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Research note

Spatial model of potential areas for avocado plantations in the State of Mexico

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Abstract

In recent years, avocado has become one of the most important and demanded crops internationally, Mexico has 30% of the world's production and the State of Mexico is the third producer nationwide, a situation that favors the excessive expansion of this crop in the state. For this reason, this research aimed to identify regions with optimal and suboptimal potential for the establishment of avocado plantations in the municipalities of: Coatepec Harinas, Donato Guerra, Temascaltepec and Tenancingo in the State of Mexico. The study was carried out in three stages, the integration of a geospatial database in the environment of geographic information systems, the construction of criteria for the analysis and weighting of territorial variables, and the development and validation of a potential allocation model for avocado crops. As a result, the areas that showed optimal potential represent a total of 9 543.82 ha, located south of the municipalities, distributed as follows: 3 261.2 ha in Coatepec Harinas, 2 973.87 ha in Temascaltepec, 2 124.41 ha in Donato Guerra, and 1 184.33 ha in Tenancingo. The areas with suboptimal potential represent a total of 6 098.54 ha, of which Coatepec Harinas has 2 183.63 ha, Temascaltepec 1 846.41 ha, Donato Guerra 1 326.34 ha, and Tenancingo 742.16 ha. The high potential of the different municipalities of the State of Mexico does not indicate that the entire area has the right conditions for the establishment of avocado crops.

Keywords:

agronomic potential, avocado crops, multivariate GIS analysis.

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Avocado (*Persea americana* Mill.) has been of interest to farmers as an alternative for the diversification of crops with high yield, profitability, and commercial and nutritional importance. In the State of Mexico, Coatepec Harinas produces 25% of the avocado in an area of 2 177 ha; in other words, one out of every four fruits in the State of Mexico comes from this municipality (El Financiero, 2019). According to the information reported by SIAP (2023), other municipalities contribute with large avocado areas, such as: Tenancingo 884 ha with a harvested area of 846 ha and production of 9 977.18 t, Temascaltepec 1 887 ha with a harvested area of 1 599 ha and production of 14 982.69 t, and Donato Guerra 1 533 ha with a harvested area of 1 329 and production of 15 515.41 t.

The increase in the cultivated area was motivated by the increase in the volume of avocado exports since 2000 and as a consequence of the sale price taking a considerable upward trend, which aroused greater interest in venturing into the production of this fruit (SENASICA, 2022). That is why it is necessary to practice a more productive agriculture with a lower level of risk, seeking the production of crops in environments that provide conditions that satisfy the agroecological requirements of the plants. This implies a zoning of crops that allows the identification of areas with different levels of agroecological suitability, from the marginal to the optimal (Ruiz, 1999). In Mexico, the National Institute of Forestry, Agriculture and Livestock Research (INIFAP, for its acronym in Spanish) has determined the productive potential of various crops using geographic information systems (GISs) by integrating information obtained from satellite images, aerial photographs, and information presented in maps and georeferenced databases (Reyes *et al*., 2017).

The importance of optimizing avocado production was considered and recognizing the need for more specific studies due to its high demand, the objective of this research was to identify regions with optimal and suboptimal potential for the establishment of avocado plantations in the municipalities of Coatepec Harinas, Donato Guerra, Temascaltepec, and Tenancingo in the State of Mexico.

The study was carried out in four municipalities in the south of the State of Mexico: Coatepec Harinas, Donato Guerra, Tenancingo and Temascaltepec, located at parallels 19° 25’ 51” and 18° 46’ 58.14” north latitude and 100° 19’ 59” and 99° 28’ 46.45” west longitude. The study was carried out in three stages, the first was the integration of a geospatial database in a GIS environment, the second was the construction of criteria for the analysis and weighting of territorial variables, and the third was the development and validation of a potential allocation model for avocado crops.

Different repositories of open geographic information were consulted, such as: (INEGI, 2020; Atlas de Riesgos Ante el Cambio Climático en el Estado de México, 2023), from which the following layers were extracted: edaphology, average annual temperature, land use, average annual precipitation, contour lines and state boundary, as well as four images obtained by the Sentinel 2 sensor of (Agencia Espacial Europea, 2022) (Table 1).

Table 1. Cartography used in the preparation of a map of suitability and agroecological requirements for Hass avocado crops.

Coverage	Source	Scale	Minimum value	Optimal value	Maximum value
Climate	Atlas de riesgos climatológicos	1: 250 000	Vertisol		
Edaphology	Atlas de riesgos climáticos	1: 250 000	12 °C	Andosol	Vertisol
Average annual temperature	Atlas de riesgos climáticos	1: 250 000		12 - 22 °C	27 °C
Land use	Atlas de riesgos climáticos	1: 250 000			
Average annual precipitation	INEGI	1: 250 000	850 mm	1 000 - 1 400 mm	1 800 mm
Contour line	INEGI	1: 250 000	1 400 masl	1 600 - 2 200 masl	2 400 masl

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Coverage	Source	Scale	Minimum value	Optimal value	Maximum value
DEM based on contour lines	Preparation based on contour lines	1: 250 000			
Slopes based on DEM	Preparation based on DEM	1: 250 000	1%	5-10%	20%
State boundary	INEGI	1: 250 000			
Sentinel 2 satellite images	European Space Agency	10 m/pixel			

The maps were joined when necessary and reprojected to the UTM Zone 14 N coordinate system with the datum WGS1984. Their related data tables were recoded based on potential criteria, generating a new suitability field. They were later converted to raster format.

A weighted overlay was developed in ArcGIS™ by integrating the suitability values of each of the variables (Table 1) and recoded, restricting those areas that one wants to exclude from the analysis and weighting each input layer according to its weight of influence on avocado crops, this weight is expressed as a percentage and the sum of the percentage weights of influence of all variables is 100 (Table 1).

A mask that excludes areas of high reflectance was applied to the resulting model. This mask was derived from the Sentinel 2B sensor scenes from November 7, 2022. These were subsampled to extract only bands 2, 3, 4, 8, 11 and 12, which are compatible with those regions covered by Landsat ETM, in order to subsequently calculate the Tasseled Cap transformation (Kauth and Thomas, 1976). This transformation synthesizes the values of the bands in the image by generating three new bands of information by multiplying them by defined factors, which show the brightness, greenness, and humidity in the image.

Subsequently, band 1 (corresponding to brightness) was reclassified using the isodata unsupervised classification method in the Envi software. This allowed the highly reflective pixels to be extracted and this surface was subtracted from the suitability model to remove these regions that were impossible for the crop.

The result of the suitability map indicates that the area with optimal suitability for the establishment of avocado crops is 120 262.91 ha, while 100 237.27 ha have suboptimal suitability and 10 481.82 ha do not have the conditions for this crop. Likewise, Coatepec Harinas is the municipality with the largest area with optimal suitability for the establishment of this crop with 3 261.2 ha, followed by Temascaltepec with 2 973.83 ha, Donato Guerra with 2 124.41 ha, and Tenancingo with 1 184.33 ha. The areas with suboptimal potential represent a total of 6 098.54 ha, of which Coatepec Harinas has 2 183.63 ha, Temascaltepec 1 846.41 ha, Donato Guerra 1 326.34 ha and Tenancingo 742.16 ha.

In the suitability map with overlay of avocado crop points (Figure 1), it was observed that the trend of areas with potential for the crop is towards the south of the municipalities, showing that, in Donato Guerra, the current plantations are developed in areas with high potential, in contrast to the current plantations in the municipalities of Temascaltepec, Coatepec Harinas and Tenancingo, which are located in areas with suboptimal suitability and unsuitable areas.

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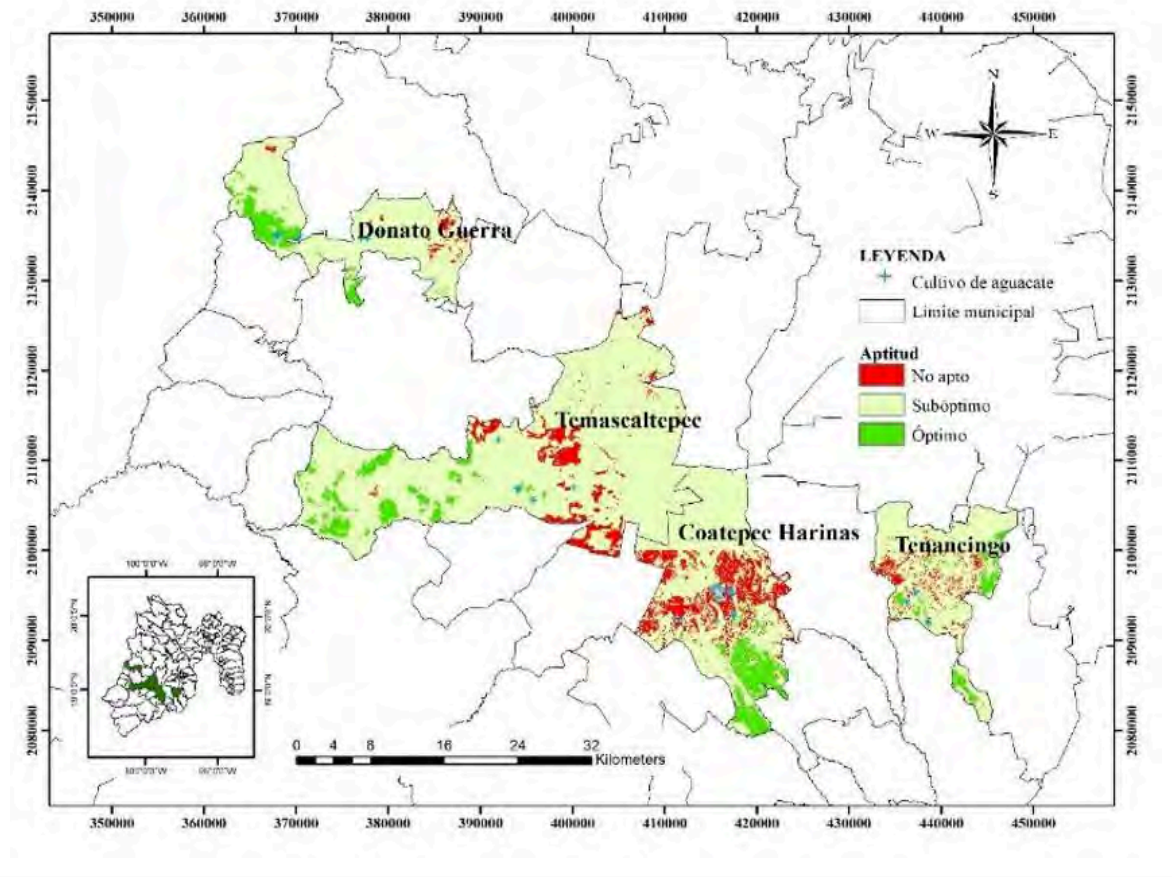
Figure 1. Suitability map with overlay of avocado crop points.



The establishment has not been based on the necessary analyses to determine the territorial potential, propagating it without considering the needs of the species, compromising the results of adaptation and yield of the crop, so it is inferred that the high potential of the different municipalities of the State of Mexico does not indicate that the entire area has the appropriate conditions for the establishment of avocado crops.

The results obtained coincide with those reported by INIFAP (2012); INIFAP (2012b), who mention that the Rural Development Districts (RDDs): Coatepec Harinas, Valle de Bravo, and Tejupilco have as their center of attention for rural development (CADER, for its acronym in Spanish) these localities as potential for avocado crops; likewise, in 2019, the Secretariat of Agriculture and Rural Development (SADER, for its acronym in Spanish), in its publication named advance of avocado production in the State of Mexico, points out that the State of Mexico is one of the most important states in terms of avocado production and some of the municipalities where the highest avocado production is recorded are: Coatepec Harinas, Donato Guerra, Temascaltepec, Tenancingo, Valle de Bravo and Villa de Allende.

Derived from the results, GISs are an efficient and accurate alternative that allows pertinent decision-making in the agricultural area. With the data obtained, those interested in the subject can carry out a more productive agriculture with a lower level of risk and an accurate planning of crop expansion programs, seeking production in environments that provide conditions that satisfy the agroecological requirements of the plants. This implies a zoning of crops that allows the identification of areas and periods with different levels of agroecological suitability, from the marginal, where the crop hardly satisfies its ecological needs, to the optimal, where the crop fully satisfies these requirements (Ruiz *et al*., 1999).

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Conclusions

The municipality of Coatepec Harinas is the one with the largest optimal area for the establishment of avocado crops, with 3 261.2 ha. Most of the plantations established in the study area are not located in areas with optimal characteristics for avocado crops, so it can be said that the high potential of the different municipalities of the State of Mexico does not indicate that the entire area has the appropriate conditions for the establishment of avocado crops. Geographic information systems are a tool with the appropriate versatility to know, visualize and propose the best options for decision-making and future planning of the available resources.

Bibliography

1 Atlas de Riesgos Ante el Cambio Climático en el Estado de México. 2023.Atlas de Riesgos Ante el Cambio Climático en el Estado de México http://ieecc.edomex.gob.mx/altas-riesgos.

2 El Financiero. 2019. Edomex buscará tener primera planta certificada de aguacate. https://www.elfinanciero.com.mx/nacional/edomex-buscara-tener-primeraplantacertificada-de-aguacate.

3 European Space Agency. 2022. ESA. El programa Copérnico. http://www.esa.int/esl/ESA-in-your-country/Spain/El-programa-Copernico.

4 INEGI. 2020. Instituto Nacional de Estadística y Geografía. Biblioteca digital de mapas. https://www.inegi.org.mx/app/mapas/.

5 INIFAP. 2012. Instituto Nacional de Investigaciones forestales, Agrícolas y Pecuarias. Determinación del potencial productivo en cultivos prioritarios en el Estado de México. Zinacantepec, Estado de México.

6 INIFAP. 2012b. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Determinación del potencial productivo en cultivos prioritarios en el Estado de México. Zinacantepec, México. https://isbn.cloud/9786074259476/determinacion-del-potencial-productivo-en-cultivos-prioritarios-en-el-estado-de-mexico/.

7 Kauth, R. J. and Thomas, G. S. 1976. The Tasselled Cap-A Graphic Description of the Spectral-Temporal Development of Agricultural Crops as Seen by LANDSAT. LARS Symposia. 159 p.

8 Reyes, A. J. C.; Monteagudo, R. O.; Valdez, P. M. E.; Mejía, C. J.; Espíndola, B. M. y Urbina, S. E. 2017. Modelo fenológico para el aguacate “Hass” en el Estado de México. Memorias del V congreso latinoamericano del aguacate. Jalisco, México. 302-308 pp.

9 Ruiz, C. J. A. 1999. Determinación del potencial productivo de la costa sur de Jalisco. Estudio piloto. Informe de investigación INIFAP-Campo Experimental Centro de Jalisco.

10 SENASICA. 2022. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. Impacto económico potencial de *Xyleborus glabratus* - *Raffaelea lauricola* en el cultivo de aguacate, en el estado de Michoacán, México. https://dj.senasica.gob.mx/Contenido/files/2022/septiembre/Impactoecon%C3%B3micopotencialdeXyleborusglabratusRaffaelealauricolaenelcultivodeaguacate,enelEstadodeMichoac%C3%A1n-4effcb0b-2b30-4ad2 abce-38360657eee5.pdf.

11 SIAP. 2023. Servicio de Información Agroalimentaria y Pesquera. http://www.siap.gob.mx/.

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