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INSPIRE Directives assessment of multiple geospatial information for vegetable production

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Abstract

This report is concerned to spatial data infrastructures about vegetable production and performance by GIS. Based on INSPIRE Directives and International Organization for Standardization (ISO) the purpose is creating conceptual model for assessment of horticulture land using. The report presents an integrated view of the heterogeneity of data components and used in geographic information. One of the main concept is collecting and analyzing information from real investigation, then convert it in spatial data and develop into multiplicity vegetable production maps. The volume of data include information about Cadastral Maps, Coordinate Reference Systems, Elevation, Hydrography, Atmospheric Conditions, Meteorological Geographical Features, Land cover and Land Use, Soil, Monitoring and Agricultural Facilities, etc. The extensive scope requires deep analysis, significant and possibly influence between all aspects about vegetable production. As a result converting all spatial data about vegetable development into detailed maps allows illustrating links between all substantial and additional information. This kind of representation facilitates working with huge amount of data, without repetitive manual intervention.

Keywords: GIS modeling, INSPIRE, vegetable crop production, conceptual model, spatial data, horticulture

Introduction

Today, geographical information is important structure of a huge amount of spatial data. It is collected from different sources like hydrology, statistics, public health, geology, civil protection, agriculture, ecology, environmental conditions and many others. All real life around us is some kind of information, which can be transformed in spatial data (Arnaudova, 2010). This changing of information allows collecting, organization, analyzing and sharing it to a large number of people and activities. Directive 2007/2/EC of the European Parliament and of the Council, adopted on 14 March 2007, takes measures to address these challenges by establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment. INSIRE is a prominent example of a legally enforced infrastructure (JRC Reference Reports, 2012). The aim is supporting environmental policies or activities that may have an impact on the environment.

The purpose is answering the question of how the reuse of geographic and environmental information, which is created and maintained by different organization, can be enabled and facilitated. This report is related to substantial and common task, which is associated with dealing with the heterogeneity of data. Also it is weighty to establish information flow between communities that use geographic information in various environmental fields. All action related to spatial data as collecting new information, organize in groups, creating connection between them, logical links, correct and sufficient presentation and sharing can be realized by Geographical Information Systems, named GIS (Arnaudova et al., 2011). This kind of presentation of all necessary information is used by a lot of organization. With GIS modeling the spatial data can be ruled quickly and without repetitive actions. Basically to INSPIRE Directives and International Organization for Standardization (ISO) all necessary spatial data can be arranged in conceptual model, describing important points and activities for regular and useful land modeling. This kind of working will be workable for dealing with spatial data about vegetable crop production. Horticulture development is large range of different king of knowledge. It concerns climate, hydrography, soil, elevation, land cover, land use, coordinate reference systems, agricultural facilities, environmental monitoring facilities and many more. This report presents conceptual model for assessment of land using for sustainable horticulture using GIS and INSIRE Directives. Investigation purpose is to create comprehensive overview for development of vegetable cultivation. Using conceptual model we transforms abstraction of reality into new digital and logical information in order to respond to many unanswered questions and to give a forecast about further actions.

Materials and methods

Assessment of multiple geospatial information for vegetable production is a special complex of environmental factors. The most important factors, impact on the horticulture development are climate, soil, landscape, monitoring and agricultural facilities. The conceptual model will consist on appropriate selected information from real investigations.

Preparation of materials and data for GIS includes:

- **Geographic information**
  - ***Administrative maps*** of the region, municipality, digital cadastral maps and maps of reclaimed property in the studied area. The digital model formats are ZEM, CAD. The spatial data presenting geographical locations of the studied area is described by one of the INSIRE Directives, named D2.8.I.6 Data Specification on Cadastral Parcels-Technical Guidelines, 17.04.2014 (http://inspire.ec.europa.eu/index.cfm/pageid/2).
  - Data about ***Coordinate System***, used in studied area and points with coordinates from real measurements. This is realized by data specification, described by INSIRE theme: D2.8.I.1 6 Data Specification on Coordinate Reference Systems –Technical Guidelines, 17.04.2014 (http://inspire.ec.europa.eu/index.cfm/pageid/2).
- **Attribute information**
  - ***Climate***
    - Temperature
    - Sunshine duration
    - Precipitation
    - Irrigation
    - Humidity
    - Wind speed
    - Evapotranspiration
- Hydrography- nearest water resource: rivers, lakes, water tank, etc.

This is realized by data specification, described by INSIRE theme: D2.8.I.1 6 Data Specification on Atmospheric Conditions and Meteorological Geographical Features -Technical Guidelines, 17.04.2014(http://inspire.ec.europa.eu/index.cfm/pageid/2).

Elevation

- slope gradient
- surface orientation
- elevation and depth, accordingly to specified origin level

The necessary information about spatial data is on theme D2.8.II.1 Data Specification on Elevation-Technical Guidelines, 10.12.2013 (http://inspire.ec.europa.eu/index.cfm/pageid/2), by INSIRE Directives.

- ***Soil***
  - Soil type
  - Soil texture
  - Soil reaction-pH
  - Soil depth
  - Organic matter component
  - Soil fertility
  - Water holding capacity
  - Soil preparation
  - Soil erosion

The necessary information about spatial data is on theme D2.8.III.3 Data Specification on Soil-Technical Guidelines, 10.12.2013 (http://inspire.ec.europa.eu/index.cfm/pageid/2), by INSIRE Directives.

- ***Agricultural Facilities***
  - Irrigation
  - Road systems
  - Size of the fields
  - Mechanization of the activities
  - Agricultural equipment
  - Production transporting

The necessary information about spatial data is on theme D2.8.III.9 Data Specification on Agricultural and Aquaculture Facilities -Technical Guidelines, 10.12.2013 (http://inspire.ec.europa.eu/index.cfm/pageid/2), by INSIRE Directives.

- ***Land Use*** - socio-economic infrastructure of vegetable production
  - ♦ Marketing
  - ♦ Economy of the country
  - ♦ Demography parameters
  - ♦ Poverty
  - ♦ Standard of living
  - ♦ Income and expenditure
  - ♦ Employment
  - ♦ Existing road systems
  - ♦ Labor systems and mechanization of the working
  - ♦ Education and qualification
  - ♦ Population migration,
  - ♦ Prices of the vegetable
  - ♦ Different kind of investments, etc.
  - ♦ Production transporting

The necessary information about spatial data is on theme D2.8.II/III.7 Data Specification on Land Use - Technical Guidelines, 10.12.2013 (http://inspire.ec.europa.eu/index.cfm/pageid/2), by INSIRE Directives.

Spatial analyst of gathered data is accomplished by Analytical Hierarchy Process (AHP), developed by Saaty (1977). The AHP process is completed by alternative matrix, through weight in pair-wise comparisons. All mention spatial data specification is based on existing standards, as far as possible. International Organization for Standardization (ISO) presents all characteristics and variety for necessary data, using by GIS tools. Applying these standards to transform information from real measurements and investigations, all usable data can be operated by scientists from various counties, governments and political members.

Results

Geographical Information Systems (GIS) consists of various components, starting with the incorporation of geographical data from remote sensing sources or maps and is then converted into a computer-readable form (Baniya, 2008). Useful suitability assessments is based on biophysical and socio-economic resource information. The spatial data can be manipulated and overlaid for analytical operations. Agricultural suitability mapping involves identifying land use patterns and assessing whether the current use is the most feasible both economically and environmentally (Baniya, 2008). This functionality required to work with different data structures. Organizing and flexibly working with all collected information required to use conceptual model. Crop modeling, including soil/water requirement, geostatistical analysis, demography, land use, human development, investment capacity, government are critical at this stage to identify and make sense of complicated spatial relationships and, ultimately, substantiate trends and theories. The conceptual diagram helps to solving spatial problems depend on climate, soil, elevation, area structure and socio-economic conditions, visible appeared on the thematic map.

In the top of the conceptual model is an appropriate location for the vegetable cultivation. The area has to be studied carefully and to be taken different kind of information for past and present activities. This kind of data can be collected from ***Cadastral Maps*** (Parcels). INSIRE presented cadastral parcels as a geographical locators with information about geometry, unique identifier, area, owners, rights on parcels, defined by national lows and another characteristics. It is important for the research to know where is located the area and which are its specifications. This information will be useful for visualization of the results. There are also characteristics about boundaries and basic property units for describing the necessary information. GIS platform allows presenting all researched area for vegetable development into suitable map projections. This is realized by data specification, described Coordinate Reference Systems. These two basic characteristics of area presented by GIS applications detailed links all geographical information with real one on the earth.

The next level of the conceptual model for assessment of vegetable crop production is named ***Climate***. This step of modeling includes spatial data from real investigation, relevant to Atmospheric Conditions and Meteorological Geographical Features.The two themes are defined by the INSPIRE Directive as:

- Atmospheric conditions: physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurements locations;
- Meteorological geographical features: weather conditions and their measurements: precipitation, temperature, evapotranspiration, wind speed and direction (D2.8.III.13-14 Data Specification on Atmospheric Conditions and Meteorological Geographical Features -Technical Guidelines, 12.10.2013).

In addition to climate characteristics will be put the theme for Hydrography. It is related to nearly located naturally water resources like a river, lake, sea, etc. All these information of climate specification of the studied regions have significant influence on vegetable growing. Presented by GIS applications it will be easier to identify priority area for correctly and profitable horticulture. The specification of climate spatial data can be used for following three cases:

- Use of meteorology in support of environmental emergency response
- Flood forecasting
- Climate assessment (with past or predicted data).

After creating a climate assessment of vegetable plan production the next level of conceptual model is ***Elevation***. The specifications of this theme describe slope gradient, surface orientation, elevation and depth, accordingly to specified origin level. Using GIS tools all these information can be transformed and presented by creating Digital Terrain Model (DTM) and Digital Surface Model (DSM). This kind of representation of necessary spatial data allows creating 3D modeling of researched surfaces and quickly analyzing the past and present situation. In line with existing technologies three spatial representation methods have been offered: grid, of mandatory provision, as well as vector and triangulated irregular network (TIN), of optional provision (D2.8.II.1 Data Specification on Elevation-Technical Guidelines, 10.12.2013). Modeling by GIS application all terrain characteristics as coverage geometry, elevation values, break lines, etc. can be collected from topographical maps or real measurements. All elevation spatial information adds geometrical overview of the studied area. In this way vegetable fields can be designed with minimum waste of useful land.

Soil characteristics are one of the most important for sustainable horticulture. Multi-criteria assessment of soil specifications will give summary overview of land use for agriculture production. The research components of soil are: Soil type, Soil texture, Soil reaction-pH, Soil depth, Organic matter component, Soil fertility, Water holding capacity, Soil preparation, Soil erosion. All kind of information is collected by measurements, examinations, soil maps, etc. Refer to vegetable growing, soil have a significant influence on plans development. Also all these characteristics in some way can be improved according to different kind of vegetable requirements. The soil is a world of biodiversity, which influences on its organisms. Mixed all soil specifications in appropriate order, GIS modeling presents full soil assessment thematic map. This king of modern presentation of spatial data is useful for predictable actions and forecasts.

The next level of conceptual model for sustainable horticulture and mentioned in INSIRE Directives is ***Agricultural Facilities***. This theme consist spatial data about the arrangement of the territory. GIS analyzing is based on the kinds of irrigation, road systems, size of the fields, mechanization of the activities, agricultural equipment, production transporting, etc. These area facilities have to be carefully studied and transferred into spatial information. GIS applications create thematic map by analyzing all these characteristics of the environment. In this way it is easily to define the most appropriate side or necessary actions for good and useful horticultural practices.

The last level this research is named ***Land Use*** and includes socio-economic infrastructure of vegetable production. This group of spatial data is related to different information connected to marketing, economy of the country, demography parameters, poverty, standard of living, income and expenditure, employment, existing road systems, labor systems and mechanization of the working, education and qualification, population migration, prices of the vegetable, different kind of investments, etc. In this case spatial information is determined by a huge amount of different information. Socio-economic conditions can be organized into two categories: improvements defined by producers and improvements defined by government. In this way quickly can be analyzed data gathering and explored degree of influence according to any one activity and aspects. Creating GIS assessment by thematic map causes for some problems will appear also and the solution of the problems (Arnaudova, 2010).

The next figure presents spatial relationships concerned to collected data of environmental characteristics.

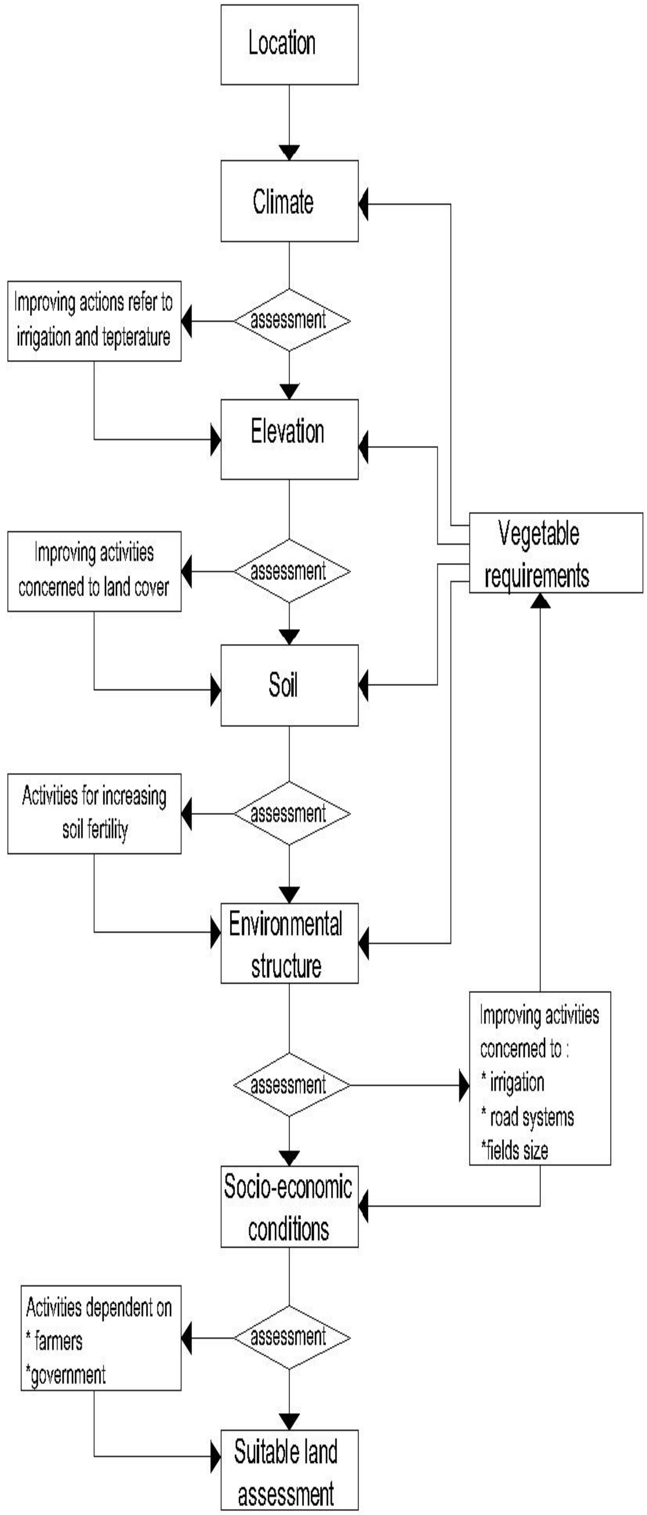

Figure 1: Conceptual model of suitable land assessment for vegetable development

Conceptual model of suitable land using for vegetable production is the framework about necessary using information and links between attributed and graphics data. GIS modeling combine different information layers and represent cross-sections of thematic maps, created by physical and socio-economic parameters of environment. Using well-known standards of ISO to describe important parameters for horticulture assessment, utilizing GIS applications produce suitable complex management for useful and rise growing cultivation of vegetable. ISO transforms information in common scientific language, accessible to ordinary people or for scientific purposes.

This framework helps us to create and organize spatial data and layers in GIS applications to achieve the final result- assessment map of vegetable crop production. All environmental characteristics are analyzed and the results appear on thematic maps (Arnaudova et al., 2011). The powerful query, analysis and integration mechanism of GIS, based on Analytical Hierarchy Process (AHP), makes it an ideal scientific tool to analyse it for land use planning. Agriculture GIS is a tool that can assist a community to plan and to support the information management during the agricultural production process. The final result is assessment map of sustainable land using for vegetable plan production.

An important advantage of GIS is the ability to update current ratings easily when new or better information becomes available (Pradhan et al., 2005) and the ability to obtain output from the improved model (Baniya, 2008). Multi-criteria land suitability evaluation in this study uses physical and environmental parameters, social attributes and economic indicator as necessary factors for best possible outcomes and vegetable yields. Spatial information like maps and land related attributive characteristics are incorporated into GIS tools as a system. Use of social and economic parameters through AHP analysis add development of vegetable cultivation about real situation of study area. GIS technique improves efficacy the outputs of the evaluation.

Conclusion

Vegetable cultivation is one of the most important part of agriculture development. All comprehensive conditions and factors, which influenced on plan production, are presented by conceptual model. Agriculture database activities as collecting, organizing, transforming, analyzing and presenting the land using of the studied area, are realized by GIS modeling. Establishing appropriate suitability factors is the construction of suitability analysis. It is very essential to understand environmental capacity to support appropriate vegetable cultivation. GIS analyzing gives us overview of all necessary factors and parameters for sustainable and profitable vegetable development. Using assessment maps agricultural activities can be planned for further improved activities and aimed minimizing yield losses. It is essential to can make forecast of vegetable benefits and to achieve complex management for improving environmental conditions.

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