AgriHealth: Journal of Agri-food, Nutrition and Public Health. 4(1), 70-80, 2023
URL: https://jurnal.uns.ac.id/agrihealth/article/view/70379
DOI: http://dx.doi.org/10.20961/agrihealth.v4i1.70379

AgriHealth Journal of Agri-food, Nutrition and Public Health
ISSN 2722-0656 (Print) 2722-0648 (Online)

The Strategy of Soybean Development on Dryland Agroecosystem in Gunungkidul Regency, D.I. Yogyakarta, Indonesia

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Received: January 13, 2023; **Accepted**: March 15, 2023

Abstract

Soybean is a highly nutritious and strategic food. The harvested area and production of soybeans tend to decrease, not sufficient for national needs, which must be met through imports. Breakthroughs are needed to develop soybean, with specific strategies to adapt to particular conditions, including in Gunungkidul Regency. This study aimed to reveal the soybean development strategies in the dryland agroecosystem in Gunungkidul Regency. Survey and interview methods were used in this research, supported by secondary data analysis and data from the previous year's research. The correlation analysis was used to determine the decrease in harvested area. Other data were analyzed descriptively. The results showed a significant decline in soybean harvested area between 2009 to 2020. The soybean development strategy is area-based, from upstream to downstream, involving both main soybean products and by-products. Soybean planting was carried out in the first, second and third growing seasons, using site-specific soybean cultivation technology, providing seeds through the Jabalsim System supported by irrigation. Policies are needed within the organization's scope, rules, guidance and protection. The final results of this research are embodied in the form of an area-based soybean development diagram in Gunungkidul Regency, which can be used as a development reference.

Keywords: drainage; economic profit; irrigation; sustainable agroecosystem; upstream to downstream

INTRODUCTION

The soybean is the third most significant crop after rice and corn. The protein content is high in soy. The food business needs fresh soybeans and the feed industry requires soybean meals. Soybean is a source of vegetable protein, is cheaper than animal protein and plays a role in improving people's nutrition. Soybean is safe for health (Haryanto and Swastika, 2013), contains valuable substances, such as proteins, fats and carbohydrates (Yudiono, 2020), contain antioxidant compounds and also contains alpha-linolenic acid, isoflavones, omega-6 fatty acids, genistein and daidzein. Dry soybeans contain 19% oil, 34% protein, 34% carbohydrates (17% dietary fiber) and 5% minerals and vitamins. Soybean is a source of iron, calcium, phosphorus, zinc, magnesium, thiamine, riboflavin, niacin and folic acid (Kanchana et al., 2006).

The planting area and production of the national soybean crops tend to decrease. Soybean production in 2015 was 963.18 thousand ton, 2016 of 859.65 thousand ton, and in 2017 of 538.73 thousand ton, continued to decline. Production in 2018 was 650.00 thousand ton, up 20.65%, but decreased by 34.74% or 424.19 thousand ton in 2018. In 2019 production fell

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Cite this as: Suswatiningsih, T. E., & Anshori, A. (2023). The Strategy of Soybean Development on Dryland Agroecosystem in Gunungkidul Regency, D.I. Yogyakarta, Indonesia. *AgriHealth: Journal of Agri-food, Nutrition and Public Health*, *4*(1), 70-80. doi: http://dx.doi.org/10.20961/agrihealth.v4i1.70379

34.74% to 424.19 thousand ton. National soybean production fell 15.54% per year during 2015 to 2019. The decline in production was due to land conversion and land use competition. For five years, this condition reduced the soybean harvested area by an average of 11.97% per year. The decline in the national soybean harvested area was significant in 2015, covering 614.10 thousand ha. In 2019 it was only 285.27 thousand ha (Center for Agricultural Data and Information System, 2020). The decrease in soybean harvested area also occurred in Gunungkidul Regency, the soybean production center for D.I. Yogyakarta (Statistics of Gunungkidul Regency, 2010-2021).

The area of rice fields in Gunungkidul Regency is 7,858 ha, consisting of 2,189 ha of irrigated rice fields and 5,669 ha of non-irrigated fields. The dryland area is 64,383 ha. Rice is the main crop in the rice fields of Gunungkidul Regency. Dryland agricultural commodities are more diverse, such as rice, corn, soybean and peanut (Statistics of Gunungkidul Regency, 2021). The strategy of soybean development can be directed at dryland because it is a broader and more suitable agroecosystem for soybean plants. Anshori et al. (2019a) claimed that the eucalyptus forest area might sustain soybean cultivation and serve as a source of soybean seed. Soybean is farmed among eucalyptus tree stands (Alam et al., 2019). During harvest, eucalyptus plants are clipped so as not to damage the soybean plant. Soybean can be sown whenever there is sufficient water.

Dryland management is limited by water availability, recurring drought events (Stewart and Peterson, 2014) and decreasing soil fertility (Viandari and Anshori, 2021). Lack of water will reduce crop production (Adunya and Benti, 2020). Water shortages can be met by irrigation from rainwater harvesting (Anshori et al., 2021a) or groundwater sources (Anshori et al., 2021b). Dryland has excellent potential for development (Indrawan et al., 2020) and proper management will support agricultural progress (Viandari et al., 2022).

Dryland dominates the area of agricultural land in Gunungkidul Regency, with the main cropping pattern being rice/palawija/fallow (Anshori et al., 2023). Most drylands rely on rainfall as a source of water. Most farmers usually plant soybeans in the second growing season (second rainy season) and third growing season (dry season). The soybean harvested area tends to decrease. This study aimed to reveal the strategy of soybean development in the dryland agroecosystem in Gunungkidul Regency, involving aspects from upstream to downstream. The research results are expected to be a reference for soybean development in the Gunungkidul Regency so that soybean production increases and contributes significantly to national soybean production and is a model for soybean development from upstream to downstream.

MATERIALS AND METHOD

The research was conducted in April to October 2022 in the area of dryland soybeans in Gunungkidul Regency of D.I. Yogyakarta Province of Indonesia. Survey and interview methods were used in this research, supported by secondary data analysis and data from previous research. Several sources, such as data from the Statistics of Gunungkidul Regency, peer-reviewed publications and other investing data, were compiled to complete this scientific article. Interviews were conducted with 3 farmers at soybean centers or who had been at the soybean center in Gunungkidul Regency as material for exploring farmers' responses to production, farmer interests, support, constraints and farming analysis in developing soybean plants. Profits are calculated based on Hendayana (2016). Data on soybean crop water requirements support farmers' cropping patterns. The data were analyzed descriptively, except for data on the harvested area, which were analyzed by correlation. The results of data analysis, interviews and related research are used to understand soybean development on dryland in Gunungkidul Regency of D.I. Yogyakarta Province.

RESULTS AND DISCUSSION

Soybean harvested area in Gunungkidul Regency

The harvested soybean area in Gunungkidul Regency decreased significantly in 2009 to 2020 (Figure 1), with an R^2 of 0.9156. In 2009 to 2012 the soybean harvested area of Gunungkidul Regency was more than 20,000 ha. After that, it continued to decrease significantly, reaching the range of 3,000 to 5,000 ha.

Soybean prices and competition with corn crops can cause a decrease in soybean harvested

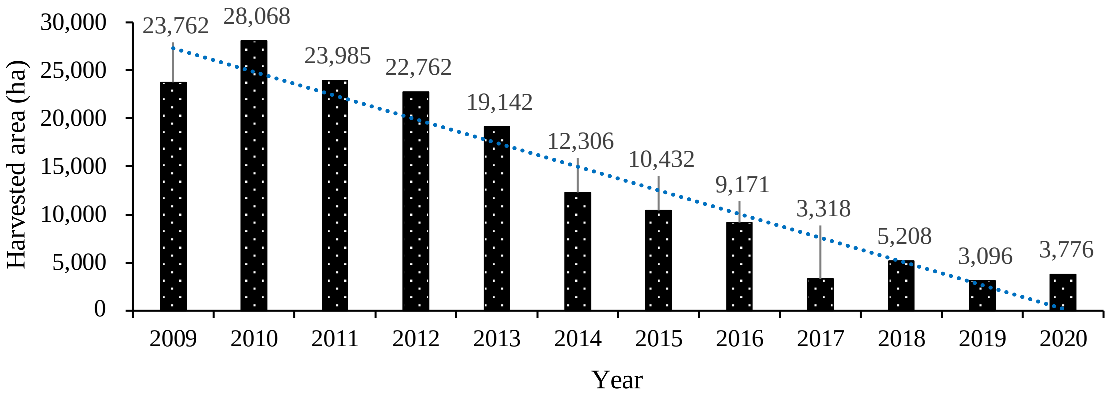


Figure 1. Soybean harvested area in Gunungkidul Regency 2009 to 2020
Source: Statistics of Gunungkidul Regency 2010 to 2021

area. Soybean competitiveness is weaker (Haryanto and Swastika, 2013). This condition can occur in Gunungkidul Regency. The profit from planting soybeans is lower, so farmers prefer other commodities such as rice, corn, groundnut or vegetables. The availability of soybean seed is more complex than other commodities, further weakening the competitiveness of soybean.

Economics of soybean farming

Soybean farming profits are calculated based on the difference between farm income and cost. Revenue is obtained from the sale of soybeans. Farming costs include inputs for seed and fertilizer, labor for planting, weeding, fertilizing, harvesting and irrigation (primarily for irrigation in the dry season). Irrigation is managed based on equipment and operator, with the fee amount adjusting to the land area. Irrigation of soybean plants does not use a labor system. Labor costs associated with planting, weeding, fertilizing and harvesting soybeans (Table 1).

Analysis of soybean farming shows that soybean cultivation in the second growing season during the second rainy season without irrigation and in the third growing season during the dry season with irrigation support still benefits farmers. The profit of soybean farming in the second growing season during the second rainy season provides higher profits of 4,905,000 IDR with a higher B/C of 0.37, compared to the dry season with profits of 4,124,000 IDR with a B/C 0.26 (Table 1). A positive B/C indicates that soybean farming is feasible and still profitable.

The strategy of soybean development in Gunungkidul Regency

Soybean development is carried out based on the area in Gunungkidul Regency. Setiyanto and Irawan (2015) state that areas are restricted based on unique characteristics, natural or non-natural, carried out in one plan, applied as area development. Area-based development carries out agricultural development. Management of land

Table 1. Economic analysis of soybean on dryland in Gunungkidul Regency

Component	Soybean crop	
	Without irrigation ‘Second rainy season’*	Irrigation ‘Dry season’**
	IDR ha^{-1}	
Materials	1,285,000	1,285,000
Labor	12,000,000	12,000,000
Irrigation	-	2,600,000
Total cost	13,285,000	15,885,000
Revenue	18,190,000	20,009,000
Profit	4,905,000	4,124,000
B/C	0.37	0.26

Source: *Primary data from farmer group of Gemah Ripah Logandeng Playen Gunungkidul; **Anshori and Suswatiningsih (2022) and water resources (Sutrisno and Heryani, 2015) and climate (Syahbuddin et al., 2015) is based on the ecoregion concept. The area concept will intersect with the ecoregion concept, including area-based soybean development. Soybean development in Gunungkidul Regency is carried out based on area development, on dryland, with rainwater as the primary water source. There is additional irrigation at certain places in climatic conditions with 5 to 6 wet months consecutively. The development of dryland soybeans in Gunungkidul Regency involves three growing seasons, the first rainy season, the second rainy season and the dry season. Based on the data obtained, in simple terms, to be easy to understand, the strategy for developing soybean in the dryland of Gunungkidul Regency was compiled and can be seen in Figure 2.

Several things need to be considered to develop soybeans in the dryland of Gunungkidul Regency. Soybean planting location and period, provision of soybean seeds, irrigation support, support for soybean cultivation technology packages, an increase in the added value of soybeans and policies will determine the success of soybean development. Increased added value is of particular concern, related to the added value of crops and by-products, both harvest by-products and the soybean processing industry.

Location and planting period of soybean

Soybean plants do not require special soil types, with good drainage and aeration. Aeration is essential for oxygen availability, while flooding soil causes soybean roots to be rotten. Soil acidity requirements are 5.8 to 7.0. Humus is needed to support soil fertility for soybeans. Soybeans are suitable at an altitude of fewer than 500 m. Soybean is classified as a short-day plant and does not flower if irradiation is more than 15 hours per day (Irwan, 2006). The water requirement for soybean plants is 350 to 450 mm and optimal production occurs at a monthly rainfall of 100 to 200 mm. Optimal soybean production is under

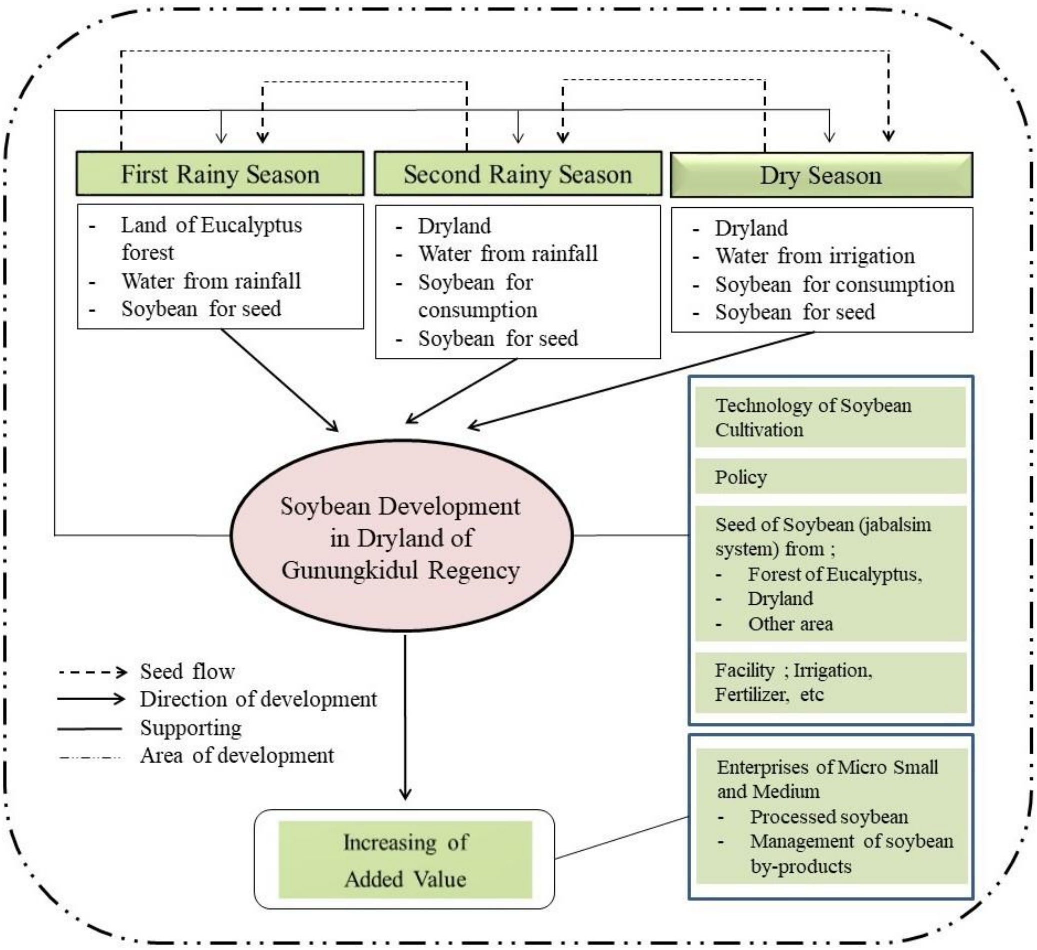


Figure 2. The diagram of the area-based soybean development in Gunungkidul Regency

Table 2. Water requirements of soybean in each growing period

Growing period	Plant age	Water requirements (mm per periods)
Early growth	0-15	53-62
Active vegetative	16-30	53-62
Flowering–pod filling	31-65	124-143
Seed ripening	66-85	70-83

Source: Aminah et al. (2002)

conditions of flat rain (Nazar et al., 2008). Fagi and Tangkuman stated that 300 to 350 mm of rainfall is sufficient for soybean plants (Aminah et al., 2002). The water needs of soybean plants in the growing period can be seen in Table 2.

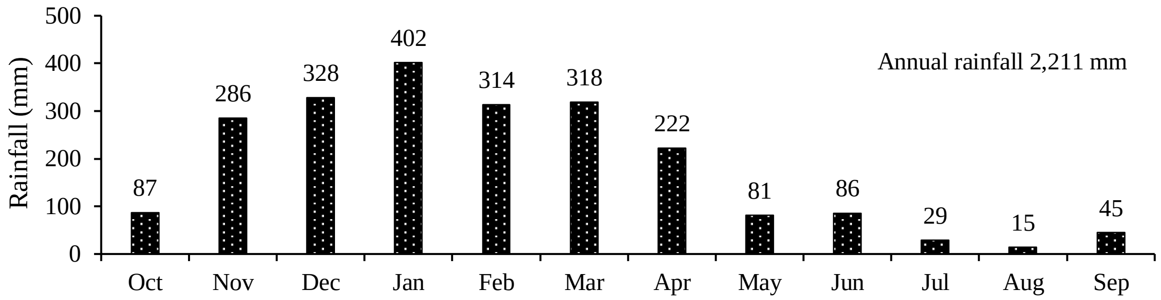
In the cropping pattern in Gunungkidul Regency, farmers plant soybeans during the dry season on rice fields and during the second rainy season on dryland. Farmers rely on water from rainfall. Beyond that, only a tiny portion of soybeans are grown by farmers. The cropping pattern of most farmers in Gunungkidul Regency can be seen in Figure 3. Farmers' cropping pattern is based on rainfall and crop water requirements. According to Srihartanto and Indradewa (2019) planting time plays a major role in determining the success of soybean cultivation.

Soybean development can be carried out according to this cropping pattern without considering other commodities such as rice and corn. Soybeans can be planted in the first, second and third growing seasons, developing cropping patterns according to agroclimatic conditions (Mujiyo et al., 2020). However, soybean development can be carried out on dryland during the dry season with additional irrigation water from irrigation of deep, medium or shallow wells and river dam irrigation. Apart from the water factor, according to Maro'ah et al. (2021) soil fertility factors must be a concern. Soil fertility can be maintained or increased by applying organic fertilizer ameliorant at the dose of 2 to 4 ton ha^{-1} (Anshori et al., 2021c).

Provision of soybean seeds

Seed is an essential component in soybean production. Quality seeds will support good plant growth and high production. The provision of soybean seeds still encounters many obstacles in terms of time, quantity and location. Storage affects seed quality. Quality soybean seeds at a moisture content of 9% and a growth capacity of 95% can last 8 months and maintain a growth capacity of > 80% (Harnowo et al., 2013). The seed route system between field and season (Jabalsim) is an alternative to meet the demand for soybean seed in Gunungkidul Regency (Anshori et al., 2019a), with a reliable seed production system. Jabalsim does not need long storage, so its growth decreases. Farmers are more independent with Jabalsim. Government policy is necessary for Jabalsim (Hanafi et al., 2015).

Gunungkidul Regency has rice fields and dryland. Dryland soybeans are planted by most farmers in the second rainy season, while rice



Land	First rainy season	Second rainy season	Dry season
Rice Field	Rice	Rice, Corn, Soybean, Groundnut	Corn, Soybean, Groundnut, Fallow
Dryland	Rice of Dryland, Corn, Soybean, Groundnut, Cassava with Monoculture or Intercropping	Corn, Soybean, Groundnut, Cassava with Monoculture or Intercropping	Corn, Soybean, Groundnut, Cassava with Monoculture or Intercropping, or Fallow
Forest of Eucalyptus	Rice of Dryland, Corn, Soybean, Groundnut	Corn, Soybean, Groundnut	Fallow; just Eucalyptus

Figure 3. The cropping pattern of most farmers in Gunungkidul Regency

field soybeans are produced in the dry season. Most farmers plant rice during the first rainy season, while a few plant soybeans on dryland. The potential for seed delivery via Jabalsim across agroecosystems, rice field and dryland agroecosystems. Soybean seeds for rice fields are provided from dryland and otherwise. The provision of soybean seeds for Gunungkidul Regency can also be met from other regencies in the D.I. Yogyakarta Province, from Kulon Progo or Bantul Regency, from soybean on rice fields, which have different planting periods (Hanafi et al., 2015).

Supporting by irrigation

Irrigation is needed when rainwater is not sufficient for plant growth. Irrigation water sources in Gunungkidul Regency can be in the form of irrigation from deep or shallow wells, river dams or ditch dams or springs. Irrigation has a strategic function to meet water shortages and increase the cropping index (Anshori et al., 2020; Anshori et al., 2021a). It isn't easy to expand the planting area, so increasing the cropping index is an option (Anshori et al., 2020), including developing the soybean cropping index. Irrigation is needed especially when planting soybeans in the dry season.

Gunungkidul Regency Agriculture and Food Service in 2021 will build 2 units of ditch dams, 2 units of deep wells, 10 units of medium groundwater irrigation and 7 units of shallow groundwater irrigation (Gunungkidul Regency Agriculture and Food Service, 2022). The government has also built several units of irrigation facilities in previous years. Irrigation facilities are available. Utilization is carried out optimally. One of them is to support soybean cultivation.

Supporting by soybean cultivation technology package

The package of location-specific dryland soybean cultivation technology in Gunungkidul Regency serves to maintain and increase soybean productivity and production. Use of superior varieties, quality seeds, optimal populations, appropriate soil moisture, control of plant pests and fertilization according to dosage and maintaining sustainability, and timely soybean harvest (Anshori et al., 2012; Subandi et al., 2013; Suradal et al., 2017; Anshori et al., 2019b). Soybean cultivation technology is fully applied according to site conditions to maintain the quality and quantity of soybean yield (Adisarwanto et al., 2013). They prioritized natural management as a primary strategy for pest and disease control (Marwoto and Hardaningsih, 2013; Saleh and Hardaningsih, 2013) as a primary strategy. Also, integrated weed control, including technical mechanics, crop rotation, land preparation, and biological and chemical control, is the last alternative (Radjit and Purwaningrahayu, 2013).

The average soybean productivity in Gunungkidul Regency is 1.08 ton ha^{-1} (Statistics of Gunungkidul Regency, 2012), 1.16 ton ha^{-1} (Statistics of Gunungkidul Regency, 2013), 1.33 ton ha^{-1} (Statistics of Gunungkidul Regency, 2014) and 1.09 ton ha^{-1} (Statistics of Gunungkidul Regency, 2015). The application of dryland soybean cultivation technology can provide high soybean productivity. Integrated management of soybean plants in the dryland of Gunungkidul Regency on Grumusol produces average productivity of 2.26 ton ha^{-1}, on the Mediterranean of 2.09 ton ha^{-1} and Latosol 1.63 ton ha^{-1} (Anshori et al., 2019b). Using the Burangrang variety resulted in productivity of 1.96 ton ha^{-1} (Srihartanto and Anshori, 2014) and Argomulyo of 2.18 ton ha^{-1} (Anshori and Bekti, 2014). Soybean cultivation technology in the eucalyptus forest provides 2.26 ton ha^{-1} (Anshori et al., 2019a). The application of cultivation technology components is needed to increase the dryland soybean productivity in Gunungkidul Regency.

Increase in soybean added value

Increasing the added value of soybeans will improve the economic value of soybeans. Processed soybeans add to the diversification of soybean products, providing choices to producers according to consumer demand. By-products of soybean and processed soybean have great potential to increase economic value as a source of animal feed and organic fertilizer. On a larger scale, processed soybean by-products are used as an energy source are in the form of biogas. The role of micro small and medium enterprises in the soybean processed and by-product sector will increase soybeans' added value and competitiveness. According to Kusnandar et al. (2020) the role of micro small and medium enterprises is needed in product development.

Processed soybeans are developed by fermentation and non-fermentation. Well-known and traditionally fermented soybean products are tempeh, soy sauce and tauco. Soy yogurt (soyghurt) is a form of fermented soybeans produced by modern industry. Tofu and beancurd are examples of unfermented soy products. Today's soybean products include soy flour, protein isolates and concentrates, imitation meat, and soybean oil (Widowati, 2013). Soybean oil can be used to make biodiesel after further processing (Pratigto and Istiadi, 2019).

The by-products of the soybean harvest and the soybean processing industry are not seen as waste but as resources that require further handling. The by-products of the soybean processing industry, such as tempeh, tofu and soy sauce dregs, meet criteria as animal feed additives, so they have the potential as supplementary ingredients in livestock (Handayanta, 2003). By-products of the tofu industry have the potential for biogas development, with > 50% methane (Subekti, 2011; Sally et al., 2019). Soybean skin flour helps mix processed food ingredients like cookies (Amanda et al., 2019). Soybean skin flour is used in a mixture of biscuits and is beneficial for people with diabetes (Jariyah et al., 2022). Organic-based resources from soybean products can potentially increase soil productivity and health by producing organic fertilizers.

Policy

The creation of area-based commodities necessitates the development of an operational concept and framework. A product requires an approach and implementation as a basis for functional outcomes. Items must follow agroecosystem, economic, socio-cultural and technological conditions, supported by policies, so they have comparative and competitive competitiveness. The development area follows the requirements, so it has a high contribution to the economy and economic development in the long term (Setiyanto, 2015).

Along with the demand for ingredients with high protein, soybeans are one of the ingredients that meet these criteria, so they have bright prospects. Soybean production is currently insufficient, even to meet tofu and tempeh production needs. Soybean development must be oriented toward downstream industries, such as soybean oil, animal feed, biodiesel, and tofu and tempeh. The soybean development program is progressive, not only in terms of self-sufficient, but also as a fulfillment of growing industrial raw materials, which improves people's well-being (Bantacut, 2017).

CONCLUSIONS

Soybean development in Gunungkidul Regency has potential on dryland. Soybean development is carried out based on the area or region. The strategy of soybean development is determined by the choice of planting location and period, the provision of soybean seeds, irrigation, soybean cultivation technology packages, increasing the added value of soybeans and policy support. The soybean planting period in the second rainy season relies on water availability from rainfall and the dry season with the backing of irrigation. The seeds are filled with the Jabalsim System. Soybean cultivation technology package based on site-specific soybean cultivation technology. Increased value through processed products and handling of by-products of soybean and the soybean industry. Area-based soybeans development policy, from upstream to downstream.

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