Factors affecting sustainability of agricultural machinery assistance program

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Abstract. One of the Ministry of Agriculture's efforts to support agricultural development is by providing equipment and machinery assistance. There are many multi-dimensional problems, both technical, socio-cultural, economic, and environmental. This study aimed to analyze the sustainability status of the agricultural equipment and machinery assistance program. This research was conducted in 2020 with the object of the two-wheeled tractor and four-wheeled tractor assistance program in 2018-2019. Research location covers six districts, the selection of site determined by the provinces considered the most successful and the least successful in realizing activities. The sustainability status of the activity program was analyzed using Multi-dimensional Scale Analysis. The collected data and information through structured questionnaires from 47 institutional respondents and literature studies, both printed and electronic. The results showed that agricultural equipment and machinery assistance program (TR2 and TR4) was less sustainable. The comparison of the MDS value and Monte Carlo's analysis was 49.93, with an R² value of 89%. The S-Stress statistical test is still relatively high, namely 0.30 (above 0.25), which means improvements and refinement needs from the implementation aspect. Improvements from various elements are divides into two groups. First, leverage factors that encourage the sustainability and success of the implementation of activities, and the second is the improvement of the performance of TR2 and TR4 beneficiary groups. Policy recommendations for implementing future program activities are a strict selection of potential beneficiaries and improvements in the management aspects of beneficiaries at the farmer level by providing guidance.

1. Introduction

Fulfilling food needs through increased production is very important in agricultural development. However, scarcity and limited labor, inefficient production, high yield losses, low product quality are some of the problems that enter into the fulfillment of food efforts. Therefore, one of the Ministry of Agriculture's efforts to support agricultural development is equipment and machinery assistance. These efforts are explicitly located because the people in the field are still lacking, and demand will increase in the future [1].

The use of agricultural machinery aims to increase cultivated area and cropping intensity. Agricultural machinery also plays a role in increasing agricultural productivity and efficiency, suppressing yield loss, increasing agricultural product quality, and expanding employment opportunities in rural areas through integrated agribusiness, ultimately stimulating economic activity in rural areas [2]. Conceptually, agricultural equipment and machinery are a technological change and appear to
substitute human or animal labor in managing agricultural land, marked by increased agricultural production and business [3–10].

The development of agricultural mechanization is directed at the use of agricultural equipment and machinery in the field. There are many multi-dimensional problems, both technical, socio-cultural, economic, and environmental. The development and application of agricultural equipment and machinery are affected according to the location, personal skilled operational, workshop facilities and spare parts availability, access to finance, and government policies to avoid negative impacts of agricultural mechanization [11–13].

Directorate General of Agriculture Infrastructure and Facilities distributed 9,926 units of two-wheeled tractors (TR2) in 2019, decreasing 66.55% compared to the previous year. This assistance is a channel through the central scheme and regional assistance tasks. The four-wheel tractor (TR4) also distributed in as many as 954 units, a decrease of 68.65% compared to 2018. For the 2016-2019 period, West Java received 6,304 units of TR2 assistance (8.83%), Banten 1,610 units (2.26%) and Central Java 9,357 units (13.11%). Meanwhile, West Java TR4 assistance received 363 units (4.01%), Banten 148 units (1.63%) and Central Java 629 (6.95%). In addition to the physical distribution of assistance, the Directorate General of Agriculture Infrastructure and Facilities has also encouraged professional machinery for business institutions, namely establishing the agricultural equipment and machinery service business (UPJA) since 1997. However, the utilization and exploitation of agricultural equipment and machinery were not optimal, and UPJA's development was not as expected. Approximately 84% of UPJA that exist today are still in the beginner class, and only 3.51% classified as a professional class [14].

Based on the description above, sustainable agricultural development requires appropriate policy support. Furthermore, the implementation of an Agriculture equipment and machinery assistance program for farmers is carried every year. Therefore, evaluation of the program is needed, and the evaluation results can be used as system improvement and future implementation so that program activities can run effectively. The purposes of this study are (1) determine the sustainability of the agricultural machinery assistance program and (2) identify leveraging factors of the performance of the agricultural machinery assistance program, especially TR2 and TR4.

2. Materials and methods
This research was conducted in 2020 to assess the agriculture equipment and machinery assistance program sustainability for 2018-2019. The objects analyzed were TR2 and TR4 because these types of machinery were the most needed and distributed. The assessment of sustainability status essentially covers the national procurement of agriculture equipment and machinery. Selected data, information, and the units analyzed in locations that were considered representative, specifically in three Provinces (Banten, West Java, and Central Java) covering six districts (Pandeglang, Serang, Tegal, Pemalang, Indramayu and Subang) in 47 groups of assistance recipient respondents. It consists of 26 farmer groups receiving assistance, eight farmer groups non-assistance, and 13 respondents from groups of both central and regional agencies.

The first objective, assessing the sustainability status of the program's activities, is analyzed using the Multi-dimensional Scale (MDS). Dimensions analyzed include the seven dimensions, context, input, process, output, outcome, effect, and impact, which compiled and derived from policy documents related to the implementation of relief agriculture equipment and machinery activity. The second objective, is the identification of performance lever factors, is analyzed by using leverage analysis which is the unitary output of the MDS analysis.

The algorithm used in the MDS analysis is ALSCAL MDS [15,16]. The ordination technique is carried out on a "bad" and "good" scale from each respondent (analysis unit) with a group of attributes (Figure 1) then transformed into multidimensional statistics with the formula [17].

\[ \zeta(S) = D^2 + \varepsilon \]
where $\zeta$ describe a monotonic transformation, $\varepsilon$ is the residual (error) matrix and $D$ is the Euclidian matrix.

MDS produces an output in the form of a perceptual mapping of the relationship between several objects in a multi-dimensional space based on the respondent's assessment of the similarity or proximity of the object analyzed. MDS has been widely used in various fields of study in evaluating the process of activities to policies. The MDS output provides an overview and alternative approaches needed by policymakers and as input to improve a better system in the future. Several studies used MDS analysis such as sustainability evaluation of fisheries resource management [18], food systems evaluation based on food availability, especially rice [19], and sustainability evaluation by mapping the ecological, economic, social, institutional, and policy dimensions in canal management irrigation system [20].

3. Results and Discussion

3.1. Sustainability status analysis of the agriculture equipment and machinery assistance program

MDS analysis shows the coefficient of determination ($R^2$) and the value of the S-Stress. This value is needed to determine whether the output of the analysis is good enough and represents the mix of variables used. The value of $R^2$ is said well if bigger and close 1, while the S-stress is said well if less or close 0. MDS is equipped with a Monte Carlo simulation analysis (MC) to determine the accuracy of the result. MC is an analysis to measure sensitivity. The difference between MDS and MC will show the confidence interval of the analysis output results. If the difference between MDS and MC is <1, then the level of confidence in the sustainability status obtained is above 90% [17,21,22].

The results of the MDS analysis shows in Table 1. The value of the sustainability status of the dimensions analyzed has a total average of 49.93 (<50); in other words, the sustainability status of the TR2 and TR4 assistance activities program is in the less sustainable category (refer to [18]). Three of the seven dimensions (context, process, and output) have a value of sustainability status above 50, while the other four dimensions (input, outcome, effect, and impact) are below 50 or in the less sustainable category. The $R^2$ value ranges 0.88–0.92, near to 1, and the S-stress value is in 0.25–0.35, relatively small near zero (0), and the difference between MDS and MC is 0.00–0.33 or below 1.

Table 1. Sustainability status value of the agriculture equipment and machinery assistance program (TR2 and TR4) in 2018-2019.

| Dimensions       | $R^2$ value | S-Stress score | Multi Dimensions Scaling (MDS) | Monte Carlo (MC) | Difference MDS dan MC |
|------------------|-------------|----------------|--------------------------------|-----------------|----------------------|
| Context          | 0.92        | 0.26           | 59.08                         | 58.94           | 0.14                 |
| Input            | 0.88        | 0.29           | 47.08                         | 46.75           | 0.33                 |
| Process          | 0.89        | 0.25           | 51.82                         | 52.02           | 0.20                 |
| Output           | 0.90        | 0.30           | 53.21                         | 53.20           | 0.00                 |
| Outcome          | 0.88        | 0.35           | 49.46                         | 49.35           | 0.11                 |
| Effect           | 0.88        | 0.32           | 42.32                         | 42.52           | 0.20                 |
| Impact           | 0.88        | 0.35           | 46.53                         | 46.75           | 0.23                 |
| Total average    | 0.89        | 0.30           | 49.93                         | 49.93           | 0.01                 |

Context dimensions for assessing sustainability status based on planning policy documents related to the agricultural equipment and machinery assistance program. Managing the program according to the responsibilities divides into three regions, (1) managing the central level in this case is the Director-General of Agricultural Infrastructure and Facilities (2) managing at the provincial level, and (3) managing at the district/city level. Managing program at the provincial and district/city levels is the agency that handles the agriculture sector; the Korem/Kodim. Gradually, the objectives of the program management are (1) procuring and distributing agricultural equipment and machinery at each level (2) optimizing the use of agricultural equipment and machinery (3) increasing the number of UPJA, and (4) mobilizing and optimizing planting brigades. The objective of optimizing the use and improvement of
UPJA is a bottom-up reporting mechanism. Based on the description of the tasks and goals of the activity program implementation, it can see that the achievement of operational targets is placed on the management at the district/city level.

By following the policy document on the input dimension, the assessment of sustainability status emphasizes the implementing organization in terms of human resources, infrastructure, budget, and timing of activities. Evaluation of data and information in the field, the availability and quality of human resources in the regions is insufficient, the availability of infrastructure is also lacking, and the regional budgets are inadequate to support activities. However, the time available to carry out activities is more than sufficient.

The dimensioning process includes assessing the sustainability in socialization activities and evaluating the suitability of program implementation by following per under policy documents. In implementing activities, it seems that the socialization was not successful in providing understanding to the regions and beneficiaries to achieve the objectives of the activities. The availability and quality of human resources in implementing activities also lack. Their use to accomplish the goal is also lacking, and assistance ultimately leads to weak monitoring and evaluation implementation.

The indicator for assessing the sustainability status on the output dimension is the receipt of physical assistance regarding quantity, quality, and suitability of its implementation. Based on the assessment and information in the field, the assistance can be received well by the beneficiaries with an average/medium category rating. Because there is still a lot of machinery that stays at the district/city offices. Based on extracting information in the field, the reasons are quite diverse. The unit is not suitable at the location, the unit damage due to usage, and the availability of spare parts is lacking.

Furthermore, on the outcome dimension which leads to the use of the machinery that has handed over, the quantity is quite good, while the quality is lacking, due to (1) the types of machinery are easily damaged and (2) the difficulty of farmers in finding spare parts. Farmers' preferences are shows by the brands that are in great demand, such as Quick, Yanmar and Kubota. Ratings on the Kubota brand tend to be dominant because the wheels and engines consider as more substantial, durable, and easy to maintain due to the ease of obtaining spare parts.

Assessment of sustainability status on the impact dimension results from the output, outcome, and effect dimensions. An increase productivity does not automatically follow the existence of the equipment and machinery assistance program (with limitation quality). The impact that can be seen is the shorter time of farmers in doing tillage, with a notation the water is available. An interesting finding in the field is, it does not reduce the rental price between before and after the assistance. Agriculture equipment and machinery rental prices are relatively the same.

3.2. Performance leverage factors of the agricultural equipment and machinery assistance program

The results of the leverage analysis from the MDS considered the attributes to have a strong influence on improving the final sustainability status of the agricultural equipment and machinery assistance program. The attribute with a high value indicates a leverage attribute, and improvement is needed to increase its role in the future. The complete attribute assessment for each dimension shows in Figure 1.

The context dimension, analyzed five attributes in implementing program activities, three attributes need to be improved, the organization's availability to implement, the perfection of planning, and the placement of goals as priorities. Based on the information, to increase performance in the context dimension are not only for the managing actors (central and regional) also for recipient institutions, the farmer group/Gapoktan/UPJA/farmer corporation/joint business group (KUB)/farmers society/community groups that support agricultural development.

Three of the five input variables for implementing activities require improvement to increase their performance status, the availability of human resources, the availability of budget, and the adequacy or availability of time in implementing the activity program. It is in line with assessing the context dimension, which emphasizes every actor who plays a role in program activities. Performance improvements in the input dimension also emphasize more attention to the management of the
agriculture equipment and machinery brigade and the planting brigade to be more able to improve the performance of TR2 and TR4 assistance in the regions.

![Leverage of attribute](image)

**Figure 1.** Leverage factors from the attribute assessment of each dimension.

In the process performance, five out of ten activity implementation variables require improvement to increase their performance status. Which is the level of socialization success, the level of objectives process conformity, the level of procedures suitability, the level of assistance implementation, and the level of monitoring and evaluation implementation. Performance in process dimension shows that TR2 and TR4 assistance completed the delivery and distribution stage until the UPJA recipient of assistance forms or joins previously UPJA formed. It has a good organizational structure, administration and
management, human resources, finance, and business sustainability. The assistance received is expected to be a trigger to be able to develop his business and be able to make new investments. Consequences of improving the process dimension are needed for every actor involved, considering that the technical guidelines require optimal utilization by program assistance recipients. Improvements in the performance of the process dimension impact the input dimensions and the performance achievement of the output, outcome, effect, and impact dimensions.

In the performance of the output dimension, improving the quality and quantity of output is a top priority. However, attention to the improvement of the input dimension and the process dimension is an inseparable part. The level of output qualitative achievement has higher leverage than the quantitative level. Types and brands of TR2 and TR4 according to specific locations, beneficiary preferences, the availability of supporting facilities such as spare parts and workshops, and after-sales service from producers and distributors of TR2 and TR4 need to be concerned.

In contrast to the performance on the output dimension, the outcome dimension quantitatively has the highest leverage value, followed by the qualitative outcome and the linkage level of input, process, output, and outcome. It can improve the outcome dimensions qualitatively through guidance and assistance to each actor, the farmers group/gapoktan/UPJA/farmer corporations/joint business groups (KUB)/farmers society/community groups, including agriculture equipment and machinery and cropping brigade.

The highest leverage value on the performance effect or benefit from the assistance of TR2 and TR4 is the level of quantitative benefits achievement and the linkage level of inputs, processes, outputs, outcomes, and benefits. Optimization and improvement efforts to achieve the benefits of TR2 and TR4 assistance and the linkages and relationships with other dimensions will improve assistance performance by following indicators as stated in the technical guidelines.

Coaching is needed from planning to achieving the benefits will obtain from the assistance activity program. At the implementing level, the division of tasks between echelon I units and related institutions in the regions is important to improve their role in achieving the benefits of this assistance program. Coordination and synergies are needed in the future between other echelons I units within the Ministry of Agriculture and agricultural agencies in the regions.

In contrast to the leverage output, outcome, and benefit, the highest leverage value on the performance impact of TR2 and TR4 assistance is the level of linkage of inputs, processes, outputs, outcomes, benefits with impact, then the level of achievement of quantitative benefits.

In addition to coordination and synergy among program managers, assistance activities require transparent cooperation and division of tasks between echelon I units and related institutions in the regions. Increasing the manager's role is needed in achieving performance in the dimensions of benefits and impacts, along with this coordination is also required with beneficiaries. The transformation can achieve by the beneficiary groups into UPJA institutions as stated in the technical guidelines.

4. Conclusions

In general, the implementation of the agricultural equipment and machinery assistance program (TR2 and TR4) was carried out quite well. Evaluating the sustainability status assessment using MDS with the existing variables compilation adequately represents the actual situation. Indicators in the model both R² and S-stress and the difference in the value of Monte Carlo to MDS met the requirements statistically. The S-stress value is relatively high, meaning improvements are still needed from various aspects in implementing program activities to improve sustainability and success. Based on the compiled dimensions assessment, the agriculture equipment and machinery assistance program (TR2 and TR4) are less sustainable. Improvements from various aspects can be grouped into two. The first is the leverage factors per each dimension that will encourage the sustainability and success of the activity implementation. The second is the improvement of the performance of the TR2 and TR4 beneficiary groups.

As for the analysis and conclusion of the assessment evaluation, an alternative policy that can be taken is a strict selection of prospective recipients of assistance required by taking into account the
availability of budgets for coaching, mentoring, and monitoring of each actor involved. Improvements in leveraging factors also require guidance and assistance from the start of the program. Socialization of activity program regulations is still needed and carrying out more actively. The development of UPJA requires guidance and assistance in its management. The provision of assistance has not fully met the site suitability requirements so that it requires planning evaluation, data validation, and a mechanism for transferring unused machinery is needed. Further studies are needed on the effect of assistance on the expansion of plant area, harvest area, productivity, and production, and measuring the density levels of TR2 and TR4 to increase the benefits, impacts, effectiveness, and efficiency of assistance.

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References

[1] Kendarto D 2016 Analisis perhitungan kebutuhan optimum traktor roda di Kabupaten Bandung Teknotan 10 68–75
[2] Manwan I and Ananto 1994 Strategi Penelitian dan Pengembangan Mekanisasi Pertanian Tanaman Pangan Prospek Mekanisasi Pertanian Tanaman Pangan ed Ananto E E (Bogor: Puslitbangtan. Badan Litbang Pertanian) pp 1-9
[3] Haruna M and Junior A 2013 Mechanization practice: a tool for agricultural development in Nigeria: a case study of Ifelodun Local Government area of Kwara State. Int. J. Basic Appl. Sci. Manta Aduba 8 98–106
[4] Umar S 2013 Pengelolaan dan pengembangan alsintan untuk mendukung usahatani padi di lahan pasang surut J. Teknol. Pertan. 8 37–48
[5] Akinbamowo R 2013 A review of government policy on agricultural mechanization in Nigeria. J. Agric. Ext. Rural Dev. 5 146–53
[6] Emami M, Almassi M, Bakhoda H and Kalantari I 2018 Agricultural mechanization, a key to food security in developing countries: strategy formulating for Iran. Agric. Food Secur. 7 1–12
[7] Mrema G, Soni P and Rolle R 2014 A Regional Strategy for Sustainable Agricultural Mechanisation: Sustainable Mechanization Across Agri-Food Chains in Asia and The Pacific Region (Food and Agriculture Organization of the United Nation.)
[8] Deykota R, Pant L, Gartaula H, Patel K, Gauchan D, Hambly-Odame H, Thapa B and Raizada M 2020 Responsible agricultural mechanization innovation for the sustainable development of Nepal’s hillside farming system Sustain. 12 1–24
[9] Onwude D, Chen G, Hashim N, Esdaile J, Gomes C, Khaled A, Alonge A and Ikrang E 2018 Mechanization of Agricultural Production in Developing Countries. In Advances in Agricultural Machinery and Technologies. (CRC Press)
[10] Food and Agricultural Organization 2018 Sustainable Agricultural Mechanization: A Framework for Africa (Food and Agriculture Organization of The United Nations and The African Union Commission Addis Ababa)
[11] Diao X, Cossar F, Houssou N and Kolavalli S 2014 Mechanization in Ghana: emerging demand, and the search for alternative supply models Food Policy 48 168–81
[12] Daum T and Birner R 2020 Agricultural mechanization in Africa: myths, realities and an emerging research agenda. Glob. Food Sec. 26 1–10
[13] Handaka and Prabowo A 2014 Kebijakan antisipatif pengembangan mekanisasi pertanian J. Anal. Kebijak. Pertan. 11 27–44
[14] Direktorat Jenderal Prasarana dan Sarana Pertanian 2020 Statistik 2015-2019 Prasarana dan Sarana Pertanian. (Jakarta: Direktorat Jenderal Prasarana dan Sarana Pertanian)
[15] Hollins M, Bensmaïa S, Karlof K and Young F 2000 Individual differences in perceptual space for tactile textures: evidence from multidimensional scaling *Perception & Psychophysics* 62 1534-44
[16] Schiffman S, Reynolds M and Young F 1981 *Introduction to Multidimensional Scaling: Theory, Methods and Applications*. (Academic Press)
[17] Kavanagh P and Pitcher T 2004 *Implementing Microsoft Excel Software for Rapfish: A Technique for The Rapid Appraisal of Fisheries Status* (Vancouver: Fisheries Centre Research)
[18] Fauzi A and Anna S 2005 *Pemodelan Sumber Daya Perikanan dan Kelautan Untuk Analisis Kebijakan* (Jakarta: Gramedia)
[19] Nurmalina R 2008 Analisis indeks dan status keberlanjutan sistem ketersediaan beras di beberapa wilayah Indonesia. *J. Agro Ekon*. 26 47–79
[20] Azis M, Hidayat A and Ismail A. 2020. Penilaian kerugian ekonomi usahatani padi sawah dan status keberlanjutan pengelolaan saluran irigasi sekunder Vanderwijck di Yogyakarta. *J. Anal. Kebijak. Pertan.* 18 1–24
[21] Pitcher T, Lam M, Ainsworth C, Martindale A, Nakamura K, Perry R and Ward T 2013 Improvement to RAPFISH: a rapid evaluation technique for fisheries integrating ecological and human dimensions *J. Fish Biol*. 83 865–89
[22] Alder J, Ferriss B, Pitcher T, Preikshot D and Kaschner K 2000 How good is good?: a rapid appraisal technique for evaluation of the sustainability status of fisheries of the north Atlantic. *Sea Around us Methodol. Rev.* 136–82