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Borich Needs Assessment to Design Sustainable Agriculture Adoption Interventions in The Context of Climate Change Mitigation

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ABSTRACT

This study aims to assess extension needs to accelerate the adoption of sustainable agricultural practices as a climate change mitigation strategy in Nort Bulango District, Gorontalo Province, Indonesia. Using a mixed methods approach, the research integrates quantitative and qualitative data collected from 248 corn farmers across eight villages. The Borinch Needs Assessment (BNA) model is applied, incorporating innovation attributes and decision making stages from the Diffusion of Innovations Theory as the analytical framework. The assessment focuses on nine key components of sustainable agriculture, including reduced chemical fertilizer use, adoption of organic fertilizers, soil cultivitation use, chemical herbicide use, and waste management. Results indicate that soil tillage, particularly plowing, ranks as the top extention priority in five villages, revealing as significant gap between its perceived importance and farmers actual knowledge. The continued use of intensive plowing contributes to long term soil degradation and icreases erosion, yet farmer awareness of these impacts remains low. In addition, the widespread use of chemical herbicides and the limited application of organic fertilizers emerged as critical areas requiring targeted intervention. The findings underscore the need for responsive, context specific agricultural extension programs to promote sustainable farmis techiniques. Strengthening farmer knowledge and awareness through tailored extension service is essential for advancing environmentally sound agriculture and enhancing local adaptive capacity to climate change. This study contributes to the literature by demonstrating how the Borinch Needs Assessment (BNA) model can be strategically applied within a climate change dengan mitigation framework to identity and prioritize extension needs in developing country contexts.

***Keywords**: sustainable agriculture, BNA, climate change mitigation, agriculture extension, innovation adoption*

BACKGROUND

Indonesia's agricultural sector remains the backbone of rural livelihoods, leveraging diverse agroecological zones and abundant natural resources. The sector covering food crops, plantations, livestock, firsheries, and forestry plays a central role in national development. More than 88% of the population depends on agriculture as a primary livelihood source (BPS, 2023), making it a strategic sector that demands sustainable management (Arsyad, Aznur, et al., 2023).

Despite its economic importance, many agricultural practices in rural areas remain environmentally unsustainable. One major concern is the open burning of agricultural waste, which

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releases large volumes of greenhouse gases. Indonesia produces around 45 million tons of agricultural waste annually, much of which is burned without processing, causing air pollution and contributing to climate change (Andini et al., 2018; Sun et al., 2016). In addition, the overuse of chemical fertilizers has been linked to soil degradation and declining environmental quality (Tongwane et al., 2016).

Climate change manifested through long term shifts in temperature and weather patterns has disrupted agricultural systems globally, with severe impacts in developing countries. Limited farmer knowledge of sustainable agricultural practices remains a critical barrier to local level climate mitigation (M. Nur et al., 2024). Sustainable agriculture, defined as economically viable farming that preserves soil, water, and biodiversity for long term productivity (Firnia et al., 2023), offers a pathway to resilience. However, achieving this requires consistent behavior change supported by effective extension services.

However, despite increasing attention from policymakers and researchers, sustainable agriculture adoption remains limited. For example, the use of organic fertilizers is still low even in areas where livestock waste is readily available. Abdullah et al. (2023) found that organic fertilizers and botanical pesticides not only reduce chemical input but also enhance farmers environmental awareness. This underlines the importance of targeted extensions interventions to improve knowledge and encourage practice change.

Previous research has largely examined the relationship between farmers socio economic characteristics and innovation adoption but rarely situates sustainable agriculture adoption within a climate change mitigation framework. This limited integration constrains the development of strategic extension programs that align sustainability goals with farmers everyday realities, ultimately slowing the transition to climate resilient agriculture.

To address this gap, this study applies the Borich Needs Assessment (BNA) model to identify and prioritize extension needs among corn farmers in North Bulango District, Gorontalo Province, a region increasingly vulnerable to climate related risks. The results are intended to provide evidence based recommendations for designing context specific extension programs that enhance adaptive capacity and accelerate the adoption of sustainable, climate mitigating agricultural practices.

RESEARCH METHODS

This study employed a mixed-method approach, integrating both quantitative and qualitative methods sequentially. Quantitative data collection and analysis were conducted first, followed by qualitative data collection to provide deeper contextual insights. This sequential explanatory design allowed for comprehensive interpretation, moving from broader statistical trends to more nuanced explanations.

The research was conducted in Bulango Utara Subdistrict, Bone Bolango Regency, Gorontalo Province, an area where most residents are engaged in farming and which is highly prone to environmental hazards. The study population consisted of 732 corn farmers, and the minimum sample size was determined using the formula developed by Isaac an Michael (Arsyad, Sitompul, et al., 2023), resulting in 247.7, which was rounded up to 248 respondents:

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S = (λ^2.N.P.Q)/(d^(2( ) N-1)+ λ^2.PQ)
= 247.7 (rounded up to 248)

Primary data were obtained through direct face to face interviews using structured questionnaires in two stages. The first stage involved collecting quantitative data on farmers' socioeconomic characteristics and their adoption of sustainable agricultural practices. The second stage collected qualitative data to explain and enrich the quantitative findings.

The study focused on nine components of sustainable agricultural innovation:

1. Reduction in the use of chemical fertilizers
2. Use of organic fertilizers
3. Use of chemical insecticides
4. Use of chemical herbicides
5. Soil tillage using plowing
6. Crop rotation
7. Intercropping
8. Agricultural waste management
9. Reforestation

Adoption data were measured on a Likert-type scale across three aspects: behavior, level of knowledge, and perceived importance.

- Behavior: Always (5) to Never (1)
- Level of knowledge: Very Knowledgeable (5) to Not Knowledgeable (1)
- Perceived importance: Very Important (5) to Not Important (1)

These scales ensured consistency in the Borich Needs Assessment (BNA) analysis. Survey results were summarized in tables and analyzed using descriptive statistics. Farmers adoption levels (low, medium, high) were treated as an ordinal dependent variable, and multinomial regression was used to identify factors influencing these levels. This statistical method was chosen because it is suitable for modeling relationships when the dependent variable consists of more than two ordered categories. To complement the quantitative findings, qualitative descriptive analysis was applied.

The Borich Needs Assessment (BNA) model was used to identify the gap between farmers' perceived importance and their level of knowledge for each Good Agricultural Practice (GAP) component. The analysis applied the Mean Weighted Discrepancy Score (MWDS) method:

1. Calculate the discrepancy score = (Perceived importance – Level of knowledge) for each respondent and competency.
2. Multiply each discrepancy score by the mean perceived importance score.
3. Average these values across all respondents to obtain the Mean Weighted Discrepancy Score (MWDS).

The formula is:

$$Borich\ Needs = \frac{\sum \quad (RCL-PCL) \times \underline{RCL}}{N}$$

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Where:

- RCL (Required Competence Level) = Perceived importance
- PCL (Present Competence Level) = Level of knowledge
- N = Total number of respondents

Priorities were ranked based on the Mean Weighted Discrepancy Score (MWDS), and the range between the highest and lowest scores was divided into three categories: high, medium, and low priority.

RESULT AND DISCUSSION

This study involved a total of 248 farmers from Bulango Utara Subdistrict. There are nine villages in this area: Bandungan, Boidu, Tupa, Longalo, Tuloa, Lomaya, Kopi, Bunuo, and Suka Damai. Bulango Utara covers a total area of 176.09 km² (BPS, 2023). Among these, Longalo Village has the largest land area, accounting for 17.11% of the total, while Kopi Village is the smallest, with only 5.67%.

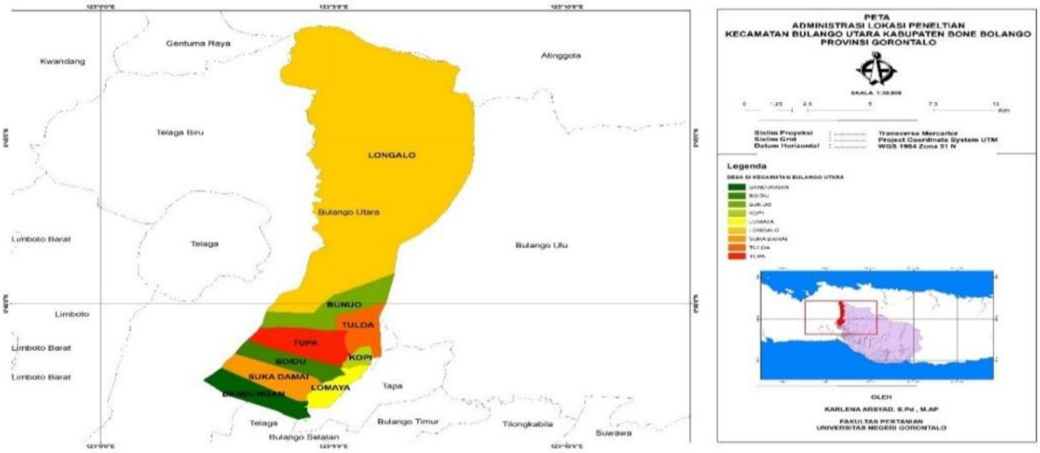

Figure 1. Research Location: North Bulango District

Bulango Utara, with a population of 8,278 people (4,189 males and 4,089 females), is bordered by Kecamatan Atinggola to the north, Bulango Ulu to the east, Tapa to the south, and Telaga to the west. Bandungan Village accounts for the largest share of the population (15.84%), while Molaya Village has the highest population density at 81.55 people per km².

Respondent Characteristics

This study, conducted across eight villages in Bulango Utara Subdistrict, involved 248 corn farmer respondents who were interviewed. The diversity of respondent characteristics is presented in Table 1.

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Table 1. Respondent Identity

Characteristics	Category	Frequency	%
Age	<30 years old	9	3.6
	30-39	39	15.7
	40-49	98	39.5
	50-59	68	27.4
	60 years and above	34	13.7
Gender	Male	202	81.0
	Female	46	18.5
Education	No School	31	12.5
	Graduated From Elementary School	128	51.6
	Graduated From Junior High School	52	21.0
	Graduated From High School	36	14.5
	Diploma/Bachelor	1	0.4
Land Area	Under 0,5 Ha	13	5.2
	0,5-0,9 Ha	78	31.5
	1-2 Ha	146	58.9
	Above 2 Ha	11	4.4
Usahatani di luar jagung	Yes	139	56.0
	No	109	44.0
Usaha off-farm	Yes	163	65.7
	No	85	34.3

Source: Primary Data Processed, 2024

The majority of farmers in Bulango Utara are within the productive age range of 40–49 years. Male farmers constitute approximately 81% of respondents, reflecting traditional labor divisions in which physically demanding agricultural activities are predominantly performed by men (Arsyad & Sirajuddin, 2023).

In terms of education level, 51.6% of respondents had completed elementary school as their highest level of education. The average landholding size among the respondents was 1 hectare, which significantly influences the potential for large-scale corn cultivation and productivity.

In addition to cultivating corn, many farmers particularly in Butu Village were also engaged in other agricultural activities or operated non-agricultural businesses. This aligns with the demographic patterns found in previous research by Sirajuddin (2021), which indicated that many corn farmers in Gorontalo cultivate other types of crops in addition to corn, and some even operate businesses outside of farming. Similar trends were observed in this study area, where some corn farmers also cultivate crops such as chili and other secondary commodities.

Sustainable Agricultural Practices

Sustainable agriculture is one of the key strategies for mitigating climate change. Several efforts can be undertaken to implement sustainable agricultural practices, as summarized in Table 2.

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Table 2. Adoption of Sustainable Agricultural Innovations

No.	Component	Description
1.	Reduction in the Use of Chemical Fertilizers	Chemical fertilizers are considered more practical and widely accessible. However, excessive use of these fertilizers can have detrimental effects on soil health. The negative impacts include the destruction of earthworms, which leads to reduced soil fertility, and the disruption of nutrient balance in the soil, ultimately causing soil compaction and a decline in its structure and quality.
2.	The Use of Organic Fertilizers	The use of organic fertilizers in agricultural land can improve soil quality, enhance soil fertility, and reduce environmental pollution caused by the application of non-organic fertilizers. When applied consistently over the long term, organic fertilizers can increase land productivity and contribute to sustainable yield improvement.
3.	Use of Chemical Insecticides	Pesticides contribute to environmental pollution and have been associated with various health problems, including cancer. While the optimal use of pesticides can enhance agricultural yields, the chemical substances they contain also pose a risk of poisoning and other adverse health effects.
4.	Use of Chemical Herbicides	Chemicals such as herbicides are used to eliminate weeds and other unwanted plants. These chemicals are typically applied during land preparation before planting and after harvesting.
5.	Soil Tillage with Plowing	Soil can be tilled using animal, human, or mechanized power, such as tractors. The purpose of tilling is to loosen and soften the soil. However, excessive tilling, especially at deep levels, can negatively affect soil health and fertility, leading to a decrease in corn production. It can also make the soil more prone to erosion by wind and rain. Proper tilling involves plowing to a depth of 12-20 cm from the soil surface, typically performed twice. The continuous use of modern machinery, such as tractors, for soil tilling can lead to a decline in soil fertility, as it alters the physical properties of the land.
6.	Crop Rotation	Crop rotation involves alternating the planting of different crops on the same land. This practice is beneficial for soil fertility as it enhances soil structure. Crop rotation can also reduce pest and disease infestations and help in the formation of a stable micro-ecosystem.
7.	Intercropping	Intercropping is a farming practice where two different crops are grown together on the same land. This method can also increase farmers' income. Intercropping offers several benefits, such as reducing the risk of losses, minimizing pest attacks, and improving nutrient absorption by plants. It helps reduce agricultural risks, increases land productivity, and ensures stable income continuity.
8.	Reforestation	Planting trees can have positive impacts on the environment. This activity helps mitigate environmental damage, such as

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No.	Component	Description
		natural disasters and global warming caused by burning. Additionally, trees provide significant benefits for human health.
9.	Agricultural Waste Management	Agricultural waste management aims to reduce environmental pollution and produce valuable products. Agricultural waste can be managed in various ways, such as by processing damaged or decomposed waste into organic fertilizers. These fertilizers, derived from plant residues, are rich in nutrients that contribute to soil fertility.

Table 2 presents nine components of sustainable agricultural practices, which emphasize both economic sustainability and ecological balance. This farming method not only considers financial profitability but also takes into account the environmental impact of agricultural activities. Agricultural extension programs play an essential role in supporting farmers to adopt sustainable agriculture by promoting practices that involve listening, observing, and applying principles of sustainability in the field.

Sustainable agriculture seeks to minimize the excessive use of chemical pesticides, herbicides, and fertilizers. These inputs can be replaced with environmentally friendly alternatives, such as natural fertilizers, botanical pesticides, crop rotation, and intercropping, all of which contribute to improved soil productivity. In essence, sustainable agriculture involves the management of natural resources, technological advancements, and institutional frameworks in a way that ensures the fulfillment of human needs for both present and future generations (Salim Hehanussa et al., 2023).

Analysis of the Priority of Extension Needs in Sustainable Agricultural Practices as an Effort to Mitigate Climate Change

The formulation of priority extension materials related to sustainable agricultural practices needed by extension workers is carried out through an analysis of the priority of sustainable agricultural practices. This is aimed at identifying the materials that are most needed to be delivered to farmers. By doing so, the extension materials can better meet the farmers' needs and improve their knowledge of corn cultivation. The extension needs analysis using the Borinch Needs Assessment (BNA) is a model that can be applied because the Borinch Needs Assessment (BNA) model identifies the actual needs that are prioritized in terms of the significance of training themes (Ashraf et al., 2020).

Table 3. Borich Needs Assessment (BNA) Results for Sustainable Agricultural Practices in Each Village

Village	Sustainable Agricultural Practices	MWDS
Bandungan	Soil Tillage	8.28
	Use of Chemical Herbicides	1.19
	Intercropping	-0.82
	Crop Rotation	-0.85
	Agricultural Waste Management	-0.90
	Reforestation	-0.91

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Village	Sustainable Agricultural Practices	MWDS
	Reduction in Chemical Fertilizer Use	-1.72
	Use of Chemical Insecticides	-2.07
	Use of Organic Fertilizers	-2.17
Longalo	Soil Tillage	8.15
	Crop Rotation	-0.58
	Use of Chemical Herbicides	-0.61
	Intercropping	-0.68
	Agricultural Waste Management	-1.13
	Reforestation	-1.14
	Use of Chemical Insecticides	-1.92
	Use of Organic Fertilizers	-2.09
	Reduction in Chemical Fertilizer Use	-2.12
Bunuo	Use of Chemical Herbicides	4.45
	Use of Organic Fertilizers	2.05
	Soil Tillage	0.84
	Intercropping	-0.65
	Reduction in Chemical Fertilizer Use	-0.87
	Agricultural Waste Management	-1.13
	Crop Rotation	-1.48
	Reforestation	-3.37
	Use of Chemical Insecticides	-3.87
Lomaya	Crop Rotation	-0.39
	Agricultural Waste Management	-0.61
	Intercropping	-0.64
	Use of Chemical Insecticides	-1.12
	Use of Chemical Herbicides	-1.32
	Reforestation	-1.51
	Reduction in Chemical Fertilizer Use	-1.71
	Use of Organic Fertilizers	-1.76
	Soil Tillage	-1.89
Boidu	Soil Tillage	4.29
	Use of Chemical Insecticides	2.11
	Crop Rotation	0.22
	Reforestation	0.17
	Agricultural Waste Management	-0.34
	Reduction in Chemical Fertilizer Use	-0.40
	Intercropping	-0.43
	Use of Organic Fertilizers	-0.60
	Use of Chemical Herbicides	-0.84
Tupa	Reforestation	-1.20
	Crop Rotation	-1.33
	Reduction in Chemical Fertilizer Use	-1.36
	Intercropping	-1.47
	Use of Chemical Herbicides	-2.00
	Use of Organic Fertilizers	-2.12
	Agricultural Waste Management	-2.20

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Village	Sustainable Agricultural Practices	MWDS
	Soil Tillage	-2.27
	Use of Chemical Insecticides	-3.10
Suka Damai	Soil Tillage	7.44
	Crop Rotation	0.44
	Reforestation	0.42
	Use of Organic Fertilizers	-0.06
	Use of Chemical Herbicides	-0.06
	Intercropping	-0.06
	Agricultural Waste Management	-0.06
	Reduction in Chemical Fertilizer Use	-0.12
	Use of Chemical Insecticides	-0.18
Tuloa	Soil Tillage	14.03
	Crop Rotation	2.54
	Reforestation	1.92
	Intercropping	0.19
	Use of Chemical Insecticides	-0.04
	Use of Chemical Herbicides	-0.04
	Agricultural Waste Management	-0.04
	Reduction in Chemical Fertilizer Use	-0.08
	Use of Organic Fertilizers	-0.08

In this study, Borinch Needs Assessment (BNA) was used to analyze the priority of sustainable agricultural practices materials, to identify which materials are most prioritized for extension regarding sustainable agricultural practices in the context of climate change mitigation. There are several stages in the Borinch Needs Assessment (BNA) analysis. First, the discrepancy between the importance level of materials for farmers to understand (perceived importance) and the farmers' knowledge of sustainable agricultural practices (knowledge of competency) is calculated for each competency. Then, the Weighted Discrepancy Score for each respondent is computed. The Mean Weighted Discrepancy Score (MWDS) is then calculated and ranked to determine priority needs. Table 3 shows the results of the analysis of priority extension materials using The Borinch Needs Assessment (BNA).

As seen in the table, the Mean Weighted Discrepancy Score (MWDS) calculation results show that Borinch Needs Assessment (BNA) analysis of the sustainable agricultural practices materials identifies 9 components of sustainable agricultural practices among corn farmers in 8 villages in Bulango Utara District.

The results show that the land cultivation component, particularly plowing, is a priority material that farmers need for extension, especially in the villages of Bandungan, Longalo, Boidu, Suka Damai, and Tuloa. The high the Mean Weighted Discrepancy Score (MWDS) score for soil tillage may also be influenced by the reverse scoring applied to negatively framed questionnaire items. Interestingly, some villages, such as Lomaya and Tupa, recorded negative MWDS scores for most components. This trend may be linked to their local farming contexts, including relatively better

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access to extension services, smaller cultivated areas, and existing adoption of certain sustainable practices, which reduce the perceived need for additional training in those areas.

Intensive land cultivation is a method used to maximize results. However, over time, this approach can reduce soil quality. Excessive land cultivation can be a major factor in causing soil structure damage. By reducing the impact of intensive plowing, such as implementing conservation tillage and using plants or weeds as mulch, farmers can reduce erosion by decreasing the destructive force of surface water flow and rainfall. This approach can be adopted by farmers in the area.

Bulango Utara District is characterized by sloped land. Due to this, most farmers avoid plowing methods. Instead, after harvest, they burn the land and then spray herbicides. This practice is reflected in the Mean Weighted Discrepancy Score (MWDS) results for chemical herbicide use, which emerged as the next priority material needed by extension workers for farmers in the villages of Bandungan and Bunuo. This is because farmers have low knowledge about the long-term impact of repeated chemical herbicide use. Herbicides, also known as weed killers, are chemical compounds used to control weeds. Due to their ease of use and low labor requirements, chemical herbicides are often used by farmers in the long term (Jusuf et al., 2024). A study by Gelyaman et al. (2020) found that farmers use synthetic herbicides like phosphinothricin, paraquat, and glyphosate, which cause soil ecosystem imbalance and lead to decreased soil fertility.

The use of organic fertilizers, although important for sustainable agricultural practices, is not currently a priority material for extension, even though it should be. At present, farmers tend to use chemical fertilizers more frequently due to their lower cost and easier availability. However, sustainable agricultural practices such as the use of organic fertilizers and soil conservation techniques are becoming increasingly important to maintain long-term productivity (Arsyad, Mustafa, et al., 2024).

In line with research by Lakatara et al. (2024), which shows that farmers knowledge of sustainable agriculture for climate change mitigation remains very low, other components such as intercropping, chemical insecticide use, agricultural waste management, reforestation, and crop rotation were consistently ranked as lower priorities. This may be due to limited farmer knowledge, low practicality within existing farming systems, or cultural preferences for conventional methods. This suggests that without targeted interventions to build awareness and capacity in these areas, opportunities to enhance long-term sustainability and resilience in local farming systems may remain underutilized.

CONCLUSION AND SUGGESTION

The findings of this study in Bulango Utara District indicate that, among the components of sustainable agricultural practices, soil tillage emerges as the highest priority for extension needs. The Borich Needs Assessment (BNA) approach proved effective in identifying specific knowledge gaps, enabling a clear prioritization of training topics. In addition to soil tillage, the use of chemical herbicides and the limited application of organic fertilizers also surfaced as important areas requiring targeted intervention. Therefore, the role of agricultural extension agents is crucial in delivering context-specific guidance and capacity-building programs. Strengthening farmers' competencies in

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these areas can enhance agricultural productivity while contributing to climate change mitigation efforts in Bulango Utara District.

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