.33%, with an average of 2.83%.

The effective soil depth is more than 1 meter. The acidity of the soil pH H_2O varies between 7.22 to 8.74 with an average of around neutral 7.04 and for KCl pH varies between 6.39 to 7.24 with an average of 5.85. Complete data is presented in Figure 7. Based on Figure 7, salinity, C-organic content (*organic matter*), and N-total soil are also explained. Soil salinity based on electrical conductivity (DHL) values, namely the ability of groundwater to carry electric current, cations ($Ca2^+$, Mg^{2+}, K^+, Na^+, and NH_4^+) and

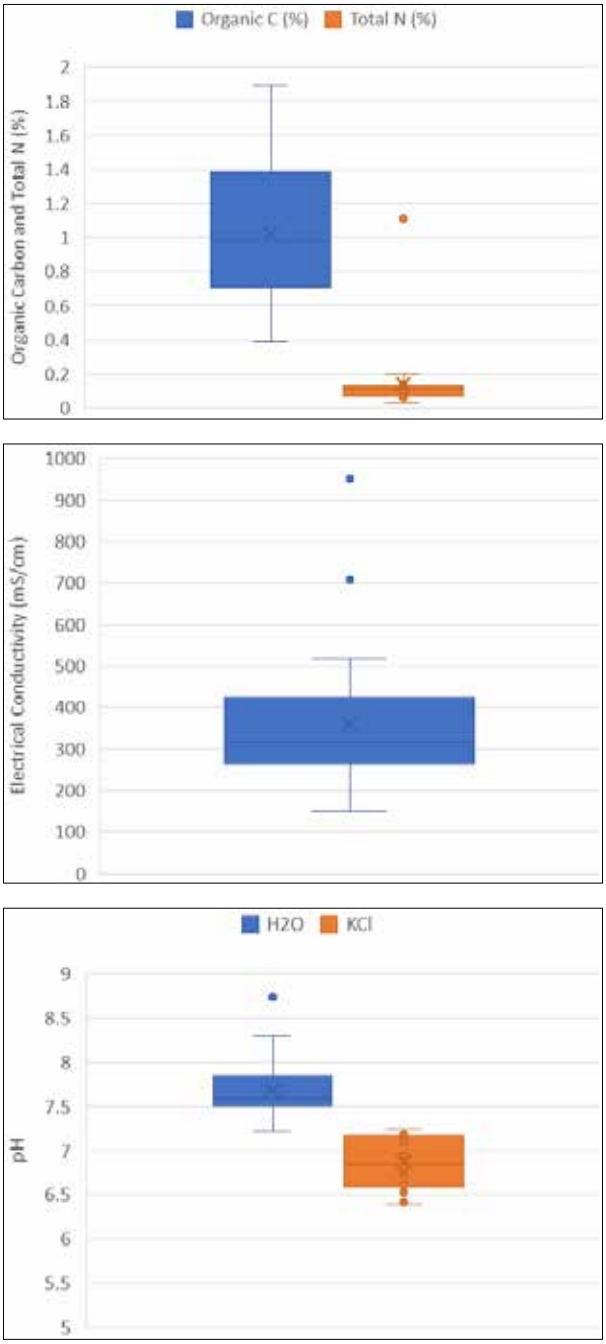

Fig. 7. Variation of Acidity (pH H_2O and KCl), Electrical Conductivity (EC), C-organic, and N-Total soil in agricultural lands of Ngadisari village, Sukapura, Probolinggo in 2023.

anions (SO_4^{2-}, Cl^-, NO_3^-, and HCO_3^-) from dissolved salts in groundwater carry and conduct electric current, varying from not saline to quite saline 150 to 951 µS/cm with an average of 359 µS/cm. This average salinity value is based on the Soil Survey Staff salinity class, USDA, including very slightly saline. This DHL value is closely associated with the concentration of nitrogen (N) or nitrate, where an increase in concentration corresponds to a rise in the DHL value (Mirzakhaninafchi, *et al*. 2012.).

The perception of farmers and the community in Ngadisari Village is that the risk of erosion is low, despite the slope and potential erosion hazard maps indicating a high risk (Figure 8). The landslide hazard on agricultural land varies from low (199.5 ha), medium (204.5 ha), to high (329.2 ha). However, the implementation of terracing, reinforced with perennial plants such as casuarina trees or elephant grass, has significantly reduced the slope of the agricultural land to about 13% on average, thereby greatly diminishing the potential for landslides. This description is in accordance with the research results of Iskandar *et al* (2023) on land with deep solum (>90 cm) with low erosion hazard levels. Likewise, based on the results of a survey of 30 farmers, they stated that there had never been a landslide, nor a flood. During land preparation, farmers never encountered surface rocks or rock outcrops, both recorded at 0%.

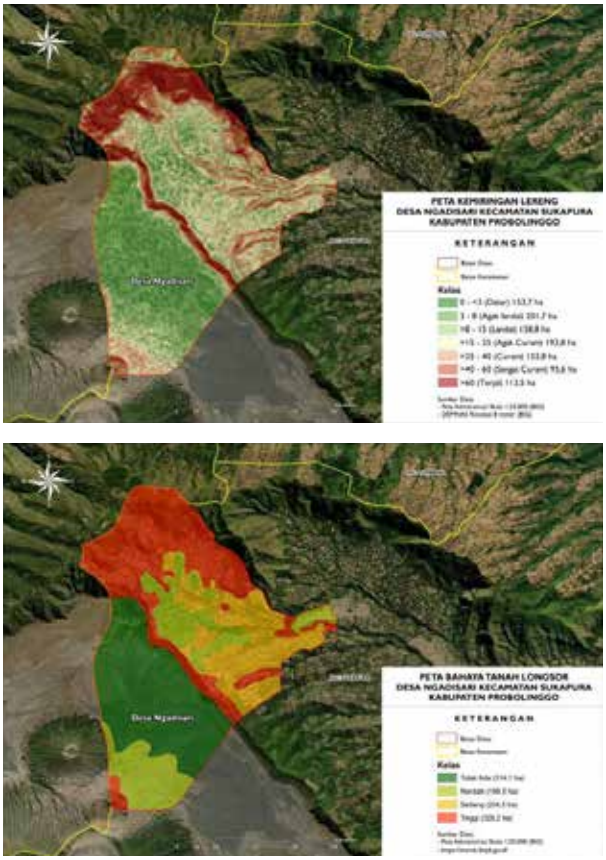

Fig. 8. Map of land slope gradients and landslide hazards Ngadisari Village

Socio-Cultural and Economic Aspects in Supporting the Productivity and Sustainability of the Agricultural Biophysical Environment in Ngadisari

A study by Sejati *et al.* (2023) investigated how the traditional ceremonies of the Tengger tribe contribute to environmental conservation and support the Mount Bromo tourism area. The Tengger tribe is a community deeply rooted in tradition and ancestral veneration, expressed through ceremonies like *Pujan Kasanga*, *Pujan Kasada*, and *Unan-Unan*. These rituals embody values of faith, environmental harmony, reverence for the land, and gratitude for its fertility. Beyond their spiritual significance, these ceremonies also serve as cultural attractions that showcase beautiful agricultural landscapes, promote awareness around reducing plastic waste, and demonstrate the harmonious relationship between people and nature. Central to Tengger belief is the principle that humans must live in balance with nature and should never exploit it carelessly.

In general, economy of Ngadisari community is shaped by a combination of

agriculture, tourism, and local trade, largely because the area lies close to Mount Bromo. The presence of this attraction has created economic opportunities in the tourism sector, including homestays, food stalls, and tour guide services. Most farmers in Ngadisari manage their own land, with farm sizes varying considerably ranging from 0.0014 to 3 hectares and an average of 0.99 hectares (Figure 9). In terms of productivity, they achieve average yields of 3.81 tons per hectare for potatoes, 2.45 tons per hectare for spring onions, and 9.1 tons per hectare for cabbage.

Previous research on the socio-economic aspects of the Tengger tribal community reveals that gender roles are generally balanced across various sectors, with no significant difference in the participation of male and female farmers in planning, implementation, and evaluation. The key factors influencing this balance include the farmers' individual characteristics, ecological environmental support, and economic institutions. Conversely, factors such as the intensity of extension or empowerment programs and the strength of customary traditions were found to have no significant impact on farmer participation (Sudarko, *et al*. 2023).

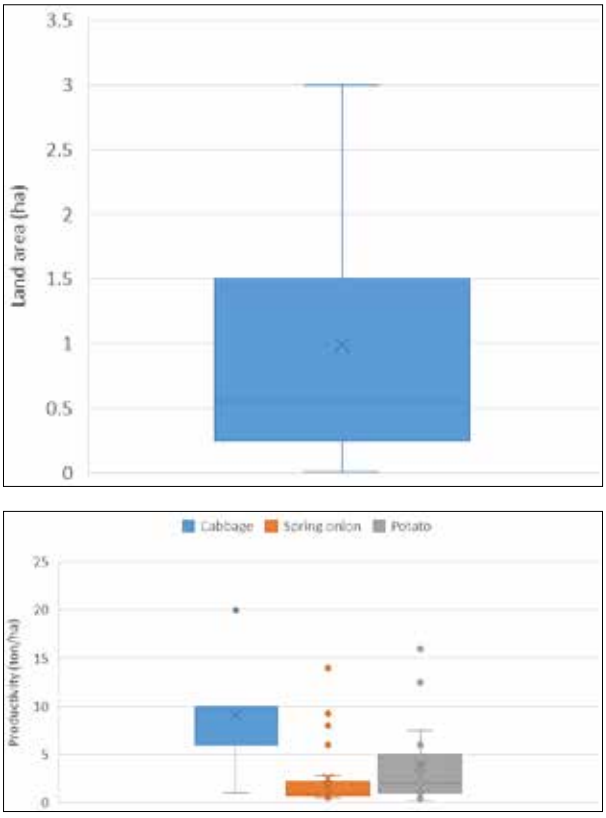

Fig. 9. Diversity of land area ownership cultivated by Nagdisari farmers and land productivity for potatoes, spring onions and cabbage.

Implementation of conservative farming

With light textured land conditions and cool temperatures, Ngadisari farmers implement various vegetable farming. However, almost all farmers still rely on rainwater as their agricultural water source. The rainy season is full of water and humid, making agricultural lands more productive compared to the dry season which lacks water. This condition determines the planting pattern or type of plants or vegetables planted. Evaluation of the implementation of a conservative farming system is very important in supporting the productivity and sustainability of agricultural lands while increasing the attractiveness of Bromo nature tourism in Ngadisari. Conservation agriculture is a cultivation or agricultural practice that combines reduced or no tillage, permanent soil cover, and better crop rotation or diversification. This agricultural practice is also often promoted as a smart practice in climate change (Farooq, 2023) and also to adapt agricultural ecosystems to its impacts, by increasing plant resilience in the face of climate variation (Sanchez *et al* 2020). However, the research results of Shumba, *et al* (2023), stated that the impact of conservative agriculture and its three principles on aboveground and belowground soil organic carbon (SOC) stocks and on soil CO_2 emissions in low-input farming systems in sub-Saharan Africa is still limited.

The evaluation of the implementation of conservation agriculture in Ngadisari Village indicates that land preparation is carried out thoroughly before planting. Both manual and tractor-based tillage practices disturb the soil intensively, as shown in Figure 5 (post-tillage for planting) and Figure 1 (during crop growth). Most farmers use manual tools, such as hoes, while a smaller proportion utilize hand tractors. Manual tillage allows for deeper soil preparation (>30 cm) compared to tractors (<30 cm). Crop residues are entirely removed, and raised beds are constructed with heights ranging from 15–30 cm.

Many farmers have adopted conservation practices, creating furrows between beds that are perpendicular to the slope or follow contour lines. Intensive soil preparation is preferred by farmers as they believe yields will decline if this is not performed. During tillage, drainage channels are also maintained to prevent waterlogging during the rainy season. However, this practice reduces the soil's water retention capacity, leading to shortages during the dry season.

The land in Ngadisari Village has deep soil profiles, with an average depth exceeding 1 m, which supports agricultural productivity and sustainability. However, the soil organic carbon (SOC) content is very low, averaging 1%, with values ranging from 0.39% to 1.89% (Figure 7). While the soil typically has high organic matter potential, continuous erosion reduces the organic carbon content. These agricultural practices contribute to greenhouse gas (GHG) emissions, exacerbating global warming. The combination of intensive plowing, the use of agricultural chemicals, and the burning of crop residues are the primary agricultural activities contributing to greenhouse gas (GHG) emissions.

Soil tillage is also carried out during the dry season, which is a critical period for CO_2 emissions and water loss from the soil system. Long-term research by Mühlbachová *et al*. (2023) demonstrated that reducing tillage practices and adopting no-tillage with surface mulch decreased CO_2 emissions by an average of 45% and 51%, respectively, over six years. The average CO_2 emissions were 6.1, 3.1, and 2.9 mol CO_2 $m^{-2}s^{-1}$ for conventional tillage (intensive), reduced tillage, and no-tillage with mulch, respectively. Similarly, Krištof *et al*. (2014) reported that increased tillage intensity leads to higher rates of CO_2 emissions released from the soil into the atmosphere.

Based on the explanation above, effective and continuous education for the community is necessary to achieve high levels of conservation agriculture implementation. This approach can serve as a valuable strategy not only for mitigating climate change but also for preventing and reducing soil erosion, improving soil quality and fertility, and ensuring better water accessibility for crops during the dry season. Establishing well-planned demonstration plots with active community involvement has great potential to yield more effective outcomes.

Implementation of permanent closure of agricultural land

The agricultural lands in Ngadisari Village, Sukapura District, are highly diverse, but the majority rely on rainfed farming (over 95%). During dry season (starting around April and lasting until September, peaking in August and September), most of land is either left bare or the crops receive minimal care. Farmers make significant efforts to cultivate crops year-round but are constrained by water availability, especially from July to September, leading to idle or unproductive land.

The use of mulch, whether plant residues or plastic mulch, remains minimal, and the soil surface is not permanently covered. Typically, the land is bare during tillage, and after planting, the soil surface gradually becomes covered during the growth and production phases, varying from about 70% to nearly full coverage (95%) during the peak vegetative phase until harvest.

The condition of soil surface coverage in agricultural land management practices in Ngadisari Village, Sukapura District, is shown in Figure 1 (during the growth and maintenance phase) and Figure 10 (during the soil preparation phase for planting) above, as well as Figure 11 below. Figure 11 the cropping pattern during the dry season (June-July) in the village. It depicts farmland owned by a farmer nearing harvest, with well-maintained crops that receive irrigation water purchased to address the shortage caused by the absence of rain or insufficient rainfall.

The agricultural practices commonly employed by most farmers result in a depletion of soil nutrients through the use of both inorganic and organic fertilizers. Inorganic fertilizers, such as ZA, NPK (Phonska), and black TSP, still dominate compared to organic fertilizers. This trend contributes to the low average organic matter content in the soil (Figure 7). As a result, the total nitrogen (N) content in the soil is also low, despite the fact that nitrogen is a crucial nutrient for plants, especially vegetables. Based on this, most farmers apply high-nitrogen fertilizers, such as Phonska (6 tons/ha) and ZA (3 tons/ha).

Fig. 10. Soil preparation practices before planting in Ngadisari Village

Fig. 11. Cropping patterns in the agricultural land management practices during the dry season in Ngadisari Village, Sukapura District.

The evaluation of the relationship between organic carbon (C) and total nitrogen (N-total) in agricultural land management practices in Ngadisari Village shows a very low correlation (Fig. 12), even though the N-total data reflects nitrogen in organic compounds. This is likely due to the main fertilizers being applied in inorganic forms (Phonska and ZA). In addition to the erosion mentioned earlier, which reduces soil organic matter, agricultural

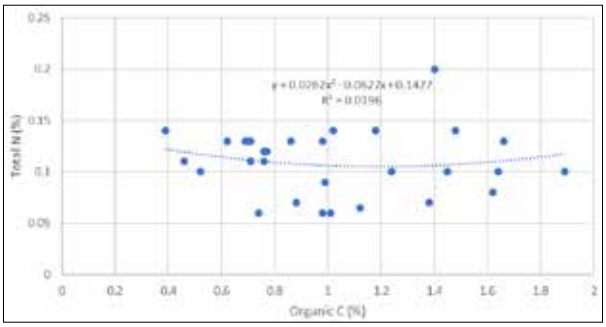

Fig. 12. The relationship between organic carbon (C-organic) and total nitrogen (N-total) in agricultural land management practices in Ngadisari Village

practices do not return crop residues to the soil, either as mulch or composted to create organic fertilizer.

Mulch, both organic and inorganic is an important technique used in crop production to increase yields. It has been proven that mulch regulates soil temperature, reduces fertilizer leaching, helps control weeds, and boosts harvests. Similarly, Demo and Bogale (2024) stated that dryland agriculture requires the efficient use of water resources and natural resources through the application of water-saving technologies. Mulch is a conservation practice used in drylands to maintain soil moisture, regulate temperature, and minimize soil evaporation. Organic mulch reduces soil degradation, improves organic matter, and enhances the soil's ability to retain water.

Mulch helps maintain moisture in the root zone, allowing plants to access water for longer periods. Under plastic mulch, soluble nutrients such as nitrates (NO_3^-), ammonium (NH_4^+), calcium (Ca_2^+), magnesium (Mg_2^+), potassium (K^+), and fulvic acid are released as organic matter decomposes, increasing the availability of soil nutrients.

Application of mulch in agricultural lands in Ngadisari Village could be a solution for water management, as water use in agriculture has become a concerning issue. Utilizing crop residues or harvest leftovers for mulch, or even starting to use plastic mulch while reducing soil tillage, is highly recommended. The use of mulch can be implemented quickly, making it an effective solution to reduce water loss. Mulch offers several advantages for dryland farming, such as reducing soil water loss, erosion, weed growth, the kinetic energy of raindrops, and competition for nutrients and water with nearby fields. The evaluation by Román-Vázquez *et al*. (2023) shows that conservation agriculture practices for annual crops in Europe, including strip seeding, no-tillage, crop diversification, and cover crops, have been implemented. Shumba *et al*. (2023) stated that Conservation Agriculture (CA), which combines reduced or no tillage, permanent soil cover, and improved crop rotation, is often promoted as a climate-smart practice. The impact of CA and its three principles on soil organic carbon (SOC) stocks, both above and below ground, as well as on CO_2 emissions from the soil in low-input cropping systems in sub-Saharan Africa, is somewhat limited.

Implementation of crop diversification or rotation in Ngadisari village

Vegetable cropping pattern and rotation implemented by farmers in Ngadisari Village are highly influenced by the seasons, especially rainfall (Table 2). During the rainy season (with ample water), the main crop is potatoes, and the land is always planted. In contrast, during the dry season, crops like cabbage and spring onions are grown around July and August, but land is often left fallow due to water shortages. The implementation of intercropping (two or more crops) or diversification is more common than monoculture. Water availability, particularly in the dry season, is also a key consideration. In intercropping, potatoes are often planted with spring onions, but the latter tends to be overshadowed by the large canopy of the

Table 2. Seasonal Planting Periods for Potatoes, Cabbage, and Spring Onions

Plants	Potato and Spring Onion				Cabbage and Spring onion							
	Potato				Cabbage				Spring onion			
	Potato				Potato				Spring onion			
Month	J	F	M	A	M	J	J	A	S	O	N	D
Seasons	Rainy season				Dry Season				Rainy season			

potato plants. Spring onions are harvested multiple times, so they are frequently present on the land. Harvesting occurs when there are more than three shoots, leaving two shoots behind to continue growing.

Implementation of crop diversification or rotation in land management in Ngadisari Village is carried out conservatively with the main crops (potatoes, cabbage, and spring onions) being planted according to the principles of conservation agriculture and land suitability. The most common cropping pattern practiced by the majority of farmers in Ngadisari includes potatoes, cabbage, and spring onions, with potatoes being grown during the rainy season and cabbage and spring onions during the dry season.

The planting of crops in Ngadisari has already taken into account conservative agriculture aspects, such as aligning with the contour direction and maintaining perennial trees (like pine) and elephant grass at the boundaries of the land, although it does not yet fully represent all aspects of conservation agriculture. The transition toward conservation agriculture by farmers in Ngadisari is gradual, based on their beliefs and understanding of the meaning and implementation of conservation agriculture.

Research by Mujiyo *et al*. (2022) on land with andisol soil, sloping terrain, and highland areas indicates that the land categories most closely related to soil degradation are slope (0.857**), rainfall (0.595**), and land use (0.415*). Similarly, Araya *et al*. (2024) evaluated the current practices, challenges, and constraints in the implementation of conservation agriculture in sub-Saharan Africa (SSA). They stated that CA is practiced on only about 1.25% of the total cultivated area, despite efforts to promote it for two decades. This may be due to: i) the lack of locally adaptable CA systems, especially those integrating livestock production needs; ii) insufficient crop residues available for surface mulch; iii) inconsistent and low harvest yields; iv) the lack of CA equipment for smallholder farmers to implement direct seeding; v) limited availability, high costs, and inadequate knowledge about the proper use of fertilizers and herbicides; and vi) a lack of CA knowledge and training.

CONCLUSION

In conclusion, the agricultural landscape of Ngadisari Village is characterized by dryland farming on sloped terrain, with over half land featuring inclines greater than 15% and light-textured soils exceeding one meter in depth. While conservation agriculture practices have been partially adopted, most notably terracing reinforced with perennial plants like pine and elephant grass, their implementation remains incomplete. Intensive land preparation is still universally practiced, and soil coverage is inconsistent, with much land left bare during the dry season due to reliance on rain-fed farming and minimal use of mulch. Although farmers predominantly practice intercropping with potatoes, spring onions, and cabbage, they have not integrated perennial crops with vegetable cultivation. Overall, the agricultural practices in Ngadisari reflect a transitional stage, incorporating some conservation elements while still falling short of fully adhering to conservation agriculture principles.

SUGGESTION

Several key recommendations emerge for advancing conservation agriculture in Tengger tourist area. First, construction of reservoirs or water catchments would enable farmers to store rainwater during the wet season for use during the dry months,

addressing a major limitation of current rainfed systems. Second, returning plant residues to soil as mulch would help protect against erosion, enhance organic matter content, and improve overall soil health. Finally, reducing intensity of soil cultivation would bring practices closer to conservation agriculture standards by minimizing disturbance and preserving soil structure.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors

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