Spatial data gathering architecture for precision farming using web services

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Abstract. Precision Farming (PF) is an agricultural business with an approach that enables careful treatment using several technologies to support it. The concept of PF can be used in all aspects of the crop production cycle from soil testing to harvesting. Soil Testing is a phase to test the conditions of the suitability of the soil to certain varieties. The land suitability variables used are soil type, slope, and altitude. However, the data was stored on other sources with different platforms and web service is the answer to this issue. This paper will approach the Soil Testing phase using the type of spatial data that can be used as a variable in determining land suitability for particular vegetation, which is using web service technology to collect the data. Using the overlay method combine the spatial, that is collected using Geographic Information System (GIS) web services, to produce a land suitable map for soil testing phrase. Land mapping can be used for decision-making processes related to the vegetation suitability. Spatial data gathering architecture for precision farming using web services, in this case, which is soil testing phrase, is the result of this paper.

1. Introduction

Food independence is one of the government’s program. Food independence can be achieved when food self-sufficiency can survive according to a predetermined target for the amount of agricultural production. The term agriculture appears when humans can benefit from regulating plant growth. The agricultural products are still the mainstay of several countries including Indonesia to meet people’s needs and to contribute to foreign exchange. However, at present, almost all plant productivity is still far from its potential, on the other hand, the cost of production goes up. Climate change and environmental conditions also influence agricultural conditions. Agricultural production that does not provide results according to these targets raises several concepts, one of the technologies used to address these problems is Precision Farming (PF) technology [1].

The basic concept of Precision Farming is to measure the diversity of land conditions (soil, climate, plants) and then manage that diversity through the provision of agrochemical inputs and all other cultivation actions according to the Physico-chemical characters of the soil and plants’ needs as effectively and efficiently as possible, by integrating agronomy principles and technological applications. This means that precision care is needed for each plant by following the plant’s characteristics condition, in which the treatment applies to technology. Through the effective, selective and efficient management, then the plant productivity will be obtained to its potential, maximizing profitability, managing risks and being environmentally friendly both physically and socially [2].
The concept of precision in precision farming means precise in time, number, location, origin, and method. The use of spatial data is the answer to the concept, which can be made using Global Position Systems (GPS), remote sensing (satellite, aircraft, UAV) and Geographic Information Systems (GIS) [3]. Precision Farming technology can be used in all aspects of the crop production cycle from pre-harvest operations to harvesting. Precision Farming consists of soil testing phrase, tillage phrase, planting phrase, fertilizing phrase, spraying phrase, crop scouting phrase, and harvesting phrase.

Soil Testing Phrase is very important to design a sustainable agriculture policy [4], wherein there is a test of the relationship between soil quality and vegetation suitability and produce land mapping. Land mapping can be used for decision-making processes related to the vegetation suitability that can be planted in the Soil Testing, where the mapping of the land is obtained from the results of overlaying variables, such as soil type, slope, and altitude [5]. The result of an overlay is a land suitable map, which can be used as a consideration in the decision making the process at the Soil Testing phase [6].

The data used as a variable is spatial data, where the data was stored on other sources with different platforms. Therefore, a concept is needed to build a distributed system model for the process of exchanging spatial data originating from different sources [7] and web services are the answer to this issue [8]. However, the issue is the technology of web service that is used to gather spatial data. How to build spatial data gathering architecture for precision farming using web services, in this case, is soil testing phrase, is the result of this paper. This architecture has a purpose to develop a Web GIS Application that helps to choose the suitable vegetation.

2. Material
The technological components of Precision Farming are such as (1) Global Positioning System (GPS), (2) Yield Monitoring, (3) Digital Soil Fertility Mapping, (4) Crop Scouting, and (5) Variable Rate Application (VRA) (Wolf et al, 1997). Precision Farming (PF) is an agricultural business with approaches and technologies that enable precise treatment of the agribusiness chain. Precision Farming technology can be used in all aspects of the crop production cycle from pre-harvest operations to harvesting. The technology is to improve soil testing, tillage, planting, fertilizing, spraying, crop scouting, and harvesting.

Soil Testing is very important for designing sustainable agricultural policies, wherein there is testing of soil quality and soil pH testing. Land quality assessment can be used for decision-making processes related to the vegetation suitability that can be planted. The land compatibility variables used are soil type, slope, the altitude of the place [5].

The concept of precision means precise on time, number, location, origin, and method. The use of spatial data is the answer to the concept, which can be made using the Global Position System (GPS), remote sensing (satellite, aircraft, UAV) and Geographic Information System (GIS). The spatial data is stored on a variety of platforms, and for exchanging spatial data it is necessary to use web service technology.

Representational State Transfer (REST) is an architecture that allows connecting different applications by encoding different data sources. Generally, it uses the Hypertext Transfer Protocol (HTTP) is a protocol for data communication. In the REST architecture, the REST server provides data and the REST client accesses and displays the data for future use. Each data is identified by Universal Resource Identifiers (URIs) and represented in text format, XML or JSON [9]. The HTTP methods commonly used in REST-based architectures are such as (1) GET, provides access for reading, (2) PUT, produces new data, (3) DELETE, delete data, (4) POST, renew or create data, (5) OPTIONS, get data-supported operations [10].

JSON (Javascript Object Notation) is a data exchange format, which is easy to read and written by humans and easily translated and generated by computers. JSON consist of 2 structure: Collection of name/value pairs (object, record, structure, dictionary, hash table, or key list) and List of sorted values (array, vector, list or sequence). GeoJSON is an open standard format to representing simple geographical feature and is based on JSON format.
The spatial data is data that is referred to spatial, where each point correlates with the real world. The spatial data consists of 2 types, raster data, and vector data. The raster data is represented in the form of a grid, while vector data represents digital geographic elements using points, lines, and area (Polygon). The classification of data types can be seen in Figure 1 below [11].

3. Literature Review
There are several studies related to GIS Web Services. In the first study, the paper has a problem that the power and electric outages cause business disruptions. The solution for this issue is a web-based system that is capable of creating a web map that enables geo-enabled to access, query and display a real-time outages status. The method is based on the Internet of Things (IoT), web mapping, web GIS, web services and GIS web services. The result is a real-time system that gives information data record such as name of the country, name of the state, total number customers located without electricity, etc. GIS web services in this paper are used to catch the location of the area, even though there are much other spatial information that can be used [12].

Another previous study discussed how to build a decision support system for precision farming by utilizing GIS web services. The phase discussed in this study is the Fertilizing phase where the web service technology used is SOAP (Simple Object Access Protocol). The object of this study is wheat. This study builds a system that can remote diagnoses and decision making. Wheat remote diagnoses and decision-making system was buildup by three levels from top to down which include the application system level, business composite level, and function components level. The result of this study is a web-based DSS model for the fertilizing phrase [7].

The next study collects spatial data using GIS web service. The core idea of this study is to achieve distributed and interoperable GIS Data Services through web services. The web service technology used is XML and JDBC. GIS web services in this study collect spatial data and it focuses to collect data and to save data. The model architecture was built a model to collect data spatial from various sources and platforms [13].

Based on previous research, this study will propose an architecture model to gather spatial data for precision farming using web services, in this case, is soil testing phrase. The web service technology used is GeoJSON to collect data spatial such as soil type, slope, and altitude. Using the overlay method combine the spatial data, that are collected to produce a land suitable map for soil testing phrase.

4. Architecture
The GIS Webservice will be used as a way to retrieve data, in this case, spatial data, which is located at different sources. The data which is obtained has a shapefile format. To be used, the shapefile format is changed to the GeoJSON format. The architecture communication method used is REST (Representational State Transfer). REST will load files that have the GeoJSON format. In Figure 1, the flowchart of the spatial data collection located at different sources to be used as the data for decision support [14] in the Soil Testing phase, and finally can be utilized by users.

On Figure 1 it can be seen:

- There are some processes of the spatial data collection from various sources to map soil compatibility to the end is the Decision Support System for Soil Testing which can see the compatibility of the soil with certain vegetation.
- The three variables that will be used are sourced from the data used to develop the Agroecological Zone of Boyolali Regency, where there are several spatial data including 3 spatial data needed for mapping the land. The data is in the form of spatial data, meaning that the data has geometry and attributes. Geometry can be represented as point, line, or polygon in the form of a shapefile. While the attribute is a feature data from the geometry, where geometry and attributes are inseparable entities.
Based on the architecture, a server-side will be designed to capture the spatial data. Using GeoJSON capture the location coordinate of the spatial data. Figure 2 is an example of spatial data sent in JSON format to the server.

![Figure 1. Propose GIS Webservice for Soil Testing](image)

```json
{
    "type": "FeatureCollection",
    "crs": {
        "type": "name",
        "properties": {
            "name": "urn:ogc:def:crs:OGC:1.3:CRS84"
        }
    },
    "features": [
        {
            "type": "Feature",
            "properties": {
                "No": null,
                "ID_district": null,
                "ID_Village": null,
                "Soil_Type": null,
                "SHAPE_Leng": 0.0009483649370999999,
                "SHAPE_Area": 6.0379419584099997e-006
            },
            "geometry": {
                "type": "MultiPolygon",
                "coordinates": [
                    [[110.51, -7.53], [110.52, -7.52], [110.53, -7.51], [110.52, -7.49]]
                ]
            }
        }
    ]
}
```

![Figure 2. Soil Data in GeoJSON Format](image)

The variables used to determine land mapping are such as (1) Soil Type, (2) Slope, and (3) Altitude of the place. The data will be overlayed to form a single layer that will be used as land mapping. Land mapping can be used to see land suitability for particular vegetation, which is a step in the Soil Testing phase.

Database DSS Soil Testing on architecture contains the database that gives information about Land Suitability that has been saved. Using the profile matching method for DSS to give recommendation vegetation based on the information that has been saved.
The soil type is information about the type of soil that exists in the area. There are 7 classes of soil types used, such as (1) Alluvial, (2) Volcanic, (3) Humus / Soil Flowers, (4) Organosol / Peat, (5) Entisol, (6) Laterites, (7) Litosol. The map of soil type in the Boyolali regency is in Figure 3.

The form of the data geometrically is such as polygon, the feature data for the attributes can be displayed are shown in Table 1.

![Figure 3. The Map of Soil Type in Boyolali Regency](image)

**Table 1. Attributes of Soil**

| No | ID_district | ID_Village | Soil_Type |
|----|-------------|------------|-----------|
| 1  | 01          | 01         | Alluvial  |
| 2  | 01          | 02         | Alluvial  |
| 3  | 01          | 03         | Litosol   |
| ...| ...         | ...        | ...       |
| 10 | 01          | 10         | Humus     |
| ...| ...         | ...        | ...       |
| 54 | 04          | 04         | Laterites |
| ...| ...         | ...        | ...       |
| 80 | 07          | 13         | Alluvial  |
| ...| ...         | ...        | ...       |
| 167| 09          | 05         | Organosol |
| ...| ...         | ...        | ...       |
| 231| 10          | 18         | Entisol   |
| ...| ...         | ...        | ...       |
| 287| 10          | 05         | Humus     |
| ...| ...         | ...        | ...       |
| 345| 14          | 10         | Organosol |
| ...| ...         | ...        | ...       |
| 444| 19          | 18         | Volcanic  |

The slope is the angle taken from the surface of the land. The slope class used are such as (1) Flat (0-8%), (2) Slightly steep (8-15%), (3) Steep (15-40%), and (4) Very Steep (>40%). The Map of the Slope in Boyolali Regency can be seen in Figure 4.
The form of the data geometrically is a polygon, the feature data for the attributes can be displayed are shown in Table 2

Table 2. Attributes of Slope

| No | ID_district | ID_Village | Slope_Type   |
|----|-------------|------------|--------------|
| 1  | 01          | 01         | Slightly steep |
| 2  | 01          | 02         | Slightly steep |
| 3  | 01          | 03         | Flat          |
| ...| ...         | ...        | ...           |
| 10 | 01          | 10         | Flat          |
| ...| ...         | ...        | ...           |
| 54 | 04          | 04         | Flat          |
| ...| ...         | ...        | ...           |
| 80 | 07          | 13         | Flat          |
| ...| ...         | ...        | ...           |
| 167| 09          | 05         | Slightly steep |
| ...| ...         | ...        | ...           |
| 231| 10          | 18         | Very Step     |
| ...| ...         | ...        | ...           |
| 287| 10          | 05         | Flat          |
| ...| ...         | ...        | ...           |
| 345| 14          | 10         | Flat          |
| ...| ...         | ...        | ...           |
| 444| 19          | 18         | Step          |

Altitude is related to air temperature. The criteria of altitude used are such as (1) Hot (<500 m asl), (2) Cool (500 - 1000 m asl), and (3) Cold (> 1000 m asl). The Map of Altitude in Boyolali Regency can be seen in Figure 5.
The form of the data geometrically is a line, the feature data for the attributes can be displayed are shown in Table 3.

Table 3. Attributes of Altitude

| No | ID_district | ID_Village | Altitude_Type |
|----|-------------|------------|---------------|
| 1  | 01          | 01         | Cool          |
| 2  | 01          | 02         | Cool          |
| 3  | 01          | 03         | Cool          |
| ...| ...         | ...        | ...           |
| 10 | 01          | 10         | Cold          |
| ...| ...         | ...        | ...           |
| 54 | 04          | 04         | Hot           |
| ...| ...         | ...        | ...           |
| 80 | 07          | 13         | Hot           |
| ...| ...         | ...        | ...           |
| 167| 09          | 05         | Hot           |
| ...| ...         | ...        | ...           |
| 231| 10          | 18         | Cold          |
| ...| ...         | ...        | ...           |
| 287| 10          | 05         | Cool          |
| ...| ...         | ...        | ...           |
| 345| 14          | 10         | Cool          |
| ...| ...         | ...        | ...           |
| 444| 19          | 18         | Cold          |

The attribute data from the overlay results will represent spatial conditions (soil type, slope, and altitude) at a certain point of location in Boyolali Regency. Using queries in the result of the overlay to determine land suitability, the example of the feature data can be displayed are shown in Table 4.

5. Conclusion

In this study, the architecture model to gather spatial data was designed to collect data for land suitability in the soil testing phrase. The data can be used as a source in mapping land to see the compatibility of the soil toward vegetation. The spatial data taken from the Agroecology Zone of the Boyolali Regency to be used as a land quality mapping variable are such as (1) Soil type, (2) Slope,
and (3) Altitude, which is located at different sources and platform. Web services are used to collect the spatial data. The web services technology used is GeoJSON, this is to capture spatial data. Also, the data will be overlayed to form a single layer. Using a profile matching method for DSS to give recommendation vegetation based on the information that has been saved. This research found that the Boyolali has fertile soil type and is suitable for agricultural.

Based on the feature data available in the Agroecology Zone of Boyolali Regency, it is possible to use the data to complete or to do a deeper analysis of land compatibility. For example, there is information on rainfall, drainage, agroecological zones, nutrient retention, and nutrient content.

**Table 4. Attributes of Land Suitability**

| No | ID_district | ID_Village | Soil_Type | Slope_Type | Altitude_Type | Veg |
|----|-------------|------------|-----------|------------|---------------|-----|
| 1  | 01          | 01         | Alluvial  | Slightly steep | Cool          | Rice |
| 2  | 01          | 02         | Alluvial  | Slightly steep | Cool          | Rice |
| 3  | 01          | 03         | Lithosol  | Flat        | Cool          | Corn |
| 10 | 01          | 10         | Humus     | Flat        | Cool          | Teak tree |
| 54 | 04          | 04         | Laterite  | Flat        | Hot           | Corn |
| 80 | 07          | 13         | Alluvial  | Flat        | Hot           | Yam |
| 167| 09          | 05         | Organosol | Slightly steep | Hot          | Teak tree |
| 231| 10          | 18         | Entisol   | Very Step   | Cold          | Corn |
| 287| 10          | 05         | Alluvial  | Flat        | Cool          | Rice |
| 345| 14          | 10         | Organosol | Flat        | Cool          | Teak tree |
| 444| 19          | 18         | Volcanic  | Step        | Cold          | Yam |

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