Analysis of the Adoption Rate of Lowland Rice Technology in Bolaang Mongondow Regency, North Sulawesi Province

Joula O.M. Sondakh[1,*], *Helena* Da Silva[1], *Janne* H.W. Rembang[2], *Meivie* Lintang[3], *Jefny* B. Markus Rawung[2], *Gabriel* H. Joseph[3], *Ronald* T.P. Hutapea[1], *Demas* Wamaer[1] and *I Gusti* Ayu Putu Mahendri[1]

[1] Research Center for Macro Economic and Financial, National Research and Innovation Agency, Jakarta 12710, Indonesia
[2] Research Center of Horticulture and Plantation Crops, National Research and Innovation Agency, Bogor 16915, Indonesia
[3] Research Center for Agroindustry, National Research and Innovation Agency, Cibinong, Indonesia

Abstract. Farming technology will be successful if farmers adopt it correctly. The research aims to determine the level of farmers' adoption of lowland rice farming technology. The research location was in Bolaang Mongondow Regency in October 2022, using a survey technique of 30 lowland rice farmers. Adoption data were analyzed descriptively and Spearman's correlation statistic test. The results of the correlation test showed that there was a negative relationship between the adoption of technology components and age and education, but was positive for farming experience, land area, innovation characteristics. The information channel correlation is not significantly related at the level of $\alpha = 0.05$ with the technology component adopted, this means that there are many information channels that can be utilized but farmers do not directly apply the technology obtained. Meanwhile, the adoption of lowland rice technology components, namely harvest handling - post-harvest, was 96.67%, the use of NSV and intermittent irrigation was 90% each, and other technological components were below 80%. The government has an important role in introducing technological innovations by adjusting the level of needs and whereabouts of farmers to technological components so that they can be adopted for the expected increase in productivity.

1 Introduction

Appropriate agricultural development policies are crucial in reducing poverty and accelerating economic growth because agricultural activity is projected to play a significant role in supplying people with food and employment.

Agricultural productivity is an important condition for achieving economic growth and development in developing countries, although the relationship between agricultural productivity and economic growth can be complex [1]. Agricultural development has also been recognized as a potential solution to the problem of food insecurity in developing

* Corresponding author: joul001@brin.go.id

countries. [2]. To increase productivity, reduce production costs, be environmentally friendly, and adapt to climate change, the adoption of various agricultural technologies has become the best option worldwide [3].

Farmers can increase agricultural productivity by adopting enhanced agricultural technology improvements. (E.g., high-yield variety crops, genetically modified crops), as well as good extension services that promote access to financing and insurance markets, as well as irrigation facilities. All of this can result in not only increased yield, income, labor savings, efficiency, and productivity, but also environmental (e.g., reduced consequences of climate change) and health benefits [4, 5, 6]. Despite the potential benefits of implementing agricultural technological advancements, relatively low adoption rates continue to be a development challenge in most developing nations.

Rice agribusiness in Indonesia has generally not optimally applied technological innovations, resulting in low productivity. On the other hand, rice productivity varies by location, both due to differences in agroecosystems, social conditions, farmer culture, and farmer responses to these innovations [7]. It is further argued that technological innovation can be utilized by farmers and communities by juxtaposing, harmonizing, and incorporating research and study activities with user stakeholders' interests. The role of institutions in efforts to create location-specific adaptive technology through a participatory approach is a strategic point to increase access to communication for farmers as technology users.

Farmers frequently base adoption decisions on their personal and social attitudes and perspectives on the subject. Different modeling approaches have been drawn to such decisions [8]. While some research incorporates risk preference or attitude as an explanatory variable, the potential endogenous nature of risk preference in adoption has never received the attention it deserves.

An innovation will not be useful without adoption. Likewise, the technology that supports the development of organic agriculture will not be useful without adoption. The level of adoption is influenced by farmers' perceptions of the characteristics of the innovation, the changes desired by the innovation in agricultural management, and the role of the farm family. Innovations are usually adopted quickly because they have relatively high returns to the farmer, are compatible with his or her values, experience, and needs, are uncomplicated, can be tried on a small scale, and are easy to observe [9].

Many attempts have been made to study the factors that influence farmers' use of technology. A major strand of this research has specifically focused on the role of socioeconomic characteristics and institutional factors such as roads, location, access to credit, markets, and extension services on farmers' adoption of new technologies [10], with limited attention given to psychological and social dynamics such as farmers' risk-taking attitudes, social networks, and spatial dependence [11, 12-13].

[14] Defines adoption as the application or use of an idea, tool, or new technology delivered in the form of a communication message (through extensionThis type of adoption can be seen or noticed in the behavior, methods, and equipment utilized in communication activities.

Several previous research results have been offered to address the issue of technology adoption and innovation (including fertilizer and increasing women's access) as an important driver for increasing yield production. [15,16,17,18,19]. Additionally, several studies investigated age differences in farmers' technology adoption [20,21,22]. However, there has been no research that discusses the role of information and communication channels simultaneously to increase technology adoption as in this research

Bolaang Mongondow Regency is a mainstay area in North Sulawesi Province as a rice production center. So that it has an important role in efforts to fulfill community food needs, especially in North Sulawesi Province. As a result, it is critical to enhance rice production by expanding rice growing areas and employing cutting-edge technologies. Based on the foregoing, this research examines the level of acceptance of rice farmers in Bolaang Mongondow Region toward the development of rice farming technology, as well as the relationship between farmer characteristics and current communication channels.

2 Methodology

The location of the survey was Bolaang Mongondow District, one of the centers of paddy rice in North Sulawesi. The implementation time was October 2022, carried out in the form of an exploratory survey of 30 farmers by exploring data and information in depth to determine the extent of adoption of wet-rice technology.

The parameters measured included farmer characteristics, innovation characteristics, information channels, and communication channels on wetland rice technology. Data analysis was carried out descriptively, qualitatively, and quantitatively. The data analysis used in the research is descriptive analysis and non-parametric correlation analysis. The data were tabulated using the Excel computer software program. Statistical tests were performed on the data using the Spearman rank correlation test and the Statistical Package for the Social Sciences (SPSS) version 17 application. The spearman correlation test formula is:

$$rs = 1 - \frac{6\sum d^2}{n(n^2-1)} \tag{1}$$

Where:
rs = coefficient correlation Spearman
$\sum d^2$ = total squared differences between rankings
n = number of research samples

3 Results and Discussion

3.1 Analysis of rice paddy technology adoption

Adoption is a process of change that occurs in a person, and it can be seen that the person can accept or reject a technology or innovation program. It is closely related to the presence or absence of behavioral changes by the farmer. Adopting technological innovation is a process of accepting new items; the process can only be seen through the conduct of the individual concerned [23].

3.1.1 Correlation between Farmer Characteristics and Adoption of Technology Components

Table 1. Correlation of Farmer Characteristics with Adoption of Technology Components, 2022

No	Farmer Characteristics	Correlation Value	P Value
1	Age	-0.137	0.469
2	Education Level	-0.027	0.888
3	Farming Experience	0.036	0.852
4	Land Area	0.363*	0.049

Notes : * significant at level $\alpha = 0.05$

Results of the analysis of the connection between characteristics and the adopted technology components show that age and education factors have a negative link but are not significant at the level α = 0. 05.. The relationship between farming experience and the adopted technology components is positive but not significant at the level of $\alpha = 0.05$. With variable land area, there is a real positive relationship at the level of $\alpha = 0.05$ with the components of rice technology. This means that it can be said that the more land owned by farmers, the more technology components are adopted.

3.1.2 Correlation of Innovation Traits with Technology Component Adoption

Table 2. Correlation of Innovation Traits with Adoption of Technology Components, 2022.

No	Farmer Characteristics	Correlation Value	P Value
1	Relative advantage	0.416*	0.022
2	Complexity	0.379*	0.039
3	Suitability	0.430*	0.018
4	Observable	0.362*	0.050
5	Can be trialed	0.347	0.060

Notes : * significant at level α= 0.05

The analysis results indicate that each of the characteristics of technological innovation (relative advantage, complexity, appropriateness, and observability) have a true positive association with the accepted technology components at the level of α= 0.05. This means that the more profitable in relative terms (relative advantage), the easier it is to apply a technological innovation, the higher the level of suitability, and the higher a technological innovation can be observed, the more technical components are adopted. Technological innovation with the characteristics of being higher or easier to try has a positive relationship to the adopted technology components at the level of α= 0.10.

3.1.3 Correlation of Information Channels with Adoption of Technology Components

Table 3. Correlation of Information Channels with Adoption of Technology Components, 2022.

No.	Media	Information Channel	P value
1	Information Channel	0.179	0.344

The correlation study results shown that communication channels are not significantly related to the components of the technology used. The correlation value is positive but not real at the level of α= 0.05 in this case, which means that the number of information channels used by farmers to obtain technological information does not necessarily mean that farmers apply the technology obtained.

Table 4. Rice Technology Communication Channels, 2022

No	Technology Communication Channels	Number of Respondents who utilised	%
1	Newspaper	6	20.00
2	Brochures	18	60.00
3	Books	12	40.00
4	Radio	3	10.00
5	Internet	26	86.67
6	Television	17	56.67
7	Extension worker	29	96.67
8	Researcher	10	3333
9	Community Leaders	9	30.00
10	Farmer Group	22	73.33
11	Other Farmers	13	43.33
12	Pest Observers	3	10.00
13	Village Government	16	53.33

Communication channels that are often (> 70%) utilized by farmers to obtain technological information are extension workers, the internet, and farmer groups. Communication channels through print media (newspapers, brochures, and books), the village government, and other farmers are quite often (40–70%) used by farmers to obtain technological information. While communication channels such as radio, newspapers, pest observers, community leaders, and researchers are rarely utilized by farmers (<40%).

3.2. Adoption of Rice Cultivation Technology Components Technology

Adoption is a mental process that involves behavioral changes in the form of knowledge, attitudes, and skills in farmers from the time they learn about it until they decide to apply it [24, 25]. In the rice agribusiness in Bolaang Mongondow District, farmers have generally applied several technology components (Table 5).

Table 5. Application of Rice Technology Components, 2022

No	Technology Components	Number of Respondents who utilised	%
1	Use of new superior variety	27	90.00
2	Seed treatment	23	76.67
3	Fertilisation methods are Leaf Color Chart (LCC) and Paddy Soil Test Device (PSTD)	21	70.00
4	Integrated Pest Management (IPM)	19	63.33
5	Planting method/legowo	21	70.00
6	Transplanting young seedlings 14 - 21 days	19	63.33
7	Use of organic fertiliser	22	73.33
8	Intermittent irrigation	27	90.00
9	Use of liquid fertiliser and growth regulator	18	60.00
10	Harvest and post-harvest handling	29	96.67

Table 5 shows that post-harvest handling of rice is the stage of activities that include harvesting, threshing, drying, packaging, storage, and processing into rice for marketing. Post-harvest handling aims to reduce yield loss, suppress the level of damage, and increase the shelf life and usability of commodities to obtain added value [26, 27]. This stage of harvest and post-harvest handling is indeed carried out by almost all respondent farmers because it is familiar and hereditary, as well as for smooth marketing. From Table 5 above, it can be seen that the use of New Superior Varieties (NSV) and Intermittent Irrigation occupied the 2nd position in their use by respondent farmers (90%), where NSV is one of the dominant technological innovations and has proven to be able to increase rice production.

This technology is the main one in the application of rice cultivation and is most easily adopted by farmers [28]. As a production component, NSV contributes the most to increasing rice production by 56.1% [29], and this has been felt directly by respondent farmers, although they often face obstacles in obtaining quality seeds of the desired variety.

Furthermore, intermittent irrigation is water inundation carried out at certain intervals, and random irrigation is where the land is not inundated with water but only sufficiently saturated (water-saturated conditions) [30]. In addition to saving water, intermittent irrigation can minimize methane gas emissions from paddy fields, and muddy irrigation is an irrigation technology that can fulfill the water needs of plants under conditions of very limited water supply and raise the value of its utilization. [31]. This is one of the technologies that is a solution during water shortages, especially in the Bolaang Mongondow area if the dry season applies a water rotation system.

https://doi.org/10.1051/e3sconf/202344401006

Fertilization efficiency can be improved through balanced fertilization, which is the fulfillment of balanced nutrients according to plant needs. Nutrient balance increases production and quality of yields, fertilizer efficiency, soil fertility, and environmental pollution. Types of nutrients in the soil that have reached optimum levels or high status do not need to be added again [32]. Excessive fertilizer application can also reduce fertilizer efficiency and harm plants and the environment. In paddy fields with high nutrient content, rice plants do not respond to fertilizer [33]. The fertilizer method is only used by 70% of respondent farmers due to the lack or absence of tools to use, such as the Leaf Color Chart (LCC) and Paddy Soil Test Device (PSTD), as well as guidance on their use, so that the efficiency of nutrient use is only based on recommendations, not to mention the problem of fertilizer availability, making this fertilizer technology difficult to fully adopt. Similarly, the use of organic fertilizer is only 73.33%, liquid fertilizer is 60%, and growth regulator is 60%, which occurs because the availability of materials is smaller than the needs.

Integrated Pest Management (IPM) is an environmentally correct way of controlling pests. The concept of integrated pest management is one of the control efforts with an application that emphasizes agroecosystem management and pest control technology based on natural resources, including [34]. The application of IPM is only implemented by 63.33% of respondent farmers, even though this activity will foster the initiative, motivation, and ability of farmers and farmer groups to manage agrosystems and carry out pest control movements jointly among farmers and farmer groups.

The Jajar Legowo planting scheme is another effort of increasing crop output. The principle of the jajar legowo planting system is to enhance plant population by changing spacing so that the plantation will have rows of plants interrupted by empty rows, with the planting distance in the outer rows being half the spacing between rows. [35] This *jajar legowo* planting system is only followed by 70% of respondent farmers, even though there are actually many advantages obtained, such as more plant population, easier fertilization, and weeding, making all plants peripheral so that productivity automatically increases. But some farmers are still accustomed to the scatter seeds directly (hambela) system and consider the jajar legowo system to require relatively more labor, while currently, it is difficult to get labor.

4 Conclusion

The results of the correlation test show that there is a negative relationship between the components of technology adoption and age and education, but there is a positive relationship with farming experience, land area and innovation characteristics. If the correlation of information channels is not significantly related at the 0.05 level with the technological components adopted, it means that the number of information channels that can be utilized is not directly related to the way farmers apply the technology obtained. Meanwhile, the components of lowland rice technology adoption that are applied are harvest-post-harvest handling (96.67%), the use of NSV and intermittent irrigation (90% each), and other technology components below 80%. It can be seen that by adopting lowland rice technology, changes in the mentality and behavior of farmers have begun to become better in carrying out farming. Therefore, the government has an important role in introducing technological innovation by adjusting the level of farmers' needs and availability of technological components so that they can continue to be adopted to increase the expected productivity. Apart from that, assistance from agricultural officers is very necessary in carrying out the technology adoption process.

References

1. Omotuyole Isiaka Ambali, Fransisco Jose Areal, dan Nikolaos Georgantziz. *Agriculture* 2021, ***11***(8),691; https://doi.org/10.3390/agriculture11080691 (2021)
2. Mainuddin, M.; Kirby, M. Food Secur. **1**, 71–82. [Google Scholar] (2009)
3. Ly Thi Nguyen, Teruaki Nanseki,Satoshi Ogawa dan Yosuke Chomei. . International Journal of Plant Production **16**, pages93–104 (2022)
4. Abdullah ; Kouser, S.; Qaim, M. Bt Cotton, J. Agric. Econ. **66**, 66–86. (2015)
5. Villano, R. ; Bravo-Ureta, B.; Solis, D.; Fleming, E. J. Agric. Econ. **66**, 129–154. (2015)
6. Dar, W.D. ; Laxmipathi Gowda, C.L. J. Crop Improv, **27**, 242–254 (2013)
7. Mira Apriani, Dwi Rachmina, dan Amzul Rifin, 2018. Jurnal Agribisnis Indonesia, **6** No 2, Desember ; halaman 121-132 121 ISSN 2354-5690; E-ISSN 2579-3594 (2018)
8. Anik dan Salam Anik, A.R. ; Salam, M.A. J. Agric. Environ. Int. Dev. 2015, **109**, 71–88 (2015). [Google Scholar]
9. Setyawati. Triagro Vol **1** No. 1 Januari – Juni hal. 24 – 39 (2016)
10. Foster, A.D. ; Rosenzweig, M.R. Rev. Econ., **2**, 395–424. [CrossRef] [PubMed][Green Version] (2010)
11. Barham, B.L.; Chavas, J.P.; Fitz, D.; Salas, V.R.; Schechter, L. J. Econ. Behav. Organ. 97, 204–218. (2014)
12. Barham, B.L.; Chavas, J.P.; Fitz, D.; Ríos-Salas, V.; Schechter, L. Agric. Econ. 46, 11–24, (2015)
13. Ward, P.S.; Singh, V. J. Dev. Stud, **51**, 707–724 (2015)
14. Ahmad Nur Rizal dan Neni Nurfuadah. Jurnal Agrita Vol 2. No. 1, Juni 2020 e-ISSN: 2721-0022 (2020)
15. Pritchard MF. Land. Land Use Policy. 30 (1):186–196. DOI:https://doi.org/10.1016/j.landusepol.2012.03.012 (2013)
16. Bachewe FN, Berhane G, Minten B, Taffesse AS. World Dev. 105:286–298. DOI:https://doi.org/10.1016/j.worlddev.2017.05.041 (2018)
17. Gautam M, Ahmed M. Food Policy. 84:165–175. DOI:https://doi.org/10.1016/j.foodpol.2018.03.013 (2019)
18. Plastina A, Lence SH. Am. J. Agric. Econ. 101(3):849–869. DOI:https://doi.org/10.1093/ajae/aay106 (2019)
19. Rada N, Helfand S, Magalhães M. Food Policy. 2019;84:176–185. DOI:https://doi.org/10.1016/j.foodpol.2018.03.014 Cutting-edge Research in Agricultural Sciences Vol. 12 A Study of the Adoption of Technology in Agriculture: Evidence from the Indonesian Paddy-Rice Farmer
20. Fried H, Tauer LW. in: Aparicio, J. Lovell, C.A.K, Pastor, J.T. (Eds.), Advances in Efficiency and Productivity. 391–407. DOI:https://doi.org/10.1007/978-3-319-48461-7 (2016)
21. Duesberg S, Bogue P, Renwick. Land Use Policy. 61:526–535. DOI:https://doi.org/10.1016/j.landusepol.2016.12.007 (2017)
22. Brown P, Daigneault A, Dawson J. J. Environ. Manag. 231:110–120. DOI:https://doi.org/10.1016/j.jenvman.2018.10.018 (2019)
23. Muhammad Sumarno Vol.**12**, No. 1: 1-10 (2010)

24. Lionberger. H. F. Adoption of New Ideas an Practices. The Iowa State University Press. Ames Iowa
25. Roger, E.M dan F. Floyd Shomaker. Memasyarakatkan Ide-Ide Baru. Disarikan Oleh Abdilah Hanafi. Usaha Nasional. Surabaya (1981)
26. Setyono, A., S. Nugraha, dan Sutrisno. Prinsip Penanganan Pascapanen Padi. dalam Padi: Introduksi Teknologi dan Ketahanan Pangan Buku I. Balai Besar Penelitian Padi. Sukamandi (2008)
27. Swastika, D.K.S. and S. Mardjan. The Constraints of Farmers, Labors, Traders, and Rice Millers to adopt The Improved Post harvest Technologies. Collaborative Study between Indonesian Centre for Agro-Socio Economic and Policy Studies, Directorate General of Processing and Marketing of Agricultural Products, and Food and Agriculture Organization (FAO). Submitted to FAO Rome and Jakarta (2010).
28. Suhendrata T. Peran Inovasi Teknologi Pertanian Dalam Peningkatan Produktivitas Padi Sawah Untuk Mendukung Ketahanan Pangan. Disampaikan Dalam Gelar Teknologi dan Seminar Nasional Teknik Pertanian 2008 di Jurusan Teknik Pertanian Fakultas Teknologi Pertanian UGM, Yogyakarta 18-19 November (2008).
29. Husaini Yusuf dan Eka Fitria Jurnal Triton, Vol. **8**, No. 1, Juni (2017)
30. Raflen Aril Gerungan dan Mecky Christofel Telis Pandelaki. Volume 21, Nomor 1, Maret 2020, 11-21
31. Surmaini, E., Runtunuwu, E., & Las, I.. Upaya sektor pertanian dalam menghadapi perubahan iklim. Jurnal Penelitian Dan Pengembangan Pertanian, 30(1), 1–7 (2015)
32. Widia Siska dan Ismon L. Jurnal Pengkajian dan Pengembangan Teknologi Pertanian, Vol. 22, No.2, 175-184; Juli 2019:
33. Ismon, L. Kajian pemupukan fosfor pada tiga tingkat status fosfor tanah terhadap tanaman padi sawah di kabupaten Dharmasraya Sumatera Barat. Jurnal Pengkajian dan Pengembangan Teknologi Pertanian 19 (1), 71– 84 (2016).
34. Sholeh.. Analisis Efisiensi Teknis Penerapan Pengendalian Hama Terpadu (PPHT) Skala Kawasan pada Tanaman Padi (Oryza sativa. L) di Pademawu Barat, Pamekasan. JSEP: Vol. 12 No. 3 (2019)
35. Nani Kusumawati, Lutfi Aris Sasongko, Rossi Prabowo. MEDIAGRO VOL. 11. NO. **1**. 75- 91 (2015)