Preliminary analysis of viable spaces for horticulture in the micro region of São José dos Campos, Brazil: a subsidy for the discussion of land use and food security linkages.

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Abstract: In Brazil, Human Rights to Adequate Food was institutionalized in January 2010, incorporating adequate feed within the Citizens Social Rights as part of Brazilian Federal Constitution. Access to adequate food that guarantees and promotes such rights has been limited due to socioeconomic issues and environmental local and global changes. Expansion of cities in size and number, as well as population growth concentrated in urban areas might directly affect land availability for agriculture, reducing viable spaces near cities to produce fresh food in order to respond to the rise on demand for food by urban consumers. Vegetables are vital for a healthy human diet, and long market chains represent a damaging step between production and consumption, resulting in great losses due to high perishability, raising prices and difficulting access to food. Thus, the identification of near consumers areas suitable for vegetables´ production, can subsidize public policies and be part of adaptation mechanisms to achieve urban population' food security in future. This work aimed to apply GIS techniques to create a map of potential areas suitable for horticulture in the micro region of São José dos Campos, Brazil. We adopted biophysical, infrastructural and spatial zoning data combined by spatial analyses techniques and tools available in SPRING 4.3.3 software. The results provide a basis to support discussion among stakeholders by showing potential areas where horticulture could be developed, and that should be tackled as priority areas to improve the nutritional security for the citizens in this region in near future.

Key-words: GIS, horticulture, nutrition security, land use policy.

1. Introduction

Global changes can result in large uncertainties and vulnerability to human populations. There are several ways to reduce the vulnerability of populations to damage, such as reducing the probability of occurrence of events, adopting prevention and mitigation, and reducing the risks of people being harmed through adaptation, with the development of resistance mechanisms to impacts and improvement of their living conditions. Among the mechanisms of adaptation, those that seek to guarantee the sufficient production of quality food, the regularity of supply and the access to food, present themselves as one of the main challenges of today. And among the most significant global changes is the intense expansion of cities, which brings the "collateral" effect of reduction of food production spaces, while also promoting an increase in demand for food to urban populations, those depending almost totally of the purchases to gain access to food (FAO-FCIT & RUAF, 2009). So in this time of changes and uncertainty, it is necessary to identify and promote areas where it is possible to allocate food production to guarantee food security for society.

In Brazil, the National Council for Food and Nutrition Security-CONSEA in 2004, defined the concept of food security as "the realization of everyone's right to regular and

permanent access to quality food in sufficient quantity without compromising access to other essential needs, based on health promoting food practices that respect cultural diversity and that are socially, economically and environmentally sustainable." The document that presents the experience of building the Brazilian System and the National Policy for Food and Nutrition Security by CONSEA, states that the concept of food security and nutrition developed in Brazil, poses as a strategic objective and permanent public policy subordinated to principles of the Human Right to Adequate Food (HRAF) and Food Sovereignty, seeking to promote intersectional actions of public programs and social participation (BRASIL, 2009). The institution of a National Food and Nutrition Security System foreseen on the National Food Security Law (Law No. 11,346) signed by President Lula on September 15th, 2006, created the National Food Security and Nutrition System (SISAN) and determined the formulation a national intersectional policy: the National Policy on Food and Nutrition Security (PNSAN) which should guide the elaboration of development strategies, as well as the formulation of public policies in relation to their goals, means of implementation and monitoring instruments.

For the promotion of nutrition security, vegetables are essential for a balanced diet, as they are important sources of vitamins, minerals, carbohydrates, fiber and other substances such as b-carotene, contributing undoubtedly to human health (TOFANELLI, 2007), but their market chain is a complex stage between production and consumption and could difficult the access due to high prices and/or big losses due to the high rate of perishability of these products. In Brazil, the losses amount of losses in this chain is around 35%, equivalent to over 5.509 million tons, a sufficient quantity of vegetables to supply 29.3% of the population (53 million inhabitants) which is excluded from the food market due to insufficient income (VILELA, 2003). Urbanization is strongly associated with increased consumption and conversion of agricultural land into other uses, making essential infrastructure and logistics to feed the urban population, in addition to direct effects on reducing availability of land for agriculture (GODFRAY et al, 2010).

The role of land as a provider of food security, relates to the "Social Function of Property". Mentioned as a premise for the maintenance of property rights in the Federal Constitution of Brazil, 1988, certifies that land should meet the needs of its owner, but also be in tune with the expectations of the community to which it belongs. In Article 182, also in the Constitution, there is a requirement of a ‘Master Plan, a tool to guide policy planning, development and urban sprawl, and the definer of "social function" in the cities. This concept derives the Law No. 10.257/01, called the ‘City Statute, which governs the use of urban property for benefit of the collective good, safety and welfare of citizens, and environmental balance. And is up to the municipal administrations to discover the economic and social vocation of municipalities, and to perform the management and planning of cities targeted effectively to the collective interest (ZANOTI,2003). In the current context, planning on the scale of one municipality would be enough? In times of globalization, when the connections on space reaches far distances, some agents tend to articulate and organize themselves into increasingly larger scales, pointing the need to increase the intermunicipal cooperation. Local sustainability and food security could strengthen with the inclusion of food production through supralocal agreements that favor the preservation of specific areas for this activity. But that requires a careful analysis of the land use and cover in the municipalities and their socio-bio-physical conditions to identify the strengths and possibilities that can be discussed at the formation of supramunicipals cooperatives, being GIS techniques fundamental at this stage.

In this context, as a preliminary assessment, this study aims to identify areas not yet urbanized in the eight municipalities within the micro-region of São José dos Campos, Brazil (Caçapava, Igaratá, Jacareí, Pindamonhangaba, São José dos Campos, Santa Branca, Taubaté

and Tremembé) and that are suitable for horticulture and could be protected in some way. As a result, intends to produce a suitability map for Horticulture, which may be useful to the discussion about land use and the promotion of food security for the local population.

2. Characterization of the Study Area

The micro-region of São José dos Campos, also known as Urban Cluster of São José dos Campos, is one of micro regions of the Brazilian state of São Paulo, belonging to "Vale do Paraíba Paulista" meso region (Figure 1). Its population is 1,415,146 people (IBGE/2011) and is divided into eight municipalities. It has a total area of 4,046.423 km², a GDP of $ 29.782,690,000 IBGE/2007 and a GDP per capita of U.S. $ 26,646.00 (IBGE/2006).

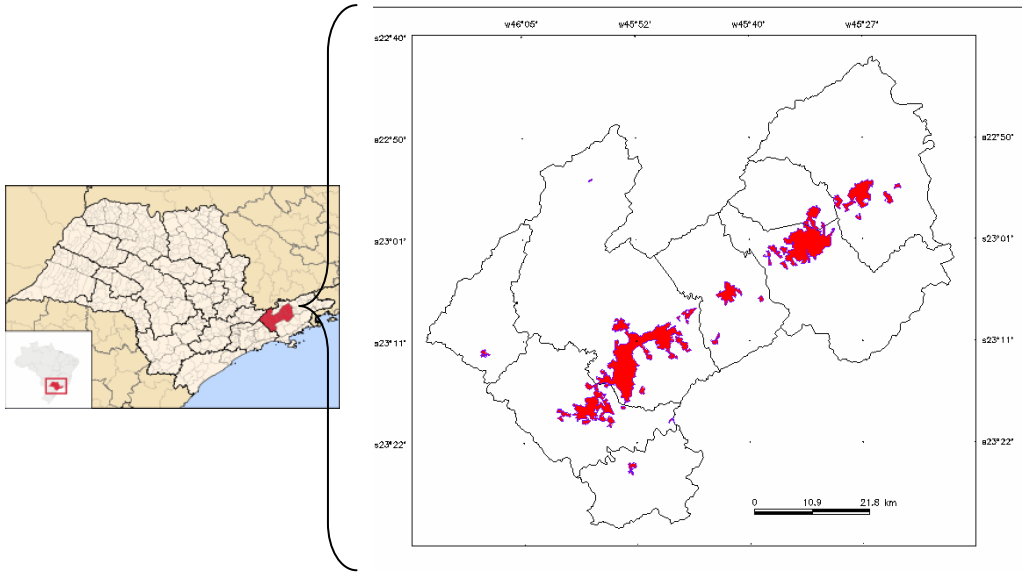

Figure 1. Localization of São José dos Campos (SJC) micro region.

Despite the economic and services activities be dominant, the micro region produce some agricultural products. The growing of vegetables for the local market, although far short of demand, according to oral information obtained from the CEAGESP-SJC and Census of agricultural production units of the State of São Paulo (LUPA), presents approximately 12,595.4 hectares (SÃO PAULO, 2008) - see Figure 2.

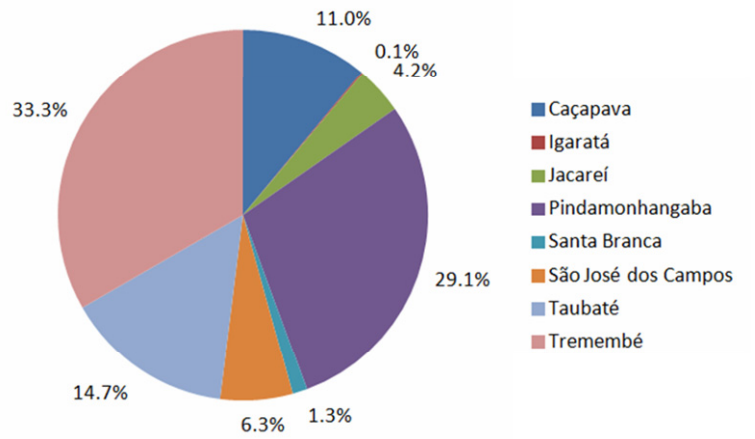

Figure 2. Percentage of cultivated area for each crop in Micro Region SJC. Source: LUPA, 2008.

Crops grown in the micro São José dos Campos accordingly to LUPA (SÃO PAULO, 2008) are as follows: Pumpkin, Lettuce, Banana, Sweet potato, Eggplant, Beets, Broccoli, Onion, Scallion, Carrot, Chayote, Mushroom, Cabbage, Cauliflower, Medicinal and aromatic herbs, Spinach, Beans, Green beans, Yams, Scarlet Eggplant, Arracacha, Sweet corn, Cucumber, Pepper, Chili, Okra, Cabbage and Tomato.

3. Methods

3.1. Data base

For the identification of areas with potential for vegetable crops, were necessary digital data containing information about the physical characteristics and structures present in the geographic space, such as roads, hydrography, slope, soil map, presence of environmental preservation areas, and urban spots. The following data were used:

Table 1.Description of source database adopted.

Name	Type	Geometry	Projection	Datum	Unit	Spatial scale	Source	Year
Limits of Municipalities	Cadastral	poligons	UTM zone 23	SAD69	degrees	1:500.000	IBGE	2005
Limits of Micro Region	Cadastral	poligons	UTM zone 23	SAD69	degrees	1:500.000	IBGE	2005
Urban Spot	Cadastral	poligons	Lat Long	SAD69	degrees	1:50.000	DAEE	2008
Soil Maps	Cadastral	poligons	Lat Long	SAD69	degrees	1:50.000	EMBRAPA	2010
Slope - topodata	Numeric	grade-Geotiff	Lat Long	SAD69	%	1:250.000	TOPODATA	2009 and 2010
Hidrography (Drain and drenage)	Cadastral	Lines	Conic of Lambert	SAD69	meters	1:50.000	DAEE/ PPMA / IGC	2008
Hidrography (Dams)	Cadastral	Lines	Conic of Lambert	SAD69	meters	1:50.000	DAEE/ PPMA / IGC	2008
Permanent Preservation Areas - APAs	Cadastral	poligons	UTM zone 23	SAD69	meters	1:50.000	DAEE	2008
Road System (Trails, Ways, Sreets and other routes, Unpaved Road, Paved Road. And the shape of Railways)	Cadastral	Lines	Conic of Lambert	SAD69	meters	1:50.000	DAEE	2008

3.2. Complementary data

Consultations were needed on socioeconomic data and stocks in the IBGE 2010 database, to characterize the study region. Also information about crop area and production per municipality were collected from research institutions, local and state agencies related to agriculture, information on marketing at the CEAGESP-Regional Unit São José dos Campos and through some informal interviews with merchants in São José dos Campos. Consultations were also held on master plans and legislation in order to understand the current dynamics and future demand.

3.3. Data treatment

To conduct the processing and data analysis we adopted SPRING 4.3.3 software. The project adopted UTM zone 23 projection, Datum SAD69. The data acquired were mostly in the cadastral form, so they were converted to numerical models, using tools available in SPRING. The main steps were: (1) Creation of the Database, (2) Definition and Creation of categories, (3) Creation and Import of IPs (cadastral), (4) Data Preparation, (5) Creation of Thematic Category, and transformation of IPs in matrix format, (6) Crossing data - Making inferences and (7) Use of LEGAL for the final map of potentiality.

A relational database allows the realization of spatial analysis using algebra maps. Spatial analysis uses spatial and non-spatial attributes of graphical entities stored in spatial database to make simulations on real-world phenomena. The algebra map is implemented through the LEGAL (GIS Spatial Algebraic Language), a query and spatial manipulation language that performs operations such as, Boolean operations, conditional, mathematics, continuous rating, neighbors and reclassification by attributes over the following data types: thematic maps, numerical model of terrain and image processing. A LEGAL program is composed of three parts: declarations, instantiations and operations. The Declaration defines the data and each plan information (PI) is declared to be manipulated explicitly, giving it a name and associating it with its category in the conceptual schema, the instantiation, recover existing data bank up data or create new IPs and new PI can then be combined with the result of operations LEGAL; Operation and perform the operations of algebra maps (INPE, 2006).

First was defined the area (mask) where is the practice of horticulture is totally unviable, either physically (extremely steep slopes, waterways, and paved areas such as roads, or the urbanized area itself (at the scale of this study) or by legal aspects, as buffer zones for Permanent Preservation Areas (there were no protected areas in the study area), on the margins of watercourses, and areas on the margins of roads and highways. Buffers were created for setting these areas. The Department of Roads (DER-SP) from the Transportation Secretariat of the State of São Paulo, through the Public Utility Decree from August 2005, determines the tracks for buffer along the highways prioritizing safety, according to the breadth and characteristics of highway: highway vicinal (range 30 m wide), one-lane highway (range 50 m wide) two-lane highway, with reduced median (range 100 m wide), two-lane highway, with wide median and access control, ie, Class Zero (range of at least 100 meters wide).. Then criteria were defined for Roads, Water Courses: Permanent protection areas (APPs), Soils, Slope, Distance from roads, Distance from water for irrigation, and Distance from an urban area (consumer market), following the rules of Brazilian laws and literature. The APPs of watercourses margins were delimited according to the width of the river, as established in the Forest Code (BRAZIL, 1989), 2nd Article.

For soil classification, Bertolini and Bellinazzi Jr (1994), claim that the areas can be assessed accordingly to the morphodynamic vulnerability of environments from each local building categories of potential instability. According to the authors, the classes can be defined as: Strong, Moderate or Low. The Brazilian System of Soil Classification (EMBRAPA, 2006) classifies soils as: Argisols, Spodosols, Cambisols, Gleisols, Histosols. Therefore, following the characteristics given in relation to erodibility of areas (Bertolini and Bellinazzi Jr, 1994) and to the soils' general characteristics according to the classification of EMBRAPA (2006), were determined ranges of classification for each type of soil in relation to the potential condition of areas to accommodate growing vegetables: Agisols (good), Spodosols (moderate), Cambisols (bad), / Gleissolos / Histosols (very bad) and Rock (null).

For the definition of classes for slope, was adopted the criteria proposed by Ramalho Filho and Beek (1995). However, the classes presented by these authors were rearranged, resulting in four slope classes for defining the potential land analyzed: Plan (0-13%-good), Soft (13-20% - moderate), Wavy (20-45% bad) and Hilly Steep (> 45% - improper).

The definition of the roads' distances were done considering the maximum distances of the limits of the micro region, and arbitrarily defined the distance ranges between areas of potential for horticulture and the nearest road to production flow (until 05Km, between 05Km and 10km; and greater than 10Km) and applied as a buffer over the IP 'Road'. However, when working the GIS data, due to the large number of roads, these ranges do not demonstrate a differential response. It was necessary to perform a fine adjustment by modifying the values for: up to 1km (good), from 1km to 3km (moderate), and greater than 3 km (bad).

The definition of distance classes for irrigation was arbitrary, with values of maximum distance between the points and the nearest rivers, where it would be possible to collect water needed for irrigation system. Issues related to the flow or water quality of these rivers were not considered. It was also not possible to consider the existence of other ways to collect water, as wells, as there was no data for such analysis. The distances were defined as: good (< 1 km), moderate (1 km – 3km) and bad (> 3km). And for the definition of the classes of distance to Consumer Market, the urban spots were considered as urban market area. Ueno (1985, apud Sato et al, 2006) found that with expansion of the urbanization of São Paulo city, the origin of the vegetables sold in CEAGESP were more distant regions, about 50-80 km from the city. Given the size of the micro region of São José dos Campos, the distances were set arbitrarily in radius of 10km (good), 10km to 30km (moderate) and 30km (bad).

4. Results and Discussion

After creating the database in Spring 4.3.3 software and the procedures necessary for data processing, the procedures for creating the map of potentiality has begun. The crossing of the data IPs 'Hydrography', 'APAs' and 'Roads', with their respective buffers, and 'Urban Spot', generated the IP "APT_Null", null potential of serving as an exclusion mask. About IP 'Roads', maps were created distance maps (buffers), for ranges up to 1km, from 1km and 3km, and greater than 3Km, resulting in the IP "Buffer_Roads"). About IP "Rivers" of hydrography, distance maps (buffers) were created, for ranges up to 100m, between 100m and 300m, and greater than 300m, resulting in the IP "Buffer_Rivers". About IP "Urban_Spot" distance maps were created (buffers) for ranges up to 10Km, between 10Km and 30Km, and greater than 30Km, resulting in the IP "Buffer_Urban". The IP "Soil_Map" after selection by attributes and reclassification gave origin to the thematic IP "Solos". The TOPODATA slope was sliced to give origin to the thematic IP "DeclTem" containing classes of slope levels in percent. To finalize the intersection of data that that would allow the definition of areas with low, moderate or high potential for cultivation of vegetables, the LEGAL tool was used by annotating a script, containing the decision rules for the decision between the classes considered in information plans to be crossed. Several attempts were made until all errors identified by the program were corrected. Rolling the last script, the Spring software then presented the results on a spatialized format, for potential classes pre-defined, selecting the areas classified as "unfit" = to areas where it is not possible to practice horticulture; "bad" = for areas with low potential; "regular" = for areas with moderate potential, "suitable" = for areas with suitable potential. Figure 3 shows the graphical result of classified areas by LEGAL.

The result seems consistent for most of the variables analyzed. However, the abrupt transition of areas "suitable" to "unfit", especially in areas close to rivers, seems to be incoherent, and could be due to the scale of analysis or the need for further adjustment in the model developed in LEGAL. Separating only the class "suitable", we can visualize the final result for areas with good potential for the practice of horticulture. In this preliminary assessment, the total area considered 'suitable' corresponds to 118,906.59 hectares (see figure 03). Reminding that the result of cultivated areas with vegetable crops in the micro region of

São José dos Campos in 2008 was 12,595.4 ha (São Paulo, 2008), this can make room for new research, more precise, that considers other data, such as detailed mapping of land use, areas of access to groundwater, and others.

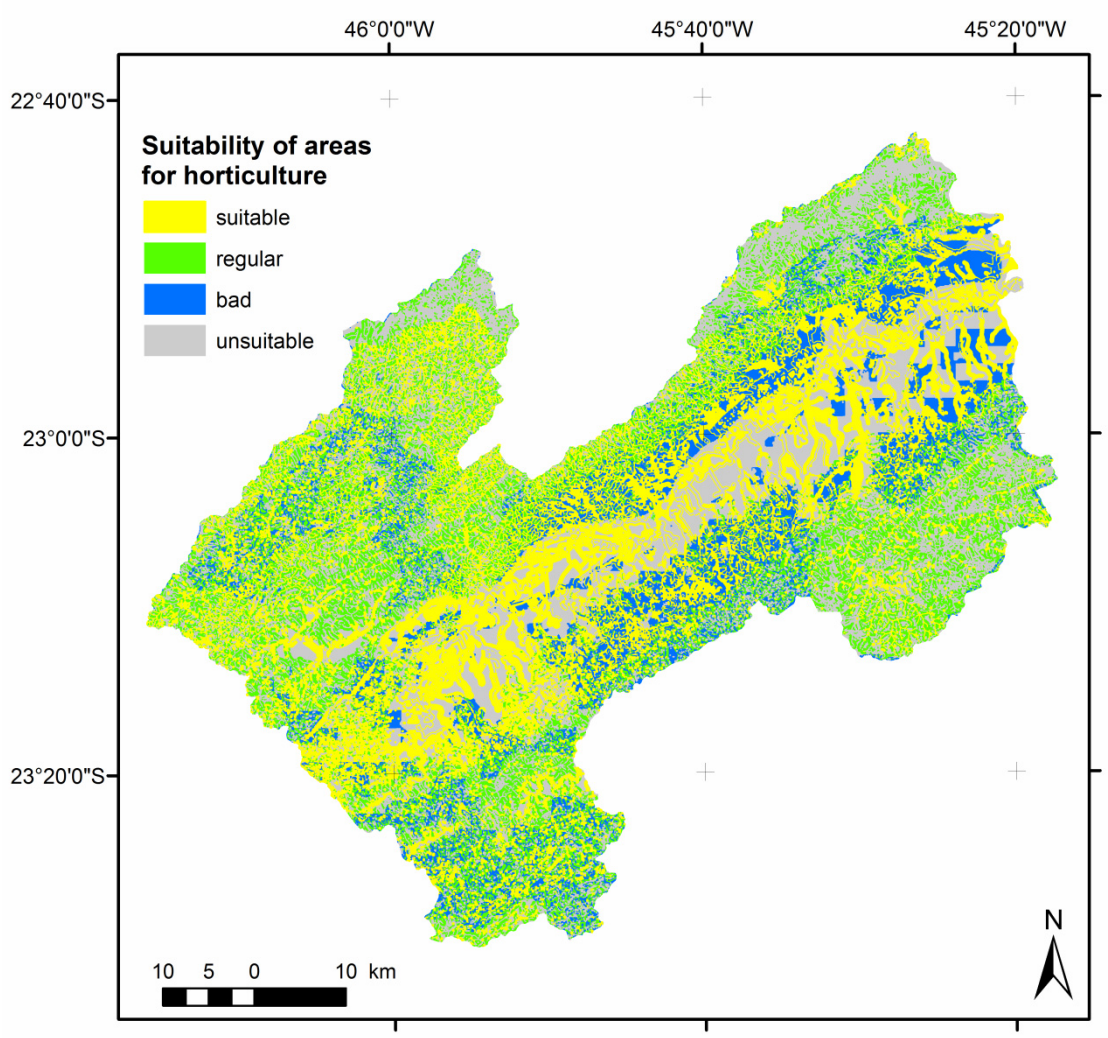

Figure 03. Suitable areas for horticulture in the Micro Region of São José dos Campos, Brazil

5. Conclusion and recommendations

During the proceedings, a great difficulty with the determination of weights involved in the classification of each variable was faced. Although the literature provides a direction for the choice, it is not an absolute truth. The choice is not free of strong subjectivity, which can lead to errors in judging the criteria adopted, and can be reflected in the final result. Also the lack of knowledge and field reference on the study area hinders the understanding of the problem and the critical analysis of the results obtained. For further analysis, other important factors must be taken into consideration, such as the land current use. On this scale of study, however, it shows up broad possibilities for encouraging new areas of horticulture, which should be discussed by society, noting that to do so more conclusive studies should be conducted. Therefore, more field visits are required to validate the result; deepen its study considering other variables, besides the need of higher knowledge of production and marketing of vegetable crops in the micro region of São José dos Campos. It is noteworthy, however, that the analyzes from GIS tools can help in discussions between government and

society on the role and use of land, in decision making by the Public Authorities regarding land management, and is an important tool in the search for a sustainable future.

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