GIS Land Suitability to Increasing Agricultural Production for the Agriculture Supply Chain: A Systematic Literature Review

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***Abstract*— Agricultural development is essential for the community's survival because it is a major source of food. Food production is a critical component of food security. Food security must be improved to meet market demand, and one of the fundamental goals of agricultural growth is to provide sufficient quantities of food. Increasing demand for natural resources, as well as environmental issues, are putting pressure on the current agricultural supply chain, which includes agricultural land suitability. Land evaluation is a process of analyzing land resources for specific uses using an established technique or method, and it is required to incorporate land appropriateness. According to the criteria, the findings of land suitability will give information and/or land use guidance. The land's appropriateness might be evaluated in its existing state (actual land suitability) or after changes have been made (potential land suitability). To address these issues, the agricultural sector must transition from traditional agriculture to smart agriculture. One of the technologies and system modeling that drives the current technique to smart agriculture with an integrated approach to evaluate the sustainability of agricultural land suitability is the geographic information system (GIS). The Systematic Literature Review (SLR) from prior investigations is presented in this publication. The articles are divided into two groups based on their approaches: agricultural land appropriateness for rice plants and the application of geographic information systems (GIS), comprising agricultural land suitability, site selection, and effect evaluation. The goal of this research is to determine what criteria are significant in increasing the quality of GIS applications in agriculture. This outcome is expected to assist stakeholders in formulating policies based on the performance of GIS data management in enhancing agricultural productivity and promoting agriculture supply chain management.**

Keywords—GIS, Land Suitability, Agriculture, Supply Chain

I. INTRODUCTION

Indonesia is an agrarian country, as stated by Law No.56 PRP, 1960, with agriculture as one of the pillars that contribute to a nation's economic foundation. Increased economic demands in satisfying basic human needs, as well as competition in land usage, both for agricultural and non-agricultural uses. Increased strain on land systems is predicted as the result of projected increases in population, income, and consumption levels. Population growth, changes in food consumption, and agricultural efficiency are the primary causes. With a modest improvement in agricultural efficiency, agricultural area is expanded, and food security is compromised [1]. According to a report published by the FAO in 2011, land resources for plants are one of the major drivers of agricultural productivity [2]. has discovered that, by 2050, population growth is anticipated to result in a 70% rise in worldwide demand for agricultural output on land now cultivated. As a result, the need for food supplies will rise [3]. Food demand and supply disparities are widening, posing a slew of new issues that add to the strain on the agricultural supply chain [4].

One of the most significant methods to increase grain production capacity is to consolidate land [5], and it requires integrated institutions for full implementation of land consolidation, appropriate regulations, and laws on the protection of follow-up potential productivity of cultivated land, and economic policies to stimulate it. It is critical to assess land in order to decrease human impact on natural resources and to identify suitable land use [6]. Such an analysis helps decision makers to identify the key limiting factors for agricultural output and to design crop management that can enhance land productivity.

In evaluating the land, the quality, and features of each unit/unit of land concerning plant growth requirements are utilized as criteria [7]. The first step in future agricultural land usage must be defining the link between soil properties and plant requirements [8]. Land suitability criteria for various strategic agricultural commodities, irrigated paddy rice (Oryza sativa) refers to land suitability criteria for agricultural commodities (BBSDLP,2003) by updating and refining the suitability criteria for strategic agricultural commodity land through the 2016 'Focus Group Discussion' forum within the Ministry of Agriculture and University (BBSDLP,2003) [9].

East Java is a national food barn with 38 districts covering 47,922 km2. East Java has a tropical environment

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with typical temperatures ranging from 21 to 34 degrees Celsius and annual rainfall of 1,900mm. In 2017, the total area of paddy fields farmed was 1,174,586 hectares, with irrigated rice fields accounting for 916,838 ha and non-irrigated rice fields accounting for 257,749 ha. East Java Province's irrigated rice field area dropped by 0.18 percent in 2017 compared to 2016. This has an impact on agricultural harvest production, which in 2016 totaled 12,903,595 tons but dropped to 12,432,793 tons in 2017, a fall of 3.65 percent. (2018, Statistic Indonesia).

Lowland rice productivity is still not steady from year to year, as evidenced by the figures above. A study on agricultural land suitability for rice paddy plants is needed so that paddy fields may be optimally utilized in increasing agricultural plant output. The challenge of determining whether agricultural land is suitable for wetland rice is a rather complicated system problem that involves the usage requirements/land characteristics of each land suitability class, among other things. Geographic information systems (GIS) are one such technology. GIS is a useful tool for storing, accessing, and manipulating huge volumes of data required to compute and map various quality indices for land suitability [9]. Although there are many research on the use of GIS in agriculture, there is less attention on assessing aspects such as land suitability, site tracking and selection, resource allocation, impact evaluation, knowledge-based systems, and GIS analysis [10][27]. Geospatial data accounts for the majority of big data in the agricultural supply chain, with its size increasing by at least 20% per year [4]. The goal of this study is to evaluate the function of GIS applications in agriculture and determine the appropriateness of agricultural land in improving agricultural harvest output for supply chain management using the most recent literature.

II. Method

The Systematic Literature Review with Kitchenham Steps [11] was the approach adopted in this study. Research topic, literature search strategy design, inclusion and exclusion criteria, quality evaluation articles, performing literature analysis, and publishing research results are some of the phases of this research technique

A. Research Question

It contains a topic that has been raised as study material at this point. This research investigates the suitability of agricultural land for increasing agricultural productivity. It will control the agricultural supply chain. The Systematic Literature Review (SLR) approach was used in this research. The research question is "How is land suitability GIS in increasing agricultural productivity for the agriculture supply chain?"

B. Design of Research Strategies

Selecting a digital library, defining search strings, correcting search strings, and retrieving a list of main studies from digital libraries that match the search string are all part of the search process. A list of database searches can be found below:

- Science Direct (Sciencedirec.com)
- Emerald Insight (Emeraldinsight.com)

The quality of research can be assured using the database search sources listed above. Then for the searches that were developed, many identifications were made, including:

1. To complete the scope of the review, identify the fundamental areas
2. Create a list of search terms based on your study questions
3. Find search terms in titles, abstracts, and keywords that are relevant to your research
4. Find synonyms, antonyms, and alternate spellings
5. Using specified search phrases and Boolean ANDs and ORs, create search strings

C. Inclusion and Exclusion Criteria

The primary study was chosen using inclusion and exclusion criteria. Among them are the following:

1. *Inclusion Criteria*

   Literature on land suitability, GIS agriculture, and supply chain may be found in this section in the form of a journal article or a research paper. Journals published within the previous five years, with a minimum of 2013 as the year of publication, Journals that are indexed in Q1-Q2, journals in compliance with RQ, and journals that are solely published in English

2. *Exclusion Criteria*

   Review articles, encyclopedias, novels, conferences, talks, news, and other types of literature. Literature unrelated to land suitability, GIS agriculture, or supply chain management. Journals that are not indexed, journals that are older than 2013, literature that is not RQ compliant, journals that are not indexed, and journals that are not in English Quality Assessment Criteria.

To get relevant literature as a reference in this study, the article will be subjected to a quality assessment (QA) using a weighting approach or score. To evaluate the completeness and relevance of the article to the research, we devised the following questions, these are some of the inquiries:

1. *QA1: Is the article concerned with agricultural land suitability?*
2. *QA2: Land suitability and GIS are discussed in this publication.*
3. *QA3: One regarding land suitability, geographic information systems, and supply chain management is discussed in the journal*

There are three possible replies to the questions asked for each criterion: "yes" (1 point), "half" (0.5 point), and "no" (0 point). The literature will be used in the Systematic Literature Review (SLR) research when the quality evaluation step is completed.

III. Result and Discussion

We found 945 publications that matched the keywords in the paper's search results. At the first stage, we set inclusion and exclusion criteria for the prospective article to be utilized. After the inclusion and exclusion processes, there were 70 papers remaining. We did a quality evaluation in the second stage to determine whether the literature was relevant for our SLR research. This level is based on the established Q1 and Q2 criteria. If the entire quantity of the literature evaluation is $\geqslant 2$, the literature is accepted and becomes a reference article for this study's discussion. The literature is rejected when the overall quantity of literature assessment weight is < 2. A total of 30 articles were received as a result of the quality assessment step. The results of the journal search are shown in Table 1, and each of these tables is listed below:

TABLE I. RESULT OF A JOURNAL SEARCH

			Search Result	
	Keyword 2	**Keyword 3**	**Science Direct**	**Emerald Insight**
Land Suitability	GIS	-	913	3
Land Suitability	Supply Chain Management	-	18	1
Land Suitability	GIS	Supply Chain Management	14	1
Total			945	5

The synthesis is the following step, and it is intended to address the formulation of the problem that was provided in the research methodology at this point. The following stages are involved in the synthesis of a Systematic Literature Review (SLR):

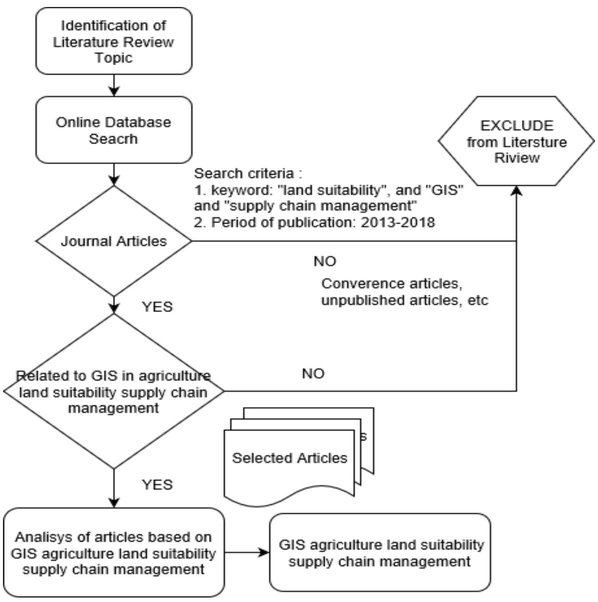

Fig. 1. Flow chart Processing View

It was collected from 30 chosen journals based on quality assessment for this systematic literature review. The findings of a literature study of 30 journals were discovered and approved as the source of land suitability in improving agricultural crop production for the agricultural supply chain. It is intended to map and evaluate the journals produced as a consequence of the aforementioned findings in order to provide solutions to the formulation of the issue that has been defined.

The result from 22 journals were summarized and mapped at the heart of the discussion, yielding three groups based on the country that conducts the research, the method used in the research, where the journal is published, the journal category, the factors discussed in the journal based on logistics, distribution, and grouping of factors from internal and external aspect. The following is a breakdown of the groupings:

A. *Grouping by Method*

Based on the method used in the research, the following picture depicts a type of grouping of 30 journals examined. The following are the results of each journal method.

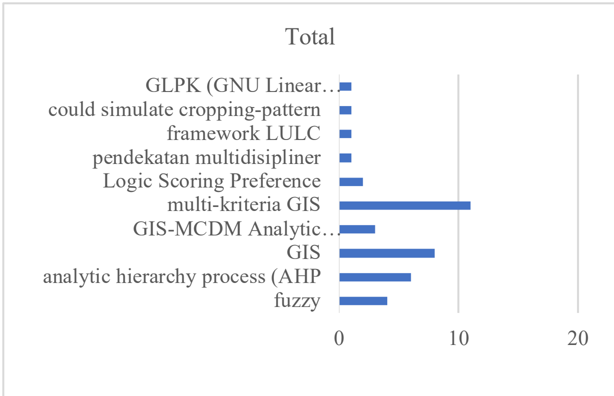

Fig. 2. Research Method

B. *Grouping by Publisher*

The following figure presents a form of the grouping of 30 journals grouped by journal publishers.

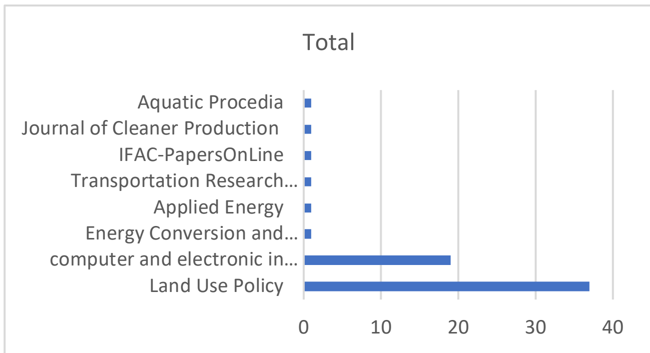

Fig. 2. Journal Publisher

C. *Grouping based on Journal Quartile*

Of the total 30 journals obtained, it is a journal with index Q1.

D. *Grouping based on Factor Discussed*

Of the 30 journals obtained, the following are discussed in the journal can be seen as shown below:

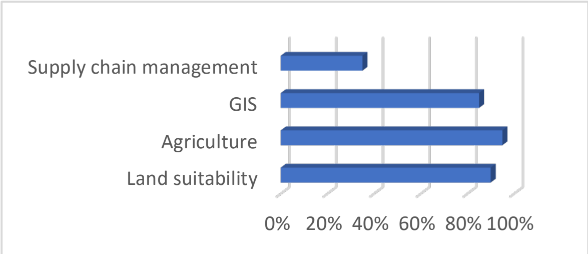

Fig. 4. Discussion Factor

- Agriculture Land Suitability

Because there is a high demand for land to be constructed on, and the available land area is limited, future land shortages are likely [12]. Suitability analysis enables decision makers to determine the major constraints to agricultural production and create crop management strategies that can increase land productivity. Its assessment gives information on land use constraints and possibilities, guiding judgments regarding the most efficient use of resources, which is a crucial prerequisite for land use planning and development [6].

The viewpoints of producers and users, the land suitability classes "very suitable" and "not suitable" in the suitability map are accurately calculated from the classes "moderately suitable" and "marginally appropriate"[13][28]. Innovative methods that combine land and climatic data for land suitability evaluation were used to create land suitability mapping [14]. The land suitability process outcomes reveal some key factors that will assist managers in achieving optimum yields and minimizing agricultural production losses [15]. Agricultural productivity has been influenced by slopes, soil depth, erosion, wetness, water holding capacity, texture, and nutrient availability [13]. Under two scenarios, crop patterns vary over time, and water availability is the primary impediment to land-use sustainability [16]. Future agricultural harvest planning choices may result in a decrease in investment and growth of agricultural crops in a certain region. The identification of precise regions is extremely essential for the success of product development and for sustainable agriculture, thus choosing the right site for agricultural goods is an important study topic [8]. In the agricultural sector, public policies based on agro-ecological zones for yield and productivity optimization must be converted into agroecological management approaches and traditional yield improvement methods [17].

- GIS (Geographic Information System) & MCDA

GIS tools and applications can conduct important data analysis due to their unique ability to visually present data with complete depth and clarity. It is useful for storing, collecting, and managing huge volumes of data needed to compute and map various land suitability quality indicators [1]. The IRS P6 LISS-IV dataset may be used to evaluate land suitability for agriculture in hilly regions using a multi-criteria GIS decision-making method. The research site selection will be strong if two MCDA analyses are used to choose the region [2]. GIS Integration can assess the potential of rural coastal regions to enhance sustainable development via agricultural recovery using a Weighted Linear Combination (WLC) method and Ordered Weighted Averaging (OWA). The geographical distribution of the area is suitable and closely linked to the hazards anticipated, so an acceptable site for restoration may be selected and, according to The OWA method, in particular, has a greater potential for performing more detailed territorial assessments and developing different decision-making strategies [3]. Intelligent systems for evaluating land suitability for various types of plants in the tropics and subtropics based on geo-environmental factors that automate the evaluation process and illustrate the results in attribute tables using the GIS method on digital map areas with the FAO-SYS framework model, ensuring that the results are correctly interpreted in relevant context and contributing to maximization[3]. The Delphi approach and analytical hierarchy process (AHP) are suitable for standardizing each assessment element that impacts crop and agricultural spatial planning, and as a result, setting weights for agricultural spatial planning may be suggested[4]. Using GIS-based Logic Scoring of Preference (LSP) as a multicriteria decision-making method for evaluating fields suitable for agriculture is an effective tool for integrated regional land use planning because it combines many criterion inputs, represents various types of human decision making, and produces realistic agricultural land capabilities and suitability maps. Land, terrain, climate, economics, land use and accessibility characteristics are among the evaluation criteria[5]. More regions within the research area are appropriate in terms of soil fertility by decreasing risk (no trade-off), increasing[6]. Using spatial conformity modelling with fuzzy logic to determine the land area in different drought index thresholds may optimize environmental and economic sustainability [3].

- Supply Chain Management

At the present, the successful and widespread deployment of positioning technology, the development of high-resolution image technology, and the contributions of numerous community users are all contributing to an exponential rise in the production of spatial Computer data [4]. Because 80% of the data is geographical, the majority of it can be georeferenced, emphasizing the significance of big geospatial data [23]. Access to geographical data is critical, and GIS is crucial. Accessibility of technology is the most desired element in the growing sharing economy. Organizations must strive to create cost-effective technological solutions for data storage and access. For all parties, this technology must enable efficient data transmission and connection. To promote power symmetry with farmers, one option to giving greater access to all stakeholders is to offer open access or keep smart agriculture data in the public domain [4]. The GIS system's accountability must guarantee that no data is lost, which, if not present, would lead to malpractice inland distribution procedures;

therefore, GIS system stakeholders are regulated by data accountability standards and regulations. To improve agricultural yields, areas that are not appropriate must be changed to agroecological management techniques coupled with conventional procedures. To maximize yields and production, the agricultural sector needs governmental policies that are differentiated by agro-ecological zones [23]. The most significant increases in the most important parameters affecting the cost of agricultural production, namely the number of plots, area, and distance from the economic center, are very important factors in the process of land consolidation, including land diversification maps or tangible forms of transportation networks, minimizing plot arrangement costs associated with cultivating agricultural plots [24]. Several important factors, such as climate conditions and topography, play a major role in the potential for agricultural expansion, then with agricultural planning decisions in the future; will lead to a reduction in investment and expansion of agricultural production to high-risk areas, which will help managers achieve optimal crop yields and reduce the loss of agricultural production [25]. The capacity of the technique to change the parameters of risk and trade-off is strongly linked to the risks anticipated and, as a result, the spatial distribution of the corresponding area. The choice of site for agricultural goods is an essential study topic since pinpointing precise locations is critical for product development and long-term agriculture sustainability. Developing decision tools that aid in the storage and analysis of primary and secondary data while systematically applying GIS-based MCDM to evaluate the spatial efficiency of transportation logistics on a regional scale will protect each region's potential, advantages, and disadvantages and can be used for strategic planning and improving logistics efficiency in regions [26]

IV. Conclusion

This research is based on SLR to investigate the suitability of agricultural land in increasing GIS-based agricultural production for the supply chain management. SLR was conducted in 30 matched research journals. The results of this SLR show that how GIS land suitability increases agricultural production for the agriculture supply chain by paying attention to factors/indicators of agricultural land suitability including climate, slope, soil depth, erosion, humidity, water holding capacity, texture, and availability of nutrients and cropping patterns on agricultural land determine the level of fertility of agricultural land supported or using MCDM methods including fuzzy, AHP, LSP, ANP and simulations integrated with GIS play an important role in improving supply chain management in agriculture.

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