Review Article

GEOGRAPHICAL ANALYSIS OF THE MUSHROOM GROWING POSSIBILITIES IN THE DEVELOPING COUNTRIES

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Abstract

Growing mushrooms (e.g. *Pleurotus ostreatus, Pleurotus eryngii, Lentinula edodes*) may be an opportunity to solve the problems of unemployment and provide an additional food source for the populations in developing countries. The possibilities of successful mushroom production must be responsibly examined and analysed. Geographical information systems (GIS) can play a key role in management, visualization and analysis of corresponding geographical data in digital form. These solutions can be used for example at consulting centres for the support of mushrooms production in the developing countries. These possibilities are demonstrated at the example of the mushroom growing in China.

Keywords: GIS; geospatial analysis; *Pleurotus ostreatus; Pleurotus eryngii; Lentinula edodes;* waste management.

INTRODUCTION

Production of mushrooms can be an excellent opportunity for the developing countries (Lu Min and Li Yu, 2006, Oei, 1996). Presently, China can be an inspiration in this context. Its leading position in the production of mushrooms shows Table 1.

Table 1: Mushroom production in China and in the world (source: CEFA)

Year	**World** (1 000 tons)	**China** (1 000 tons)	**China/world** *(%)*
1986	2 176	585	26.9
1990	3 763	1 000	26.6
1994	4 909	2 640	53.8
1997	6 158	3 415	55.5
2000	10 815	6 630	61.3
2004	12 250	8 560	70.6
2008	26 000	18 200	70.0

Successful mushroom growing in the developing countries must meet the following conditions:

- appropriate climatic conditions,
- workforce availability,
- raw material availability,
- availability of information support (consultation centres) (Vostrovský and Jablonská, 2007).

The successful implementation of a mushroom farming strategy in China offers the possibility to make a living for a large number of local farmers. The most important prerequisites for the production of mushrooms in developing countries that meet the above requirements are as follows:

- suitable climate,
- sufficiency of the workforce (costly mechanization must be compensated by cheap workforce),
- abundance of plant waste for the substrate,
- urgent need to solve the problem of lack of food protein and eliminating hunger of the human population.

China is becoming a dominant player in both fresh and processed mushroom markets in the world. The major destination for Chinese mushroom export is Asia, accounting for almost half of the total production (Fig. 1, Table 2).

The traditional mushroom production region is located in the south and south-east of China, where the climate is very suitable for mushroom cultivation. The main mushroom production areas in China are located in the provinces of Fujian, Zhejiang, Shandong, Henan, Heilongjiang, Sichuan, Jiangsu, Guangxi and Hebei (Fig. 2).

Mushroom production in China is dominated by small-scale households with an average size of 1-2 mu plastic tunnels (1 ha = 15 mu). Nevertheless, private mushroom companies at a scale of 10-15 ha can also be found in major production areas. These large companies are often engaged in the whole chain of mushroom business, from basic materials to cultivation to mushroom processing. In some cases, these private companies are working together with small-scale households in outgrowing schemes. Well harmonised to this seasonal pattern of mushroom growing is rice cultivation, which provides ample stocks of rice straw after the harvest at the end of the warm season. This straw is used as a raw material to prepare compost for the mushroom growing (Square, 2010).

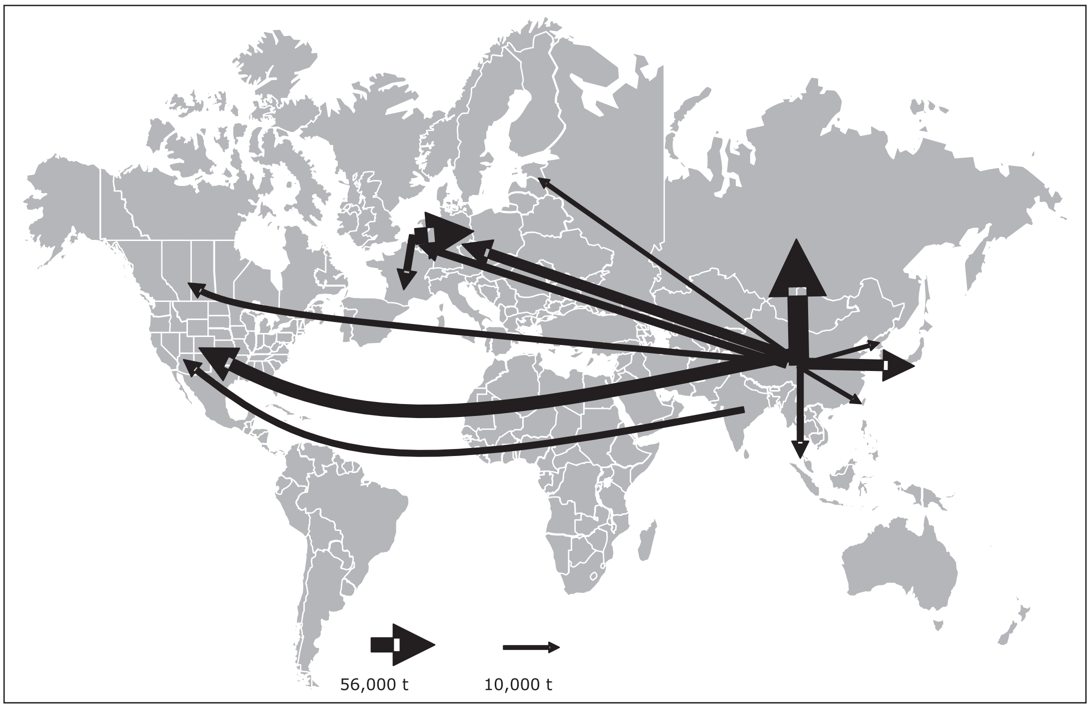

Figure 1: Routing of the Chinese mushroom export (source: UN-Comtrade, 2008)

Geographical analysis of potentially suitable areas for growing mushrooms in developing countries

The possibility of the successful mushroom growing in other developing countries must be responsibly examined and analysed. Goodchild (2006) defines the geospatial analysis as a set of techniques that requires both the locations of objects (spatial information) and their attributes. In this process, geographical information systems (GIS) can play a key role in the management, visualization and analysis of corresponding geographical data in digital format.

GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location (GIS, 2010). GIS integrates hardware, software, and data for capturing, managing, analyzing and displaying all forms of geographically referenced information. GIS allows view, understand, question, interpret and visualize data in many ways that reveal relationships, patterns and trends in the form of maps, globes, reports, and charts (Fig. 3). Coupled with GIS, geography is helping to better understand the earth and applies geographic knowledge to numerous agricultural activities and problems. The corresponding GIS technology offers the following tools (Klimešová, 2008):

- inventory GIS,
- control GIS and
- analytical GIS.

Table 2: Major destinations of Chinese mushroom export (source: Information Centre of the General Administration of Customs of the PRC)

	Quantity (tons)			**Proportion** (%)		
	1995	**2000**	**2003**	**1995**	**2000**	**2003**
Japan	58 059	70 582	80 857	23.0	25.3	23.0
Hong Kong	22 729	21 544	36 114	9.0	7.7	10.3
Germany	30 114	35 685	32 591	12.0	12.8	9.3
U.S.A.	39 532	8 556	26 442	15.7	3.1	7.5
Malaysia	6 833	8 604	18 044	2.7	3.1	5.3
Russia	472	3 370	12 684	0.2	1.2	3.6
Netherlands	5 464	17 004	12 509	2.2	6.1	3.6
South Korea	4 821	8 569	11 815	1.9	3.1	3.4
Total export:	**251 885**	**278 831**	**351 118**	**100.0**	**100.0**	**100.0**

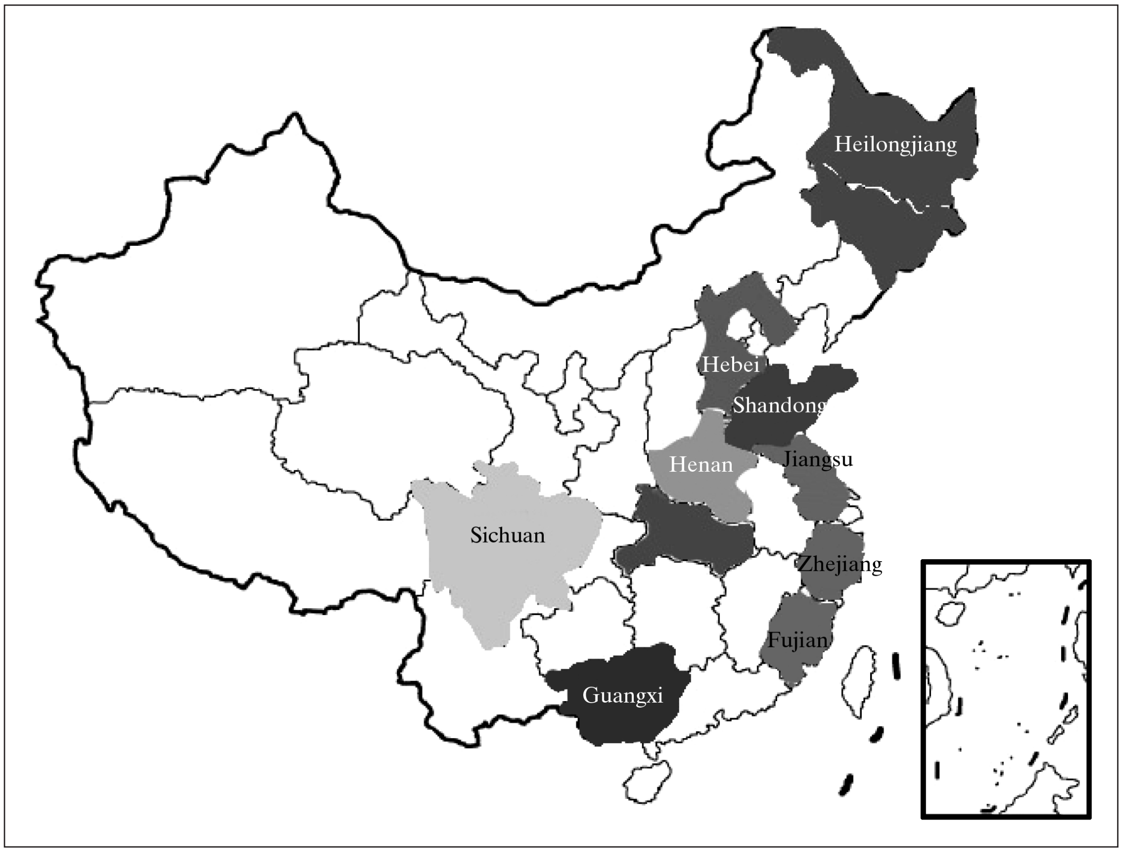

Figure 2: The traditional mushroom production China's regions (source: Rabobank, 2008)

To the inventory GIS fits the imagination of the cadastre. It is usually a large and masterly managed database where it is possible to find and also provide all information for touched sides and we can do it with comparatively simple function tools and with context corresponding to the reasonable number of information layers.

The top level of GIS usage is control GIS, where as touch information layers (themes) hold true the same as in case of analytical GIS and the large ability is aided to implement knowledge models from different branches of scientific investigation of around world for wide context of evident as well as less evident connections, models of trends, objects and expected or predicted relations (Benedikt et al., 2002).

The integral part of control GIS is the modelling where the information layers from real, artificial and virtual world are composed together to select an optimal scenario or verify a given hypothesis. The contextual design of spatial data and further development of geo-information technologies, image processing techniques and the possibilities of object history modelling together with the geographical networks environment will provide new and considerably wider possibilities of using GIS. GIS architecture is open to incorporate new requirements of knowledge-based analysis and modelling, namely in connection with web designed spatial databases and temporal oriented approaches.

For the analytical GIS it is typical, without accounting of the range of database, in some sense permanently growing and very changeable amount of information layers that cover the different extent of changeable area of interest and call for the application of sequences of whole scale of functions named before. For the mushrooms growing practice GIS offers the analysis of

- current mushroom growing localities in light of their attributes,
- potential mushroom growing localities in light of their usability and availability,
- potential markets,
- prognosis of the supposed economic benefit from the mushroom growing.

Most GIS offers the possibility to implement complex models covering a range of analytical functions. Aronoff (1989) stated the following categories of analytical functions of GIS:

- Retrieval, Reclassification, and Generalization. Retrieval involves a selective search, manipulation, and output data without having to alter their geographic location. Reclassification involves the selection and

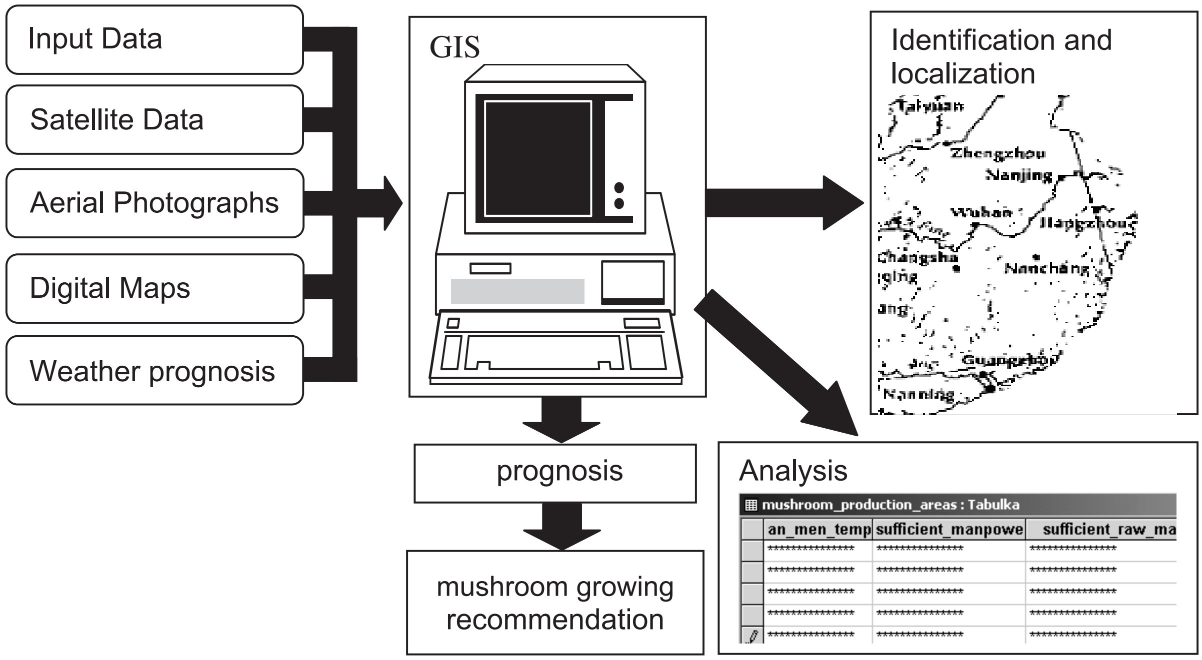

Figure 3: Data integration is the linking of information in different forms through GIS

presentation of the selected data layers based on the classes or specific attribute values. It is an analysis of one or more attributes within a single data layer, and their classification on the basis of a range of values.

- Topological Overlay Techniques. GIS software implements the overlay of layers by combining spatial and attributed data from these layers to create a new data layer.
- Neighbourhood Operations is to evaluate the characteristics of a neighbourhood place. This includes various techniques of interpolation points, including slope and aspect, contour generation calculations, and Thiessen polygons. Interpolation is a method of predicting unknown values through known values of neighbouring sites.
- Proximity analysis, Network analysis. Methods for analysis of proximity focused primarily on the proximity of one function to another, and this closeness is defined as the ability to identify all functions that are close to other functions based on the location, the value attribute or a specific distance. Network analysis uses the functions of networks. Examples of the method of network analysis may be a distribution of values for selected functions to determine the capacity of the zone, and to determine the shortest path between connected points or nodes in the network based on the values of attributes (Aronoff, 1989).

Other authors suggest similar possibilities of GIS technology (Longley, Batty, 1996), (Levine, et al., 1995). GISs have for these purposes, the database component (eg Query Builder in ESRI's ArcView GIS), which is sufficient for the above matters. Its usage for this purpose is based on the following principle: Current mushroom growing localities are limited by their parameters, e.g. place (including altitude), time, intensity, overall climate (weather), the abundance of plant waste etc. These parameters can be stored in a GIS application as the attributes of the table referring to these places – localities. If the current locations are sufficiently identified and located, one can then use simple or complex database queries, search for new potential sites with appropriate parameters. If the analytical capabilities of GIS database components were inadequate, it is not complicated to export attribute data into a highly specialized analytical instruments, process it and return the results back into the GIS to visualize their transparent. It is possible to run a more detailed analysis using other analytical methods such as e.g. determining the correlation or the method of regression. These methods are available, for example in Microsoft Excel, a built-in function, or it is possible to use formulas created in the cells of the table to calculate a function.

GIS can help to answer questions of the following types:

- Where are localities suitable for the efficient mushroom production in light of the abundance of plant waste for the substrate?
- Where are localities suitable for the efficient mushroom production in light of the suitable climate?

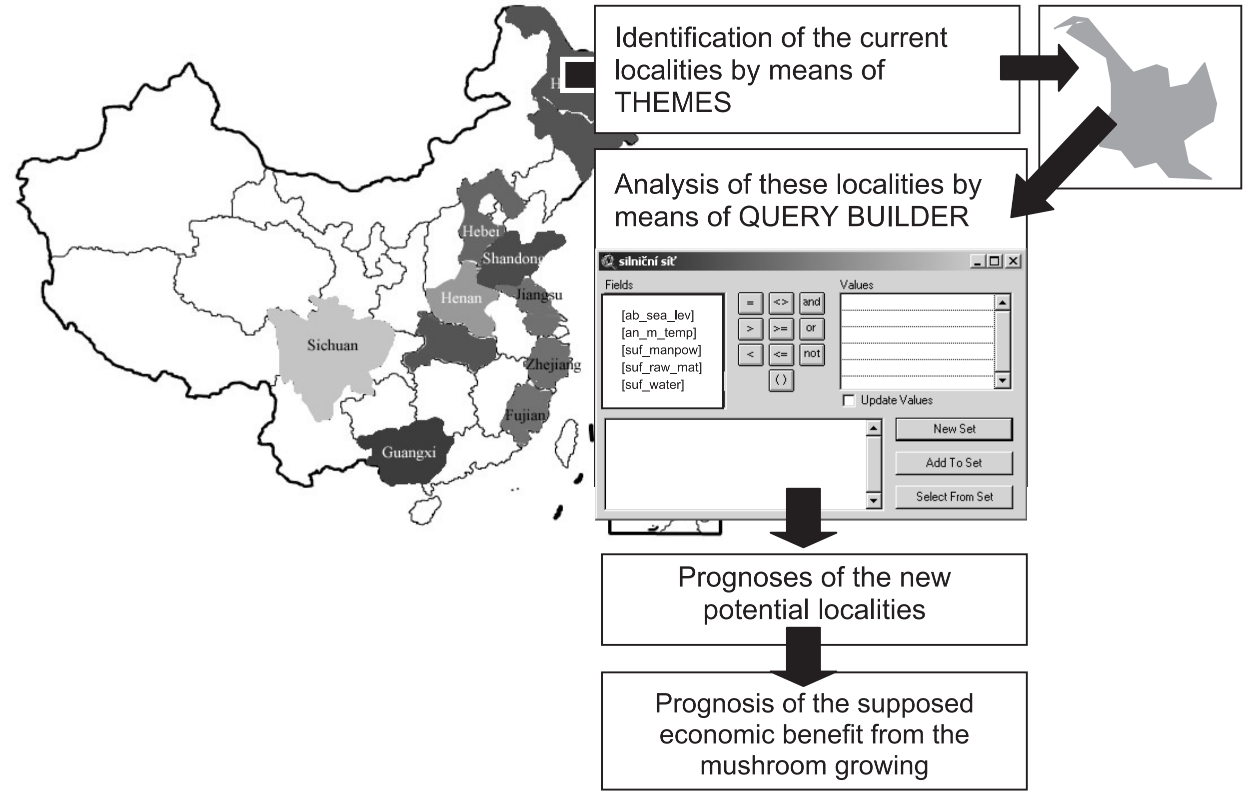

Figure 4: Principle of the designed GIS analysis of the new potential localities, suitable for mushroom growing

- Where are localities suitable for the efficient mushroom production in light of the sufficiency of the workforce?
- What are the shortest distances to potential markets?
- What economic benefit can be expected from the mushroom production in the new localities?

One of the best reasons to use a GIS is to unearth and analyze the geographic components of corresponding data. GIS products offer a bewildering array of report types. Reports can consist of paper maps, tables, charts, graphs, or computer images. Selecting which report type is the most useful will depend on the particular application (Cigliano et al., 1995). For viewing an overlay consisting of vegetation type, land use, rivers and roads, one would likely choose a simple paper map presentation.

Of course, in developing countries the affordability of the technology and somewhat limited financial capabilities play an important role. There is an entire range of free applications, so called open source of GIS (eg EDBS Reader, Fmaps, GeoTools, GRASS, OpenEV, OpenMap, Quantum GIS). The proposed solution is intended for the central authorities of the respective ministries of agriculture of the developing countries that these issues should be coordinated and managed. These institutions often have somewhat greater financial resources from various international development or support projects that allow them to buy more sophisticated tools (applications) such as ESRI's ArcView GIS.

The principle of the proposed GIS analysis of potential sites suitable for mushroom production is shown in Fig. 4.

CONCLUSIONS

Geographical analysis of the mushroom production possibilities in the new developing countries may help to solve:

- the problem of lack of protein in food and eliminating hunger
- problem of insufficiency of job opportunities
- utilization of abundance of plant waste (e.g. straw, bagasse, corn)
- reduction of environmental pollution
- lack of financial resources for establishment of modern enterprises

There is no doubt that the most expensive issues will be the acquisition of the spatial and attribute data. In this context, it can be assumed that the competent authorities of the Ministry of Agriculture recorded the vast majority of these data. This is often necessary for the purpose of drawing money from various international development programs (FAO development projects, WFP) to support agricultural production.

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