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Research Paper

Analysis of Red Chili Production Segregation Information Design Using Spatial Methods in West Java - Indonesia

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ABSTRACT: *This study aims to determine aspects of red chili plant segregation and spatial aspects of land in West Java province which can be factors influencing the level of red chili production in West Java. Research has observed the area of West Java using a literature study approach through qualitative descriptive analysis. Data collection was obtained through published data from the Central Bureau of Statistics, published data from the Center for Research and Development of Agricultural Land Resources, Ministry of Agriculture, published data for Research and Development of the Ministry of Agriculture and published data for the Red Chili Commodity Trade Catalog. These data are then processed using spatial analysis methods with the help of ArcGis 10.2 Software. The Spatial-Segregation Information System (SISS) is to analyze red chili plant segregation data using a spatial approach. The results showed that based on the segregation analysis that had been carried out, it was known that the types of red chili plants that had segregated characters that could be utilized for breeding programs were fruit weight per plant and number of fruits per plant. This is indicated by the presence of segregation which has a maximum fruit weight of 2,681.3 g/plant and the number of fruits per plant is 1,145 fruits/plant. Meanwhile, based on spatial analysis for the West Java region, it is known that the southern region of West Java, which is at altitude and has cold weather, is an optimal area for planting red chilies. SISS has many benefits in managing and planning the productivity of red chili plants in the West Java region.*

KEYWORDS: *Segregation Analysis, Spatial Analysis, Red Chili, Information Design, West Java*

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I. INTRODUCTION

Red chili (Capsicum annum L.) is one of the agricultural commodities needed in Indonesia. Lack of information regarding planting schedules, land availability, geographical conditions and production at red chili production centers will have a significant effect on supply and become one of the obstacles in increasing the effectiveness of the red chili logistics and supply chain system which results in fluctuations in commodity prices. Spatial-based red chili segregation information system was built to design an agricultural information system that is capable of overcoming the problem of limited spatial information on red chili cultivation [1].

One of the factors that greatly influences the success of efforts to increase productivity is the availability of superior plant seeds. This can be obtained from the plant breeding process through the segregation process. A good segregation process will produce superior genetic diversity [1], [2].

From the activities of introduction, crossing, mutation, or through the transgenic process, the intended genetic diversity will be obtained. This process is followed by a selection process which is a common source of diversity compared to creating sources of diversity in other ways. Parents who are still heterozygous will produce diverse (segregated) F1 offspring, while homozygous parents will produce uniform F1 offspring and segregation will appear in the F2 generation. The presence of segregation indicates the presence of genetic diversity that needs to be selected and evaluated according to breeding purposes [1], [3].

One of the factors that influence the process of segregation of a type of plant is natural factors and the environment in the planting medium where the plant is planted. The factors contained in a type of soil, the geographical contour conditions of an area and the weather that often occurs can affect the process of segregation of offspring of a plant type [4], [5].

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II. LITERATURE REVIEW

Productivity

The word productivity has gained popularity in all business sectors, including in the field of horticultural cultivation. Economists explain productivity through estimating the state of existing production conditions and therefore interpreting the impact of each change in conditions by shifting to broader limits to increase production. When economists talk about productivity growth, they basically mean that rate of growth in the economy's ability to produce output from a given supply of inputs [6]. Therefore productivity refers to an increase in output without any change in the scale of operations. Thus, the total factor productivity of an economy only increases if it obtains more output from a given supply of inputs[7] . On the other hand, the characteristics of productivity as an economic activity must also be understood. Thus, the focus is on the factors that contribute to productivity associated with economies of scale.

Segregation Analysis

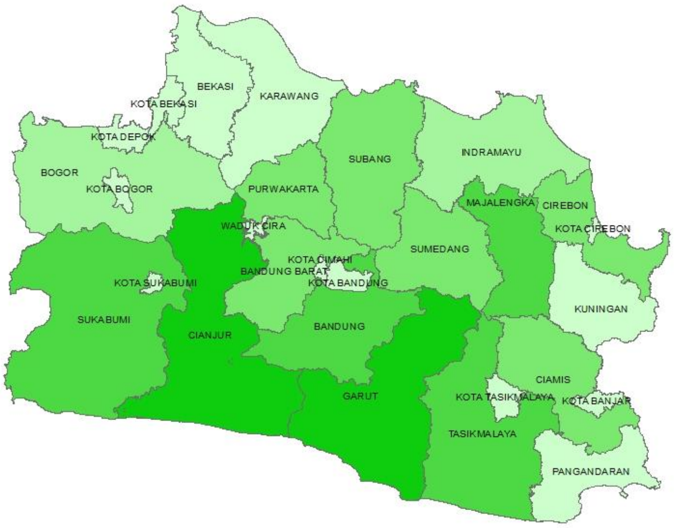
One of the factors that greatly influence the success of a plant breeding business is the large amount of genetic diversity. The existence of this genetic diversity in a population means that there are variations in genotype values between individuals in that population [1]. This is a necessary condition for successful selection within the population as planned. Introduction activities, crosses, mutations, or through transgenic processes can produce a lot of genetic diversity. The crossing process is followed by a selection process so that it becomes a common source of diversity compared to creating a source of diversity in other ways[8]. Parents who are still heterozygous will produce diverse (segregated) F1 offspring, while homozygous parents will produce uniform F1 offspring and segregation will appear in the F2 generation [5]. The presence of segregation indicates the presence of genetic diversity that needs to be selected and evaluated according to breeding purposes. All of these processes aim to obtain a genetic type that has a high level of productivity.

Spatial Analysis

Understanding the spatial distribution of data from phenomena that occur in an area/region is a big challenge at this time to get explanations regarding the many questions in many fields of knowledge, both in health, environment, geology, in agronomy[9]. Such studies are now becoming popular due to the availability of support from Geographic Information System (GIS) software. This system allows spatial visualization of variables such as individual populations, quality of life indexes or company sales in an area using maps [10]. To achieve this, it is enough to have a database and geographic base (such as city/district maps), and GIS is able to provide color maps that allow visualization of the spatial pattern of the phenomenon. The emphasis of Spatial Analysis is to measure the properties and relationships, taking into account the spatial localization of the phenomenon directly studied. That is, the central idea is to include space/area/region in an analysis that will be made.

III. RESEARCH METHODOLOGY

This research is based on segregation analysis research on chili plants that was conducted by Sofiari and Kirana in 2009 [1]. Meanwhile, research related to spatial analysis was carried out in parts of the administrative area of West Java Province. Administratively, the research area covers four districts and 18 districts and 9 cities. As shown in the image below:



Source: Data Processing with ArcGis 10.2
Figure 1. Research Coverage Area

The data used in this study is divided into two, namely spatial data (maps) and secondary data. Spatial data includes land use maps, soil type maps, erosion maps and topographic maps with a scale of 1: 25,000. Spatial data can be presented in two models, namely the raster model (grid or lattice) and the vector model. In the raster model, all objects are presented in the form of cells called pixels (picture elements) [11]. Each cell has coordinates and information (spatial and time attributes). Objects in the form of points, lines or planes are all presented and expressed in points or cells. Whereas in the vector model, objects are presented as points or line segments. This data model has more to do with the form of an object being stored [12].

IV. FINDING A NUMERYCAL SOLUTION AND APPENIXES

Based on data from the Central Statistics Agency for 2022 [13], information regarding the need for red chilies in Indonesia can be obtained, as shown in table 1.

Table 1. The need for red chilies in Indonesia

Year	Consumption (kg/capita/year)	Total population (Thousand)	Consumption (Ton)	Export (Ton)	Need* (Ton)
2013	1,62	224.179	362.363	1.183	363.547
2014	1,77	227.521	403.35	1.362	404.712
2015	1,81	230.913	418.992	1.218	420.209
2016	1,76	234.356	411.81	744	412.553
2017	1,78	238.519	425.351	1.504	426.854
2018	1,76	241.991	425.226	1.448	426.674
2019	1,87	245.425	458.135	545	458.68
2020	1,62	248.818	403.483	570	404.054
2021	1,67	252.165	422.073	250	422.324
2022	1,87	255.462	476.87	536	477.407
2023	1,87	258.705	482.925	371	483.296
2024	1,87	261.891	488.872	265	489.137

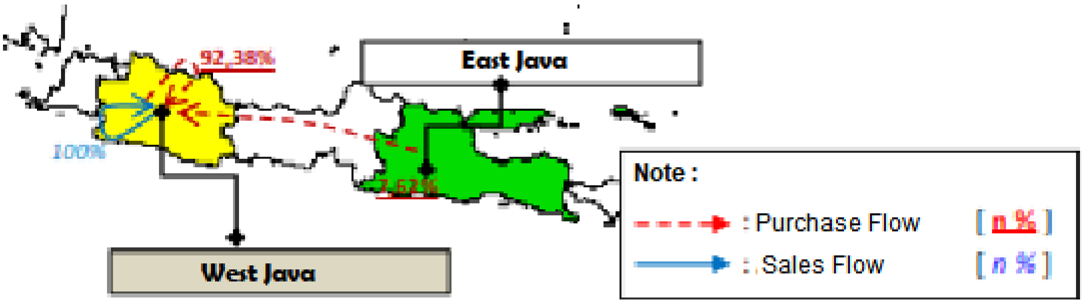
Note : *) Need = Consumption + Export
2023 and 2024 are projection results
Source: BPS (processed)

Based on the table above, the total consumption of national chili is projected to reach 482,925 tons in 2023, an increase of 1.27% compared to 2022 and it is estimated that in 2024 it will increase 1.23% from the projected figure in 2023 to 488,872 tons. Meanwhile, chili exports in 2023 are projected to decrease by 30.74% from the previous year to 371 tons and in 2024 it will decrease again by 28.56% from the 2023 projection to 265 tons.

Thus, the projected need for chili in 2023 will increase by 0.23% from the previous year and become 483,296 tons. Then, in 2024 it is estimated that it will increase another 1.21% from the projected value in 2023 to 489,137 tonnes.

Distribution Map of Red Chili Trade in West Java

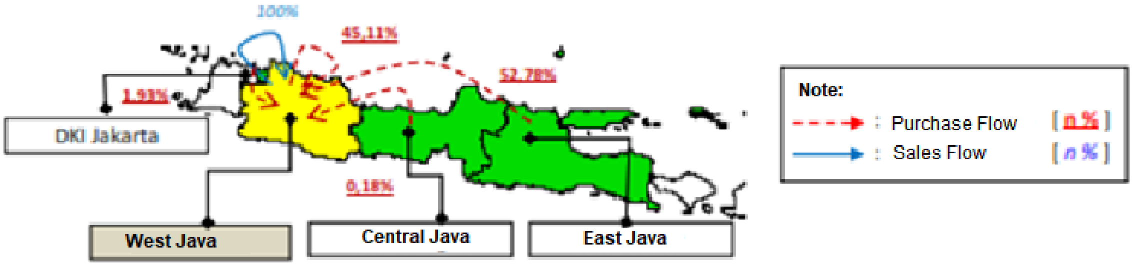
Based on sales of red chili production, it was found that red chili producers in West Java Province obtained raw materials from their own region (92.38%) and also from other provinces, namely East Java (7.62%). According to the sales area, red chili producers in West Java Province only sell red chilies to their own area (100.00%) [14]. For more details, see the image below.



Source: BPS Catalog 2022

Figure 2. Map of Red Chili Production Sales in West Java Province

Meanwhile, based on the pattern of trade distribution, it is known that the buying areas for red chilies in the West Java region come from West Java Province itself (45.11%) and other provinces such as DKI Jakarta (1.93%), Central Java (0.18%) and East Java (52.78%). Sales of red chili entirely to West Java Province itself (100.00%)[14]. For more details, see the image below.



Source: BPS Catalog 2022

Figure 3. Map of Red Chili Trade Distribution in West Java Province

Segregation Analysis of Red Chili Plants.

The research that has been done [1], explains how the quantitative character of the F2 generation (segregation type). It was explained that all plants in the F2 generation for characters of flowering age fall into the category of character types between F1 and P2. In F2 there was a fruit length segregation process that formed 4 types of segregation, namely types P1-F1, types F1-P2, types P2, and types >P2. Of the four types, 82.2% are included in the F1-P2 type, which means they have a tendency to have a shorter lifespan. However, these F2 plants bore fruit more than 130.9 fruits/plant.

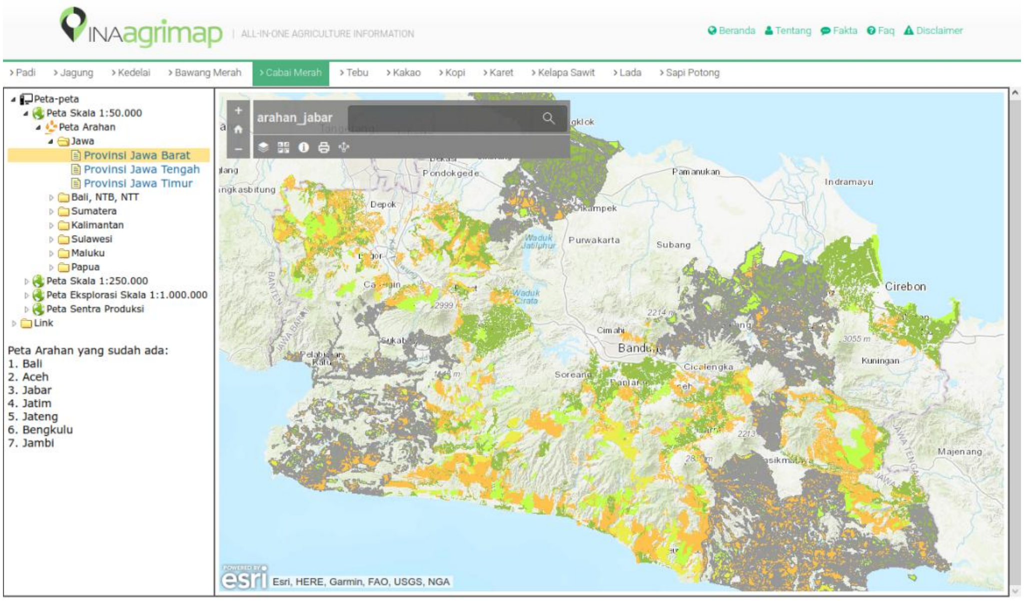
The flowering age of the F2 population varied between 44-62 HST/day after planting, with an average of 56.7 HST/day after planting [1]. Fruit length varies from 0.9-10.8 cm, with an average of 2.7 cm. Character fruit width between 0.8-2.4 cm with an average of 1.5 cm. Fruit weight per plant varies from 10.9-2681.3 g/plant, while the number of fruits per plant is between 11-1145 fruits/plant. Segregan characters that can be used for breeding programs are fruit weight per plant and number of fruit per plant. This is indicated by the presence of segregation which has a maximum fruit weight of 2,681.3 g/plant and the number of fruits per plant is 1,145 fruits/plant, while the segregated characters that must be corrected first are fruit length. This certainly attracts the interest of cultivators to plant this type of red chili.

From the explanation above, it can be discussed further regarding the type of planting media that is suitable for the type of segregation of chili plants based on the results of Sofiari and Kirana's research mentioned above.

Land suitability

Based on past data, red chili production in Indonesia in 2014 was around 1.846 million tons, and West Java Province is one of 4 Provinces in Indonesia which has the widest distribution of land, apart from the Provinces of East Java, Central Java and North Sumatra, where the total land area in the four provinces is around 257,790 ha [15] .

The land planted with red chilies in West Java Province according to data in 2014 was 26,058 ha and this province has the highest level of land productivity for red chilies, namely 369,673 tons. This is how West Java has a higher planting index or higher productivity than other provinces in Indonesia.



Source: http://inaagrimap.litbang.pertanian.go.id/map_cabai_merah.php

Figure 4. Land suitability map for red chilies in West Java

From these data it can also describe matters related to land suitability, where land where biophysically can be said to be sufficiently in accordance with the requirements for growing a particular plant optimally. Almost the same as shallots, red chili plants are mostly grown in paddy fields, can be planted in the second growing season after rice, but some are planted throughout the year in alternating blocks. The main requirement for planting chilies is the availability of sufficient water because chilies require intensive watering.

Red chili plants can also be developed in dry land, provided that sufficient water is available during their growth period. Therefore, chili farming on dry land will require higher costs for water supply.
For red chili plants, in order to grow properly, several requirements are needed as illustrated in the table below:

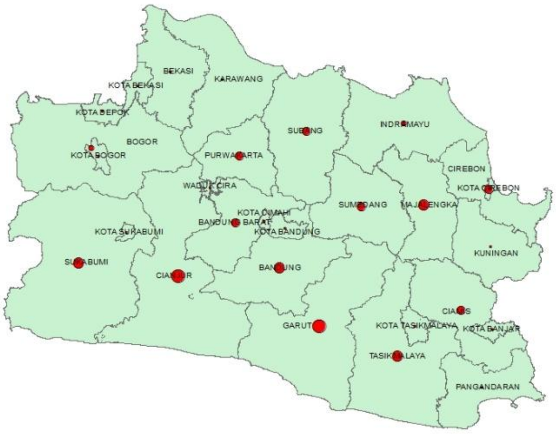
Table 2. Requirements for land use/characteristics needed for planting red chilies

Requirements for land use/characteristics	**Land suitability class**			
	S1	**S2**	**S3**	**N**
Temperature (tc) Average temperature (°C)	21 - 27	27 - 28 16 - 21	28 - 30 14 - 16	> 30 < 14
Availability of water (wa) Rainfall (mm)	600 - 1.200	500 - 600 1.200 - 1.400	400 - 500 > 1.400	< 400
Oxygen availability (oa) Drainage	well, a bit hampered	rather fast, moderate	hampered	very hampered, fast
Rooting media (rc)	fine, slightly	fine, slightly	rather rough	rough

Texture	smooth, medium	smooth, medium		
Coarse Material (%)	< 15	15 - 35	35 - 55	> 55
Soil depth(cm)	> 75	50 - 75	30 - 50	< 30
Peat:				
Thickness (cm) Maturity	< 50 saprik	50 - 100 saprik, hemik	100 - 150 hemik	>150 fibrik
Retensi hara (nr)				
KTK tanah (cmol)	> 16	5-16	< 5	
Kejenuhan basa (%) pH H_2O	> 35	20 - 35	< 20	
	6,0 - 7,6	5,5 - 6,0	< 5,5	
C-organik (%)		7,6 - 8,0	> 8,0	
	> 1,2	0,8 – 1,2	< 0,8	
Hara Availability (na)			Low	
N total (%)	Medium	Low	Very Low	-
P_2O_5 (mg/100 g)	High	Medium		-
			Very Low	
K_2O (mg/100 g)	Medium	Low		-
Toksisitas (xc)			5-7	
Salinity (dS/m)	< 3	3 - 5		> 7
Sodicity (xn)			20 - 25	
Alkalinity /ESP (%)	< 15	15 - 20		> 25
Sulfidic hazard (xs)			40 - 75	
Sulfidic depth (cm)	> 100	75 - 100		< 40
Erosion hazard (eh)			8 - 15	
Slope (%)	< 3	3 - 8	Light - Medium	> 15
Erosion hazard		Very light		Heavy-very heavy
Danger of flooding/puddles during planting (fh)			25	
- High (cm)	-	-	<7	>25
- Duration (day)	-	-		≥7
Land preparation (lp)			15 - 40	
Rocks on the surface (%)	< 5	5 - 15	15 - 25	> 40
Rock outcrop (%)	< 5	5 - 15		> 25

Source: [16].

Based on data processing using the Spatial Analysis approach, several explanations are obtained as follows:



Source: Data Processing with ArcGis 10.2
Figure 5. Distribution area of red chili producers in West Java province

Almost all districts and cities in West Java Province produce red chilies. Although the quantity and distribution area is very fluctuating. More details on the amount of red chili production for each district/city area can be seen in the table below.

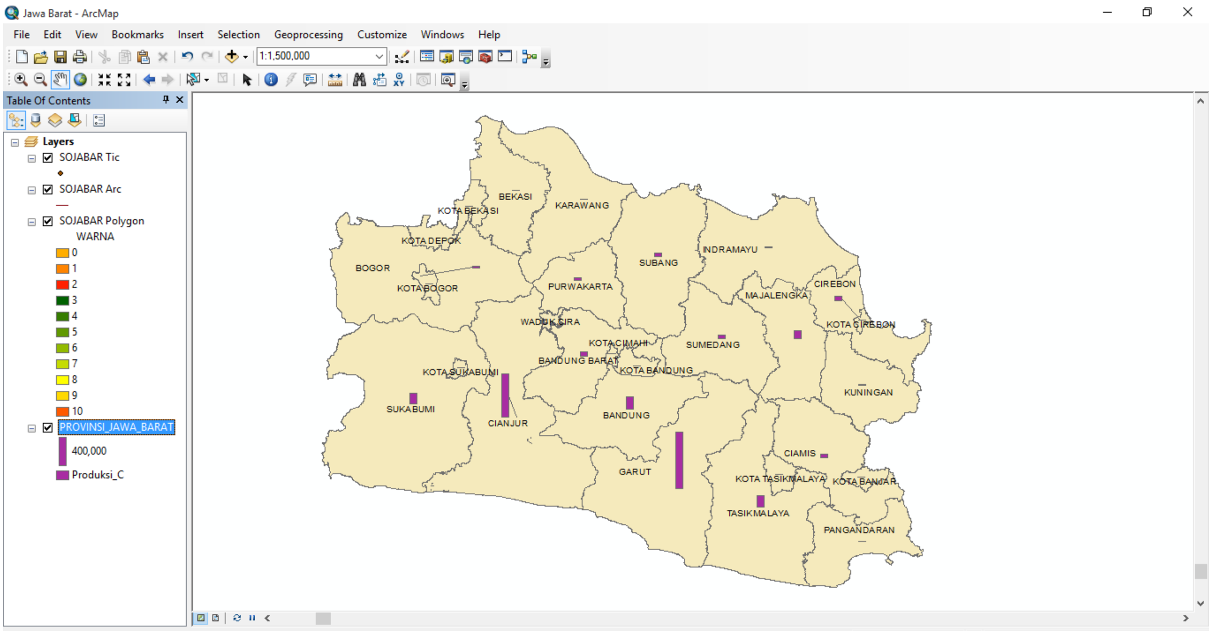
Table 3. Production of Large Red Chilies by Distric in West Java Province, 2016

Distric		Cabai Merah Besar (Kwintal)
1	Bogor	29,931
2	Sukabumi	149,081
3	Cianjur	617,037
4	Bandung	172,243
5	Garut	807,428
6	Tasikmalaya	168,249
7	Ciamis	41,987
8	Kuningan	10,176
9	Cirebon	60,489
10	Majalengka	119,319
11	Sumedang	50,240
12	Indramayu	19,898
13	Subang	60,106
14	Purwakarta	43,295
15	Karawang	776
16	Bekasi	1,092
17	Bandung Barat	60,668
18	Pangandaran	292
Kota		Cabai Merah Besar (Kwintal)
1	Bogor	3,510
2	Sukabumi	830
3	Bandung	10
4	Cirebon	3
5	Bekasi	144
6	Depok	-

7	Cimahi	410
8	Tasikmalaya	3,629
9	Banjar	287
Jawa Barat		2,421,130

Sumber : [14]

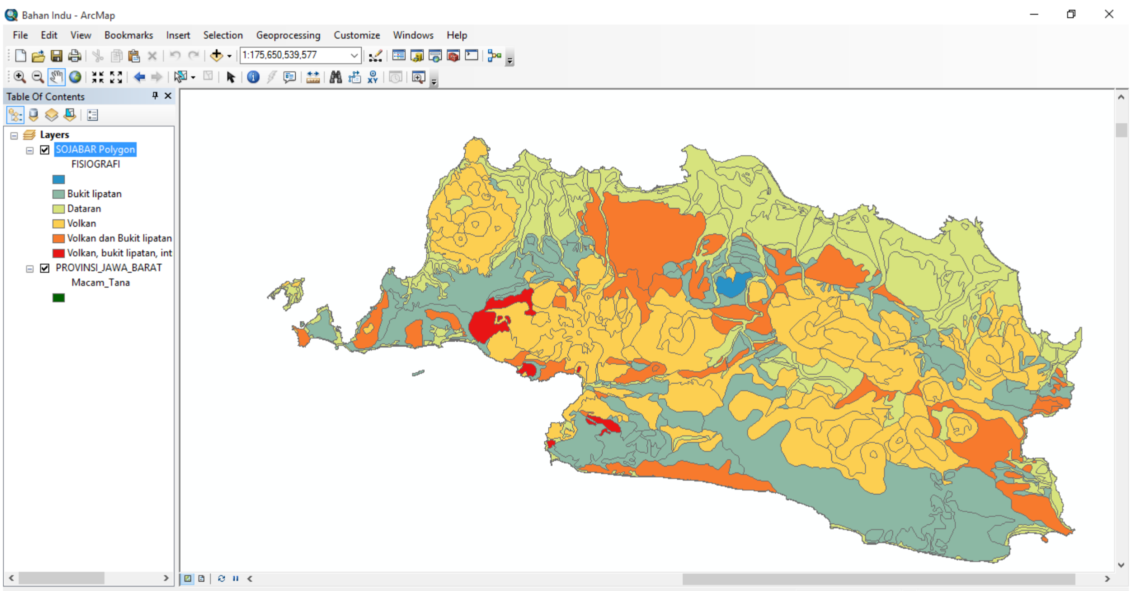
The data in the table above can be projected onto a map of the West Java region so as to provide a clearer picture regarding the distribution of red chili production areas in West Java, as shown in the map image below.



Source: Data Processing with ArcGis 10.2

Figure 6. Distribution of Red Chili Producing Areas in West Java Province based on Land Productivity

Then with the ArcGis 10.2 Software tool, the existing data was further developed into information related to the distribution of Red Chili Producing Areas in West Java Province based on Soil Fiography, as shown in the image below.



Source: Data Processing with ArcGis 10.2

Figure 7. Distribution of Red Chili Producing Areas in West Java Province based on Soil Physiography

From regional data processing based on Soil Fiography criteria in West Java Province, it can be seen that land in West Java is dominated by fold hill soil types in the southern part of West Java and plains soil types in the northern part of West Java. And if you pay close attention, several districts/cities in West Java that have quite high levels of red chili production are the Regencies/Cities of Garut, Cianjur, Bandung, Sukabumi and Tasikmalaya. And according to the soil physiographic distribution map, the areas mentioned above are in the southern region of West Java which has a folded hill soil type. As is well known, the area has a fairly high altitude above sea level and has a cold climate.

Information System Design

Based on the initial objective of the Segregation-Spatial Information System (SISS) was to analyze red chili plant segregation data using a spatial approach. Some of the SISS functions are as follows:

a. Input Data, before geographic data is used in SISS, the data must first be converted into digital form.
b. Making maps, the process of making maps in SISS is more flexible with the help of ArcGis 10.2. The process begins with creating a database. The resulting maps can be made at various scales and can show selected information according to certain characteristics.
c. Data manipulation, data in SISS will require transformation or manipulation to make the data compatible with the system. Existing technologies provide a wide range of tools to manipulate data sufficiently.
d. File management, when the volume of existing data is getting bigger and the number of user data is getting bigger, the best thing to do is to use a database management system (DBMS) to help store, organize, and manage data.
e. Query analysis, SISS provides the capability to display queries and tools to analyze existing information. Available technologies are used to analyze geographic data to see patterns and trends.
f. Visualizing results, for various types of geographic operations, the final results are visualized in the form of maps or graphs. Maps are very efficient for storing and communicating geographic information.

In simple terms, the stages of the Spatial-Seggregation Information System design process are shown in the figure below:

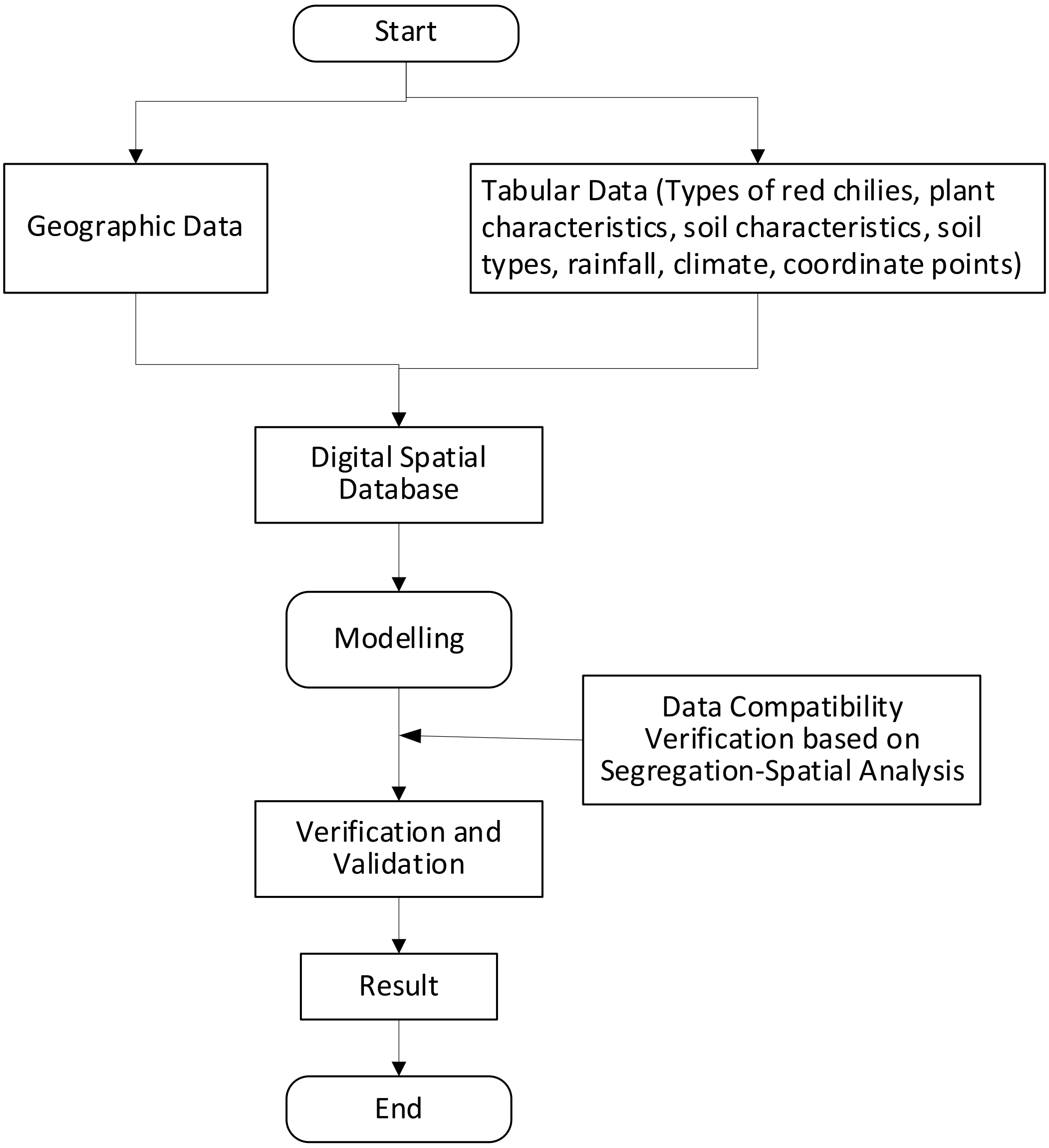


Figure 8. Information System Design

To produce accurate information that must be conveyed, several research steps are needed, in which case several methods are used as follows:

a. System Planning
At this stage, the initial stage of system development is carried out where the system will be able to define estimates of resource requirements such as physical devices (hardware), people, methods (technical and operations), and budgets which are still general in nature (not yet detailed/detailed).

b. System Analysis
At this stage an analysis of the existing system is carried out with the aim of designing a new or updated system and fixing things that are considered lacking.

c. System Design
At this stage, the stage after system analysis is carried out which determines the processes and data required by the new system. System design consists of two kinds of systems, namely general system design and detailed system design.

d. System Implementation
The implementation or application phase is the stage where the system design is formed into a code (program) that is ready to run.

e. System Testing
At this stage testing is carried out to test the application that has been made so that it can be implemented properly.

The system design uses the Unified Modeling Language (UML) because the programming language used in making this system is an object-oriented programming language. The following shows a use case diagram that shows a system and describes certain jobs between the admin and the system and the user/users with the system.

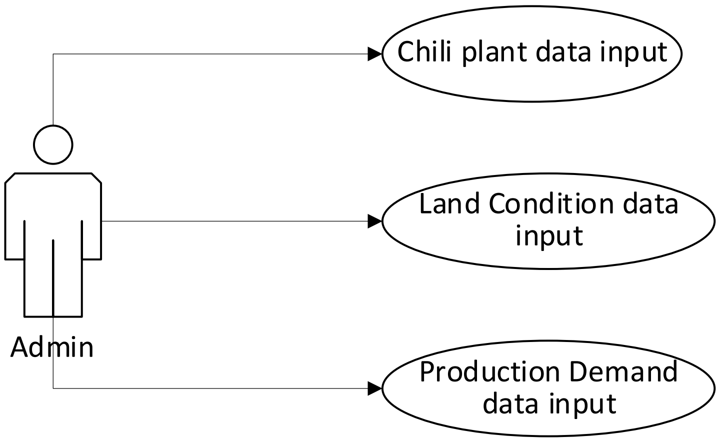


Figure 10. Admin UML Use Case Diagram

Shows between what the system does through actors, actors can carry out all three activities, namely entering, changing, and deleting data if he has logged into the system.

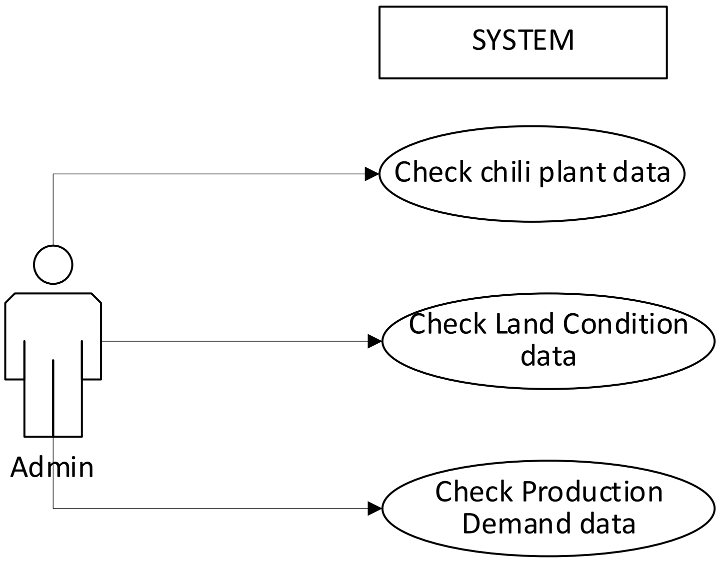


Figure 11. UML Use Case Diagram User

Showing between what the system does through the user, the actor can carry out all three activities, namely viewing lists, data, and the location of suitable red chili fields by performing on-click actions on buttons.

Information System Design Analysis

The use of Spatial-Segregation Information Systems (SISS) in agricultural horticultural research is still very little done even though Information System technology has been discussed quite a lot in the agricultural literature over the last decade. Agriculture is an activity that is very dependent on environmental resources so that proper planning is needed in its management. Spatial-Segregation Information System Technology (SISS) can be applied in order to achieve sustainable agricultural development. The following table describes the outstanding functional capabilities and potential of SISS.

Table 4. SISS Capability in Red Chili Farming

SISS Functional Capability	Basic Questions about SISS		Basic Questions about SISS
Data Entry, storage, and manipulation	Location	What's that ?	Availability of suitable land
Map Production	Condition	Where's that?	Identification of the most suitable land location for the cultivation of segregated red chilies
Database Integration and Management	Trend	What's changed?	Measuring the impact on the productivity of red chili cultivation
Data Queries	Land Choices	Which land is the best?	Availability of suitable land, weather/climate conditions
Spatial Analysis	Pattern	What's the Pattern?	Analyze the relationship related to land use and supporting resources
Spatial Modeling	Modelling	What if?	Assess the potential impact of regional development and development
Decision support			

Sumber: [17], p. 159 (adapted)

From the table above it is clear that SISS has many benefits in managing and planning the productivity of red chili plants in the West Java region. Some of the main features of SISS that are useful for planning the productivity of red chili plants in the West Java region are as follows:

a. Ability to manipulate data and spatial attributes
b. Provide the necessary value added information
c. Ease in allocating resources
d. Adaptability in providing data from time to time
e. Decision making based on ability to identify patterns or relationships based on certain criteria.

V. CONCLUSION

Based on the spatial analysis that has been carried out, it is known that the types of red chili plants that have segregated characters that can be used for breeding programs are fruit weight per plant and number of fruits per plant. This is indicated by the presence of segregation which has a maximum fruit weight of 2,681.3 g/plant and the number of fruits per plant is 1,145 fruits/plant.

Meanwhile, based on segregation analysis for the West Java region, it is known that the southern region of West Java, which is at high altitude and cold, is the optimal area for planting red chilies. However, the northern region of West Java can still be optimized considering that this area is a rice field area, according to the criteria for land that can be planted for red chilies.

With the Spatial-Based Segregation Information System (SISS), it is hoped that it can maximize information regarding suitable locations for red chili cultivation in the West Java region, so that it can make it easier for farmers-farmer groups-red chili cultivators to increase the productivity of red chili plants.

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