

Mapping the Diversity and Distribution of Appropriate Technology in University Student Community Services

Eni Muryani^{1*}, Retno Hendariningrum², Avido Yuliestyan³, Reshinda Zulfa¹

¹ Department of Environmental Engineering, Faculty of Mineral and Energy Technology, Universitas Pembangunan Nasional “Veteran” Yogyakarta, Indonesia

² Department of Communication Studies, Universitas Pembangunan Nasional “Veteran” Yogyakarta, Indonesia

³ Department of Chemical Engineering, Universitas Pembangunan Nasional “Veteran” Yogyakarta, Indonesia

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Abstract

Appropriate Technology is a form of technology application used to address community needs according to regional conditions. The 2024 UPN “Veteran” Yogyakarta Student Community Services Program (KKN) produced various TTG outputs that have not been comprehensively mapped by field and application location. This study aims to map the diversity and distribution of TTG based on 295 reports from the 2024 KKN activities and determine priority TTG as a basis for developing superior technology. A quantitative descriptive approach was used to recapitulate and classify TTG data from secondary KKN reports based on field of application-agriculture, environment, and information systems-and locations. The mapping identified 207 TTG, with agriculture being the most widely applied field (91 TTG, 44.0%), followed by environment (65 TTG, 31.4%) and information systems (51 TTG, 24.6%). Several TTG, including organic fertilizer and botanical pesticides, were frequently applied across multiple KKN locations. These frequency and distribution patterns served as the basis for determining priority TTG for prototype development. This study provides the first systematic institutional inventory of community-service technology outputs at UPN “Veteran” Yogyakarta, offering an evidence base for identifying community technology needs and directing the development of TTG more appropriate to field conditions.

Keywords *Appropriate Technology, Community Services, Innovation Inventory, Rural Development, Technology Adoption*

INTRODUCTION

Appropriate Technology, locally referred to in Indonesia as *Teknologi Tepat Guna* (TTG), is technology that is deliberately adapted to a community's needs, local resources, and capacity to operate and maintain it, rather than technology selected purely for technical sophistication. TTG can address gaps in meeting basic needs, such as access to electricity, food processing, and waste management, which remain challenges in many rural areas. Research by [Del-Río-Carazo et al. \(2022\)](#) demonstrates this concretely through a case study on electricity provision in remote settlements along the Napo River, where the selection of electrical technologies depended not only on technical efficiency but also on the community's ability to operate and maintain them independently over the long term.

Applying TTG in community life produces innovations suited to regional problems and characteristics. For example, [Worldailmi et al. \(2025\)](#) implemented an energy-efficient grass chopper for a livestock group in Yogyakarta, reducing operational costs and improving worker safety. [Wahyuni et al. \(2023\)](#) developed a solar panel-powered water pump as an alternative

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Corresponding author's email: eni.muryani@upnyk.ac.id

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household energy source. These studies show that ITG varies across sectors and that successful implementation depends on community capacity to adopt, operate, and maintain it.

Universities play a critical role in extending technology use through community partnerships and community service initiatives. These linkages provide channels for information and technology transfer while stimulating collaborative learning between universities and communities. [Mancini et al. \(2022\)](#), studying a partnership between the University of Parma and farmers in the Apennine Mountains, showed that trust between partners and clear roles are crucial for successful collaboration, while differing expectations and limited institutional support can affect partnership sustainability.

The community's ability to accept, understand, develop, and maintain technology is as important to sustainable use as technology quality. In rural Colombia, [Holmén et al. \(2025\)](#) found that one-way transfer is less effective than approaches enabling ongoing engagement and learning because recipients' capacity develops over time. [Dhillon's \(2026\)](#) bibliometric analysis of 251 publications found increased research since 2015 on digital platform-based knowledge transfer, including agricultural extension. This evidence highlights the need to document technological diversity and distribution before assessing sustainability or benefits.

UPN "Veteran" Yogyakarta routinely implements the Student Community Services Program as part of the Tri Dharma of Higher Education. KKN has produced various Appropriate Technology innovations tailored to community needs and local conditions, but their diversity has not been systematically documented. Consequently, technology distribution, potential re-application, and sustainability remain incompletely understood. Without systematic documentation, the university cannot identify TTGs that are repeatedly applied, replicable, or potentially sustainable. Therefore, this study maps the diversity and distribution of TTGs produced or implemented through the 2024 KKN activities and identifies priority TTGs based on frequency and spread across locations to inform future development.

LITERATURE REVIEW

Appropriate Technology

The term "appropriate technology" refers to small-scale, labor-intensive, inexpensive, energy-efficient technology that local communities can adopt ([Del Río Carazo et al., 2022](#)). In general, TTG emphasizes tailoring technology to the community's needs, circumstances, and users' capabilities. [Wang et al. \(2021\)](#) used a capabilities-led approach and demonstrated that community capabilities and local context should be considered when evaluating technological solutions, particularly in rural communities. [Angom and Viswanathan \(2023\)](#) examined understanding the various factors influencing smallholder farmers' decisions to accept and use technology. Recent reviews highlight the evolution of appropriate technology from an alternative to conventional modern technology to a broader, context-sensitive approach that integrates social, economic, and environmental dimensions of sustainable development ([Yasar et al., 2025](#)). Meanwhile, [Régnier \(2023\)](#) notes that international bodies (G7, G20, UN) increasingly support appropriate, resource-efficient technologies as instruments for achieving sustainable development goals.

Student Community Services Program as a Means of Implementing Appropriate Technology

Universities connect academic knowledge with societal needs through collaboration. [Mancini et al. \(2022\)](#) show that university-community partnerships in rural development are shaped by trust, communication, and a clear division of roles, enabling knowledge exchange and the implementation of activities based on local needs. Such collaboration also supports knowledge and value transfer, as well as practice-based learning for students ([Kusmulyono et al., 2023](#)). Research by [Harinurdin et al. \(2025\)](#) further emphasizes the importance of community

participation, knowledge networks, and innovation in community empowerment. Furthermore, universities can foster social innovation through interconnected levels of engagement among individuals, organizations, and communities ([Burke et al., 2024](#)). Therefore, trust, communication, and clearly defined roles are essential for translating research into technologies that can be utilized locally ([Hailu, 2024](#)).

Current research largely focuses on the collaborative processes. [Zhou and Baines \(2024\)](#) point out that, unlike patents and other commercialization-oriented outputs, informal knowledge-sharing activities such as community engagement programs are rarely tracked or documented systematically. Studies tend to describe how a program was carried out and its impact on the community, but they seldom record which technologies were actually produced, where, or for what purpose. This lack of systematic documentation is what the mapping approach in this study aims to address.

Technology Classification Frameworks

Technology classification frameworks help organize diverse technologies by application area, function, and characteristics. [Rolandi et al. \(2021\)](#) developed a taxonomy that categorizes the impacts of digital technologies in agriculture and rural areas into domains, impact areas, and outcome areas, showing how classification can group technologies by application context. Applying environmentally friendly technologies in rural contexts considers local resources, environmental conditions, and community capabilities ([Sianipar, 2022](#)). In the context of information systems, [Santoso et al. \(2023\)](#) studied agricultural information systems as technology-based services that support farmers' access to information and decision-making in Indonesia. Based on this sectoral perspective, this study operationally classifies TTG outcomes into three application areas: agriculture, the environment, and information systems.

Mapping Technology Potential

Mapping technological potential is necessary to obtain an overview of the existence, diversity, location, and characteristics of technology applied in a region. [Čerba \(2025\)](#) shows that open spatial data such as OpenStreetMap can assess a region's innovation potential by identifying technologies related to innovation capacity. Mapping can also involve the community and stakeholders. [Van den Akker et al. \(2023\)](#) showed that participatory systems mapping can help understand complex systems by incorporating stakeholder perspectives and identifying relationships and intervention points. [Barrett et al. \(2025\)](#) also place community involvement as a crucial part of the process of identifying community needs and assets.

RESEARCH METHOD

This study uses a quantitative descriptive approach with a mapping method to identify the diversity and distribution of Appropriate Technology in the 2024 UPN "Veteran" Yogyakarta KKN activities, as shown in the flow diagram in Figure 1.

Data Sources

The data used is a summary of the 2024 UPN "Veteran" Yogyakarta Student Community Services activity reports. Each report summary includes the KKN location, the name or type of TTG (Technology Group), the field of application, and the number of technology applications. A total of 295 KKN group activity reports from the 2024 implementation period were reviewed. From these reports, 207 activities were identified as meeting the criteria for TTG and were retained for classification and mapping; the remaining reports either did not involve a distinct technological output or fell outside the scope of the three focus fields and were excluded. LPPM UPN "Veteran"

Yogyakarta, as the institutional body responsible for the Community Service Program, authorized the use of KKN report data for this analysis. The unit of analysis is a TTG implementation recorded in a report; one report may contain several TTGs or none.

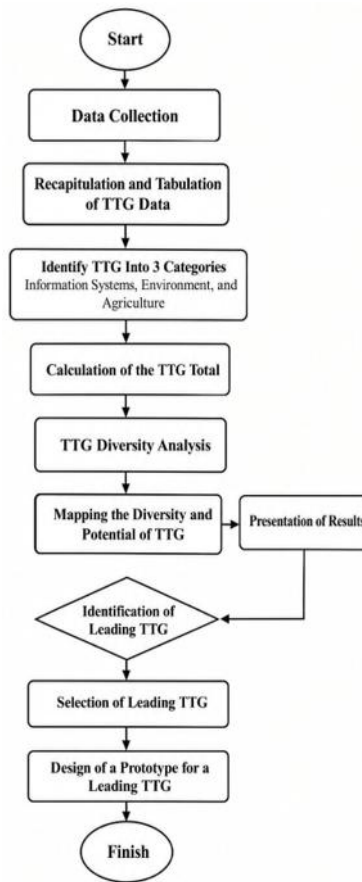


Figure 1. Research Flowchart

Identification and Classification of TTG

Identification was conducted by summarizing the 2024 KKN reports to identify activities that produced or implemented technologies that could be categorized as TTG. An activity is classified as TTG if it produces technological outputs, tools, products, or systems and can be reused to meet community needs. Activities are excluded if they consist solely of general training, counseling, or administrative assistance without producing technology. The classification rules and their review are described below. The identified TTGs were then classified into three main areas based on the research focus:

1. Information systems include technology related to disaster risk maps, village maps, tourist maps, and other technology-based information management
2. Environment includes technologies related to environmental management, waste processing, resource utilization, and environmental problems
3. Agriculture includes technology that supports agricultural activities, agricultural product processing, animal husbandry, and the use of agricultural resources

Each TTG was assigned to a field based on its primary purpose: environment (waste processing, resource conservation, risk reduction), agriculture (crop production, maintenance, or protection), or information systems (providing, managing, or disseminating information). For

example, used cooking oil processed into candles and soap, and fish farming in reused gallon containers, were classified as environment because their main purpose is reusing waste. Technologies that could serve more than one field were assigned to the field that best matched their primary purpose. These rules were formalized after the initial classification. Classification was carried out by one author and reviewed by another for consistency; disagreements were resolved through discussion.

Spatial Mapping Procedure

The distribution of KKN and TTG groups across locations was mapped in ArcGIS using the administrative boundaries of the nine regencies and cities where the 2024 KKN program was conducted. Each location was assigned a geographic name, along with the number of groups and TTG findings. The data were then visualized in graph form.

Analysis of Diversity and Distribution of TTG

The analysis calculated the number of TTGs by type, field of application, and KKN program location. The numbers for each field were compared to determine which field had the highest TTG application. Furthermore, the number of technologies at each location was compared to determine the location with the highest concentration of TTG application.

Determination of Dominant TTG as a Prototype Basis

The TTGs selected for development as prototypes were determined based on the results of the recapitulation and mapping. The dominant TTGs were determined based on the highest frequency of implementation in the 2024 KKN data. The TTGs with the highest implementation frequency were designated as candidate priority TTGs for prototype development, pending field verification.

Data Quality and Potential Biases

Because the data are self-reported student documents, reporting bias (uneven detail, omitted outputs) and selection bias (only documented outputs in the three fields) are possible, and no field verification was done. Counts therefore reflect documented implementations, not verified adoption.

FINDINGS AND DISCUSSION

Distribution of KKN Locations in 2024

A review of the 2024 UPN "Veteran" Yogyakarta Student Community Services Program activity report shows the diverse application of Appropriate Technology across various KKN locations. Kulonprogo Regency had the largest number of KKN groups, with 73, followed by Gunungkidul Regency with 72. Furthermore, Wonosobo Regency had 44 groups, Klaten 31, Kebumen 28, Bantul 17, Boyolali 15, Sleman 13, and Yogyakarta City 2. However, the number of groups cannot directly indicate the number of TTGs implemented because each group can produce different types and quantities of technology. Therefore, the TTG analysis was conducted based on the results of the technology recapitulation from the KKN report, which was then grouped by field and location of application. This approach was used to obtain an overview of the pattern of TTG diversity produced during the 2024 KKN implementation, as shown in Figure 2.

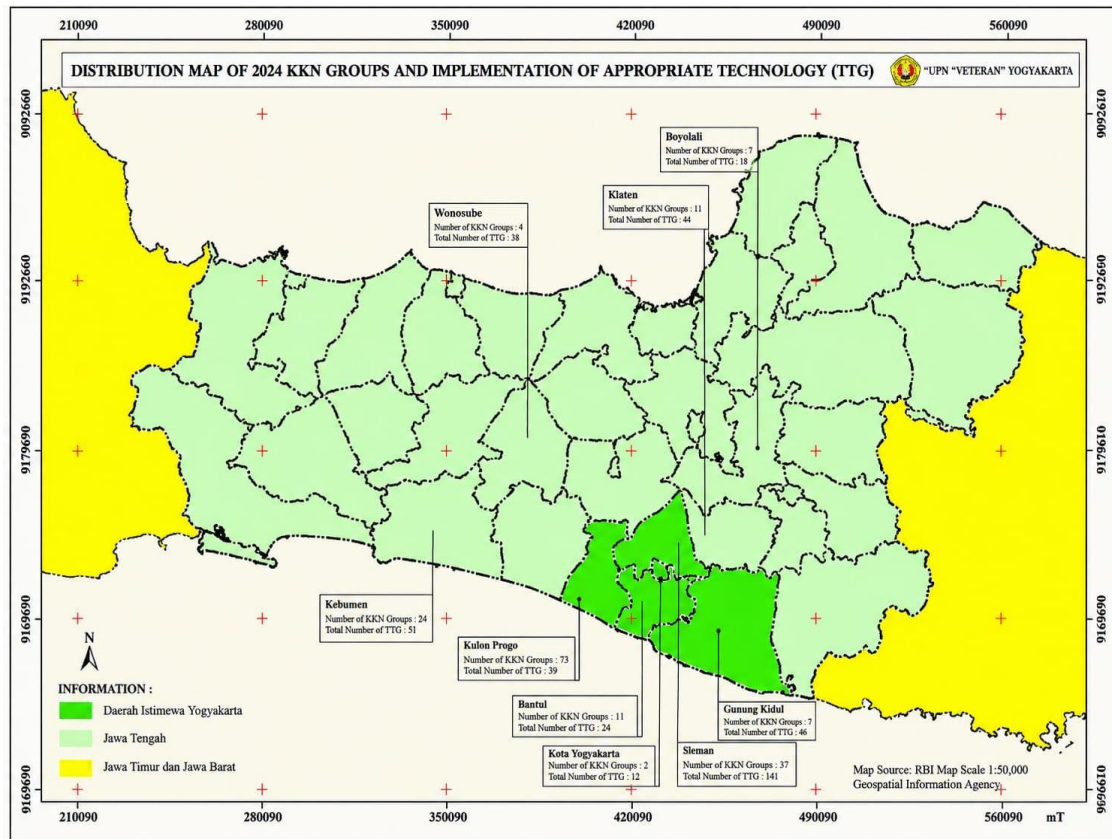


Figure 2. Map of the Distribution of Locations and Number of KKN Groups in 2024

Diversity of TTG Based on Field of Application

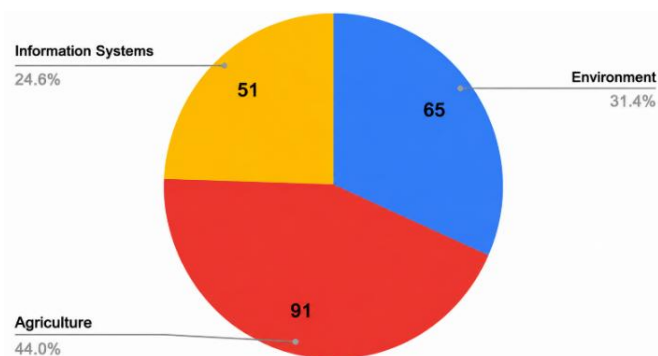


Figure 3. Diagram of the Number of Appropriate Technologies in 2024 Based on Application Field

The recapitulation results shown in Figure 3 show that 207 TTGs are included in the three research focus areas: information systems, environment, and agriculture. The agricultural sector has the highest number of applications, with 91 TTGs (44.0%), followed by the environmental sector with 65 TTGs (31.4%), and information systems with 51 TTGs (24.6%). This composition indicates that almost half of the identified TTGs are related to agricultural activities. This may reflect community needs in agrarian regions, participants' backgrounds and interests, or institutional priorities; the data cannot separate these factors. Table 1 presents detailed

information on the types of appropriate technologies (TTGs) identified in each field.

Table 1. Types of TTG in Each Field

Field	Types of TTG	Frequency (n)	Total
Environment	Used cooking oil candles	12	65
	Biopores	11	
	Maggot cultivation	7	
	Eco-enzyme	7	
	Ecobrick	6	
	Used cooking oil soap	5	
	Mosquito repellent spray	2	
	Simple irrigation system	2	
	Family medicinal plants	2	
	Fish farming	2	
	Organic waste compost	2	
	Filter tap	1	
	Water quality monitoring (IoT system)	1	
	Corn cob briquettes	1	
	Biogas processing	1	
	Stacked-bucket composter	1	
	Briquettes from coconut fiber	1	
	Hand sanitizer made from natural ingredients	1	
Agriculture	Liquid and solid organic fertilizer	44	91
	Botanical pesticides	23	
	Hydroponics/aquaponics	16	
	Vertical farming	4	
	PSB (Photosynthetic Bacteria)	1	
	Microgreen cultivation	1	
	Installation Trap Barrier System (TBS)	1	
	Pest control tools	1	
Information Systems	Administrative map	14	51
	Website UMKM	9	
	Village map	7	
	Disaster-prone map	5	
	Village website	5	
	Regional planning map	2	
	Tourist map	2	
	Water quality map	1	
	MSME Website	1	
	Population maps and infographics	1	
	Landslide-prone area map	1	
	Groundwater poster	1	
	Water spring map	1	
	Landslide hazard map	1	

Field	Types of TTG	Frequency (n)	Total
Total TTG: 207			

TTG in agriculture demonstrates the application of technology related to cultivation, productivity improvement, and pest control. The use of locally available materials, such as in producing organic fertilizers and botanical pesticides, shows how technology adapts to local resources. Meanwhile, hydroponics, aquaponics, and vertical farming demonstrate the application of alternative cultivation methods that can adapt to limited land conditions. In the environmental sector, TTG applications tend to relate to waste management, resource reuse, and water management. Furthermore, technology in water management and wastewater treatment shows that environmental TTG includes simple approaches to using digital-based technology.

Meanwhile, the information systems sector uses technology to support the provision, management, and dissemination of information. Its application includes website-based media and mapping related to administrative conditions, regional potential, resources, and disaster vulnerability. This technology shows that the community's need for TTG is not only related to physical resource management, but also to the availability of information that supports regional management and decision-making. However, websites and digital maps require continued updating, connectivity, and digital skills; whether communities can maintain them after KKN is not captured in the reports.

Distribution Pattern of TTG Between Locations

TTG mapping was conducted to determine the distribution of technology implementation at each KKN location in 2024. Data were grouped by KKN location and the number of TTGs recorded in each region. Figure 4 displays the TTG distribution mapping results.

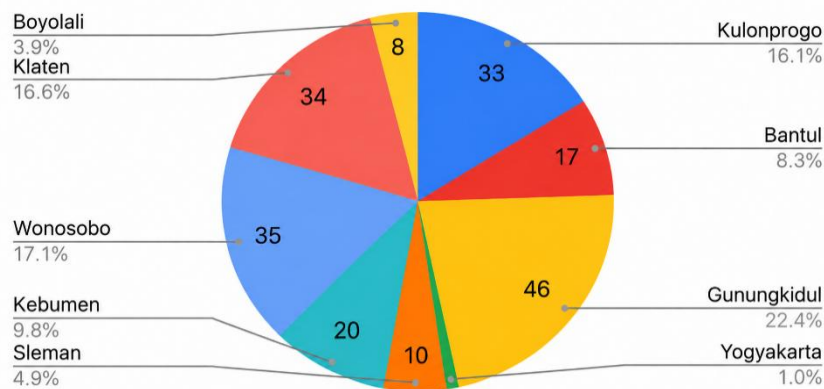


Figure 4. Diagram: Number of Appropriate Technologies in 2024 by Region

In the regional recapitulation chart, Gunungkidul has the highest number of TTG implementations (46), followed by Wonosobo (35), Klaten (34), and Kulonprogo (33). Meanwhile, the remaining regions recorded lower numbers of implementations: Kebumen with 20, Bantul with 17, Sleman with 10, Boyolali with 8, and Yogyakarta City with 2 implementations.

Data patterns indicate that the diversity of Appropriate Technology is influenced not only by the scope of the KKN program's implementation but also by the specific needs identified at each location. Consequently, a ratio analysis was conducted to determine which region was the most

productive in terms of TTG output. The data reveal that Klaten, despite having fewer groups (31) than Kulonprogo (73), generated a comparable number of TTG solutions (34 versus 33), resulting in a significantly higher technology-per-group ratio (1.10 versus 0.45). These differences may reflect differing intervention focus and documentation practices, so the ratios are indicative rather than a performance ranking.

Featured TTG

The TTG mapping results from the 2024 KKN activity report show that the types of TTG implemented differ across locations. This pattern aligns with research conducted by [Sambodo et al. \(2023\)](#), which found differences in community-based development practices in agricultural, forestry, and fishery villages. These differences in characteristics demonstrate the importance of considering local conditions and potential in determining the form of intervention implemented in the community. In terms of sectoral patterns, agriculture emerged as the dominant sector, followed by the environment and information systems. This aligns with research on grassroots innovation in other contexts, where agriculture-related innovations also tend to dominate ([Sharma, 2022](#)). However, few studies have measured sectoral distribution at the level of entire institutional programs. Meanwhile, in non-agricultural contexts-such as coastal fishing communities-digital access is actually the most urgent unmet need ([Hossain et al., 2025](#)). Therefore, this distribution reflects local livelihood structures rather than a universal pattern.

Organic fertilizer is one of the most widely applied TTGs in several KKN locations, such as Wonosobo, Sleman, Kebumen, Gunungkidul, Kulonprogo, and Bantul. Botanical pesticides are used in Sleman, Kebumen, and Yogyakarta City. Meanwhile, in fieldwork program information systems, TTG applications were used to create administrative maps in Klaten and tourism maps in Boyolali. Organic fertilizer is the strongest candidate for prototype development, as it is both the most frequently applied and the most widely distributed, with a total frequency of 44 work programs across six locations. Botanical pesticides rank second, with a total frequency of 23 work programs across eight locations. [Pandyaswargo et al. \(2022\)](#) showed that designing appropriate technology for the community requires considering social, technical, and economic aspects. Frequency and spread indicate that a technology is commonly chosen, not that it is adopted, sustained, or beneficial. Priority TTGs are therefore candidates for prototyping pending field verification. The novelty of this study lies in its systematic, institution-wide quantification of TTG diversity, frequency, and distribution across an entire community service program, rather than a single case, technology, or location as in prior studies, providing a replicable. evidence-based method for prioritizing future technology development.

CONCLUSIONS

This study successfully mapped the diversity and distribution of Appropriate Technology produced through the 2024 UPN "Veteran" Yogyakarta Student Community Service Program, identifying 207 TTG across agriculture (91, 44.0%), environment (65, 31.4%), and information systems (51, 24.6%), and determined priority TTG for prototype development based on frequency and distribution: organic fertilizer (44 work programs across six locations) and botanical pesticides (23 work programs across eight locations).

This study offers two contributions. Practically, it gives UPN "Veteran" Yogyakarta an evidence base for prioritizing which TTG to develop into prototypes, based on how frequently and widely a technology is already applied. Prototyping would require the university to provide design and testing, communities to specify needs and pilot, and partners to support funding and maintenance. Academically, it offers a replicable method for systematically inventorying the technological outputs of a university community service program, which may be applicable to other

institutions running similar programs, although program structures and context differ.

LIMITATIONS & FURTHER RESEARCH

This study is limited by its single-year, single-institution scope; reliance on unverified secondary report data classified by a single coder; and its use of frequency and distribution as a proxy for suitability, without measuring actual benefit or sustainability. Future research should verify priority TTG in the field, extend the analysis across years or institutions, and assess post-KKN sustainability, tracking adoption over 6-24 months and interviewing community partners.

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