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Innovative Downstream Technology in Agriculture; A Case Study on Rice and Shallot Commodities

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Abstract: **The pace of downstream agricultural technology implementation by the government currently legs behind the needs of farmers and the advancement of modern science and knowledge. This study aims to1) analyze institutional patterns in the downstream application of innovative technology in agriculture, 2) examine farmers' responses to downstream innovative technology, 3) identify the factors influencing the success of downstream innovative agricultural technology. The research was conducted in two districts across two provinces from December 2022 to September 2023, with case studies focusing on rice and shallot commodities. Data were collected through a survey of 240 randomly selected farmer respondents. Data analysis was performed qualitatively and descriptively, involving both formal and non-formal institutions from the central to regional levels. The results indicated that: 1) formal and non-formal institutional support from the central to regional levels significantly affected the downstream process of agricultural innovation; 2) farmers' response to rice cultivation technology was more favorable than that to shallot cultivation technology; 3) internal factors such as age, education, farming experience, and land area, and external factors such as access to capital, technology, and transportation influenced the success of downstream agricultural innovation. In general, a deep understanding of these factors is crucial for designing more effective strategies to promote technology adoption among farmers. The government should consider the local characteristics of farmers in downstream innovation to increase production and productivity, thereby enhancing farmers' economic income.**

Keywords: downstream, technology, innovative, rice cultivation, shallots.

1. Introduction

Along with the rapid advancement of science and technology, as well as the implementation of regional autonomy and the transfer of part of government authority to regions in the agricultural sector, some institutions previously involved in the preparation and implementation of site-specific agricultural technology have been abolished. The paradigm and framework in research and development were no longer appropriate; therefore, the Minister of Agriculture Regulation No. 03/2005 was launched, later amended by the Decree of the Minister of Agriculture No. 804/1995 as a corrective action. In the prevailing regulations, innovative technological innovation transformations are required that are appropriate to the location [1] to increase technological improvements to optimize the utilization of agricultural resources and improve the implementation of technology by the location [2]

In its operations, creating innovation concepts until farmers adapt them involves institutional networks from the center to remote villages [3,4]. The Agricultural Research and Development

Agency, together with its Work Units – Center for Food Crop Research and Development, Horticultural Research and Development Center, Center for Agricultural Technology Study and Development, Rice Center, and Vegetable Plant Instrument Standard Testing Center – is a generating system or segment of invention-creation, as well as a delivery subsystem and a receiving subsystem. Other institutions, from the Director General of Food Crops to the Regional Agricultural Equipment Organization and village farmer groups, have become delivery system networks that flow innovation and receive receiving system technology [5].

In addition, there is an Agricultural Technology Management Center Work Unit that manages the transfer of agricultural technology from the source of technology creation to the user. The Agricultural Technology Management Center Work Unit divides the transfer of innovative technology into two approaches; licensing and dissemination. License for agricultural technology worth intellectual property (IP) [6], while dissemination for public domain [6]. Institutional existence plays a role in supporting the acceleration of downstream innovative technological innovation. Institutional activities play a role in building harmonious functional linkages among downstream [7]; [8] and the adoption of technological innovations by end users [9].

Several innovative technologies have been widely used and proven to be critical drivers of growth [10] and the development of agriculture [11]. However, the speed at which science is developing is not matched by the adoption of technology by government agencies [12], even though the number of institutions that exist today is quite large [13]. In addition, the adoption of developed technology has not affected the fundamental needs of farmers in the form of consumer preferences for the final product produced.

Research related to downstream innovation has been conducted by [12-27]. However, the results of this study mainly discuss downstream technology in general on specific commodities. In contrast, this study will look at and compare two locations and things with the support of government downstream institutions. Therefore, this study aims to 1) analyze institutional patterns in downstream innovative technology in agriculture 2) analyze farmers responses to downstream innovative technology, and identify factors that influence the success of downstream innovative agricultural technologies.

2. Literature Review and Objectives

Using agricultural technology can help improve the efficiency, quality, and productivity of sustainable agriculture [14,15]. Technological innovation is still growing to support food security [16], population growth, and extreme weather changes [17]. With innovative technology from agriculture, it is expected to lift agricultural productivity, reduce negative impacts on the environment, and improve the welfare of farmers. Downstream technology is a process of development and application of advanced technology from several sectors to increase competitiveness, productivity, and efficiency [18,19]. Some of the benefits of downstream food technology in Indonesia include increasing the added value of food products, improving food safety and quality, increasing food productivity, expanding market access, establishing cooperation, and transferring food technology [18,20]. According to [21], adoption of innovation is one of the processes of social change with novelty that the community can then adopt. [22] Elements of innovation adoption include communication channels [23], innovation of social systems, and time. The stages in the innovation adoption process are knowledge, persuasion, decision making implementation, and confirmation [24]. The cultivation of rice plants (*Oryza Sativa* L.) and food self-sufficiency carried out by the government has resulted rice commodities [25,26] up to 80.08 tons/year [27] so that the need for rice in the community becomes a priority [28]—shallots with the Latin name *Allium cepa L.* is a plant that is used as a spice in cooking and as an ingredient in traditional medicines [29]. The government has attempted o increase the productivity of shallots by increasing intensification and intensification [30]. In 2022, the productivity yield of shallots will reach 9.43 tons per year [31].

3. Methods

The research was conducted in the Provinces of East Java and South Sulawesi of Indonesia, which area rice and shallot-producing regions whose contribution is quite significant to the production of rice and shallots nationally. From each selected province, one district was determined to be a relatively high rice produce and shallot producer in each chosen province. The research was conducted in August 2022- September 2023 through a survey of 240 respondent farmers (Table 1) and involved several institutions from the central to regional levels.

Table 1. Respondents at the Research Site

No	Provinsi	Regency	Subdistrict	Sum
1	Jawa Timur	Ngawi	1. Geneng	64
			2. Karang Anyar	56
2	South Sulawesi	Bone	1. Tanete RT	40
			2. Awangp one	30
			3. Amali	50
	Sum			240

Source: Primary Data Analysis

To diagnose the downstream performance of innovative technology, a quantitative descriptive analysis is carried out on the basis Constructive Grounded Theory, which refers to the concepts [32], [33], [34], [35], [36]. The data will be filtered on the bases of the innovation component and analyzed using the Likert Scale, which has a range of 1 to 5. On this scale, number 1 represents the level of unsatisfactory or unsatisfactory, number 2 indicates the level of bad or less good, number 3 shows the level of satisfactory or good enough, number 4 shows the level of sound or fair, and number 5 indicates the level of excellent or very fine. Based on the analysis using the Likert scale, the results are described qualitatively. To analyze the factors that

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influence technology adoption, a qualitative descriptive manner starts with describing land tenure as the basis of agricultural activities and then adopting innovative technology from each rice and onion cultivation technology. As another indicator of successful adoption, the productivity achievements of each commodity are displayed, namely rice and shallots.

4. Results and Discussion

a. Characteristics of the Respondent Farmers

The main characteristics discussed in the context of downstream innovative technology focus on three elements; age, formal education base, and farming experience. Through the analysis of the age element (Figure 1), it can be seen that most respondents involved in rice and onion cultivation are in the age range of 31 to 50 years. This shows that they are in the productive phase of the millennial age. This age condition will have a significant impact on the development of rice and onion cultivation.

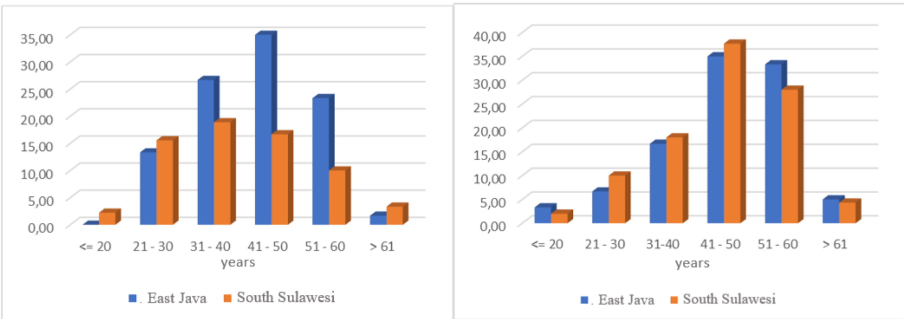


Figure 1. Age Diversity of Rice (left) and Shallot (right) Respondents at the Research Site
Source: Primary Data Analysis, 2023

In terms of formal education, the range of education starts from primary education to the undergraduate level. From the analysis in Figure 2, it appears that onion farmers generally achieve a relatively higher level of formal education than rice farmers (Figure 2).

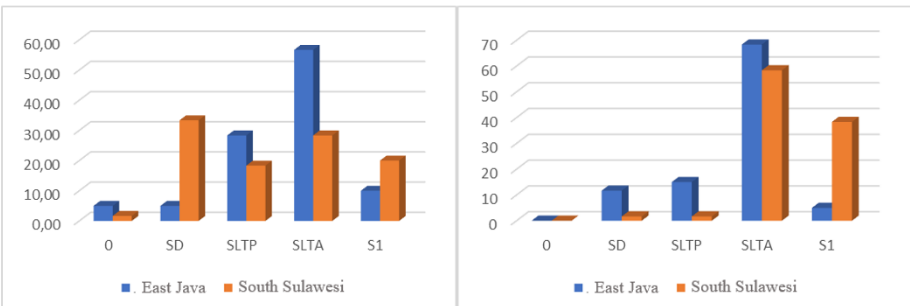


Figure 2. Diversity of Respondents' Formal Education on Rice Cultivation (left) and Shallots (right)
Source: Primary Data Analysis, 2023

Regarding farming experience, the period lasts between less than 10 and 45 years. Most rice farmers (about 77.50%) have less than 20 years of experience, whereas most onion areas n farmers (approximately 50.83%) have less than ten years of experience. This shows a significant difference between rice and onion farming (Figure 3).

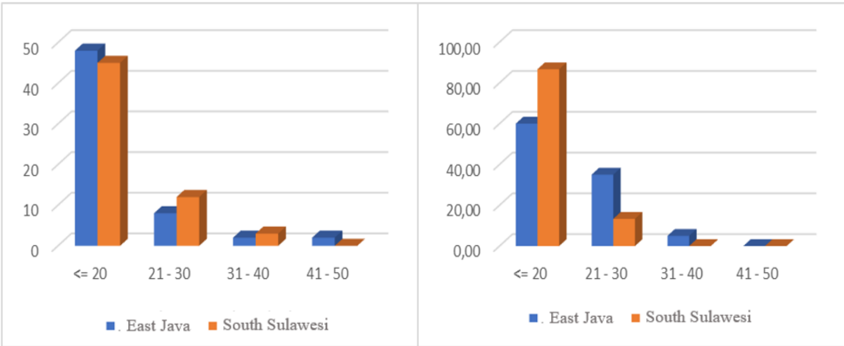


Figure 3. Farming experience of rice respondents (left) and shallots (right) at the research site
Source: Primary Data Analysis, 2023

b. Institutional Support

In this innovative technology downstream activity, there are institutions whose authority is categorized as a generator system (creation/invention), delivery system (distribution), and receiving system (receiver) technology [37]. According to the status, institutions are distinguished from formal institutions and informal institutions [38]. In addition, there are institutions whose status is not included in the system, but their role is essential as supporters. The institutional position is at the national (central) and the regional (province, district sub-district, and village) [39]. On the basis the results of observation and elaboration of information, the existence of institutions involved in downstream innovative technology can be arranged diagrammatically, as shown in Figure 4.

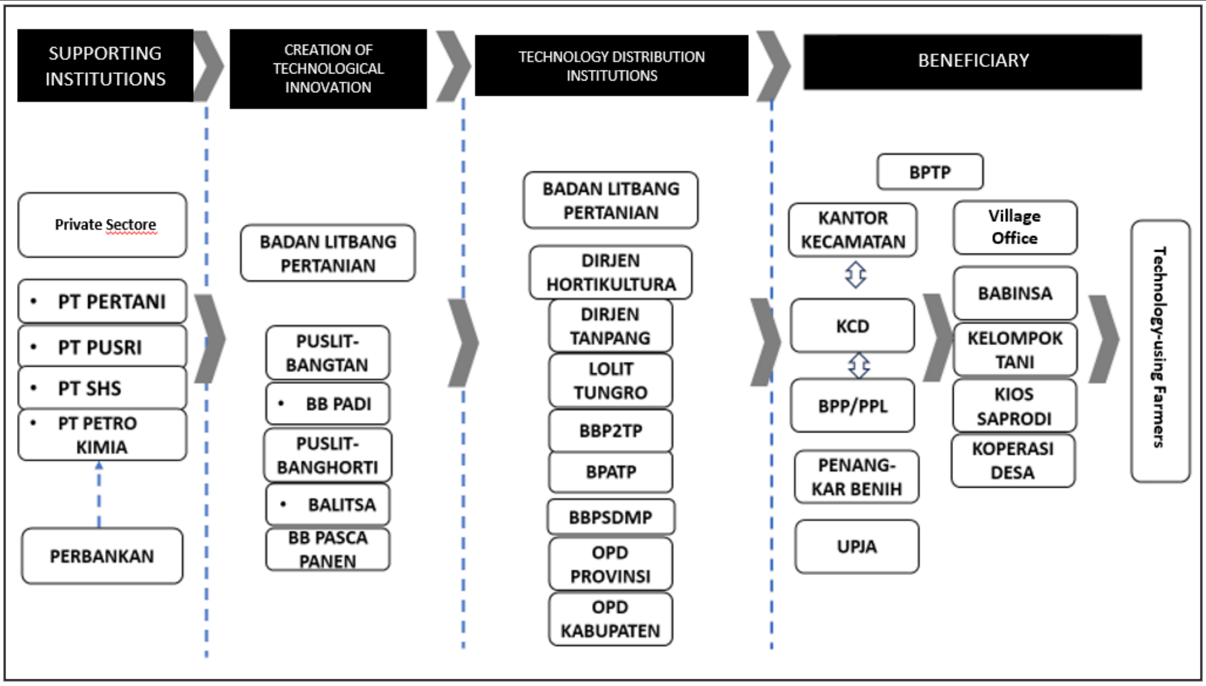
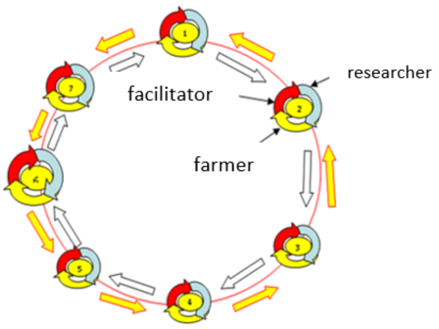


Figure 4. The Existence of Formal and Informal Institutions in Downstreaming Innovative Technology of the Agricultural Research and Development Agency from the National Regional

Source: Primary Data Analysis, 2023

In the downstream practice of innovative technology, the institution role is not fixed on its status and position. Institutions that play a role in creating innovation also play a role as technology distributors. Likewise, institutional support is not partial according to territorial zones, meaning that institutions at the center also perform their role in the regions. Role differentiation is only differentiated on the basis of the primary duties and functions of each. In this case, government institutions act as regulators (making policies), providing budgetary/financial support, and providing research infrastructure. At the same time, the private sector contributes to developing, commercializing, and expanding the use of innovative technologies on a broader scale.

The position of farmers in downstream innovative technology acts as a recipient and implementer of innovative technology, according to [40; 41]. They become agents of change in implementing new technologies in the field, and experiences and knowledge with other farmers. Meanwhile, coordination of the production of innovation results, as well as increasing the capacity of members to adopt new technology, became the joint authority of farmer groups. Chronologically, the downstream of innovative technology begins with the research stage that produces innovative technology components (invention), involving the Agricultural Research Commission. Before being intervened y the user, the technology component performed an adaptation test to obtain technology that suits the location's needs. The Agricultural Technology Commission validated the following technology activity as a step toward the development stage. At the development stage, various approaches are used, including large-scale demonstrations, to produce technologies that are ready for users to implement. Before farmers adopt the technology, a technology assembly is first carried out involving extension workers, researchers, and farmers who will use the technology. The process through several stages, as shown in Figure 5.



Information:

1. Identify the Problem
2. Formulation of the technology institutional needs
3. Participatory Program development
4. Study and dissemination planning
5. Implementation of studies and dissemination
6. Performance evaluation of institutional technology and dissemination methods
7. Deployment at scale

Figure 5. Technology Assembly Diagram
Source: Primary Data Analysis, 2023

The dissemination of information technology at the regional level occurs through various channels (*multi-channel*), as shown in Figure 6.

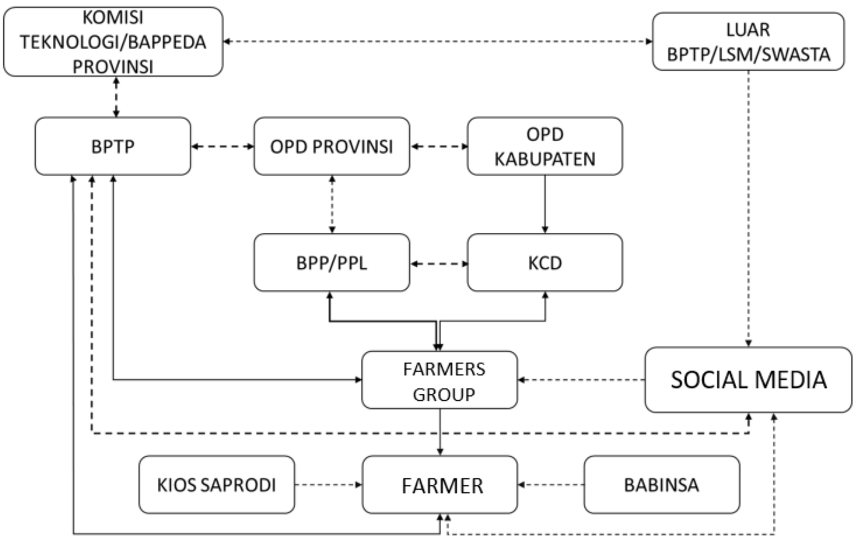


Figure 6. Technology Information Delivery Channel
Source: Primary Data Analysis, 2023

Technology information received by farmers is not only from sources directly related to technology preparation institutions but also from cyberspace media [42] ; [41]; [40]; [43] Facts in the field, farmers who meet their seed needs by ordering through the market place.

4.3 Farmer's Responses to Technology

One indicator of the success of downstream innovative technology is the adoption of technology [44] and agricultural productivity achievements [45]. The size of technology adoption is measured from two aspects. First, it is based on the proportion of respondents who adopt several recommended technologies, meaning that the higher the ratio of farmers who adopt technology, the better the adoption rate. Second, from the proportion of the planting land area that applies recommendation technology. The higher the proportion of planting area that uses technology recommendations, the better. Agroecosystem conditions, and the size of land ownership influence farmers, responses to rice and onion cultivation technology. Land tenure by rice farmers at the study site is presented in in Tables 2, and 3.

Table 2. Land Tenure by Rice Respondents in East Java and South Sulawesi

Agro ecosystem	Land Size (ha)	Ngawi Regency, Jawa Timur Province (ha)		Bone Regency, South Sulawesi Province (ha)	
		Sum	Propose (%)	Sum	Propose (%)
Sawah Irrigation	< 0,5	37	61,67	41	34,17
	0,51 - 1	13	21,67	17	14,17
	1,1 -1,5	3	5,00	1	0,83
		1	1,67	0	0,00
	> 2	6	10,00	1	0,83
Tadah Rain	< 0,5	2	3,33	40	33,33
		0	0,00	3	2,50
	1,1 -1,5	0	0,00	2	1,67
	1,51 – 2	0	0,00	2	1,67
	> 2	1	1,67	0	0,00
Garden/ Ladang	< 0,5	52	86,67	46	38,33
		0	0,00	5	4,17
		1	1,67	1	0,83
	> 2	0	0,00	7	5,83

Source: Primary Data Analysis, 2023

The condition of land tenure by rice farmers in East Java and South Sulawesi generally consists of irrigated rice fields, rained rice fields, and gardens or fields with tenure areas ranging from < 0.5 hectares to > 2 hectares. The condition of land tenure by rice farmers is relatively the same as that by onion farmers, both from agroecosystems and land tenure status. Land tenure by onion farmers at the study site in detail is presented in Table 3

Table 3. Land Tenure by Shallot respondent in East Java and South Sulawesi

Agro ecosystem	Land Size (ha)	Ngawi Regency, Jawa Timur Province (ha)		Bone Regency, South Sulawesi Province (ha)	
		Sum	Propose (%)	Sum	Propose (%)
Rice fields	< 0,5	40	66,67	56	46,67

Irrigation	0. 51%- 0. 51	15	25,00	1	0,83
	1,1 -1,5	1	1,67	2	1,67
	1,51 – 2	3	5,00	0	0,00
	> 2	1	1,67	1	0,83
	< 0,5	55	91,67	60	50,00
Rice fields	0. 51 %-	3	5,00	0	0,00
	1,1 -1,5	0	0,00	0	0,00
	1,51 – 2	0	0,00	0	0,00
	> 2	0	0,00	0	0,00
	< 0,5	58	96,67	41	34,17
Garden/ Ladang	0. 51%-	1	1,67	11	9,17
	1,1 - 1,5	0	0,00	4	3,33
	1,51 – 2	0	0,00	0	0,00
	> 2	0	0,00	1	0,83

Source: Primary Data Analysis, 2023

Regarding the adoption of innovative technology, farmers, response to technology, shown by the proportion of farmers who adopt technology, can be used as a proxy for the success or failure of downstream technology. For adoption measurement needs, it is divided into five categories, namely: < 50 – 59 percent = low; 60 – 69 percent = medium; 70 – 79 percent = high enough; 80 – 89 percent = high, and > 90 Percent = very high. In rice crop cultivation, farmers have adopted as many as nine technological components that contribute to increased agricultural productivity and efficiency. These technical components include the use of Quality Superior Varieties (VUB) to produce better quality crops, the application of the legowo planting method (jarwo), which focuses on increasing plant density and more efficient use of resources, the use of organic fertilizer and inorganic fertilizers to improve soil fertility, control strategies for Plant Disturbing Organisms (OPT) to reduce losses due to pest and disease attacks, and the utilization of young seedlings in fewer than 21 days to start planting.

In addition, intermittent technology, proper harvest timing, efficient threshing process, and various other technologies have also been adopted by farmers to optimize their rice cultivation yields. Assessments of regarding the adoption rate of these technologies are illustrated in Table 4.

Table 4. Proportion of Farmers Adopting Rice Cultivation Technology in East Java and South Sulawesi

Technology Components	Ngawi Regency, Jawa Timur Province (ha)		Bone Regency, South Sulawesi Province	
	Sum	Propose (%)	Sum	Propose (%)
1. VUB	51	85,00	34	56,67
2. Jarwo	33	55,00	33	55,00
3. Organic fertilizer	47	78,33	41	68,33

4. Non Organic fertilizer	55	91,67	56	93,33
5. OPT	55	91,67	52	86,67
6. Young seedlings	45	75,00	57	95,00
7. Intermitten	44	73,33	45	75,00
8. Timely harvesting	50	83,33	42	70,00
9. Fall	52	86,67	44	73,33
10. Other	5	8,33	1	1,67

Source: Primary Data Analysis, 2023

In the context of onion cultivation, farmers have adopted various technological components to increase the productivity and efficiency of agricultural businesses. Seven main specialized features have been adopted by farmers, including the use of superior quality varieties (VUB) to ensure better crop quality, the use of shallots seeds that have advantages in plant propagation and growth, and the application of organic and inorganic fertilizers to increase soil fertility and production. In addition, farmers also apply Plant Disturbing Organisms (OPT) control technology to reduce the risk of pest and disease attacks on onion plants. Determining the right harvest time is also a critical factor in achieving optimal yields. Withering, or pruning of certain parts of plants, is another adopted to regulate plant growth and produce quality onion bulbs.
In the East Java region, most rice cultivation technologies have been well received y farmers, with adoption rates ranging from relatively high to very high. However, there are exceptions to adopting *"jajar legowo (jarwo)"* planting technology, which has a relatively low adoption rate. The highest adoption of fertilization technology shows that farmers recognize the significant benefits of fertilizer use in increasing crop yields. In South Sulawesi, the highest adoption of rice technology was recorded using young seedlings with a planting time of less than 21 days. This indicates that farmers in this region are aware the advantages of young seedlings when starting planting. However, the adoption of *"jajar legow (jarwo)"* technology in the area is low, which can be influenced by environmental conditions and local preferences. The adoption of technology in shallot commodities is presented in Table 5.

Table 5. Proportion of Farmers Adopting Shallot Cultivation Technology in East Java and South Sulawesi

Technology Components	Ngawi Regency, Jawa Timur Province	Bone Regency, South Sulawesi Province
	Propose (%)	Propose (%)
1. VUB	65,00	66,67
2. Seeds TSS	16,67	45,00
3. Organic	86,67	75,00
4. Anorganic	90,00	76,67

5. OPT	90,00	76,67
6. Proper Harvesting	78,33	76,67
7. Wilted	76,67	76,67
8. Other	33,33	0,00

Source: Primary Data Analysis, 2023

The performance of technology adoption in the context of rice and onion cultivation contributes significantly to the achievement of agricultural productivity. The application of technological components in rice cultivation, such as the use of high quality variety (VUB) to improve crop quality, the planting method *(jarwo)* for resource efficiency, and organic and inorganic fertilization to increase soil fertility, has been proven to increase overall crop yields. In addition, other technological approaches, such as the control of Plant Disturbing Organisms (OPT), the use of young seedlings with the proper planting time, and efficient threshing practices, also play a role in maximizing the productivity of rice cultivation.

Similarly, in onion cultivation, the adoption of technological components such as the use of (VUB), organic and inorganic fertilizers, and the control of plant disturbing (OPT), has helped increase production yields. In addition, factors such as proper timing of harvesting, regular withering, and the application of other technologies have contributed positively to the productivity of shallots.

However, although most components of shallot cultivation technology are adopted with a high success rate in East Java, two technological parts tend to have lower adoption rates. The technology of using TSS seeds and VUB did not experience significant adoption in the region. This may indicate certain factors that influence farmers, acceptance of the technology, such as awareness of its benefits, availability of relevant seeds or varieties, and technical skills required to apply the technology.

In the South Sulawesi region, the overall adoption rate of shallot cultivation technology varies, Technology adoption ranges from low to moderately high, as shown in Table 5. Factors such as environmental conditions, accessibility to resources, and government support or local agricultural institutions can play an essential role in determining the level of agricultural technology adoption in the region.

The adoption of technology in both cultivation reflects the commitment of farmers to adopt a more scientific and effective approach in their agricultural ventures. This is directly related to the achievement of higher productivity, which ultimately has a positive impact on improving food supply and farmers welfare.

The adoption of technology in rice and onion cultivation, as observed in the context of East Java and South Sulawesi Provinces, can be interpreted as a manifestation of downstream innovative technology. Downstream innovative technology refers to the process of applying new or innovative technology in the agricultural and crop cultivation sectors, which in turn has an impact on increasing productivity and efficiency at the local level [46].

The diversity in technology adoption in rice and onion cultivation in the two provinces reflects empirical facts that illustrate the operationalization of factors influencing technology adoption. These factors can be sourced from the internal environment of the farmer or external factors in the surrounding environment.

4.3 Success Factors in Downstream Innovative Agricultural Technology

Based on the results of interviews with respondents in the field, internal factors play a significant role in influencing the adoption of innovative technology in rice and onion cultivation. These factors include the age of the farmer, the level of formal education, experience in farming, and the extent of land tenure. Likewise, farmers who have higher formal education tend to be better able to understand the benefits and ways of using new technologies. External factors also have a significant impact on the process of technology adoption. These factors involve environmental aspects around farmers, such as the accessibility of the area where the farm is located, the availability of capital to support investment in new technologies, the availability of technological resources such as training or technical guidance, and the availability of access to transportation networks such as highways that facilitate the distribution of crops.

Based on the conditions of age, education, and farming experience, these three factors are proven to be interrelated determinants. Age diversity conditions reflect differences in life stages and career cycles, which can affect perceptions and readiness to adopt technological change. The variety of formal education bases gives an idea of the literacy level and underlying conceptual understanding, which may affect their ability to understand and apply new technologies. Finally, the diversity of farming experiences reflects different levels of exposure to previous innovations, which shape attitudes toward the adoption of innovative technologies. Through careful qualitative descriptive analysis, it was found that age, educational base, and farming experience collectively contribute to the willingness and capability of rice farmers and onion farmers to respond to technological changes. Taking these factors into account, this research provides deeper insights into the dynamics of innovative technology adoption within the agricultural sector, which in turn can help design more effective strategies to facilitate technology deployment among diverse farming communities.

Technological advances have had a significant impact on the agricultural sector in Indonesia. The two regions highlighted in this regard are East Java and South Sulawesi. Both regions have developed and adopted innovative technology packages for rice and onion cultivation.

Although both countries have successfully adopted innovative technologies in cultivating their respective crops, there are striking differences in conditions between East Java and South Sulawesi. East Java is more prominent in rice cultivation, whereas South Sulawesi focuses on developing successful shallot cultivation. Environmental conditions, climate, and natural resources of each region also affect the choice of cultivation taken The Innovative technology packages designed in East Java and South Sulawesi have had a significant impact on rice and onion cultivation. Although both regions showed mixed conditions, the results were equally impressive. This success indicates that technological development in the agricultural sector has great potential to improve Indonesia overall productivity and food security.

5. Conclusion

This study seeks to reveal institutional patterns in downstream innovative technology, analyze farmers" responses to the technology delivered, and examine the factors that influence the success of downstream technology the case of rice and onion commodities in Ngawi Regency, East Java Province, and Bone Regency, South Sulawesi Province. The downstream pattern of innovative technology of the Agricultural Research and Development Agency is characterized by stages starting from preparing innovations through upstream research (mainstream), assessment (adaptation testing), development (model making), and application by users whose processes involve formal and non-formal institutions from the central to regional levels. Farmers responses to technological innovations evaluate the success of downstream and the conditions vary. In this case, farmers response to rice cultivation technology is higher than that to onion cultivation technology. Internal and external factors influence it. The internal factors in question are age, education, farming experience, and land area owned by farmers, whereas external factors are access to capital, technology, and transportation. A deep understanding of these factors can help design more effective strategies to promote technology adoption among farmers, considering the unique context and characteristics of each region.

This research is a case study limited to 2 regions in rice and onion production centers. Therefore, the results of this research cannot be generalized to all areas of Indonesia. The patterns, responses, and factors causing the success of downstream production in this study can be adopted in areas with the same characteristics as the research sample. Therefore, researchers suggested that more in-depth research should be conducted on adopting technology in commodities other than rice and shallots and non-central areas.

References

[1] Hermann RR, Pansera M, Nogueira LA, Monteiro M. Socio-technical imaginaries of a circular economy in governmental discourse and among science, technology, and innovation actors: A Norwegian case study. Technology Forecast Soc Change 2022;183. https://doi.org/10.1016/j.techfore.2022.121903.

[2] Lu C, Zhao P, Lin X. Does green technology innovation contribute to energy efficiency improvement: Empirical evidence from Chinese cities. Energy Reports 2023;9:462–73. https://doi.org/10.1016/j.egyr.2023.04.254.

[3] Mesdaghi B, Ghorbani A, de Bruijne M. Institutional dependencies in climate adaptation of transport infrastructures: an Institutional Network Analysis approach. Environ Sci Policy 2022;127:120–36. https://doi.org/10.1016/j.envsci.2021.10.010.

[4] Blesh J, Mehrabi Z, Wittman H, Kerr RB, James D, Madsen S, et al. Against the odds: Network and institutional pathways enabling agricultural diversification. One Earth 2023;6:479–91. https://doi.org/10.1016/j.oneear.2023.03.004.

[5] Perdana RP, Agustian A, Wahyudi, Indraningsih KS, Muslim C. Development and problems in the spread of new, improved rice varieties in Central Java Province. E3S Web of Conferences, vol. 316, EDP Sciences; 2021. https://doi.org/10.1051/e3sconf/202131602032.

[6] BPATP. Kegiatan Pengelolaan Kekayaan Intelektual dan Alih Teknologi. LaporanTahunan 2020. Balai Pengelola Alih Teknologi Pertanian. Badan Penelitian dan Pengembangan Pertanian. Kementerian Pertanian; 2021.

[7] Yuriawan K. Strategi Komunikasi Sains LIPI dalam Kegiatan Diseminasi Pupuk Organik Hayati Kepada Masyarakat. Jurnal Komunikasi Pembangunan 2021;19:97–110. https://doi.org/10.46937/19202136320.

[8] Vaquero Martín M, Reinhardt R, Gurtner S. The dilemma of downstream market stakeholder involvement in NPD: Untangling the effects of involvement and capabilities on performance. J Bus Res 2021;124:136–51. https://doi.org/10.1016/j.jbusres.2020.11.040.

[9] Iyanna S, Kaur P, Ractham P, Talwar S, Najmul Islam AKM. Digital transformation of the healthcare sector. What is impeding the adoption and continued usage of technology-driven innovations by end users? J Bus Res 2022;153:150–61. https://doi.org/10.1016/j.jbusres.2022.08.007.

[10] Galli P, Vecellio G. Technology: the driving force behind innovation and growth of polyolefins. Prog Polym Sci 2001;26:1287–336.

[11] Takahashi K, Muraoka R, Otsuka K. Technology adoption, impact, and extension in developing countries' agriculture: A review of the recent literature. Agricultural Economics (United Kingdom) 2020;51:31–45. https://doi.org/10.1111/agec.12539.

[12] Wahyudi, Mujahidin Fahmid I, Salman D, Suhab S. Impact of the Covid-19 Pandemic on Rice Farming Planning in Indramayu District, West Java. IOP Conf Ser Earth Environ Sci, vol. 1012, IOP Publishing Ltd; 2021. https://doi.org/10.1088/1755-1315/1012/1/012074.

[13] Aghmiuni SK, Siyal S, Wang Q, Duan Y. Assessment of factors affecting innovation policy in biotechnology. Journal of Innovation and Knowledge 2020;5:180–90. https://doi.org/10.1016/j.jik.2019.10.002.

[14] Morchid A, El Alami R, Raezah AA, Sabbar Y. Applications of Internet of things (IoT) and sensors technology to increase food security and agricultural Sustainability: Benefits and challenges. Ain Shams Engineering Journal 2023. https://doi.org/10.1016/j.asej.2023.102509.

[15] Bernardini Papalia R, Gullà D, Nastati E. Quantum agriculture and experimental detection of wheat flour quality using thermal image technology. Heliyon 2023;9. https://doi.org/10.1016/j.heliyon.2023.e19899.

[16] Beddington J. Food security: Contributions from science to a new and greener revolution. Philosophical Transactions of the Royal Society B: Biological Sciences 2010;365:61–71. https://doi.org/10.1098/rstb.2009.0201.

[17] Vermeulen SJ, Aggarwal PK, Ainslie A, Angelone C, Campbell BM, Challinor AJ, et al. Options for support to agriculture and food security under climate change. Environ Sci Policy 2012;15:136–44. https://doi.org/10.1016/j.envsci.2011.09.003.

[18] Nurtiana W, Meindrawan BB. Pelatihan Pembuatan Muffin Talas Beneng Di Yayasan Ummatan Wasathon, Kecamatan Kasemen, Kota Serang Sebagai Pemanfaatan Pangan Lokal. Sebatik 2023;27:257–64. https://doi.org/10.46984/sebatik.v27i1.2277.

[19] Elizabeth R, Setiajie I, Pusat A, Ekonomi S, Pertanian K, Tentara J, et al. Akselerasi Hilirisasi Produk Agroindustri Berdayasaing Mendongkrak Kesejahteraan Petani Dan Ekonomi Pedesaan Acceleration Of Hilirization Of Competitiveness Agroindustry Products To Supply The Farmer's Welfare And Rural Economy. Mimbar Agribisnis: Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis 2020;6:890–918.

[20] Morchid A, El Alami R, Raezah AA, Sabbar Y. Applications of Internet of Things (IoT) and sensors technology to increase food security and agricultural Sustainability: Benefits and challenges. Ain Shams Engineering Journal 2023. https://doi.org/10.1016/j.asej.2023.102509.

[21] Greenhalgh T, Robert G, Bate P, Macfarlane F, Kyriakidou O, Donaldson L. Diffusion of Innovations in Health Service Organisations A systematic literature review FOREWORD BY. 2003.

[22] Vargo SL, Akaka MA, Wieland H. Rethinking the diffusion process in innovation: A service-ecosystems and institutional perspective. J Bus Res 2020;116:526–34. https://doi.org/10.1016/j.jbusres.2020.01.038.

[23] Wardani RRIK. The Role of Religion-based Communication in Environmental Revitalization and Community Empowerment in Wonosobo Article Info Article History. Indonesian Journal of Social Responsibility Review (IJSRR) 2022;1:190–7. https://doi.org/10.55831/ijsrr.v1i3.71.

[24] García-Avilés JA. Diffusion of Innovation. The International Encyclopedia of Media Psychology, Wiley; 2020, p. 1–8. https://doi.org/10.1002/9781119011071.iemp0137.

[25] Bakari Yuliana. ANALISIS KARAKERISTIK BIAYA DAN PENDAPATAN USAHATANI PADI SAWAH: Analysis Of Cost And Income Characteristic Of Paddy Farming System Study case in Tilongkabila Sub-district, Bone Bolango Regency, Gorontalo Province. Jurnal Sosial Ekonomi Pertanian 2019;15:265–77.

[26] Airiza Budianti Y, Yuliati N. Analisis Produksi Usahatani Padi Dengan Metode Salibu Analisis Faktor Produksi Usahatani Padi Dengan Metode Salibu Di Kecamatan Madiun Kabupaten Madiun Jawa Timur. Jurnal Agribisnis 2021;23.

[27] Pello WY, Renoat E, Banunaek MF. Pengaruh Peran dan Motivasi Penyuluh Pertanian Terhadap Inovasi Teknologi Budidaya Tanaman Padi Sawah di Kecamatan Kupang Timur Kabupaten Kupang Provinsi Nusa Tenggara Timur. Jurnal Penyuluhan 2019;15:184–94.

[28] Nurkholis A, Muhaqiqin, Susanto T. Algoritme Spatial Decision Tree untuk Evaluasi Kesesuaian Lahan Padi Sawah Irigasi. JURNAL RESTI: Rekaya Sistem Dan Teknologi Informasi 2017;1:978–87.

[29] Jaya Edy H, Jayanti M, Parwanto E. Pemanfaatan Bawang Merah (Allium cepa L) Sebagai Antibakteri di Indonesia Utilization of Shallot (Allium cepa L) as Antibacterial in Indonesia. Pharmacy Medical Journal 2022;5:27–35.

[30] Santoso AB, Nurdin M, Hidayah I. Daya Saing Bawang Merah di Provinsi Maluku dan Upaya Peningkatannya. Jurnal Ilmu Pertanian Indonesia 2020;25:365–72. https://doi.org/10.18343/jipi.25.3.365.

[31] Nursandi F, Santoso U, Ishartati E, Pertiwi A, Agroteknologi P, Pertanian-Peternakan F, et al. Aplikasi Zat Pengatur Tumbuh Auksin, Sitokinin Dan Giberelin Pada Tanaman Bawang Merah (Allium Cepa L.) Application Of Plant Growth Regulator Of Auxin, Citokinin, And Giberelin In Shallot (Allium cepa L.). Jurnal Ilmu-Ilmu Pertanian 2022;16.

[32] Charmaz K. Constructing Grounded Theory (2nd ed.). Sage Publication; 2014.

[33] Glaser BG,, Strauss AL. . The Discovery of Grounded Theory: Strategies for Qualitative Research. Routledge 2017.

[34] Glaser B. Basics of grounded theory analysis: Emergence vs. forcing. Mill Valley. CA: Sociology Press 1992.

[35] Neuman WL. Social research methods: Qualitative and quantitative approaches (6th ed.). New York: Allyn & Bacon 2006.

[36] Shank GeryD. Qualitative research : a personal skills approach. Prentice Hall Merrill/Prentice Hall; 2002.

[37] Pujantiyo BS. Kebijakan Penguatan Hilirisasi Produk Berbasis Teknologi Policy Of Strengthening Downstream Technology-Based Products. vol. 13. 2022.

[38] Ault JK, Spicer A. The formal institutional context of informal entrepreneurship: A cross-national, configurational-based perspective. Res Policy 2022;51. https://doi.org/10.1016/j.respol.2020.104160.

[39] Saint Ville AS, Hickey GM, Phillip LE. Institutional analysis of food and agriculture policy in the Caribbean: The case of Saint Lucia. J Rural Stud 2017;51:198–210. https://doi.org/10.1016/j.jrurstud.2017.03.004.

[40] Pesci S, Galt RE, Durant JL, Manser GM, Asprooth L, Pinzón N. A digital divide in direct market farmers' online sales and marketing: Early pandemic evidence from California. J Rural Stud 2023;101. https://doi.org/10.1016/j.jrurstud.2023.103038.

[41] LI K, JIN Y, ZHOU J. Are vulnerable farmers more easily influenced? Heterogeneous effects of Internet use on the adoption of integrated pest management1. J Integr Agric 2023. https://doi.org/10.1016/j.jia.2023.08.005.

[42] Dwi Fidaus Ramadhana Y, Subekti S. Pemanfaatan Metode Penyuluhan Pertanian oleh Petani Cabai Merah. Jurnal Kirana 2021;2:113–33.

[43] Hasan N, Wardani RRIK, Fahmi KI, Ciptasari SAA, Arfiansyah YC, Widiawati, et al. Design of interactive agricultural extension media for students in the material of family medicinal plant utilization. IOP Conf Ser Earth Environ Sci, vol. 759, IOP Publishing Ltd; 2021. https://doi.org/10.1088/1755-1315/759/1/012064.

[44] Mulugeta HT, Heshmati A. Impacts of improved agricultural technology adoption on welfare in Africa: A meta-analysis. Heliyon 2023;9. https://doi.org/10.1016/j.heliyon.2023.e17463.

[45] Sarma PK. Adoption and impact of super granulated urea (guti urea) technology on farm productivity in Bangladesh: A Heckman two-stage model approach. Environmental Challenges 2021;5. https://doi.org/10.1016/j.envc.2021.100228.

[46] Wardani RIK, Widiyanto, Rusdiyana E, Rinanto Y, Sudibya. Farmers' adaptation in dealing with limited water (A case study on Wonogiri Regency). IOP Conf Ser Earth Environ Sci, vol. 824, IOP Publishing Ltd; 2021. https://doi.org/10.1088/1755-1315/824/1/012077.