Revitalising the role of interconnectedness on agricultural innovation platform: A network analysis

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Abstract. Innovation platforms are widely benefited in agricultural research to connect different stakeholders to achieve common goals. This paper aims to discuss the analytical framework of network governance in enhancing the role of interconnectedness among relevant actors of innovation platforms in the agriculture sector. In facing the upcoming turbulence of the current pandemic, the agriculture sector as a backbone for food resilience at the national level should embrace an adaptive system for the future policy. This paper conducts a network analysis to emphasize the main actors working actively in providing innovative technology and agricultural products. There are three main actors identified in the conceptual framework of the innovation platform; research and development institution (RDI), government, and users/beneficiaries/farmers group. However, interconnectedness among actors is possibly coming from other partners such as intermediaries that relevant to the innovation system. With a case study from agricultural practice from research institutions, this research explores interconnectedness problem need to be addressed and supportive policies at local government level enabled social capital among actors. The result of analysis suggests that the degree of network to the business environment, tangible and intangible, determines the nature of engagement to result a successful model for innovation platform.

1. Introduction

The agriculture sector is a vital sector in most developing countries. Under the current crisis of the Covid-19 pandemic, issues in the agriculture sector have become more challenging, which bring significant impacts on many sectors, and left Indonesia vulnerable to food shortages. Innovation in the agriculture sector is believed to be the main driver in increasing productivity [1]. Innovations in this sector are also considered to be able to increase efficiency and provide a competitive advantage [2], while simultaneously preserving the environment [3]. In the context of the agricultural innovation system, the process of accelerating the diffusion of R&D results can be carried out through an innovation platform, where this approach is believed to increase the impact of utilizing R&D results through a multi-stakeholder collaboration scheme [4].

According to the current entrepreneurship study, network relations of several business partners like suppliers, distributors and customers will help small firms to acquire new knowledge to commercialize innovation [5]. Other scholars also encouraged that diverse networks and relations can provide a
contribution to address challenges of commercialization and establish a crucial context for new product development [6]. It then analyzed how the network approach in supporting commercialization and how external partners contribute to the commercialization of innovations. By taking sort of the previous discussions, this paper aims to advance understanding of the role of networks in the innovation platform. This study also creates a pivotal contribution to building the initial framework of network governance in an innovation platform.

In brief, this paper will be organized as follows. First, it presents a brief description of the innovation platform, network governance and technology adoption in the agriculture sector. The next section explains the conceptual framework of System Network Analysis (SNA) and provides an empirical study from the adoption of technology. Some analytical findings of the research enable us to provide recommendations for relevant stakeholders particularly the Ministry of Agriculture.

2. Materials and Methods

2.1. Innovation platforms (IPs)

With the rise of technological change and market, the adoption of innovation in agricultural technology requires interrelated and interconnected between organizations and individuals. This interaction will have a reciprocal influence in deciding to use or switch to a new product or not [7]. As such, the network actors can contribute to support commercializing new products and services, by combining existing resources that are relevant to the markets. This study emphasizes the innovation platform as a collective action in which farmers and relevant stakeholders join together to build an innovation network to co-produce various innovation outputs in the arrangement of socio-technical and institutional settings [8]. Multi-stakeholder innovation platforms are considered to be a practical approach to improving the research impact in the agriculture sector, beyond its initial development [4, 9]. Furthermore, innovation platforms (IPs) are believed to integrate relevant stakeholders to achieve a wider impact [10].

Conducting a study on how collaborations and networks can contribute is a critical part of the innovation process [7]. However, only a few firms have capacity to develop innovation management, it requires collaboration among actors and organizations to gain innovative performances [11]. In addition to this, it stated that in the context of commercialization, a new product or service tends to fail when excluding the stakeholders’ supports in the process of adoption and diffusion to the market.

2.1.1. Network governance and technology adoption

The network is viewed as a mechanism of coordination, or what has often been referred to as network governance. The effectiveness of the network suggests cooperation among individual organizations to result in a positive outcome. In other words, the level of network is the key to the effectiveness of goals achievements. Networks are also considered as collaborative arrangements, governance that indicates the existence of control and hierarchy is no longer appropriate [12].

In terms of definition, adoption and diffusion in this study comprise different contexts. Diffusion reflects how the innovation could be delivered to the markets. In a different view, adoption is defined as how the innovation is accepted and adopted in a certain way [13]. Dissemination is an act of innovation that is prepared according to careful planning, through discussions or other forums that are deliberately programmed, so that there is an agreement to implement innovation. The implementation is really based on a directed program. Adoption is the decision to fully use a new idea as a way of acting that best either accepts or rejects it and then confirms it.

Most empirical evidences of IPs were conducted in the agriculture sector, particularly to facilitate the adoption of technologies [9]. Some scholars argued that IPs can be an effective framework to establish institutional changes across levels and scale [14, 15, 16]. As such, the most government in developing countries have widely practiced the IP approach as an opportunity to provide strategic policy such as land consolidation and intensification of the agriculture sector [17].
To bring the effectiveness of multistakeholder IPs in the agriculture sector, the analysis of networks among the individual and organizations is important to be carried out. It has been widely recognized that network as an important form of multi-organizational governance. There are some benefits of using network coordination in both public and private sectors, including enhanced planning capacity to address complex problems, efficient use of resources, greater competitiveness, better services, and the learning process [18, 19, 20]. Related to this study, analysis of network governance on innovation platform focuses on the effectiveness of a program that has been organized by the government in agricultural technology adoption. It stated that to study the effectiveness of policy program has been quite debatable not only in the organizational, but also in the network context to whom it will be directed to [21].

2.2. Methods
2.2.1. Collecting relevant articles
In the first stage, this study aims to explore how diverse network activities in the derivative context of innovation platform based on relevant articles. This study employs a database from Scopus with restricting the search to some boundaries in particular issues like technology adoption, technology transfer, dissemination, relevant to agricultural products and services. The database of publication is focused on the Indonesia context during 1999 – 2020 from the earliest retrievable records of the Scopus database to 2 August 2020. However, there is no limitation of journal rankings, since the number of publications related to the field is rather limited.

In the first process, it started with a systematic search by exploring the keywords in conjunction with the network in agricultural technology adoption in the title, keywords, or abstract on all articles. By employing this database, it meant there was a filter process of an extensive number of relevant articles. It should be recognized that one article might be linked to one or more keywords. After filtered based on relevant keywords, this study found the search for 97 articles. Then these articles were sorted out into 47 articles to reduce the possible duplications. From this process, then the relevant articles were checked from the abstract, and if it was not clear whether the article related to our focus, we skimmed the full papers. With this number of articles, based on network issues for technology adoption, we resulted in 6 relevant articles.

Articles related to the issue of innovation platform at which defined as technology adoption, technology transfer and dissemination of technology in the agriculture sector are included as well as the topic related to the network in respective activities. Even the articles were not directly related to network governance as the core study, the shortlisted articles are still needed to give description on the variety of actors and typical technology that indicate interconnectedness. The analysis of data focuses on the findings of key content and discussions within the research team.

2.2.2. Analysis of network
One of the unique features of social networks is community structure. A significant research effort was undertaken in the agricultural community of innovation platforms. A social network in an innovation platform can be constructed from relational data. It can be defined as a set of social entities of agricultural technology adoption, such as people, groups, and organizations, with some relationships or interactions between them. Networks among these actors are usually modeled by graphs, consisting of two indicators; vertices represent the social entities and edges represent the ties established between them. Social Network Analysis (SNA) approach were applied in this study to discover patterns of interaction between social actors in the network of innovation platform [22]. The main objective is to examine the patterns of relationships in social networks.

A network is indicated by the relation/link between its nodes. In a network, there can be distinct relations between a single set of nodes. Some indicators of the social network are degree, betweenness, closeness, and eigenvector centrality. The measurement of degree account for the number of the relationship among actors. Centrality is defined as a measure to present the position of an actor within the overall structure of the social network, and it can be computed resorting to several metrics. The
indicator of betweenness indicates the level of intermediation in the network, particularly related to interest. Using SNA could help to understand the position of the actors in the network and how the interaction among actors in providing resources and having knowledge exchange [23].

3. Results and Discussion

3.1 Results

Data analysis of this study focuses on the topic of network governance for innovation platforms and particular attention addresses to the process of technology adoption or dissemination that has been discussed in the articles. Our analysis recognized the multidisciplinary nature of technology adoption and dissemination in the agriculture sector in Indonesia. There are considerable topics from the technical issue in technology adoption, economic feasibility, climate change, integrated pest management, and other strategic concept of agricultural on-farm development. Few studies on network issues were discussed within the technology adoption challenges. In addition, many articles published by Indonesian authors were resulted from collaborations with external partners as part of funding agency.

In fact, research articles on network governance in innovation platforms are still emergent, and the number of authors contributing to the relevant topics is still limited. However, some authors have initiated to build a joint publication with the international organisations to improve the quality and to give wide support in resulting in the best scientific output.

Table 1. Degree of centrality and betweenness of centralities among institutions in technology adoption.

| No | Institution                                                                 | Degree | Betweenness |
|----|-----------------------------------------------------------------------------|--------|-------------|
| 1  | Provincial/District/city Agricultural Agency/Extension Coordination Agency/local government | 22     | 21.5        |
| 2  | Central Statistical Agency (BPS)                                             | 15     | 4.5         |
| 3  | Meteorological Climatological Geophysics Agency/BMKG                         | 15     | 4.5         |
| 4  | The Indonesian Agency for Agricultural Research and Development (Balitbangtan) MoA | 15     | 4.5         |
| 5  | Farmers                                                                     | 13     | 5           |
| 6  | Assessment Institute for Agricultural Technology (AIAT)                      | 9      | 0           |
| 7  | Indonesian Center for Agricultural Technology Assessment and Development (ICATAD) | 9      | 0           |
| 8  | Indonesian Center for Rice Research (ICRR)/BB Padi                          | 9      | 0           |
| 9  | Universities                                                                | 9      | 0           |
| 10 | Farmers’ associations                                                        | 9      | 0           |
| 11 | International organization                                                  | 9      | 0           |
| 12 | Head of Branch Office/Local Technical Implementing Unit, Agricultural Extension Center/Agricultural Extension Coordinator/Plant Pest Observer (POPT) | 6      | 0           |
| 13 | The Agricultural Technology Assessment Centers/Balai Pengkajian Teknologi Pertanian (BPTP) | 6      | 0           |
| 14 | R&D institution                                                             | 5      | 0           |
| 15 | Seed growers                                                                | 3      | 0           |

Source: Authors (2020)
In this study, we present a concise overview of social network analysis in the innovation platform of agricultural technology adoption. Table 1 incorporates among institutions conducting technology adoption in the agriculture sector. From the six articles, most of them show different technology adoption in terms of tools and methods. We also identify the network organization of each article by referring to the technology adoption and related institutions to support the activities. The findings of this study reveal that there are some key players in the technology adoption in the agricultural innovation platform, ranging from the agency for agriculture R&D (Ministry of Agriculture), local government, universities, farmers, related Ministry/Agencies and external partners. The significant level has been analyzed by the degree of centrality and “the betweenness” among institutions. In this result, local government is recognized to be the most critical actor in playing role in technology adoption in agricultural products and services with the highest degree of centrality (22) and the highest betweenness (21.5) among other institutions.

The lack of research articles on the network governance in the agriculture sector might be potential evidence of disconnection between innovation platforms and technology adoption research. Most studies emphasized the issue of technology adoption in technical perspectives, particularly related to the method and tool of a transfer process. Articles focusing on innovation platforms and multistakeholder interconnectedness in the agricultural innovation system are likely missing in this investigation.

The result of the analysis could be described in the following graph of network (Figure 1). This map of actors corresponds to the situation of the network based on technology adoption in the agriculture sector. We can observe a relative scattering of actors in the network with no domination of any institutions and with relative links. It could be noticed that the main actor of technology adoption is the local government, either at the provincial, district and city level. Their contribution can be expressed by the links that cover various stakeholders in the chain of the technology adoption process. Another key stakeholder of technology adoption is the Agency of agricultural research and development (Balitbangtan), either as the policymaker or as a research and development institution that has the biggest authority to disseminate the technology adoption policy and program. However, there are other research organisations mentioned in some articles indicating that many people concern in this field due to the emerging problems that are still in the line of most discussions.

Figure 1. Network map of agricultural institutions in technology adoption.
Instead of formal institutions, the role of farmers in the network is important as the beneficiaries of the technology. Not only with the IAARD, but also with some universities, farmers have good cooperation to improve the productivity of their commodities by appropriate technology adoption. The wide challenge of agriculture productivity in Indonesia is also highly influenced by climate change. This concern has motivated most international organisations to address these grand challenges and invite relevant participations, such as the Agency of Meteorological Climatological Geophysics (BMKG) to work together in developing technology applications to observe the impact of climate change on the agriculture sector.

3.2. Discussion

This study also presents empirical evidence of the innovation platform in technology adoption produced by government research agency in agriculture (Balitbangtan). In 2015, this research agency launched a policy package on managing agricultural technology adoption, namely Jajar Legowo Super (Jarwo Super). This technology package requires technological innovation in the agriculture sector to the creation of innovative food crops, horticulture, plantations, animal husbandry, land and environmental resources, mechanization, and post-harvest in the form of new superior varieties, technology, models or prototypes [24].

As part of integrated rice crop management (PTT), Jarwo Super is an innovation platform of several technology components that are integrated into one package for technology adoption. Unlike the conventional legowo row, the super legowo row technology is a technological recommendation consisting of: 1) Use of New Superior Variety (VUB) for producing high yield potential, 2) Biodecomposers during soil processing, 3) Biofertilizer and fertilization balanced based on soil nutrient status, 4) Pest control with vegetable pesticides and inorganic pesticides based on control thresholds, and 6) Use of agricultural tools and machines (transplanter and combine harvester) [25].

The innovation platform seeks to strengthen the agricultural innovation system by building actor interactions, encouraging institutional and policy changes, and effectively utilizing resources and opportunities in finding solutions to the problems at hand [26]. The successful adoption of agricultural R&D results in an innovation platform is expected to have a broad impact, not only limited to the platform actors [27] but also impacting society and industry. The alignment of innovation platform activities with a broader political agenda and government policy can facilitate the process of innovation scaling activities [28], either scaling out or scaling up [10]. In order to disseminate research results to the users, especially farmers, the agency of Agricultural R&D communicates with BPTP to spread the technology adoption package across 33 provinces in Indonesia. This effort is part of the government long term program to support the need of regions to increase their local productivities with appropriate technology (location specific).

Jarwo Super planting system is believed as a technique of combining technology to increase rice productivity in a sustainable way [29]. The implementation of the legowo row system provides potential benefits such as supporting plant growth and optimal plant population. Instead of increasing rice productivity and farmers’ income, this system also provides solutions to control pests, weeds and plant maintenance [30]. According to [31], the adoption of superior rice variety in Jarwo Super technology accounts only for 40% of farmers and most of the variety used is Inpari 32, while other variety introduced by Jarwo Super such as Inpari 33 still lacks preference. One possible reason for the low response in technology adoption is related to the availability of varieties in the market. For example in West Java, most farmers (60%) still prefer to use old varieties rather than the varieties recommended in the Jarwo Super. This option is quite challenging for the government to pursue the implementation of this technology, since the farmers has experienced such traditional culture for many years.

With these challenges, the government keeps continuing the efforts to maintain local productivity by providing new varieties with a new component of technology that more adaptive with the extreme climate. Since 2005, the Ministry of Agriculture has released more than 300 new super varieties, and
farmers can access those varieties with the partnership with a local extension agency (BPTP). This agency through the provision of the Service Center for Agricultural Seed supports the adoption of Jarwo Super to provide Inpari 30, Inpari 32 and Inpari 33 in which the farmers can easily select and obtain the varieties. In some regions, legowo row technology is facing a big challenge. It can be seen that only 10% of the total farmers adopted the technology package, while the rest of the farmers still use the tile system.

The application of the Jarwo Super technology package in various regions in Indonesia has generated many different responses. The perception of farmers in South Sulawesi is quite positive, and the interest in the adoption of this technology is also high. The farmers realize that every component of the technology package is capable of boosting the production of rice. In Central Java, the application of Jarwo Super technology innovation has successfully increased local productivity by 57.09% over the existing technology [31]. From these examples, the preference for legowo super row technology innovation is driven by different perspectives, such as relative advantages, high level of suitability, low level of complexity (easy to apply), easy to implement on a small scale, and easy to observe in a relatively short time. This finding was also confirmed in the case of East Java, where Jarwo Super technology innovation has proven its superiority through the wide application of demplot area (demplot farming) in several locations.

The application of the Jarwo Super Technology emphasizes the implementation as a package, from five technology components provided. With the full application of Jarwo Super Technology, it is believed to be able to produce ± 10 tonnes of GKG / ha per season. For example, in Lampung, the use of new varieties (VUB) has been shown to have good compatibility with the Jarwo Super technology in the successful dissemination of innovation [31]. The high level of use in varieties depends on the availability of supply in the market. It also important for the farmers that the information of new varieties complemented with the adaptation assessment and relevant product knowledge. In South Kalimantan, the implementation of Jarwo Super also shows a prospective development with the provision of Jarwo Super components such as Agrimeth, MDec and Bioprotector [31]. Although the adoption rate of the Jarwo Super technology component has not been optimal, this technology is widely replicated in many districts, including Tapin Regency, Banjar Regency and Barito Kuala Regency. On the one hand, there is a tendency that farmer institutions in developing countries are still weak, including Indonesia, since the current institutions are considered to be failed in providing solutions to manage the problem of economic disparities at the farmer’s level. On the other hand, the level of globalization and economic liberalization must be met with the right policy strategy [32]. Therefore, the government through technology dissemination and extension programs plays an active role in spreading technological innovation to the farmer level so that farmers can compete and survive in the midst of global competition.

In terms of social change, some farmers still have difficulties to perceive the adoption of new technology as a new culture [33]. In addition, the decision-making process in technology adoption is started from the individual context. The changes in a person's behavior are caused by interactions with other elements in the social system. When a local farmer avoids adopting new technology, it seems to be likely influenced by the decision of the most group. Even though the current level of application is relatively low, the development of research is still continuing, particularly innovative products to address new changes. The previous study described that agricultural innovation resulted from government research institutions is expected to be applied by farmers, so it could help increase the farmers’ welfare [34]. The involvement of various stakeholders in innovation adoption and feedback activities is expected to accelerate the process of disseminating agricultural innovation, which is of course supported by central and regional policies that favor the agriculture sector.

4. Conclusions
Inter-connectedness among stakeholders in the network of the agriculture sector is an emergent issue. By reviewing the extant research on the network of innovation platform, this study generates new knowledge on how network governance in technology adoption should be addressed to ensure the
success of agricultural policy programs. By systematic literature review, this study explains that most technology adoption in the agriculture sector is less likely to focus on network issues. The review highlights that there are three types of actors in the network; (i) research and development institution (RDI), (ii) government, and (iii) users/beneficiaries/farmers group. The analysis suggests that the degree of diversity among actors in agricultural technology adoption is still high, and the important actors such as the business sector are still missing in the network. In fact, the role of industry in innovation platforms is critical to increase the scale of production as well as the intermediary agency to the farmers. Local government is analyzed to be the key actor of technology adoption and plays an important role as the agency of extension between government policy and farmers.

The result of this research shows that there is a need to develop a synergy within collaborations among relevant stakeholders in the technology adoption to provide a successful model of an innovation platform. Our analysis also reveals that there are still different results of technology adoption in various regions in Indonesia. It implies that divergent network approaches in different regions will determine the nature of engagement and the success of technology adoption of a certain program. Therefore, it needs supportive policies at the local government level enabled social capital among actors.

The findings of the study suggest at least two implications. First, the government through the Agency of Research and Development in Agriculture of the Ministry of Agriculture needs to encourage network governance in the innovation platform by providing an ecosystem that enables the business sector to participate in the value chain. Second, to generate a larger impact of innovation platform, the participation of external actors such as international organizations is important to provide resources, tangible and intangible, for the successful technology adoption in the network.

Acknowledgment
Ria Hardiyati and Lutfah Ariana are the main contributors of this paper. This study is initiated from a working research project entitled “Innovation Platform in Supporting Scaling Activities of Agricultural Products from Government Research Institution”. The authors also grateful to the Research Center for Science, Technology and Innovation Policy and Management, the Indonesian Institute of Sciences (LIPI) for providing a grant that enabled this research.

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