Indonesian sugarcane seed system performance: an assessment from the perspective of institutional and technological innovation support

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Abstract. Provision of plant seeds involves various stakeholders in a relatively complex supply chain, starting from tracing the source of superior seeds, producing, storing, and distributing to the end user. Research on the performance of the Indonesian sugarcane seed system from the perspective of institutional and technological innovation was conducted from March to October 2018. The survey method with snowball sampling and the multidimensional scaling analysis was used in this study. The results showed that the performance of the Indonesian sugarcane seed system was categorized as "pretty good" with a range of performance indexes in each dimension 54.23 - 73.13 and an average index of 65.89. The highest performance is achieved in the organizational dimension, while the lowest is in the dissemination dimension. The lever for improving the performance of seed institutions is the regulation of tariffs and the carrying capacity of tissue culture laboratory infrastructure, while technology licensing partnerships and training for seed producers are levers from the perspective of supporting technological innovation.

1. Introduction
Indonesian sugar production data shows a downward trend every year. Apart from the decrease in area size, the decrease in production is also due to the decrease in plant productivity. In 2010 the national sugarcane productivity reached 81.8 tonnes/ha. In 2014 it fell to 70.7 tonnes/ha, and in 2018, respectively 67.1 tonnes/ha [1].

The decline in sugarcane productivity in Indonesia is inseparable from various problems, including in the seed system which is the starting point for plant cultivation activities. Provision of sugarcane seeds in Indonesia involves some stakeholders in a supply chain starting from tracing the source of superior seeds, producing, storing, and distributing to the end user. The suitability of seed supply in quantity, quality and time has an effect on productivity.

On the one hand, the achievement of quantity, quality and timeliness of seed supply depends on the availability of technology and the willingness of farmers to apply the use of production factors that are components of the technology. The determinant of agricultural technology adoption does not always have the same effect on adoption rather the effect varies depending on the type of technology being introduced [2]. On the other hand, institutional innovation in the form of counseling, financial support, and government policies, plays an important role in encouraging technology adoption [3]. The research question is: how is the supporting of institutional and technological innovations to the sugarcane seed system in Indonesia? This paper presents the results of a study on the performance of the sugarcane seed
system from the perspective of institutional and technological innovation with a multidimensional approach. From the performance appraisal based on the scale, in addition to presenting the performance categories for each dimension, it is also discussed the attributes in each dimension that are identified as leverage factors.

2. Methodology

2.1. Study site
Research was conducted from March to October 2018 at West Java (Bogor and Jatitujuh), Central Java (Pati), East Java (Malang and Kediri), and Southeast Sulawesi (Konawe).

2.2. Data collection
Data collection were carried out through: (1) literature study, (2) interviews with sugarcane seed growers/producers, and farmers, (3) discussions (FGD) with sugarcane researchers/breeders and management at the Research Institute, and (4) observation of the application of sugarcane seed creation/propagation. The literature study was conducted to collect secondary data on the distribution of area and sugarcane production, as well as the rules related to the certification of sugarcane seed. Interviews were conducted to collect primary data. Observations were made to confirm data on the application of sugarcane seed creation and propagation obtained from interviews.

2.3. Analysis
Apart from being influenced by economic and social factors, the level of technology adoption is also determined by the characteristics of the technology itself, namely in terms of its suitability and ease of application [4]. In more specific terms, the adoption of precision agricultural technology is also determined by the technological factors themselves in addition to the following factors: (1) socio-economic, (2) agroecological, (3) institutional, (4) information sources, and (5) farmers' perceptions and behavior [5]. Therefore, in this study the analytical methods include: (1) Mapping of institutional descriptions and technological innovation with cross tabulation and descriptive interpretation, and (2) Analysis of the performance of the sugarcane seed system using a multidimensional scaling (MDS) approach with perspectives, dimensions and attributes as shown in Table 1. The performance appraisal of attributes in each dimension used expert judgment with a scale from 0 to 10, reflecting bad to good performance. Determination of the performance status of sugarcane seed system used a performance index referring to sustainability index [6] that was developed and used for the performance assessment [7,8,9]. Performance status divided into 4 interval categories of indices: bad 0–25, Poor 26–50, fairly good 51–75, and good 76–100. Data analyses used the Rapfish software [10].

Table 1. List of perspectives, dimensions, and attributes for the multidimensional scaling analysis of sugarcane seed system performance

| Perspective               | Dimension     | Attribute                                      |
|---------------------------|---------------|------------------------------------------------|
| Institutional support     | Organization  | Research institute, Seed grower, Seed trader, Farmer, Certification center. |
|                           | Regulation    | Cultivation law, Seed producer business licence, Certification regulation, Tariffs regulation, Subsidy. |
|                           | Infrastructure| Laboratory, Experimental garden, Mother plant collection, Seed garden, Sugarcane plantation. |
| Technological innovation support | Technology | High yielding variety, Propagation technology, Cultivation technology, Packaging technology, Transportation technology. |
|                           | Logistic      | Stock seed, Extension seed, Input factor, Agricultural machinery, Guideline. |
|                           | Dissemination | Publication, Licence partnership, Technology assistance, Training, Technology display. |
3. Results and discussion

3.1. Description of sugarcane seed system

Based on the data and information obtained, a description of the sugarcane seed system can be described. In this study, the description of the sugarcane seed system is focused on aspects of institutional and technological innovation.

3.1.1. Institutional aspect. Organizational dimension: In the institutional aspect, the organizational structure already exists at the level of the Ministry of Agriculture, Regional Government, State and private companies that manage sugar factories, seed producer communities, and farmer groups. At the level of the Ministry of Agriculture, research institute as a unit of Agricultural Ministry and some of PTPN Company, certification center as liaison office of Directorate General for Estate Crops is located in Surabaya. Seed growers, seed traders, and farmers group distributed at sugarcane development area. This condition is in line with the definition that an institution consists of groups of individuals who work together and jointly manage resources towards a common goal, consisting of informal groups and formal institutions [11]. The tasks and functions of creation, propagation, and certification for the breeder and foundation seed until the stock seed have been running well. However, the capacity of seed producers to produce extension seeds still needs to be improved, especially in terms of utilizing new superior varieties and implementing standard operational procedures. Likewise at the farmer level, it is still necessary to encourage the use of seeds from new high yielding varieties to overcome genetic degradation due to the use of old varieties that have been planted repeatedly for a long time.

Regulation dimension: Several government regulations and policies related to plant seeds have been implemented, such as cultivation laws [12], certification regulations, tariff regulations, seed producer business licenses, and seed subsidies or assistance policies. So far, the implementation of this regulation has mostly been applied to seed procurement activities by government agencies. Formally, the procurement of sugarcane seeds to meet the needs of government programs, both for intensification (unloading ratoon, maintaining for ratoon) and extensification through an auction process involving seed producing companies. This mechanism requires a certified seed and seed producer business license. So there is the role of the center for certification and quality control of seeds. The provision of sugarcane seeds to meet the needs of sugarcane plantations on land owned by state-owned enterprises that manage sugar factories is carried out by a separate unit that is assigned a special task of conducting research and development of sugarcane seeds. The unit usually also fosters seed breeders and encourages them to produce seeds to meet the needs of sugarcane farmers in the area around the sugar factory. Apart from these two channels, there is also an informal channel, where farmers meet their seed needs from their own production gardens or obtain seeds from other farmers, even if the number of farmers like this is quite significant. This condition is in line with the conclusion that formal, informal and integrated combinations seed chanel are actually working to reach smallholders with the seed products and information that such farmers want and need [13]. In an effort to increase the availability of certified seeds, the government is running a seed assistance program. This program is expected to accelerate the socialization of varieties, increase the use of certified seeds, and achieve self-sufficiency in seeds [14]. However, the program does not include sugarcane seeds.

Infrastructure dimension: The implementation of the sugarcane seed business process in government agencies and state or private companies has been supported by technical infrastructure such as tissue culture laboratories, parent plant collections, experimental gardens and seed gardens. Tissue culture laboratories as the main facility for the initial process of creation and propagation of non-conventional sugarcane seeds are available in West Java (Bogor and Jatitujuh) and East Java (Malang, Pasuruan and Kediri).

3.1.2. Technological innovation aspect. The description of the technological innovation aspects can be described as follows.
Technology dimension: Research based technologies related to sugarcane seed consist of superior variety as material of seed creation/propagation, tissue culture propagation, agricultural machinery for the budchip/budset, cultivation, packaging, and transportation are readily available and sufficiently understood by stakeholders. One of the innovative technologies in sugarcane seeding is seed propagation by tissue culture. The advantages of this technology are improvements in multiplication and flexibility in time, especially at the stage of creation and propagation in tissue culture laboratories, so that it does not depend on the growing season and climatic conditions.

Logistic dimension: Technology logistics, especially seeds and several input factors, are relatively available but have not provided optimal benefits for farmers because their availability is deemed not always in accordance with farmers' preferences. Other supporting logistics, agricultural machine tools are relatively limited and technical guides for cultivation are available on publications and online sites.

Dissemination dimension: Technology dissemination has been carried out through several channels. Scientific and popular publications are published regularly. Partnerships between government agencies and the agricultural industry towards technology licensing have been initiated. Services for technology assistance, displays, and training are prepared to meet user demands. Figure 1 shows the locus of seed production centers with tissue culture technology and its distribution to eleven provinces as sugarcane development areas in Indonesia.

Figure 1. Map of seed production centers with tissue culture technology and its distribution to eleven provinces as sugarcane development areas in Indonesia

3.2. Sugarcane seed system performance assessment
Based on a multidimensional assessment using six dimensions, the aggregate performance of the Indonesian sugarcane seed system reaches a score of 65.89 with a score for each dimension ranging from 54.53 to 73.13 (Figure 2).

The performance appraisal can be further elaborated from an institutional and technological innovation perspective. From an institutional perspective, the performance of Indonesia's sugarcane seed system is fairly good, with an index of 67.58. The highest index was 73.13 for the organizational dimension, while the lowest index was 60.01 for the regulatory dimension. Likewise, from the perspective of technological innovation, the performance of Indonesia's sugarcane seed system is also fairly good, with an index of 64.21. The highest index was 72.28 for the technology dimension itself, while the lowest index was 54.53 for the dissemination dimension. Graphically, the performance of the
sugarcane seed system from the perspective of supporting institutional and technological innovation is presented in Figure 3 and 4.

Based on the analysis of the effect of attributes on the root mean square of dimensional performance in two assessment perspectives, it can be identified the leverage factor to improve the performance of the sugarcane seed system from both perspectives. From an institutional perspective, it is quite clear that the tariff regulation factor in the regulatory dimension and the laboratory support factor in the infrastructure dimension are the dominant leverage (Figure 5).

In the perspective of technological innovation, the dominant lever are technology licensing partnerships and training for seed producers, in the dissemination dimension (Figure 6). Masalization of technology through licensing has the potential to reduce the cost of dissemination and is expected to accelerate the adoption of seed technology at the farmer level. Lessons from one study in a developing country such as Uganda show that the extension activities significantly increase farmers’ use of...
improved cultivation methods that are relatively costless, but there is minimal impact on adoption of relatively expensive inputs including high yielding variety seeds [15].

4. Conclusion
Indonesian sugarcane seed system performance was categorized as "fairly good" from the perspective of institutional and technological innovation support with a range of performance indexes in each dimension 54.23 - 73.13 and an average index of 65.89. The highest performance is achieved in the organizational dimension of institutional perspective, while the lowest is in the dissemination dimension of technological perspective. The lever for improving the performance of seed institutions is the regulation of tariffs and the carrying capacity of tissue culture laboratory infrastructure, while
technology licensing partnerships and training for seed producers are levers from the perspective of supporting technological innovation.

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