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Analysis of the Factors Causing a Decline in Soil Quality and Their Solutions as an Effort to Increase Agricultural Productivity in Dry Areas

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Abstract

West Nusa Tenggara (NTB) is an area that has abundant agricultural resources apart from the tourism sector. Generally, the climate in NTB is tropical, which is in the southern part of Lombok, namely in the Central Lombok area. The technique of determining the location and population was carried out using a purposive sampling method, meaning that the population used as a research sample was a population that met specific sample criteria according to the research objectives, and what had to be represented depended on the assessment or considerations of the researcher. Meanwhile, the data analysis used was descriptive data analysis, quantitative with multiple linear regression analysis, t-tests, and F-tests, and qualitative descriptive analysis using interview techniques with questionnaires, counseling, and FGD. The stages of the research are surveys, interviews, distribution of respondents, forum group discussion (FGD), counseling, and evaluation. Land conversion, excessive use of pesticides, and burning of crop residues were carried out on this basis by the Forum Group Discussion (FGD), which aims to provide solutions to existing problems. From the results of multiple linear regression testing, there is a significant relationship between the variable Y (level of agricultural productivity) in Pujut District and the factors that cause a decrease in soil quality or soil degradation (variable X) that occurs at the research location with the results of the regression equation, namely $Y=5{,}398+0.97X_1+0.125X_2+0886X_3+0.861X_4$. The regression equation results show a strong relationship between the decline in soil quality and the factors causing the decline in soil quality in the Pujut sub-district.

Keywords: *Agricultural Productivity; Dry Area; Soil Quality*

1. Introduction

Indonesia is part of a wet tropical ecosystem classified as very vulnerable to degradation if management is not appropriate (Farhan and Lim 2012; Pratiwi et al. 2021). Wet tropical ecosystems cover an area of about 1.5 billion hectares of land with a human population of around 2 billion, spread over 60 countries; 20% of the area is in Asia. To live and develop vegetation, good soil (a living medium) is required. However, at this time, much soil is experiencing degradation, which causes decreased plant productivity and is prone to erosion (Ayu et al. 2020; Reswita et al. 2021). In general, soil degradation means a decrease in soil quality in the sense of losing one or more functions in the soil (Johnson et al. 1997). Soil is a natural resource that is very useful for human life (Karlen et al. 2019; Ruwayan et al. 2020). The most significant benefit is water storage and the growth of various plants. The sector that is highly dependent on land is agriculture. The decline in soil quality or soil degradation results in a decrease in the land's quality, quantity, and status value.

Many things are feasible to prevent the decline in soil quality. The problem solution must be done immediately if there is soil degradation so as not to interfere with productivity.

Salim (2013) stated that organic farming and its various production and post-harvest activities stated, "That material was rarely used to produce bioethanol as alternative biofuels that were environmentally friendly (Kodirov et al. 2020; Roy et al. 2009). This means that farmers' attention is less on organic things. Integrated or conservation farming systems combine several technological components to achieve goals, namely the sustainability of increasing the productivity of food crops and people's incomes, strengthening resilience to climate change and diversity, and reducing sources of climate change such as greenhouse gas emissions while increasing carbon stocks in the land. The application of conservation and climate-friendly agriculture can improve soil quality where the soil can support plant growth, including tillage depth, aggregation, organic matter content, water holding capacity, infiltration, availability of essential nutrients, infiltration rate, and changes in soil reaction. Land productivity is crucial to supporting the cultivation of plants that grow on it. Land parameters that affect crop yields include nutrients, soil solubility, soil texture, slope, and irrigation water conditions (Suriadi et al. 2021; Tomaz et al. 2020). The scarcity of farmers willing to pay attention to organic farming affects environmental quality.

Natural factors cause soil degradation, among others: areas with steep slopes, easily damaged soil, intensive rainfall, and others (Chalise et al. 2019). Factors of land degradation due to human intervention, both directly and indirectly, dominate more than natural factors, including population changes, population marginalization, population poverty, land tenure problems, political instability and mismanagement, social and economic conditions, health problems, and the development of improper agriculture. Soil conservation means placing each plot of land in a way that follows its ability and treats it according to the requirements needed to prevent land damage (Kheirfam et al. 2020). The soil's physical and chemical properties and the field topography's state determine the suitability for a particular use and the treatment required (Mentis 2020). For land valuation, it is formulated in a land capability classification system aimed at (1) preventing soil damage by erosion, (2) repairing damaged soil, and (3) maintaining and increasing soil productivity so that it can be used sustainably (Abdel Rahman 2023; Sumarniasih and Antara, 2020). One way to control or prevent soil degradation is by rehabilitating the soil structure. Rehabilitation is also thoughtful in repairing, restoring, and improving the condition of damaged land so that it can function optimally both as an element of production, a medium for regulating water management, and an element of nature and environmental protection (Hussain et al. 2022).

West Nusa Tenggara (NTB) is an area that has abundant agricultural resources, apart from the tourism sector. Generally, the climate in NTB is tropical, around the southern part of Lombok, namely in the Central Lombok area (Radiarta et al. 2016; Suriadi and Nasam 2017). Based on Schmid and Ferguson's classification, Central Lombok Regency has climate D and E, namely tropical rain with a dry season. Central Lombok has a paddy field area of 54,287 ha and a dry land area of 33,348 ha. Central Lombok was identified as experiencing degradation caused by various factors, causing a decrease in agricultural productivity. On this basis, this research was conducted to determine the extent to which the decline in soil quality affected agricultural production. The results of this study can provide solutions to farmers' problems. Hence, the researchers raised the research theme "Analysis of the Factors Causing a Decline in Soil Quality and Their Solutions as an Effort to Increase Agricultural Productivity in Dry Areas, Pujut District, Central Lombok Regency, West Nusa Tenggara.

2. Material and Methods

2.1. Time and Place of Research

This research was carried out for eight months, from November 2022 to June 2023, in Pujut District, Central Lombok Regency, focusing on three villages: Tumpak Village, Kuta Village, and Teruwai Village. The location was taken based on the land area classified as the driest in the Pujut sub-district.

2.2. Data Type

The types of data used in this research are primary and secondary. Primary data is data that comes from interviews, the distribution of questionnaires, counseling, and forum group discussions (FGD). Meanwhile, secondary data comes from villages, Pujut District, the Agriculture and Livestock Service Office of Central Lombok Regency, and the Central Statistics Agency.

2.3. Data Collection Techniques

Observation The observation method can produce more detailed data regarding behavior (subjects), objects, or events (objects) compared to survey methods. Compared to the survey method, the advantages of the observation method are that the data collected is generally undistorted, more accurate, and free from response bias.

2.3.1. Questionnaire

An interview using a questionnaire is a data collection technique that gives a set of questions or written statements to the respondent to answer. Questionnaires are an efficient data collection technique when the researcher knows precisely the variable to be measured and what can be expected from the respondent. In addition, the questionnaire is also suitable for use when the number of respondents is quite large and spread over a large area. Questionnaires can be closed or open, and questions or statements can be given to respondents directly or via social media.

2.3.2. Counseling

Counseling is a technique for conveying information and collecting data used by researchers to collect data from research-related data.

2.3.3. Forum Group Discussion

Forum Group Discussion (FGD) is an activity that involves respondents and stakeholders in discussing the issues being studied. Evaluation of research results is performed while continuing to collaborate with sub-districts regarding the sustainability of implementing solutions to reduce the problems of decreasing soil quality and soil degradation

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2.4. Data analysis

The analyses used in this study are descriptive, qualitative, and quantitative. Qualitative data were obtained using survey and observation methods by collecting data, namely questionnaires, structured interviews, FGDs, and so on (Sugiyono 2015). The analysis of quantitative data used is the percentage of factors causing the decline in soil quality by taking the results of the opinions of respondents in the three research locations and multiple regression analysis because there is more than one dependent variable; multiple linear regression is a regression model that involves more than one independent variable. Multiple linear regression analyses were conducted to determine

the direction and how much influence the independent variables have on the dependent variable. Multiple linear regression analysis is applied to measure the effect of variables involving more than one independent variable (X_1, X_2, X_3,..., X_n). It is called linear because each estimate of the value is expected to experience an increase or decrease following a straight line. The formula for multiple linear regression analysis is:

$$Y=a+b_1X_1+b_2X_2+b_3X_3+...+b_nX_n \quad (1)$$

Information: Y: dependent variable (dependent) X (1, 2, 3, so on): independent variable a: constant value; b (1, 2, 3, so on): regression coefficient value Statistical constant values are used if the units of variable X (independent) and variable Y (dependent) are not the same. Meanwhile, suppose variable X (independent) and variable Y (dependent), both simple and multiple linear, have the same units. In that case, the value of the constant is ignored with the assumption that the change in variable Y (dependent) will be proportional to the change in variable X (independent). In determining the value of 'a' and 'b_1', 'b_2', 'b_3',..., the multiple linear regression.

$$SY=an+b_1SX_1++b_2SX_2+b_3SX_3+...$$
$$SX_1Y=aSX_1+b_1SX_1^2+b_2SX_1X_2+...$$
$$SX_2Y=aSX_2+b_2SX_1X_2+b_2SX_{21}^2+ \text{ ... and so on. (2)}$$

To calculate the value of 'a','b1','b2','b3',... in the multiple linear regression equation, it can be formulated as nx-1, where nx = the number of independent variables (X). Parameter Testing: Parameter accuracy test (test statistic t). The t-statistical test shows how far the influence of one explanatory variable individually explains the variation of the dependent variable (Kuncoro 2001). Model Accuracy Test 1) F test: The F statistical test shows whether all the independent variables included in the model have a joint effect on the dependent variable (Kuncoro 2001). The coefficient of determination (R2) The coefficient of determination (R2) is the comparison between the variation of the dependent variable, which is explained by the independent variables together, compared to the total variation of the dependent variable (Setiaji 2006).

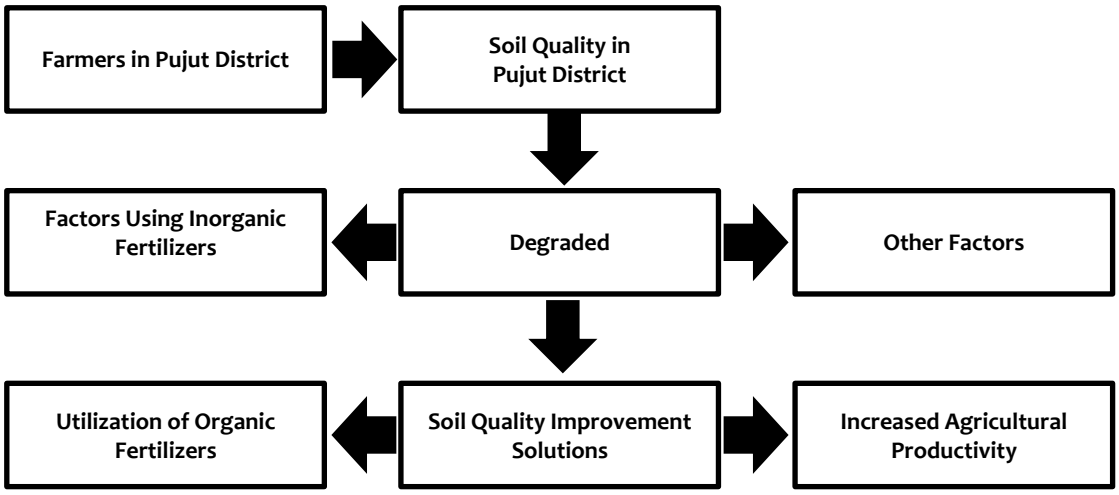

Fig. 1. Schema of Research

3. Results and Discussion

Pujut District is a sub-district in Central Lombok Regency with the largest area among the 12 existing sub-districts, which is around 23,355 ha or occupies around 19.33 percent of the total area of Central Lombok Regency. Geographically, Pujut District is in the southern part of Central Lombok Regency and borders the Indonesian Ocean. That is one of the reasons for the emergence of many tourist attractions, especially marine tourism, which has beautiful beaches and unique waves. To the north, it is bordered by the district of Central Praya, bordering East Praya District to the east and West Praya District to the west. Central Praya borders the East Praya District to the east and the West Praya District to the west. Observations were made by observing the condition of the area in Pujut District, which is dominated by dry and sandy soil. Pujut District has 16 villages, with most having a tropical climate and a rain-fed farming system—the total area of Subdistrict Pujut is 23,355. Table 1 shows the area of land in the study locations based on the area with the highest percentage, namely Tumpak Village 3,454, with a percentage of 14.79%, Teruwai 2,965 with a percentage of 12.70%, and Kuta 2,366 with a percentage of 10.13%. These three villages have sandy, dry soil textures. Pujut subdistrict generally has a dry and sandy soil texture with a total paddy field area of 6,875 and a dry land area of 8,363. More details are shown in Table 2 below.

Fig. 2. Map of the Pujut Subdistrict Area.

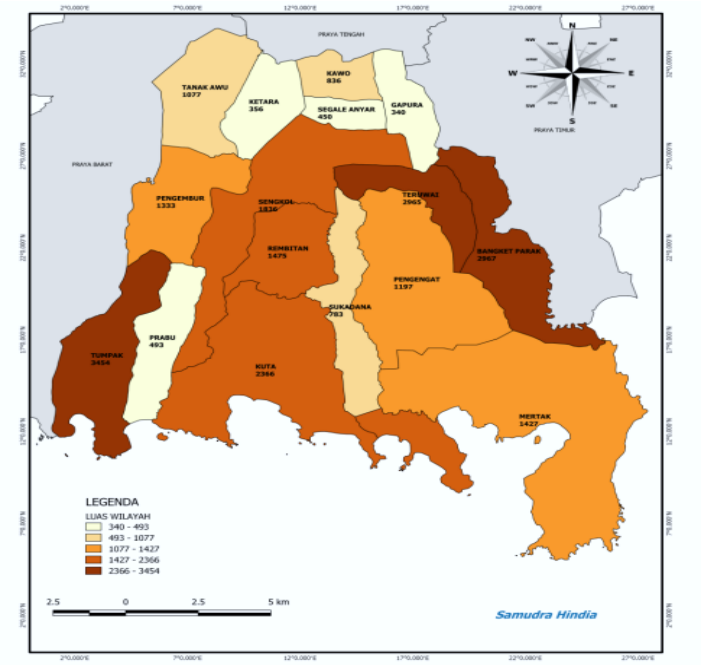

Fig. 3. Area by village in Pujut subdistrict.

Table 1.
The area of the Pujut subdistrict is based on the village.

	Village	Area (km^2)	Percentage (%)
1.	Tumpak	3454	14.79
2.	Prabu	493	2.11
3.	Kuta	2366	10.13
4.	Rembitan	1475	6.32
5.	Sukadana	783	3.35
6.	Mertak	1427	6.11
7.	Pangengat	1197	5.13
8.	Teruwai	2965	12.70
9.	Gapura	340	1.46
10.	Kawo	836	3.58
11.	Segala Anyar	450	1.93
12.	Sengkol	1836	7.86
13.	Pengembur	1333	5.71
14.	Ketara	356	1.52
15.	Tanak Awu	1077	4.61
16.	Bangket Parak	2967	12.70
	TOTAL	23355	100.00

Table 2 shows that the Pujut sub-district has more dry land than paddy fields. The three research locations were Tumpak Village, with 300 ha of paddy fields and 2,504 ha of dry land; Kuta Village, with 158 ha of paddy fields and 1,446 ha of dry land; and Teruwai Village, with 883 ha of paddy fields and 1,424 ha of dry land. The soil texture in the three locations is dominated by dry land with a rain-fed farming system, causing farmers in this area to plant once a year. Based on the results of in-depth interviews, farmers in this area inform us that they plant corn or soybeans to fill the void in their land. Dry land is a type of agriculture that is carried out on dry land, namely land that has a low water content. Even more extreme is that this dry land tends to be arid and does not have a definite water source, such as rivers, lakes, or irrigation canals. Dryland expects

only rainfall. Dryland belongs to the suboptimal land type, defined as land that is less able to support food production due to a lack of one or more supporting elements or components. Dryland is usually planted with many crops, such as horticultural and plantation crops, and food crops, such as upland rice, corn, cassava, sweet potatoes, peanuts, and soybeans. Dryland crops discussed using an expert system are breadfruit, snake fruit, sapodilla, mangosteen, and soursop (Heliza et al. 2018).

Table 2.
Area of paddy field land and dry land in Pujut subdistrict.

Village	Wetland	Dryland	Total
1. Tumpak	300	2504	2804
2. Prabu	110	283	393
3. Rembitan	158	1446	1604
4. Sukadana	882	413	1295
5. Mertak	196	494	690
6. Pangengat	230	286	516
7. Teruwai	318	331	649
8. Gapura	883	1424	2307
9. Kawo	274	4	278
10. Segala Anyar	728	27	755
11. Sengkol	303	106	409
12. Pengembur	725	263	988
13. Ketara	942	297	1239
14. Tanak Awu	270	63	333
15. Bangket Parak	556	422	978
TOTAL	**6875**	**8363**	**15238**

Factors Causing Deterioration in Soil Quality

To find out in depth the causes of the decline in soil quality in the research location, it was carried out descriptively through 3 activities, namely in-depth interviews using a questionnaire of 45 respondents (farmers) with 15 farmers in each village, counseling activities of 30 participants presenting ten people from each village in the three locations, and the forum group discussion (FGD), which presented eight stakeholders and policymakers, including the head of the Central Lombok Agriculture and livestock service, Pujut Sub-district head, secretary of the Tumpak Village head, Terwai Village head, Kuta Village head, extension coordinator, Danramil Pujut, and Pujut police chief.

Table 3.
Factors Causing Soil Quality Decline

Factors causing the decline in soil quality	Number of People	Percentage (%)
Eruption	1	1
Excessive use of perticides	13	17
Reduced soil nutrients	2	3
Burning leftovers	12	16
Monoculture planting pattern	18	24
Deforestation	1	1
Type C mining and quarrying	0	0
Use of heavy equipment	19	25
Environmentally unfriendly	5	7
Development	4	8
Total	**75**	**100**

Independent interview using questionnaires and counseling

Based on the results of in-depth interviews and counseling using a questionnaire involving 75 farmers, with 25 farmers per village, it is known that the causes of the decline in soil quality are shown in Table 3. Table 3 shows the main factors of the decline in soil quality according to farmers in the three locations, caused by four main factors with the highest percentage results: mining business (25%), industrial pollution (24%), use of pesticide fertilizers (17%), and burning leftovers (16%).

Forum Group Discussion (FGD) To resolve the problem of decreasing soil quality, FGD activities aim to inform stakeholders and policymakers in making policies to improve soil quality to reduce soil degradation (Thorsøe et al. 2019).The four factors are shown in the following table.

Table 4.
The main factors causing land degradation

Soil Quality Deterioration Factors	Number of people	Percentage (%)
Mining and quarrying business type C	19	25
Land function ttransfer	18	24
Excessive use of pesticides	13	17
Burning leftovers	12	16

Table 4 shows that mining is the main factor in decreasing soil quality or degradation, with a percentage of 25%—construction or excavation of types C and B in the Kuta and Prabu areas. Many people complain because it impacts agricultural land, which is the source of livelihood in this area. In addition, with a percentage of 24%, land conversion was caused by the Mandalika KEK and the construction of the Mandalika circuit because most people still question the construction of the Mandalika circuit, which is detrimental to society. The use of pesticides or organic fertilizers with a percentage of 17% Until now, the community or farmers in the area have admitted that 100% use organic fertilizers due to a lack of understanding and limitations of inorganic fertilizers suggested by the government and burning crop residues, with a percentage of 16%. From survey results and observations, farmers still clean up crop residues by burning crop yields, even though harvested straw can be used as fertilizer (Pranata 2010). Based on the percentage results of the factors causing the decline in soil quality, an FGD was conducted to follow up on existing problems. The FGD activities involving the district, related agencies, and other stakeholders resulted in the determination of solutions and the socialization of the benefits of the solutions provided. The solutions and benefits to the causes of soil degradation can be seen in Table 5. Evaluation activities carried out during the research included coordinating with the sub-districts and related agencies related to solutions or policies to solve the problem of soil degradation. The influence of factors causing soil degradation (soil degradation) on the level of agricultural productivity in Pujut District was determined to determine the effect of factors causing land subsidence on the level of agricultural productivity in Pujut District with three villages as the central locations, namely Tumpak Village, Kuta Village, and Teruwai Village. The regression results were obtained as shown in Table 6. Based on the output display of the SPSS model summary, the value of R^2 is 0.788, meaning that 78.8% of the change or variation in the value of the dependent variable (Y) can be explained by variations of all independent variables (X_1, X_2, and X_3). The remainder (100% - 78.8% = 21.2%) is explained by other reasons outside the model.

Tabel 5.
FGD result; provision of solutions and benefits to the factors causing land subsidence in Pujut Subdistrict.

Soil Quality Deterioration Factors	Solution	Benefit
Mining and Quarrying Business Type C	Closing the former mine excavation	minimize the kinetic energy of rain hitting the ground surface and inhibiting surface water flow (run-off) and causing water that enters the soil to increase so that soil erosion decreases and the environmental ecosystem is also improved. The more the soil surface is covered by vegetation, the better it is in protecting the soil from erosion.
Land Function Transfer	Providing assistance and incentives for farmers, increasing the capacity of human resources in the agricultural sector and strengthening policies in the agricultural sector	Farmers have capital in making businesses more independent
Excessive use of pesticides	Inorganic fertilizer application	Able to provide nutrients in a relatively short time, produce available nutrients that are ready to be absorbed by plants, contain more nutrients, do not smell pungent, practical and easy to apply.
Burning Leftovers	Application of rules prohibiting burning of crop residues in rice fields	Increasing soil nutrients which have an impact on improving soil quality and increasing production, Reducing pests and diseases caused by burning ash, reducing environmental pollution.

Table 6.
SPSS output results in coefficient determination (R^2).

Model	R	R square	Adjusted R square	Std. Error of Estimate
1	0.280[a]	0.788	0.026	1.00479

Table 7.
Anova result.

Model	Sum of Square	df	Mean Square	F	Sig.
1 Regresion	5.994	4	1.498	1.484	0.0003[b]
Residual	70.673	70	1.010		
TOTAL	76.667	74			

Based on Table 7. ANOVA test or F-test: the F-count value is 1,484 with a probability of 0.003; because the probability is smaller than α = 0.05, Ho is rejected. This means that together (simultaneously), all the independent variables (X_1, X_2, X_3, and X_4) included in the model have a significant effect on the level of agricultural productivity (Y). Partial Significance Test (t-test) Based on the coefficients table, it is known that the t-count value for X_1 is 0.840 with a probability of 0.004; because the probability is smaller than α = 0.05, Ho is rejected, meaning that the regression coefficient X_1 is significant or has a significant effect on the dependent variable (Y). The t-count value for X_2 is 1,449 with a probability of 0.001; because the probability is smaller than α = 0.05, Ho is rejected, meaning that the regression coefficient X_2 is significant or has a significant (negative) effect on the dependent variable (Y). The t-count value for X_3 is 0.746 with a probability of 0.003; because the probability is smaller than α = 0.05, Ho is rejected, meaning that the regression coefficient X_3 is significant or has a significant effect on the dependent variable (Y). X_4 is 0.732 with a probability of 0.002; because the probability is smaller than α = 0.05, Ho is rejected, meaning that the regression coefficient X_4 is significant or has a significant effect on the dependent variable (Y). Based on the coefficient table, the regression equation can be written as follows:

$$Y=5.398+0.97X_1+0.125X_2+0886X_3+0.861X_4 \quad \text{.....(3)}$$

A constant of 5,398 states that if all independent variables are considered constant (fixed), then the average productivity level is 5,398; the X_1 regression coefficient of 0.971 states that if the X_1 variable (mining and quarrying business types c and b) increases by one unit and the other variables are considered constant (fixed), then the productivity level increases by 0.971; the X_2 regression

coefficient of 0.125 states that if the X_2 variable (land conversion) increases by one unit and the other variables are considered constant (fixed), then the productivity level is 0.125; the X_3 regression coefficient of 0.886 states that if the X_3 variable (excessive use of pesticides) increases by one unit and the other variables are considered constant (fixed), the productivity level is 0.886; and the X_4 regression coefficient of 0.861 states that if the X_4 variable (burning of crop residues) increases by one unit and the other variables are considered constant (fixed), the productivity level is 0.861.

4. Conclusion and Recommendations

Pujut District is a sub-district in Central Lombok Regency with the widest area among the 12 existing sub-districts, which is around 23,355 ha or occupies around 19.33 hectares. The research locations are Tumpak Village (3,454) with a percentage of 14.79%, Teruwai (2,965) with a percentage of 12.70%, and Kuta (2,366) with a percentage of 10.13%. These three villages have dry, sandy soil textures. Pujut sub-district generally has a dry and sandy soil texture, with a total paddy field area of 6875 and a dry land area of 8,363. Research activities include surveys, observations, in-depth interviews, counseling, FGDs, and evaluation of follow-up FGDs.

Based on the primary data processed, ten factors cause land subsidence in the Pujut sub-district. However, four major factors cause a decrease in soil quality, which results in a decrease in agricultural productivity, namely mining and raking types C and B, land conversion, excessive use of pesticides, and burning of crop residues. On this basis, a forum group discussion (FGD) is conducted. There is a significant relationship between the level of agricultural productivity in Pujut District and the factors that cause a decrease in soil quality or soil degradation at the study site.

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