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Spatial ecological risk analysis in peach farming in Manisa

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ABSTRACT

With the help of information technologies, which are developing day by day, it has become easier to perform agricultural analyzes. Positional analyses can be performed with the help of Geographical Information Systems by gathering Climate, Soil, Topography and İrrigation data related to Agriculture. These analyses enables to generate analyses for agricultural investment maps, areas of agricultural conformity, plant pattern determination, etc. The purpose of this study is to prepare "Product Based Agricultural Risk Analysis Maps". Climate, Soil, Topography and Irrigation data, which are important in the growing of agricultural products are collected, severity and prospects for risk analysis are determined separately and risk values are established for each risk factor. The total risk value was calculated by prioritizing risk factors using the Analytical Hierarchy Process (AHP), one of the multi-criteria decision-making methods. Thanks to AHP, a methodology for calculating scenario-based risk values has been developed taking into account different probabilities. With the developed model, risk maps were created for climate, soil, topography and water constraints. The total risk map was obtained by combining the risk maps created with AHP. In this study, a model was established by taking the Peach and Fig product of Manisa and as a result of the model, Total Risk values were divided into classes such as "High Risk Areas", "Medium Risk Areas", "Low Risk Areas" and "Strictly Not Recommended Areas" according to the scores they received positional.

1. Introduction

According to the latest report of the United Nations, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100. Many difficulties on agricultural supply chains, shrinking agricultural land sizes, environmental problems and the inability to protect natural resources have made it necessary to take urgent measures to meet the food needs of the increasing world population. To meet these challenges, farming systems require a major and fundamental shift from traditional practices to precision farming or smart farming practices. Geographic information system (GIS) is a useful technology that facilitates the transition from existing methods to precision agriculture. (Sharma et al., 2018).

About 13 billion hectares of the earth's surface are covered with land, of which 37 percent is agricultural lands, about 5 billion hectares. Considering the distribution of the agricultural land asset in question according to the way of use, it is seen that field crops are grown in approximately 1.5 billion hectares of land, and perennial plants are planted in 1.5 billion hectares. The remaining 2 billion hectares are evaluated as meadows and pastures (OKP, 2013).

The strategic importance of the protection and development of agricultural production, the continuity of nutrition, which is the basic need of human beings, the supply of food raw materials and the sustainability of the agricultural industry, has become more evident especially during the COVID-19 Pandemic process. The existing agricultural areas in the world are decreasing by about 0.1-0.2% in every 5 years. On the other hand, the world population has increased by about 6.2% in the last 5 years. (UN, 2013). In our country, the total amount of land cultivated between 2001 and 2020 decreased by 3 million 205 thousand hectares, from 26 million 350 thousand hectares to 23 million 145 thousand hectares. (TUIK, 2021a). The rate of decrease was realized as 12 percent. In the same period, our population increased by 18 million 219 thousand and became 83 million 385 thousand. The rate of increase is 28%. (TUIK, 2021b).

As a result, although the increasing world population increases the demand for food, decreasing agricultural areas and disasters as a result of changing climatic conditions bring along serious decreases in food supply in the opposite proportion. At this point, it seems that the way out is to switch to smart, planned and

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sensitive agriculture, which is also called Agriculture 4.0, where information systems are used from traditional agricultural methods. In smart and planned agriculture, it is possible to determine from the very beginning what to grow and where, and to obtain products that are least affected by diseases and pests due to both an increase in yield and products grown under ideal conditions. However, it is not always possible to choose land with ideal conditions. At this point, knowing in advance what kind of risks the existing land has, thanks to the work done, enables the creation of artificial conditions to correct the factors that cause damage.

2. Method

Fault tree analysis (FTA) is a well-constructed, precise and powerful tool that can be used to assist the analyst in identifying, evaluating and analyzing all root causes and pathways leading up to the occurrence of a particular event. In the traditional approach, the probability of fundamental events is considered either as a definite point value or as a random time dependent variable. However, due to the inherent impreciseness and uncertainty of the available data, it is often impossible to obtain a precise estimate of the incidence or distribution function of an event. (Jafarian et al., 2012)

Events graphically described in the fault tree diagram and the factors that cause these events can be attributed to different events that cause errors, accidents, losses or undesirable results. The FTA method can be used qualitatively to identify the causes and events leading to a fault, and can also be used quantitatively to calculate the probability of recurrence of the root cause. During the design phase of a system, the FTA method is also used to calculate potential losses and sum them up from different design options, to estimate the significance of potential losses during the operation phase (Çınar, 2004). To build a tree, a final event is placed at the top and then linked to logic symbols representing the conditions for the event to occur, and then to intermediate events that cause the high event. For example, the symbol OR means that at least one intermediate event must occur for the higher event to occur, while the symbol AND means that at least two or more intermediate events must occur for the higher event to occur.

In the study, the reasons that may cause an undesirable situation are determined and analyzed based on the deductive logic. The severity of the risk arising from undesirable conditions is calculated by the FTA method. Risk factors are organized, defined and presented in a tree diagram with a logical system. Undesirable peak events are detected and any factor considered in this event should be analysed. The model setup is started by using the total risk value of a selected fruit product. As a result, sub-risks such as climate, soil, topography, water restrictions that cause total risk are determined. Factors causing sub-risks are selected on a product basis and entered into the system in layers. The risk analysis model developed with the FTA method used in complex systems focuses on the risk of only one product at a time. The layers that may cause product risk for each product are entered separately and the total product risk maps are formed.

2.1. Dataset

Statistical and numerical data obtained from various public institutions and organizations were transferred to the geographic database created in ArcGIS 10.5 application. Transformation of statistical data into digital format has been done.

Climate data set prepared by the General Directorate of Meteorology, land cover, land use capability, current land use, soil maps prepared by the abolished general directorate of soil and water, created by the abolished Ministry of Agriculture and Rural Affairs, 1/25,000 topographic maps provided by the General Command of Mapping and irrigated land assets, streams, streams and rivers data prepared by DSI and DSI were obtained and all climate, soil, topography and water asset maps were standardized by making projection transformations.

Climate Data: The last 30 years (1990-2020) climate data of Manisa Province were used by the General Directorate of Meteorology. These data were classified as monthly and monthly average, minimum and maximum values were calculated. Finally, statistical data obtained from meteorological observation stations with known coordinates were transformed into spatial format by applying surface spread with "co-kriging" and inverse distance weighting (IDW) methods with ArcGIS software. In the process of spreading to the surface, taking into account the topography, the values were assigned to the cells with the dimensions of 20 x 20 meters and the climate maps classified in the raster format in table 1 were created. A GIS database has been created specifically for the province.

Statistical and numerical data obtained from various public institutions and organizations were transferred to the geographic database created in ArcGIS 10.5 application. Transformation of statistical data into digital format has been done.

2.2. Risk analysis

Risk analysis is the process of identifying and analyzing potential problems that may adversely affect investment ventures or production. This process is done to help organizations prevent or mitigate these risks.

FTA is a type of defect analysis in which an undesirable condition in a manufacturing process is examined (Figure 1). This analysis method is used to understand how systems can fail, determine the best ways to mitigate risk, or determine the tolerance level of a particular system for risks. FTA is used in aerospace, nuclear power, chemical and process, pharmaceutical, petrochemical and other high-risk industries; however, it is also used in a wide variety of fields such as determining risk factors that cause yield loss in agricultural production (Tuncay, 2017).

Table 1. GIS datasets

Climate Data	**Temperature**	**Soil Data**	**Soil Depth**
	Average Temperature on a Monthly		Uthosolic
	Maximum Temperature on a Monthly		Very Shallow (0-30cm)
	Minimum Temperature on a Monthly		Shallow (30-50cm)
	Extreme Maximum Temperature on a Monthly		Medium Deep (50-90cm)
	Extreme Minimum mum Temperature on a Monthly		Deep (90-150m)
	Precipitation		Very Deep (>150cm)
	Total Precipitation on a Monthly		**Soil Erosion**
	Summer Months Total Precipitation		Wind Erosion
	Total Annual Precipitation		**Rain Erosion**
	Sunbathing		**Land Use Capability**
	Total Sunbathing Times on a Monthly		1-8th Class Land
	Total Annual Sunbathing Times		**Available Land Use**
	Evaporation		Absolute Irrigated Farmland
	Evaporation Values on a Monthly		Marginal Irrigated Farmland
	Average Annual Amount		Absolutely Dry Farmland
	Humidity		Marginal Dry Farmland
	Average Humidity Values on a Monthly		Planted Agricultural Land
	Spring Months Average Humidity Value		Meadowland Pasture Areas
	Wind		Wetlands
	Average Wind Speed on a Monthly		Forest Areas
	Soil Temperature		More Fields
Water Data	Irrigation		**Drainage**
	Streams	**Topography Data**	Height
	Dams and Lakes		Slope
			Aspect

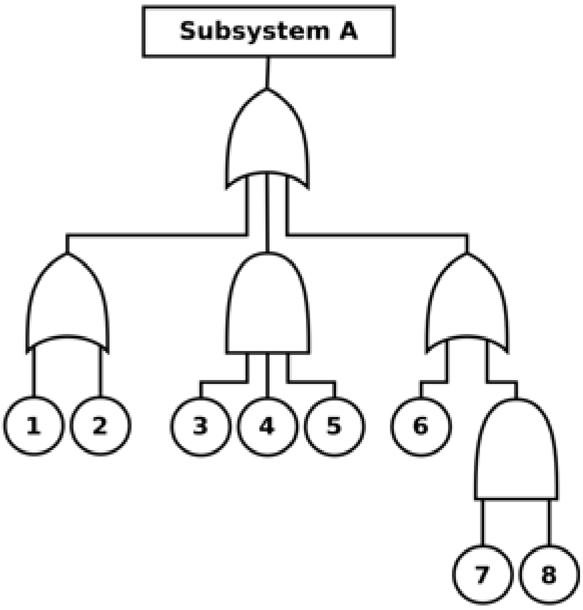

Figure 1. A fault tree diagram

In agriculture, the more general term "yield loss" is used for the "failure" / top event of the fault tree. These conditions are classified according to the severity of their effects. The most severe environmental conditions require the most comprehensive fault tree analysis in which ecological factors are examined in detail. These yield loss conditions and their classification are often predetermined in the hazard analysis by the effects of factors such as climate, soil, topography and irrigation.

2.3. Agricultural risk analysis

FTA is a tool that can be used to help the analyst identify, evaluate, and analyze all root causes and pathways leading up to the occurrence of a particular event (Jafarian et al., 2012).

To construct a tree, a top event is placed at the top and then connected to logic symbols representing the conditions for the event to occur, and then connected to the intermediate events that caused the top event. (WHO, 2011).

The risks faced by farmers are grouped under two headings: ecological risks arising from natural events and economic risks arising from financial conditions. Today, risks such as increasing disasters (drought, hurricane, flood, frost, and hail), change of seasons, erosion, diseases and pests due to climate change are grouped under the title of ecological risks. In a recent study, researchers estimated that 23% of field crops were lost due to adverse weather conditions. In horticultural crops, this rate increases remarkably (Islam et al., 2018).

In this study, spatial risk analysis was performed with a model developed in GIS on the determination of ecological risks in fruit growing. The process proceeds in three steps. The first step is to establish the model with the FTA method, the second step is to enter the intensities and probabilities of the causes, and the third and last step is to run the model developed on the ArcGIS software and create the maps.

In the climate, soil, topography and water presence layers, the values that may pose a risk during the growth of the plant and value of the severity and probability this risk are entered. Suitable areas where a selected plant grows with high yield, that is, with the least risk, will receive the lowest score, while areas where the growing conditions for the plant are unfavorable and contain high risk will receive the highest score in the risk matrix (Altay et al., 2018).

In addition, by assigning values between these layers according to their importance, the risk scores from the layers can be re-scored hierarchically thanks to the Weighted Overlay Analysis tool (Ahmed et al., 2013).

First of all, the process begins with the collection of data and recording it on the database after standardization. Then, the risks that may cause yield loss for each product and the probability and severity values of these risks should be determined. AHP priority values created for each sub-risk value of the risk analysis will be determined. Finally, the final total risk map will be created by combining all sub-risk layers according to hierarchical ranking and scoring according to the fault tree logic in figure 2 (Yeniay et al., 2022).

The Risk Matrix was created in table 2 using the formula "Risk= Severity x Probability (Probability)". According to the scores they got after the entered values;

- Green areas: 1-6 low risk (1 pointless risk)
- Yellow areas: 6 -12 medium risk
- Red areas: 12-25 are determined as high risk (25 irreparable risk).

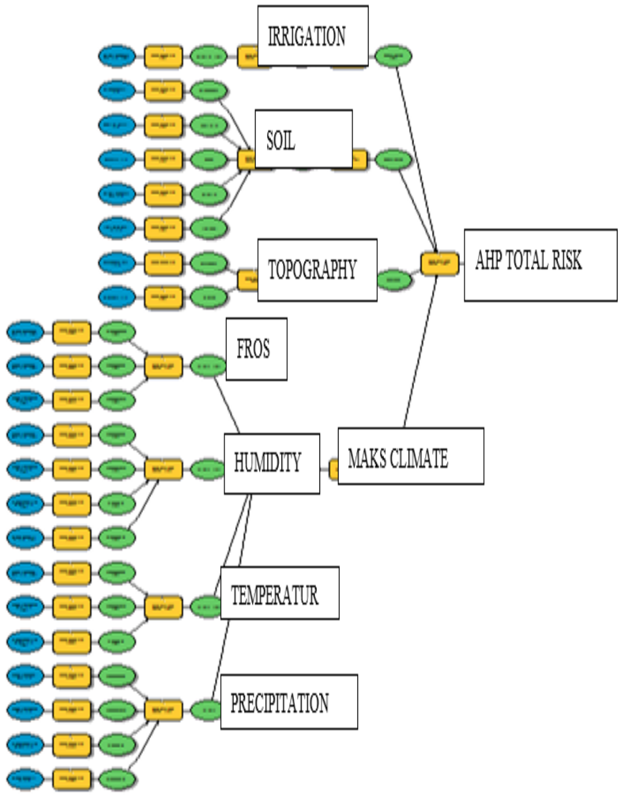

Figure 2. GIS model fault tree

Table 2. Risk matrix

Matrix	Severity				
Probability	**Very Light 1**	**Light 2**	**Moderate 3**	**Serious 4**	**Very Serious 5**
Very Small 1	Meanless 1	Low 2	Low 3	Low 4	Low 5
Small 2	Low 2	Low 4	Low 6	Medium 8	Medium 10
Medium 3	Low 3	Low 6	Medium 9	Medium 12	High 15
High 4	Low 4	Medium 8	Medium 12	High 16	High 20
Too High5	Low 5	Medium 10	High 15	High 20	Irreparable 25

The GIS model assigns the probability values entered for the layers as values into each cell spatially. The average temperature value of a point selected as an example in Manisa in April is -1 °C and the severity of frost damage to the peach trees at this point is moderate 3. The average temperature value of the same point is -5 °C in March and +3 °C in May. Therefore, the average temperature value in March and May will be 4 and 1 frost severity. However, considering the blooming periods of the peach trees at the chosen point, the probability of frost in April, when the flowering is the highest, is 5, and the probability of frost is 3 and 1 due to the low flowering in March and May (Öztekin et al,, 2008; Gür et al., 2011, Eroğlu et al, 2012.).

Table 3. Risk factors

Selected Point Layers	Temperature	Severity	Probabilities	Risk Severity	Frost Risk Factor
March	-5 °C	Serious 4	Medium 3	4x3 12	Maximum Risk Severity 15
April	-1 °C	Moderate 3	Too High 5	3x5 15	
May	+3 °C	Very Light 1	Small 1	1x2 1	

For this reason, for each risk factor, a sample table is filled as in table 3 and a "Significance Evaluation" is made by using the AHP over the risk factors. AHP is used to prioritize risk factors among risk factors. This is done with the "Weighted Overlay" analysis tool in GIS.

After the criteria and sub-criteria are determined by using the Super Decision program, the criteria that affect each other can be determined by analyzing the interactions between the criteria, and the network structure in figure 3 is created by making connections between the criteria, internal and external dependencies, and feedbacks with the help of the program (Yeniay et al., 2022, El-Sheikh, 2010).

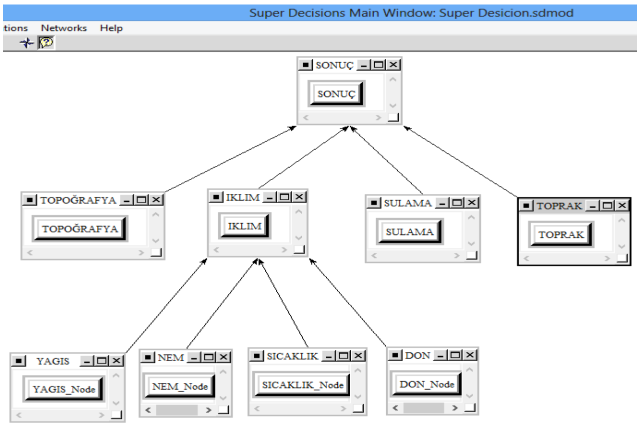

Figure 3. Super decision program interface

After entering the risk probability and severity values of all layers under the climate, soil, topography and irrigation layer groups for the peach crop, the "superiority" importance scores among the risk factors are entered in table 4 (Yeniay et al., 2022, Chuong, 2008).

Table 4. Total risk superiority table

Risk Factors			Severity Weight	Total Risk
Irrigation			0.10303	**Climate+Topography+Soil+Irrigation =1**
Soil			0.11887	
Topography			0.29271	
Climate	**Layers**	**Climate Max Risk**		
	Frost Humidity Temperature Precipitation	Max (Frost, Humidity, Temperature, Precipitation)	0.4809	

After this stage, risk factors ranging from 0 to 25 values were obtained in each group. “AHP priority values” between climate, soil, topography and irrigation layers are entered in the “weighted overlay” tool in GIS. Since the sum of the values entered in the AHP is equal to the full value of "1", the final values will be "total risk" values between 0 and 25. In the peach sample, the “frost risk factor” took a value of 15 at a selected point. Again, the same point took the values of "humidity", "temperature", "precipitation" 10, 12, 8 by manual calculation (Equation 1). While calculating the climate risk factor, the value of 15, which is the maximum risk among the subgroups, was taken as shown in table 3 (Mokarram et al., 2011, Nyeko 2012).

$$\begin{aligned} &Climate\ Risk\ Factor = Maximum\ [Frost\ Risk, Humidity\ Risk, Precipitation\ Risk, Temperature\ Risk] \qquad (1)\\ &Climate\ Risk\ Factor = Maksimum[\,15, 10, 12, 8] = 15] \end{aligned}$$

Again, in the manual calculations made for the same point, the soil took the risk value of 8, the topography 12, and the irrigation 18 risk value. The final ecological risk value was calculated by entering the prioritization scores for climate, soil, topography and irrigation with AHP (Equation 2).

$$\begin{aligned} &Final\ Risk\ = Climate\ x\ 0{,}48\ +\ Soil\ x\ 0{,}12\ +\ Topography\ x\ 0{,}30\ +\ Irrigation\ x\ 0{,}10 \qquad (2)\\ &Final\ Risk\ = 15\ x\ 0{,}48\ +\ 13\ x\ 0{,}12\ +\ 8\ x\ 0{,}30\ +\ 16\ x\ 0{,}10\ = 12{,}40 \end{aligned}$$

3. Results

As a result of the process, it is seen that the point selected for the cultivation of peach crops is "moderate" in the risk matrix according to the calculations. This manual calculation for a single point was automatically performed on the GIS for millions of points and group as shown in "climate", "soil", "topography", "irrigation" separate risk maps were created for the layers.

In figure 4 climate risk map created as a result of the model, it is seen that the plain region of Manisa province is at high risk in terms of peach cultivation, while the mountainous regions are at low risk.

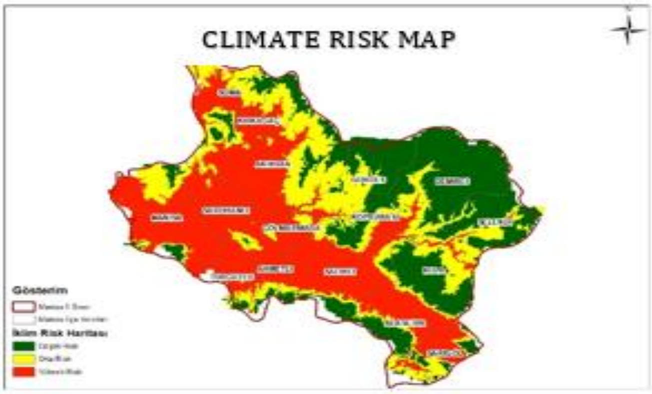

Figure 4. Climate risk map

Soil structure is used as the most important factor in determining agricultural areas. It is not possible to carry out agricultural activities in, rocky, lithosol (shallow azonal soils), swamp, extremely salty, desert, etc. areas. Therefore, in the GIS model, primarily non-agricultural areas were masked in the soil layer and were not included in the risk analysis.

In the figure 5 soil risk map created as a result of the model, there is no homogeneous distribution in the province of Manisa in terms of peach cultivation among the existing agricultural lands.

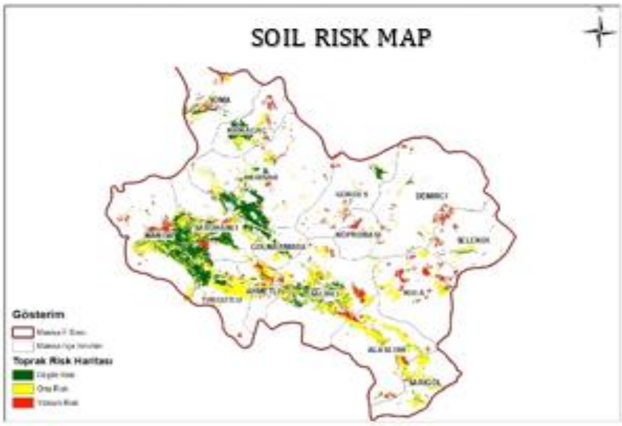

Figure 5. Soil risk map

Topography factor in fruit growing is a risk group that can be intervened more easily than other factors. With the terracing method, the minimum level of slope risk factor can be reduced. The elevation risk factor can play a role in increasing the quality of fruit growing when the climatic risks are eliminated. In Figure 7, it is seen that the low risk ratio is spread over wider areas in the topography risk map.

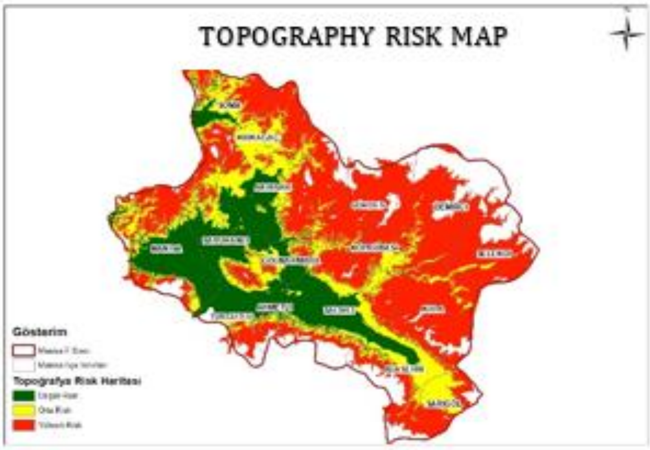

Figure 6. Topography risk map

Another important layer in fruit growing is irrigation. Peach cultivation is done in the form of irrigated agriculture. The existing public irrigation area is low risk, and other areas where individual irrigation activities can be carried out are determined as high risk in the irrigation risk map in figure 7.

Figure 7. Irrigation risk map

The negative impact of each sub-risk factor on crop yield is different. Therefore, the effect of the sub-risk factor on the total risk will be different according to the AHP priority value. The final risk map of the peach crop in figure 8 was obtained by combining the climate, soil, topography and irrigation sub-risks as a result of hierarchical scoring.

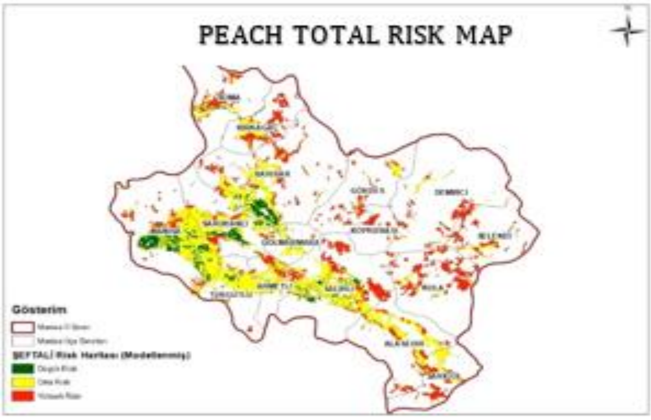

Figure 8. Peach total risk maps in Manisa, Türkiye

In table 5, TUIK 2020 plant production statistics are given for the peach product in Manisa Province. According to TUIK 2020 data, the maximum peach yield in Turkey is 85 kg per tree, and the average yield is 49 kg. It is understood that the average yield of peach products in all other districts of Manisa, except Şehzadeler (Center), Turgutlu and Sarıgöl districts, is below the country average. It is seen that the yield is quite low in direct proportion to the statistics in the high-risk red areas on the map, while the yield is relatively high in the low-risk green areas.

Most of the Manisa Plain appears to be medium risk. When the sub-risk factors are examined, the plain region seems to be low risk in soil, topography and irrigation layers, but climatic factors, which are the main limiting factors in fruit growing, resulted in high risk in the plain. It is seen that the climate risk factor is of high importance and the total risk factor also affects it in that direction.

Table 5. TUIK 2020 plant production statistics (Manisa province, peach product)

Manisa Peach	Number of Trees	Yield (Kg/Tree)	Production Amount (Ton)
Ahmetli	1.875	30	56
Akhisar	4.000	32	128
Alaşehir	12.550	30	377
Demirci	1.160	17	20
Gölmarmara	1.350	22	30
Gördes	6.750	12	81
Kula	1.901	20	38
Köprübaşı	1.450	15	22
Kırkağaç	7.530	24	181
Salihli	19.880	30	596
Saruhanlı	1.670	20	33
Sarıgöl	20.400	61	1.244
Selendi	2.740	30	82
Soma	3.100	20	62
Turgutlu	180.320	50	9.016
Yunusemre	900	20	18
Manisa (Şehzadeler)	80.000	60	4.800

4. Discussion

In this study, it is aimed to create product risk maps that aim to maximize the amount of product obtained from limited resources by being affected by less risks thanks to the developing information technologies in agricultural production. In the researches, it is understood that the biggest problem of the current century is agricultural disasters and harvest losses as a result of the devastating effects of climate change, in addition to the food security hazard to be caused by the increasing population and decreasing agricultural lands. In the COVID-19 pandemic period we are in, the need to develop policies for the protection of food safety on a global scale has made agriculture a strategic sector like never before. Despite this, many innovations brought by today's technologies provide many advantages in terms of ensuring food safety. Therefore, instead of ancestral methods, it has become a necessity to use precision agriculture techniques, also called agriculture 4.0, by taking advantage of the opportunities of developing technology, where all stages of agriculture are recorded and as a result, we will obtain a more predictable harvest (Gitz et al., 2016, Pablo et al., 2014).

Geographical information systems (GIS), on the other hand, is an information platform where location-based analyzes can be made. Since agriculture is a sector based on location and data, it is among the areas where GIS examples are most commonly used. With GIS, various simulations can be made by using the data produced based on observations, records and predictions for many years. In this study, simulations were made with modeling methods using climate, soil, topography and irrigation data produced for many years at this point. Of course, the biggest factor determining the accuracy of the study is the accuracy rate of the data used. One hundred percent correct preparation will be so accurate in the results obtained with soil maps, climate data and irrigation data. Knowing that the basis of the data used in the study dates back to the previous century is a question mark in terms of the reliability of the results of the study. However, no contradiction was encountered in the results obtained with statistical validations. (SDÜ, 2020)

When risk analysis methods are examined, it is evaluated that methods and theorems developed for the complex industry sector and accepted in international platforms will be valid in agriculture. Based on this, the risks that may cause yield loss in fruit growing were determined by entering the fault tree matrix, which is the most common method in risk analysis. With the deductive method, the main factors causing yield loss were determined as climate, soil, topography and irrigation, and a fault tree was formed by determining the sub-factors determining these main factors. The GIS data of each risk factor in the fault tree were obtained from the relevant institutions and organizations statistically, such as meteorological data, and converted into GIS format by spreading over the surface with IDW, Kriking and Ko-Kriking methods, and already provided in GIS format such as soil, topography and irrigation data. .

After creating a geographic database from all GIS data and determining the risks that cause loss of productivity, it has come to the stage of creating the information about the risk area model institution and which risk will affect the severity and probability of the loss of efficiency. Here, however, there are some uncertainties such as the type, type and variety of the fruit grown. Because it is a creature that lives in fruit, and just like humans, it may have experienced different adaptations in different ecological conditions. However, since it is not possible to proceed with this uncertainty, the data needed for the model is entered based on the general ecological demands of the most common fruit varieties produced and cultivated for commercial purposes. Ecological demands were determined as a result of studies in which a plant's growing conditions were observed in the most suitable conditions with the highest efficiency. In addition, adverse climatic conditions that occurred over the years and caused yield loss were recorded as marginal conditions.

The ecological conditions with the highest yield were determined as the lowest score in terms of risk severity, and the marginal conditions causing yield loss were determined as the highest score according to the risk severity degree. The risk probability value was determined by considering the developmental physiology of the plant on a monthly basis under climatic conditions. In the soil, topography and irrigation risk layers, the probability values were determined according to the probability of affecting the yield among the lower layers of each layer the most.

Finally, since the risk factors coming from the climate, soil and topography risk layers cannot cause equal yield loss, prioritization between the layers was made with the Analytical Hierarchy Process (AHP) method and the total risk value was obtained for millions of points with a size of 20x20 square meters. The risk values at these millions of points were classified according to the values in the risk matrix on the GIS and separate risk maps were obtained for each product.

First of all, producers who want to establish new gardens can choose the land using these risk maps and achieve the highest production by experiencing minimum yield loss in the lowest risk lands. Of course, production in low-risk regions will reduce input costs, increase profitability and contribute to more natural and healthy production in the decrease in fertilizers, pesticides and agricultural structures.

As a result of the risk map examinations to be made, it will be possible to determine the existing risks in the orchards that have already been established. It will be possible to see from which factors the risks created by the fault tree originate in the lower layers. In this way, there will be an opportunity to take precautions since the factors that may cause loss of efficiency are known in advance. Thanks to meteorological early warning systems, some small cost measures that can be taken for previously known risks will result in a significant increase in efficiency (Yeniay et al., 2022).

According to the 2020 data of the Turkish Statistical Institute, the maximum peach yield per tree in Turkey is 85 kg, and the average yield is 49 kg. According to the same data, peach yield is high in Manisa Province Center, Saruhanlı, Akhisar, Turgutlu, Salihli and Sarıgöl districts. In the high-risk red areas in the risk map created as a result of the model, the yield is low in direct proportion to the statistics, while the yield is high in the low-risk green areas. Most of the Manisa Plain appears to be medium risk. When the sub-risk factors are examined, the plain region seems to be low risk in soil, topography and irrigation layers, but climatic factors, which are the main limiting factors in fruit growing, resulted in high risk in the plain.

5. Conclusion

The developed model can be revised on a product-based basis, in the light of more reliable data using more precise ecological demands for each product type. In the commercial use of products registered as certified saplings, maps showing the areas where seedlings can be grown can be given to the producer. It is even possible to give a specific variety recommendation for the producer's parcel. In this way, maximum benefit can be obtained from limited areas by switching to a planned production.

Using the created model, risk analysis maps were created for the province of Manisa. Peach and fig products were selected as examples in Manisa. The peach product in Manisa is among the provinces where the most cultivated crops are grown in Turkey. In addition, due to ecological factors, many fruit products are grown in Manisa with high yield.

Separate risk maps were drawn for climate, soil, topography and irrigation factors for two crops. After prioritizing all layers with the fault tree method and AHP, a total risk map of the peach product was created. Thanks to the defect tree analysis, it is possible to easily access the sub-risks that cause the main yield loss of the peach product, with a retrospective analysis.

When the peach risk map is examined in detail; It has been determined that the peach crop is more sensitive to climatic and soil conditions and is highly affected by the risk factors coming from the climate and topography layers. There are large plains throughout the province of Manisa. Although the topography risk is low in the plain region, the risk is higher in the transitional regions. There are large and fertile plains in Manisa province. This plain area is not considered as a serious risk in terms of soil and irrigation. However, in the months when windless and high temperatures are experienced, climatic risks against diseases and pests increase. In addition, areas with high climatic risks have been identified in some transition regions. It has been concluded that total peach risk factors can be improved with cultural and mechanical climatic improvements. Thanks to such improvements, healthier products will be obtained as there will be less disease fighting. As a result of the digitization of the maps, a total of 2,145,219 decares of land can be grown in peach, and 274,626 decares of these areas are low risk, 1,199,908 decares are medium risk, and 670,684 decares are high risk.

It has been determined that the fig crop is less sensitive to soil conditions and is highly affected by the risk factors coming from the climatic layers. In total, crops can be grown in 2,840,771 decares, and 1,256,186 decares of these areas are low risk, 1,561,777 decares are medium risk, and 32,813 decares are high risk. According to these results, peach product can be affected by risk factors in wider narrow areas and risk factors compared to figs, while fig product can be grown in wider areas with low risk. It is considered that the main risk factor in the cultivation of peach crops in Manisa is late spring frosts.

Considering the climate, soil, topography and irrigation data throughout Turkey, a site selection analysis can be made for all plant products with known ecological demands by using the developed model in this study. . After examining the risk maps, a methodology study can be carried out to find answers to the questions of which crops may grow more risky in various regions and which of these risks are caused by climate, soil, topography and irrigation factors, and finally, what measures can be taken against them can be easily determined with the help of fault tree analysis.

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Author Contributions

Author1: Methodology, software, data curation, Writing-Original draft preparation, validation, visualization, **Author2:** Reviewing, editing.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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