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# Harvesting the Hidden Value of Vacant Lands: A GIS-Based Approach to Urban Agriculture

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**Abstract**

*The study aims to determine the urban agriculture potential of vacant lands in the city center of Usak, Turkey, and to create a GIS-based urban agriculture inventory. Our analysis focuses on available vacant lands of the municipally-owned lands, foundation lands, public properties, forest lands, and pasture lands within the boundaries of the implementary development plan of the city center of Usak. The optimal urban agriculture map was created using GIS and considered different categories of urban agriculture, including small-scale agriculture, large-scale agriculture, community gardens, and impervious surface or poor soil urban agriculture. The study results showed a significant amount of vacant lands in Usak suitable for urban agriculture, with 7.32 ha being highly suitable, 80.58 ha moderately suitable, and 110.94 ha marginally suitable. Results indicate that vacant lands in the city can be utilized for urban agriculture, which can provide numerous benefits to the local food system.*

***Keywords:*** *Urban agriculture potential, urban agriculture, vacant lands, geographic information system, land use.*

# Boş Arazilerin Kentsel Tarım için Kullanılması: Kentsel Tarıma CBS Tabanlı Bir Yaklaşım

**Öz**

*Bu çalışma, Türkiye'nin Uşak ili merkezindeki boş arazilerin kentsel tarım potansiyelini belirlemeyi ve kentsel tarım envanterini belirlemek için CBS tabanlı bir metodoloji oluşturmayı amaçlamaktadır. Analiz, Uşak il merkezi uygulama imar planı sınırları içerisinde bulunan belediyeye ait araziler, vakıf arazileri, kamu taşınmazları, orman arazileri ve mera arazilerinin mevcut boş arazilerine odaklanmaktadır. Çalışma sonucunda küçük ölçekli tarım, büyük ölçekli tarım, topluluk bahçeleri ve geçirimsiz yüzey veya zayıf toprak kentsel tarım dahil olmak üzere farklı kentsel tarım kategorileri dikkate alınarak CBS tabanlı optimal kentsel tarım haritası oluşturulmuştur. Çalışma sonuçları, Uşak'ta önemli miktarda boş arazinin kentsel tarıma uygun olduğunu, 7.32 ha yüksek derecede uygun, 80.58 ha orta derecede uygun ve 110.94 ha marjinal olarak uygun olduğunu göstermiştir. Sonuçlar, şehirdeki boş arazilerin önemli derecede kentsel tarım potansiyeli olduğunu ve yerel gıda sistemine çok sayıda fayda sağlayabileceğini göstermektedir.*

***Anahtar kelimeler:*** *Kentsel tarım potansiyeli, kentsel tarım, coğrafi bilgi sistemi, arazi kullanımı.*

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## 1. Introduction

The growth of the urban population has caused a range of ecological, economic, and social challenges for cities. The United Nations (2019), reported that the global population reached about 7.7 billion in 2019 and is expected to reach 8.5 billion in 2030, 9.7 billion in 2050, and 10.9 billion in 2100. In 2018, about 55.3% of the global population lived in cities, which is expected to reach 60% by 2030. Cities such as Delhi, Tokyo, and Shanghai are expected to have populations exceeding 30 million (United Nations, 2018). Today, with the rapid population growth of cities and settlement areas with high attraction power and the multifaceted demands of many sectors and related actors such as housing, service, commercial, education, industry, etc., the tendency to obtain effortless economic benefits, etc. factors have created and are creating unhealthy and irregular cities and urbanisation (Gezer & Gül, 2009).

This rapid population growth has implications for urban areas and requires careful planning and management to address the challenges. Rapid urbanization brings local policies and approaches toward the urban food system to the fore, the built environment, consumption, and nature. Cities provide an opportunity to rethink the management of food systems (Gül, 2022).

One way to address these challenges is through urban agriculture (UA), which has recently gained popularity. Urban agriculture solves many problems in cities and helps to create more sustainable cities. Urban agriculture is the cultivation of food products and all related activities in urban and around the cities (Van Veenhuizen & Danso, 2007). Urban agriculture is an alternative food system, and it is always interacting and cooperating with the city's food systems and rural agriculture. Therefore, the food system in the city can offer an important solution tool for the food supply problem caused by climate change (Türker et al., 2021). It is a sector that covers all activities (production, marketing, etc.) of food and related non-food products to meet the daily needs of city dwellers by using urban waste and natural resources and recycling in urban and periurban areas (Smit et al., 1996).

Urban agriculture is an alternative food system and an integral element of rural agriculture. It has many benefits for cities and their residents. Urban agriculture has a positive impact on urban biodiversity (Doherty, 2015; Lin et al., 2015; Deelstra & Girardet, 2000; Matteson et al., 2008), rainwater management (Hankard et al. 2016; Deelstra & Girardet, 2000), air quality (Deelstra & Girardet, 2000), waste management (Amirtahmasebi, 2008), food security (Mougeot, 2000; Smit et al. 2001; Armar Klemesu, 2000), rehabilitation (Hynes, 1996), household income (Bryld, 2003; Ackerman et al. 2014) and real estate value (Voicu & Been, 2008). There are many different types of urban agriculture, and Table 1 provides information on the production scales, types of activities, objectives, products, and distribution targets for these different typologies.

**Table 1.** Proposal for production scales, types of activities, objectives, products, and distribution targets for potential urban agriculture categories

| Category | Scale | Type of Activity | Model | Products | Distribution |
|---|---|---|---|---|---|
| **Small-scale urban agriculture** | Micro | Farmer's markets, educational agricultural programs, permaculture, beekeeping, flower growing, commercial food production, and vegetable growing (Balmer et al. 2005) | Commercial and Non-Commercial | Vegetables, fruits, compost, medicinal and aromatic plants, etc.) poultry products, beekeeping products, ornamental plants | Direct sales, farmer's stands, markets |
| **Large-Scale Urban Agriculture** | Macro | Community-supported agriculture (CSA), urban farms, orchards, animal husbandry, immigrant programs, nurseries, beekeeping, and horticulture. (Balmer et al. 2005) rehabilitation programs | Commercial and Non-Commercial | Vegetables, fruits, compost, medicinal and aromatic plants, etc.) and animal products (milk, eggs, meat, fertilizer, leather, hides, etc.) forestry products (firewood, etc.) nuts, forage plants, ornamental plants, beekeeping products | Restaurants, retailers, markets, hotels, cafes |
| **Community Garden** | Micro | Allotment gardens, organization gardens, demonstration gardens, immigrant programs/ | Non-Commercial | Vegetables, fruits, compost, medicinal and aromatic plants, etc.) poultry products, beekeeping products, ornamental plants | Food aid to those in need, personal consumption |

| | | | | | |
|---|---|---|---|---|---|
| **Impervious/poor soil urban agriculture** | Micro-Macro | Vertical gardens, indoor gardens, greenhouses, farmer's markets, container farms, hydroponics (Balmer et al. 2005) | Commercial | Vegetable, fruit, compost, medicinal and aromatic plants, etc.), forage plants, ornamental plants, aquaculture, mushroom, and yeast production | Restaurants, retailers, markets, hotels, cafeterias |

### 1.1. Urban Agriculture in Türkiye

Intense urban growth is occupying agricultural lands day by day. Air pollution, global warming, and ecological destruction significantly impact agriculture. Agricultural lands are being destroyed worldwide and in Türkiye for various reasons. Over the past few decades, the amount of agricultural land per person has decreased significantly globally and in Türkiye. According to the Tema Foundation (2018), the global average fell by 1.8 hectares between 1961 and 2015, while Türkiye decreased by 5.6 hectares over the same period. This trend is concerning because it can lead to reduced food production and negative environmental impacts. The Metropolitan Municipality Act No. 5216 and the Metropolitan Law No. 6360 put agricultural lands in Türkiye at risk of urbanization (Yenigül, 2016). There are currently a limited number of urban agriculture areas in Türkiye. This is due to deficiencies in legislation and insufficient incentives.

### 1.2. GIS and Urban Agriculture Potential

Benefits of urban agriculture and its potential provide an essential tool for policy-makers. GIS has been widely used in literature to explore the vacant land potential for urban agriculture. Balmer et al. (2005) identified the urban agriculture potential of public vacant lots in Portland using GIS. Kaethler (2006) aimed to identify the potential of public vacant spaces in Vancouver for urban agriculture using VanMap software. Balmer et al., (2005) and Kaetler (2006) classified urban agriculture areas into two main categories (large-scale and small-scale urban agriculture) and two sub-categories (community garden and impervious surface agriculture) in their studies. Horst (2008) used GIS to analyze the potential of public vacant spaces for community gardens in Seattle, Washington. McClintock et al., (2013) assessed the potential for urban agriculture of Oakland's public and private vacant lands and presented a GIS-based inventory. MacRae et al., (2010) investigated whether Toronto can produce 10% of its vegetables and analyzed land inventory using GIS. In this study, zoning plans and aerial photography were used, and it was aimed to determine the potential urban agriculture areas and food production potential in the city. Eanes & Ventura (2015) assessed the suitability of community gardens in Madison using GIS methodology. Using GIS, they created an urban agriculture inventory for community gardens by analyzing public and some private land. This study used size, surface, slope, water access, solar access, area, land-use conflicts, size, vehicle access, and proximity criteria. Using the GIS method, Allen (2015) determined the urban agriculture potential of vacant or underutilized land. They identified essential criteria for urban agriculture; land use slope, sunlight, access to water, soil, ownership, accessibility, neighborhood income, neighborhood population density, proximity to other community facilities, community support, percentage of people living in apartments, neighborhood crime rates, aesthetics, and visibility criteria were used. Dumitrescu (2013) aimed to map the physical, economic, and social criteria for urban agriculture in Rotterdam and identify potential areas suitable for urban agriculture. As a result of the analysis, a suitability map has been revealed for four different scenarios with different physical, economic, and social characteristics for Rotterdam. Taylor & Lovell (2012) analyzed and mapped urban agriculture practiced in public and private spaces using ArcGIS and Google Earth in Chicago, USA. McClintock &Cooper (2010) aimed to determine the food production potential of public spaces belonging to Federal, State, Municipal, and Regional institutions in line with the criteria using GIS. The study determined the potential of vacant lands for urban agriculture in Oakland, California. In some studies, GIS was combined with multi-criteria decision methods. Thapa & Murayama (2008) investigated suitable areas for urban agriculture in the peri-urban area of Hanoi, Vietnam, using GIS and the Analytical Hierarch Process (AHP).

All of these studies have been conducted at ground level. However, Saha & Eckelman (2017) examined the urban agricultural potential of ground level and rooftops in Boston. They used remote sensing and GIS to determine the urban agriculture potential of Boston. This study used ownership, slope, soil quality, and adequate light availability criteria. Previous studies on urban agriculture have limited the use of GIS methods, and the potential for urban agriculture in Türkiye has not been studied. This study aims to fill this gap in the literature and provide decision-makers and planners with a helpful tool for integrating urban agriculture into the city and developing strategies to address existing urban problems. The study aims to determine the urban agriculture potential of vacant lands in the city center of Usak, Türkiye

## 2. Material and Method

The study area for this research is the boundary of the complementary development plan (2019) of the city center of Usak. Usak Province is located in the Central Anatolia region of the Aegean in Türkiye between 38°13′ to 38°56′E and 28°48′, 29°57′S (Figure 1). It has a long history dating back to 4000 BC. It has been home to many civilizations over the years. In the 19th century, it saw significant commercial development (Usak Municipality, 2020), and today, it is an industrial center known for its textile, leather, and ceramic industries. Usak has a rural character (Sarp, 1994) and most of the population living in the city center are from village origins. The population of the city center is 228,328 (TURKSTAT, 2020), and Usak has a semi-arid climate with hot, dry summers and cold winters. The annual average temperature is 12.8°C, with daily maximum temperatures averaging 19.1°C and daily minimum temperatures averaging 7.2°C. The highest recorded temperature is 40.2°C, and the lowest is -15.4°C (Turkish State Meteorological Service, 2020).

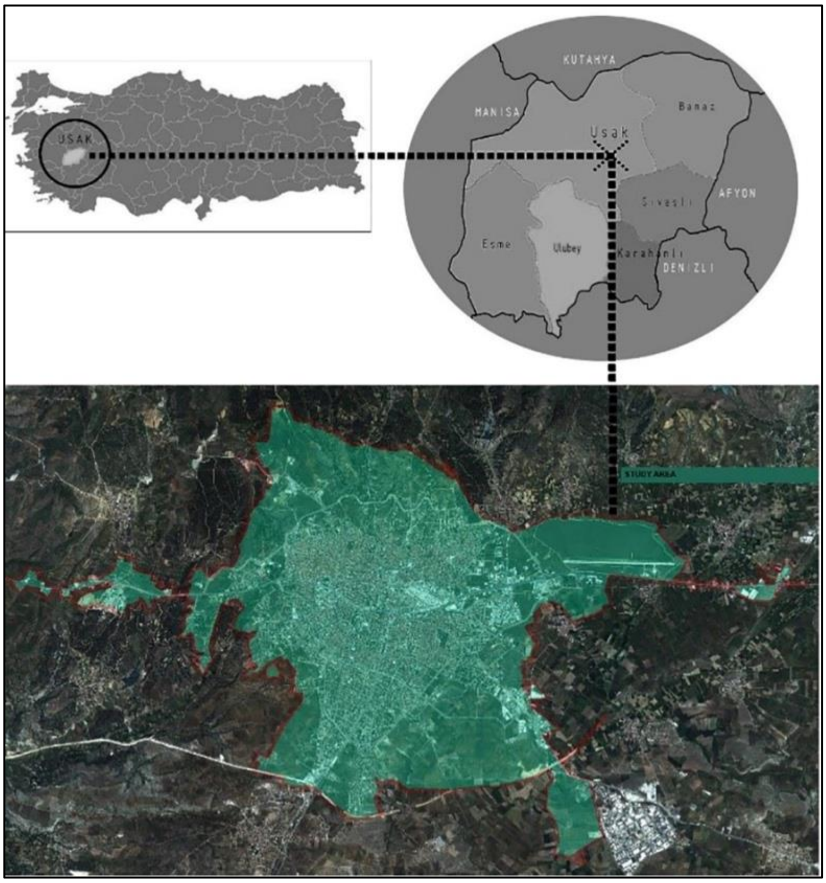



**Figure 1.** The geographical location of the research area

### 2.1. Data sources

The primary material of the study is a total of 2821 public parcels (municipally-owned lands, foundation lands, public properties, forest lands, and pasture lands) belonging to 19 neighborhoods in the city center of Usak. Data used in this study were assembled from various sources (Table 2).

**Table 2.** List of data and sources

| Data | Scale | Source |
|---|---|---|
| Implementary development plan 2019 | 1:1000 | Department of Urban Planning, Usak |
| Excel file of 2821 parcels of information | - | Department of Land Office, Usak |
| Base map of Usak (2007) | 1:1000 | Department of Urban Planning, Usak |
| Satellite Pictures (2018 and 2019) | - | Department of Urban Planning, Usak |
| True Ortofoto WMS (Web Map Service) (2014) | - | Ministry Of Environment And Urbanisation, Turkey |
| Road Map | | Open Street Maps |
| Mains Water Map (2019) | | Department of Urban Planning, Usak |
| DEM (30 x 30 m) (View-shed Map) | | USGS Web Site |
| Soil map | | The Ministry Of Agriculture And Rural Affairs, Turkey |

## 2.2. Methodology

The study aims to determine the potential for urban agriculture of public vacant lands in Usak and presents a GISbased inventory. There were six significant steps to produce an optimal urban agriculture map and these are: (1) Identify available vacant lands by aerial photo analysis (2), Determination of urban agriculture categories (3), Determination of factors and classification of criteria (4), Criteria maps generation (5), Calculation of degree of influence for each criterion for categories by expert score (6), Suitability analysis. The flowchart in Figure 2 summarizes the steps involved in the GIS methodology of the study.

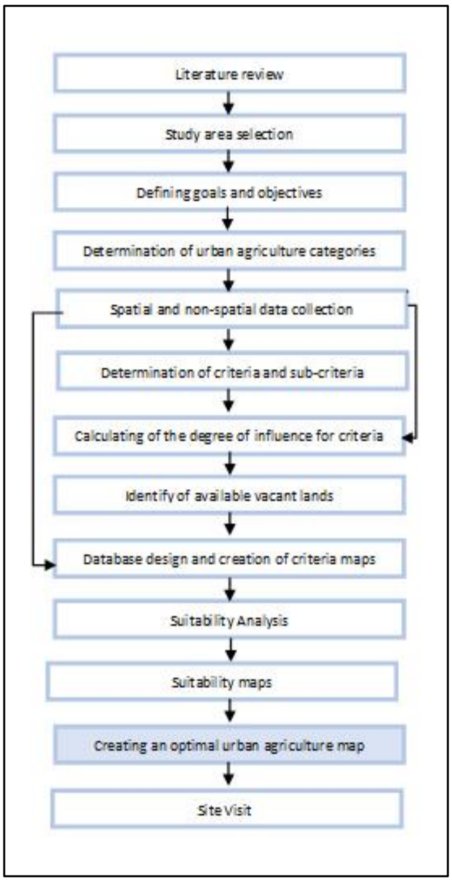



**Figure 2.** Schematic overview of the research

### 2.2.1. Determination of urban agriculture categories

There are many different typologies for categorizing urban agriculture (Table 1), and the specific categories and sizes used in this study varied depending on this research's specific focus and goals. Balmer et al., (2005) and Kaethler (2006) divided urban agriculture categories into two main categories (small-scale urban agriculture and large-scale urban agriculture), and two sub-categories (community garden and impervious surface / poor soil) in their studies. The four categories and category sizes of urban agriculture used in this study were based on the typologies defined by Balmer et al., (2005) and Kaethler (2006). The categories are divided into two main categories: previous urban agriculture and impervious urban agriculture. Previous urban agriculture refers to agricultural activities on land that are not covered by pavement or other hard surfaces. This category includes three sub-categories: small-scale urban agriculture, large-scale urban agriculture, and community garden. Small-scale urban agriculture refers to agricultural activities on parcels of land smaller than 1000 $m^2$, while large-scale urban agriculture refers to agricultural activities on land larger than 1000 $m^2$. Community gardens are typically between 700 and 2100 $m^2$ in size. Impervious urban agriculture refers to agricultural activities on land covered by pavement or other hard surfaces or on land with poor soil quality and unsuitable for traditional agriculture. This category includes a sub-category called impervious surface / poor soil urban agriculture, which does not have a specific size requirement. It may include activities such as hydroponics or aeroponics etc., which do not require soil to grow plants. Detailed information about these categories is provided in Table 1.

### 2.2.2. Identify available vacant lands

In this study, parcel data in Excel was digitized into a Shapefile format using the General Directorate of Land Registry Cadastre Parcel Search Application. In total, 2810 parcels were downloaded in Shapefile file format, and added ArcGIS 10.6.1 software. The parcels were overlapped with satellite photos and True Orthophoto and made ready to identify available vacant lands in ArcGIS. Based on the typologies of urban agriculture defined by Balmer et al., (2005) and expert opinions, a minimum size criterion of 82 square meters was set for urban agriculture areas. Any parcels smaller than 82 square meters were excluded from the analysis. Next, an aerial photo analysis of the study area was conducted to identify available vacant lands suitable for urban agriculture. This involved visually examining each parcel and deleting those that were deemed unsuitable. Adjacent parcels were also merged to create larger contiguous areas. In the end, 603 study sites were determined to be suitable for urban agriculture, along with ten active and passive green areas. This gave a total of 613 study sites ready for suitability analysis.

### 2.2.3. Determination of factors and classification of criteria

Determining the suitability of urban agriculture requires an assessment of various factors. This study used specific criteria, selected based on a literature review and expert opinions, and divided into natural and urban factors. Natural factors considered in the study include slope, with flatter lands being more favorable and accessible, and aspect, which refers to the direction the land faces, affecting factors such as sunlight, temperature, and wind that can impact crop productivity. Other natural factors considered include LUCC, erosion, soil depth, drainage problems, and LUCS. The urban factors considered in the study include environmental sensitivity, proximity to industrial or waste sites, spatial location, area size, proximity to roads, access to water, and vehicle access. The criteria were standardized using a four-level scale (4 = highly suitable; 3 =moderately suitable, 2 = marginally suitable, 1 = not suitable (Table 3). This allows for consistent and systematic evaluation of the suitability of different lands for urban agriculture.

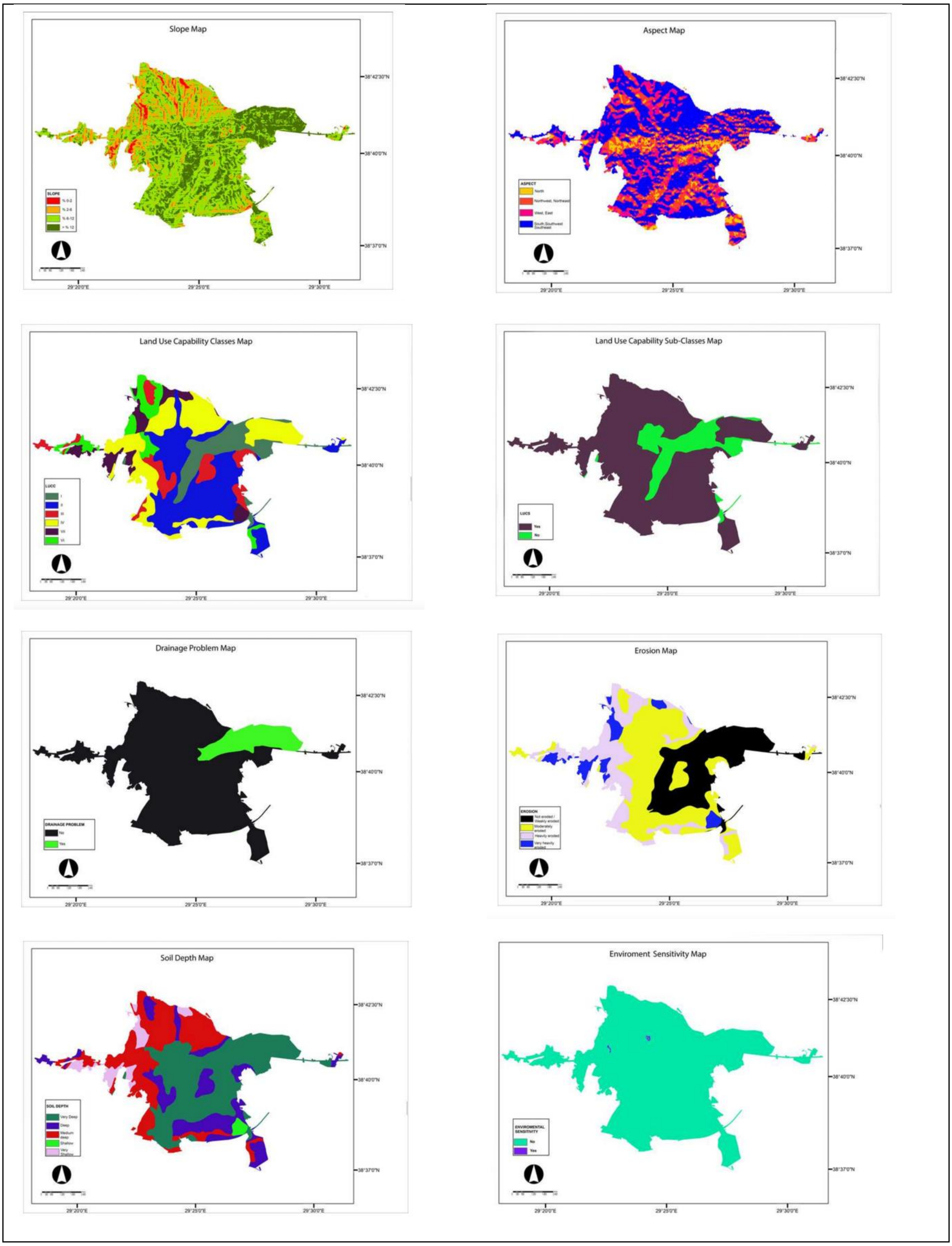
**Table 3.** Criteria in suitability analysis for urban agriculture categories

| Criteria | Sub-Criteria | Small Scale | Large Scale | Community | Impervious surface | Reference |
|---|---|---|---|---|---|---|
| Slope | 0-2 | 4 | 4 | 4 | 4 | Balmer et al., (2005) and Allen (2015) set the slope threshold upper limit of 10%, Horst (2008) set the slope threshold upper limit of 40%, McClintock & Cooper (2010) and McClintock et al., (2013) set the slope threshold upper limit as 30%, and Eanes & Ventura (2015) set this limit as 20%. |
| | 2-6 | 3 | 3 | 3 | 3 | |
| | 6-12 | 2 | 2 | 2 | 2 | |
| | >12 | 1 | 1 | 1 | 1 | |
| Aspect | South, Southwest, South East | 4 | 4 | 4 | 4 | McClintock et al., (2013) stated in their study that optimal aspects for urban agriculture are western, south or east, and north. North-west and northeast aspects are less preferred for urban agriculture |
| | West and East | 3 | 3 | 3 | 3 | |
| | Northwest, Northeast | 2 | 2 | 2 | 2 | |
| | North | 1 | 1 | 1 | 1 | |
| Land use capability sub-class **(**LUCC) | I | 4 | 4 | 4 | 1 | TRGM (2008) Class I, II, and III lands are suitable for agriculture, and Class IV lands are classified as partly suitable for agriculture. Class V, VI, VII. VII lands are not suitable for agriculture. |
| | II | 3 | 3 | 3 | 2 | |
| | III. | 2 | 2 | 2 | 3 | |
| | IV | 1 | 1 | 1 | 4 | |
| | VI | 1 | 1 | 1 | 4 | |
| | VII | 1 | 1 | 1 | 4 | |
| Erosion | Not eroded or little eroded | 4 | 4 | 4 | 4 | |
| | Weakly eroded | 2 | 2 | 2 | 2 | |
| | Moderate eroded | 1 | 1 | 1 | 1 | |
| | Heavily eroded | 1 | 1 | 1 | 1 | |
| Soil depth | Very deep | 4 | 4 | 4 | 1 | Deep and medium-depth soils are the best soil type for agriculture. Soils with shallow depths are partially favorable. The soil structure with a very shallow depth is not suitable for cultivated soil (Akten, 2008; Akten et al., 2009). |
| | Deep | 3 | 3 | 3 | 1 | |
| | Medium | 2 | 2 | 2 | 1 | |
| | Shallow | 1 | 2 | 2 | 4 | |
| | Very Shallow | 1 | 1 | 1 | 4 | |
| Drainage problem | No | 4 | 4 | 4 | 1 | |
| | Yes | 2 | 2 | 1 | 4 | |
| Land use capability sub-class **(**LUCS) | No | 4 | 4 | 4 | 1 | |
| | Yes | 1 | 1 | 1 | 4 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Environmental sensitivity | No | 4 | 4 | 4 | 4 | |
| | Yes | 1 | 1 | 1 | 1 | |
| Spatial location | Urban area | - | - | 4 | - | |
| | Peri-urban area | - | - | 1 | - | |
| Proximity to industrial and solid waste storage site | > 3 | 4 | 4 | 4 | 4 | TRGM (2002), "Organic farming cannot be carried out in agricultural lands within 3 km of heavy industrial facilities, reactors, hydraulic and thermal power plants, …." |
| | < 3 | 1 | 1 | 1 | 1 | |
| Proximity to dense traffic roads | > 10 | 4 | 4 | 4 | 4 | Saumel et al., (2012) found intense trace elements in vegetables grown at a distance of 10 m. In Allen (2015), Samuel et al., (2012) based on the findings, the distance to the main roads accepted the threshold limit as> 10 m. MacRae et al., (2010) used a distance of> 10 m from all roads in their study. |
| | <10 | 1 | 1 | 1 | 1 | |
| Land use | Vacant lands | 4 | 4 | 4 | 4 | |
| | Green areas | 4 | 4 | 4 | 1 | |
| | > 15% impervious surface / poor soil | 1 | 1 | 1 | 1 | |
| Access to water | 0-10 | 4 | 4 | 4 | 4 | Dumitrescu (2013) examined the water access criteria in 3 sub-criteria: Easy access < 5 m, difficult access, 5-100 m, and problematic access > 100 m. In this study, the same parameters were used. |
| | 10-100 | 3 | 3 | 2 | 3 | |
| | >100 | 2 | 3 | 1 | 3 | |
| Vehicle access | Yes | 4 | 4 | 4 | 4 | |
| | No | 1 | 1 | 1 | 1 | |

### 2.2.4. Criteria maps generation

A database was designed, and criteria maps were created for suitability analysis (Figure 3). The maps were created using a variety of data sources. The slope and aspect maps were created by classifying DEM data, while the land use capability class (LUCC), erosion soil depth, drainage problem, and land use capability sub-class (LUCS) maps were derived from the soil map. The environment sensitivity map was generated by marking geologically sensitive areas in the zoning plan. The spatial location map was created using aerial photo analysis to identify the settlement pattern of the city. The industrial site and solid waste storage site maps were created by creating a 3 km buffer zone around these sites using ArcMap's buffer zone tool. The dense traffic road map was created by first identifying roads with dense traffic in the city and adding them to the database, then creating a 10 m buffer zone around these roads using ArcMap's buffer zone tool. The access to water map was created using the mains water map, and the vehicle access map was generated using aerial photo analysis in ArcMap. These criteria maps were then used in the suitability analysis to evaluate the potential for urban agriculture on the vacant public lands in Usak.


Slope Map
Aspect Map
Land Use Capability Classes Map
Land Use Capability Sub-Classes Map
Drainage Problem Map
Erosion Map
Soil Depth Map
Enviroment Sensitivity Map
DRAINAGE PROBLEM
No
Yes
EROSION
SOIL DEPTH
Very Deep
Deep
Medium deep
Shallow
Very Shallow
ENVIROMENTAL SENSITIVITY
38°42'30"N
38°40'0"N
38°37'0"N
29°20'0"E
29°25'0"E
29°30'0"E

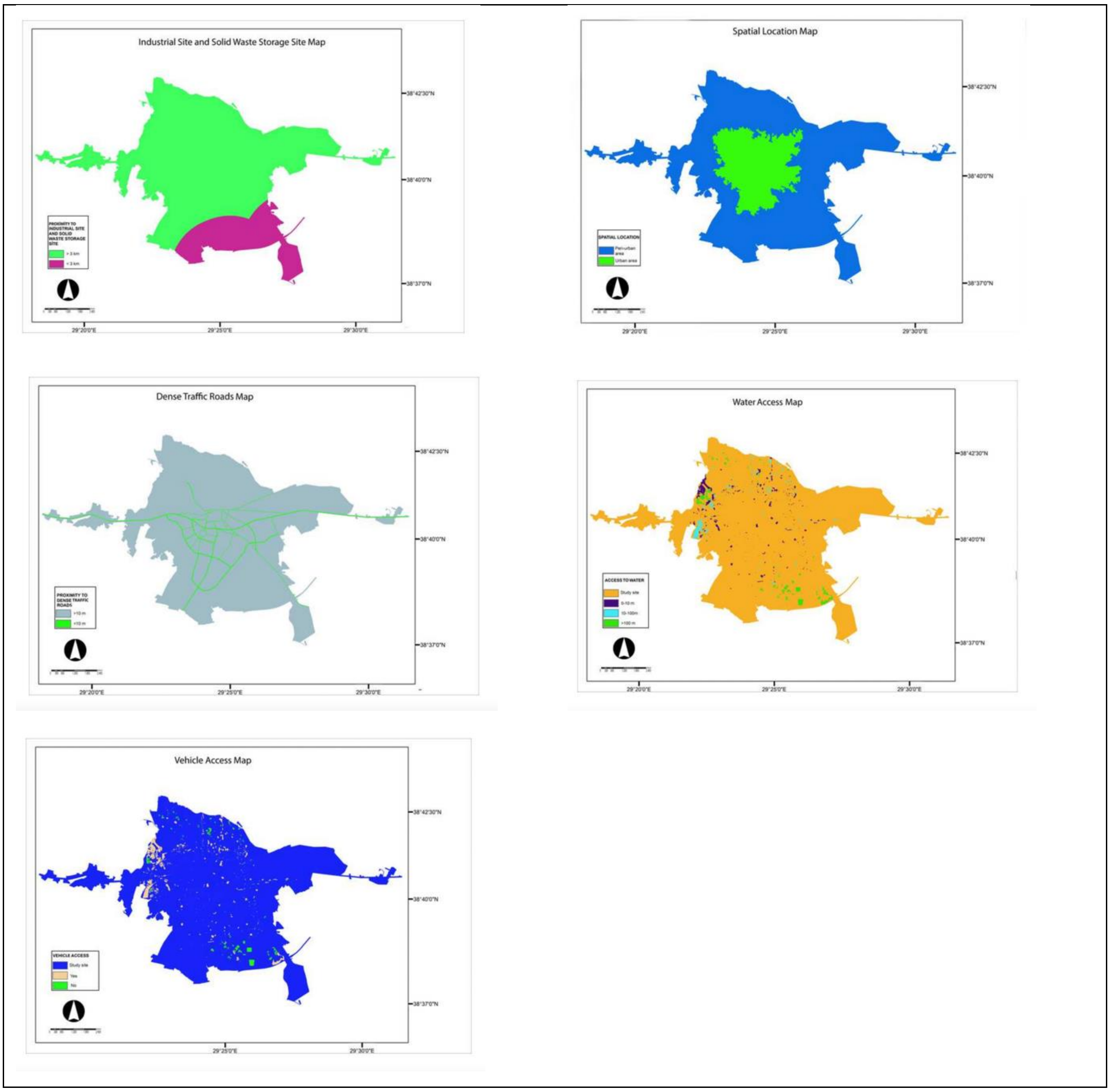



**Figure 3.** Criteria maps for urban agriculture analysis

### 2.2.5. Calculation of degree of influence for each criterion

The calculation method used in this study is a way to determine the relative importance or influence of each criterion in the evaluation of urban agriculture. The degree of influence of each criterion was calculated by expert score. Fifteen experts from different disciplines related to urban agriculture, including Landscape Architecture, Field crops, Garden plants, Plant protection, and Urban and Regional planning scored each criterion on a scale from 1 to 10. (1 = Highly Important; …….; 10 = Not important). The calculating approach described by Akpınar (1994), Karaelmas (2003), and Zengin (2017) was used to determine the degree of influence of each criterion. The formula is given below:

DT= ∑ Dfu Af= DT / ∑ DT DT= Sum of the values given to the f evaluation factor by experts
u= Number of experts from 1 to n
f= Number of factors from 1 to m
Dfu= Values given by the experts to the f evaluation factor
Af = Weight of the f evaluation factor

### 2.2.6. Suitability analysis

Suitability techniques are an approach that enables planners and local administrators to analyse multiple aspects of the decision-making process (Gül et al., 2006). The suitability maps were generated for each urban agriculture category by utilizing ArcMap. The standardized criteria and the degree of influence of each criterion were taken into account during the analysis (Figure 4, Figure 5, Figure 6, Figure 7). These suitability maps were divided into three classes: highly suitable, marginally suitable, and not suitable. The suitability maps for small and large-scale urban agriculture and community gardens were then overlaid to create an optimal urban agriculture map (Figure 8). The results of the suitability analysis were then validated through a site visit phase.

## 3. Findings

Suitability analysis results are given in Table 4. Based on the suitability maps for the different urban agriculture categories, it was found that there was a total of 1.04 hectares of highly suitable area, 9.72 hectares of moderately suitable area, and 0.62 hectares of not suitable area for small-scale urban agriculture. For large-scale urban agriculture, there was a total of 12.20 hectares of highly suitable area, 175.80 hectares of moderately suitable area, and 30.86 hectares of unsuitable area. For community gardens, there was a total of 0.89 hectares of highly suitable area, 8.18 hectares of moderately suitable area, and 3.82 hectares of unsuitable area. For impervious surface/poor soil urban agriculture, there was a total of 153.2 hectares of highly suitable area and 93.98 hectares of moderately suitable area. By overlaying the suitability maps for small and large-scale urban agriculture and community gardens, an optimal urban agriculture map was created for these categories (Figure 8). Based on this map, it was determined that there was a total of 7.32 hectares of highly suitable area, 80.58 hectares of moderately suitable area, 110.94 hectares of marginally suitable area, and 31.42 hectares of a not suitable area in the study area (Table 5).

**Table 4.** The distribution of urban agriculture suitability analysis results

| Suitability degree | Category | | | |
|---|---|---|---|---|
| | **Small-scale urban agriculture** | **Large-scale urban agriculture** | **Community Garden** | **Impervious surface / poor soil urban agriculture** |
| Highly Suitable | 1.04 ha | 12.20 ha | 0.89 ha | 153.2 ha |
| Moderately suitable | 9.72 ha | 175.80 ha | 8.18 ha | 93.98 ha |
| Not suitable | 0.62 ha | 30.86 ha | 3.82 ha | - |

**Table 5.** The distribution of optimal urban agriculture analysis results

| Suitability degree | Area |
|---|---|
| Highly Suitable | 7.32 ha |
| Moderately suitable | 80.58 ha |
| Marginally suitable | 110.94 ha |
| Not suitable | 31.42 ha |

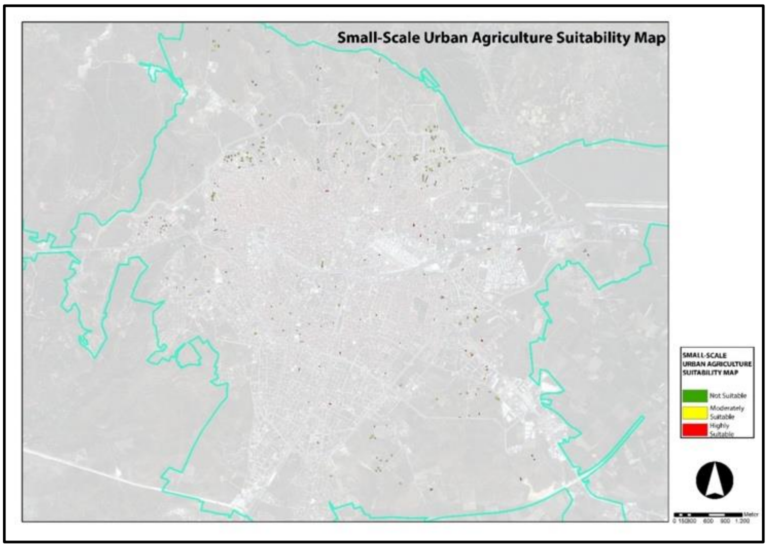



**Figure 4.** Small-scale urban agriculture suitability map

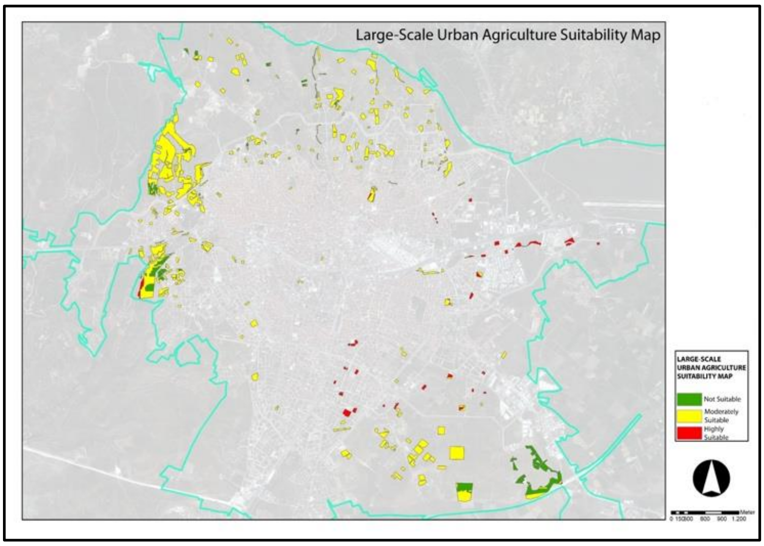



**Figure 5**. Large-scale urban agriculture suitability map

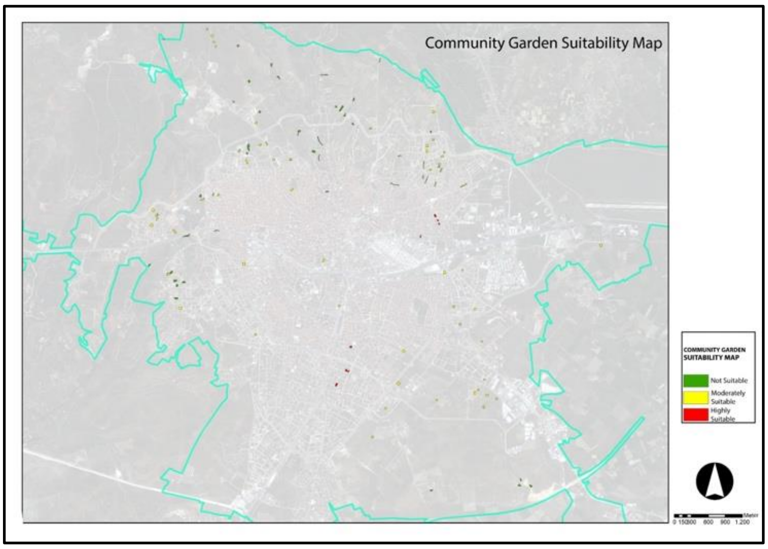



**Figure 6.** Community garden suitability map

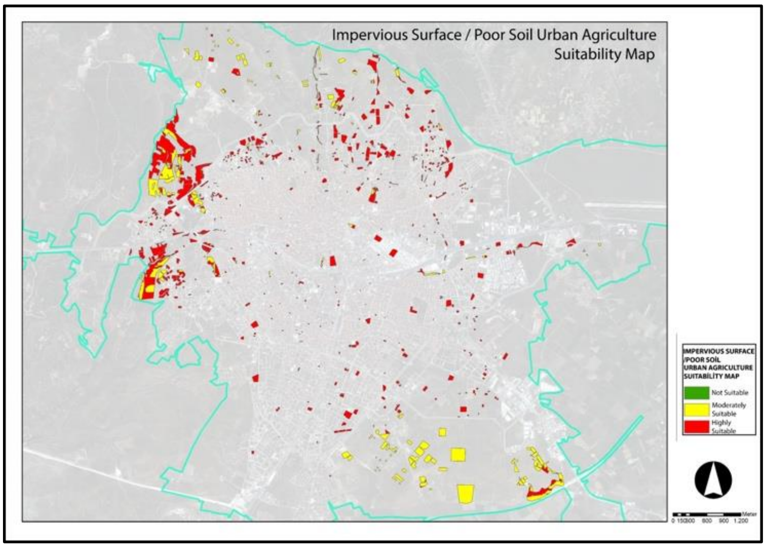



**Figure 7.** Impervious surface/poor soil urban agriculture suitability map

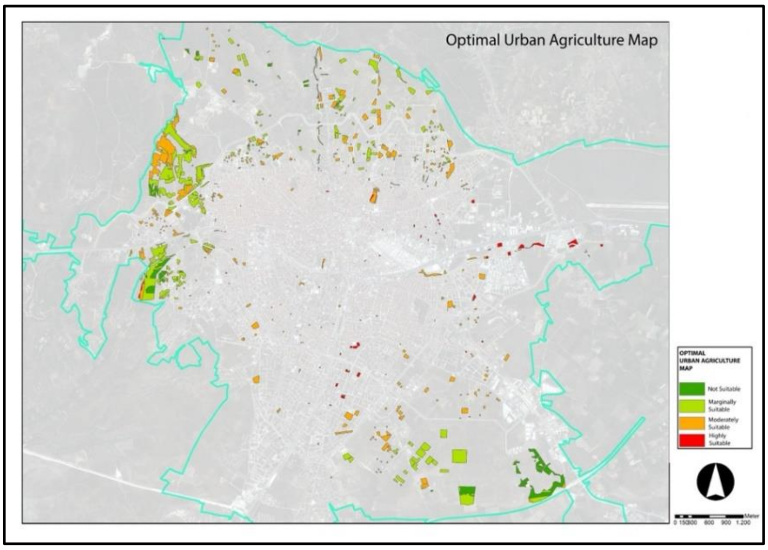



**Figure 8.** Optimal urban agriculture map

## 4. Conclusion and Suggestions

This study aimed to evaluate the urban agriculture potential on vacant lands in the city center of Usak using GIS. The study identified potential urban agriculture sites for four categories in Usak based on 15 criteria. By combining these categories, GIS-based optimal urban agriculture maps were created. The results showed 7.32 hectares of highly suitable, 80.58 hectares of moderately suitable, and 110.94 hectares of marginally suitable areas for urban agriculture. According to these findings that highly suitable areas are generally located in intra-urban areas, while moderately suitable and marginally suitable areas are located in peri-urban areas. The highly suitable, moderately suitable, and marginally suitable for urban agriculture identified in the study should be allocated for developing urban agriculture projects on these lands. This could involve working with urban agriculture organizations and other stakeholders to identify and prioritize projects that align with the potential and suitability of these lands. The study's findings reveal promising opportunities for utilizing vacant land in Usak for urban agriculture. By identifying areas of high, moderate, and marginal suitability, decision-makers can prioritize areas that are most conducive to high productivity and yield. Areas with high and moderate suitability may also be useful for a range of urban agriculture projects, while marginally suitable areas could be used for less intensive projects that still contribute to the city's food system and sustainability.

Incorporating the identified suitable areas into urban planning and development processes is another way to leverage their potential. By working with decision-makers to integrate urban agriculture into the city's planning strategies, we can create more sustainable and resilient cities. Similar studies in the literature have also shown that vacant lands have significant potential for urban agriculture, further underscoring the importance of utilizing these spaces to their fullest potential (Balmer et al., 2005; Eanes & Ventura, 2015; Allen, 2015; Horst, 2008; McClintock et al., 2013; MacRae et al., 2010; McClintock & Cooper, 2010; Taylor & Lovell, 2012; Kaethler, 2006; Dumitrescu, 2013). While the study presents exciting possibilities for utilizing vacant lands for urban agriculture in Usak, it also has some limitations. Gathering data proved challenging, and some institutions did not make their information available in digital formats. Despite these challenges, the study offers valuable insights into how urban agriculture can provide alternative and sustainable food systems for the city's residents. By identifying potential sites for urban agriculture, this study may pave the way for a more sustainable food system in and around Usak. Furthermore, the GIS-based methodology used in the study can be applied in other cities to identify potential urban agriculture sites. Decision-makers and researchers can use the study's findings to inform the development of urban agriculture policies and strategies. By utilizing vacant lands in the city for urban agriculture, cities can support local food production, reduce the environmental impacts of food miles, and create opportunities for economic development. In this research, the urban agriculture potential of a city was determined for the first time in Türkiye using GIS.

For this reason, the study has original value. In addition, in this study, the subject is discussed much more comprehensively than the related studies in the literature. Overall, the study provides valuable insights into the potential for urban agriculture on vacant lands in Usak and demonstrates the potential benefits of utilizing these lands for this purpose. The GIS-based methodology used in the study can be replicated in other cities to identify potential urban agriculture sites. The study results can be used to inform the development of urban agriculture policies and strategies.

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**Author Contribution and Conflict of Interest Declaration Information**

1st author 60%, 2nd author 40% contributed. There is no conflict of interest.

**References**

Ackerman, K., Conard, M., Culligan, P., Plunz, R., Sutto, M. P. & Whittinghill, L. (2014). Sustainable food systems for future cities: The potential of urban agriculture. *The Economic and Social Review,* 45(2, Summer), 189-206.

Akten, M. (2008). Isparta Ovasının Optimal Alan Kullanım Planlaması Üzerine Bir Araştırma. SDÜ Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı ABD, 247s, Doctoral Dissertation, Isparta.

Akten, M., Yılmaz, O. & Gül, A. (2009). Alan kullanım planlamasında rekreasyonel alan kullanım ölçütlerinin belirlenmesi: Isparta Ovası örneği. S*üleyman Demirel Üniversitesi Orman Fakültesi Dergisi,* Seri: A, Cilt: 2, ISSN: 1302-7085, Sayfa: 119-133, Isparta.

Akpınar, N. (1994). Açık kömür ocaklarında çevresel etkilerin değerlendirilmesi ve doğa onarımı çalışmalarının Milas-Sekköy Açık Kömür Ocağı örneğinde irdelenmesi. Ankara Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı ABD, Ankara, 277s.

Allen, L. (2015). Growing in the city: Analyzing public urban agriculture in Ottawa. Carleton University, Doctoral Dissertation, 164s, Ottawa, Ontario.

Amirtahmasebi, R. (2008). Food urbanism: urban agriculture as a strategy to facilitate social mobility in informal settlements. Massachusetts Institute of Technology, Doctoral dissertation.155p, USA.

Armar-Klemesu, M. (2000). Urban agriculture and food security, nutrition and health. Growing cities, growing food. *Urban Agriculture on The Policy Agenda*, 99-118.

Balmer, K., Gill, J., Kaplinger, H., Miller, J., Peterson, M., Rhoads, A., Rosenbloom, P. & Wall, T. (2005). The diggable city: Making urban agriculture a planning priority. Portland. Portland State University, Nohad A. *Toulan School of Urban Studies and Planning*.

Bryld, E. (2003). Potentials, problems, and policy implications for urban agriculture in developing countries. *Agriculture and Human Values*, 20(1), 79-86.

Deelstra, T. & Girardet, H. (2000). Urban agriculture and sustainable cities.

Doherty, K. (2015). Urban agriculture and ecosystem services: a typology and toolkit for planners. The University of Massachusetts Amherst, Master's Thesis, 110p, USA.

Dumitrescu, V. (2013). Mapping Urban Agriculture Potential in Rotterdam.

Eanes, F. & Ventura, S. J. (2015). Inventorying land availability and suitability for community gardens in Madison, Wisconsin. *Cities and the Environment* (CATE), 8(2).

Gezer, A. & Gül, A. Eds. (2009). Kent Ormancılığı (Kavramsal-Teknik ve Kültürel Boyutu). SDU Orman Fakültesi, Kitap Yayın No: 86, s: 01-246. Isparta. (ISBN: 978-9944-452-30-4) SDU Basım evi-Isparta.https://mimarlikbilimleri.com/2022/04/22/kent-ormanciligi-kavramsal-teknik-ve-kulturel-yaklasimlar/

Gül, A., Örücü, Ö. K. & Karaca, Ö. (2006). An approach for recreation suitability analysis to recreation planning in Gölcük Nature Park. *Environmental Management*. Volume 37, Number 5, May, 2006, 606–625 (2006). Online ISSN: 1432-1009.

Gül, A. (2022). Urban Agroforestry Systems in Urban Agriculture. In H. B. Türker, & A. Gül. (Eds.) Architectural Sciences and Urban Agriculture (26-68). ISBN:978-625-8213-84-3. Ankara: Iksad Publications. https://iksadyayinevi.com/wp-content/uploads/2022/11/Architectural-Sciences-and-Urban-Agriculture.pdf

Hankard, M., Reid, M., Schaefer, R. & Ve Vang, K. (2016). Stormwater Runoff Benefits of Urban Agriculture.

Horst, M. (2008). Growing Green: An Inventory of Public Lands Suitable for Gardening in Seattle, Washington. University of Washington, College of Architecture and Urban Planning.

Hynes, P. (1996). A pinch of Eden. Chelsea Green, White River Junction.USA, 2, 35-37. 2001 edition.

Karaelmas, O. (2003). Çerkes Havzasının Optimal Alan Kullanımının Belirlenmesi Üzerine Bir Araştırma, Ankara Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı Anabilim Dalı, Doktora Tezi, 153s, Ankara.

Kaethler, T. M. (2006). Growing space: The potential for urban agriculture in the city of Vancouver. School of Community and Regional Planning University of British Columbia.

Lin, B. B., Philpott, S. M. & Jha, S. (2015). The future of urban agriculture and biodiversity ecosystem services: Challenges and next steps. *Basic and Applied Ecology*, 16(3), 189- 201.

MacRae, R., Gallant, E., Patel, S., Michalak, M., Bunch, M. & Schaffner, S. (2010). Could Toronto provide 10% of its fresh vegetable requirements from within its boundaries? Matching consumption requirements with growing spaces. *Journal of Agriculture, Food Systems, and Community Development,* 1(2), 105-127.

Matteson, K. C., Ascher, J. S. & Langellotto, G. A. (2008). Bee richness and abundance in New York City urban gardens. *Annals of the Entomological Society of America*, 101(1), 140- 150.

McClintock, N. & Cooper, J. (2010). Cultivating the Commons an assessment of the potential for urban agriculture on Oakland’s public land. Urban Studies and Planning Faculty Publications.

McClintock, N., Cooper, J. & Khandeshi, S. (2013). Assessing the potential contribution of vacant land to urban vegetable production and consumption in Oakland, California. *Landscape and Urban Planning*, 111, 46-58.

Mougeot, L. J. (2000). Urban Agriculture: Definition, Presence, Potentials And Risks, And Policy Challenges. Cities Feeding People Series, Report 31, 58p.

Saha, M. & Eckelman, M. J. (2017). Growing fresh fruits and vegetables in an urban landscape: A geospatial assessment of the ground level and rooftop urban agriculture potential in Boston, USA. *Landscape and Urban Planning,* 165, 130-141

Sarp, K, M. (1994). Uşak Merkez 1/5000 Ölçekli İlave Nazım İmar Planı Araştırma Raporu.

Saumel, I., Kotsyuk, I., Holscher, M., Lenkereit, C., Weber, F. & Kowarik, I. (2012). How healthy is urban horticulture in high-traffic areas? Trace metal concentrations in vegetable crops from plantings within inner-city neighborhoods.

Smit, J., Nasr, J. & Ratta, A. (1996). Urban Agriculture: Food, Jobs, And Sustainable Cities. United Nations Development Programme Publications Series For Habitat II Volume One, 302p, New York, USA.

Smit, J., Nasr, J. & Ratta, A. (2001). Urban Agriculture: Food, Jobs, and Sustainable Cities (2001 edition). The Urban Agriculture Network. Inc., New York, NY.

Taylor, J. R. & Lovell, S. T. (2012). Mapping public and private spaces of urban agriculture in Chicago through the analysis of high-resolution aerial images in Google Earth. *Landscape and urban planning,* 108(1), 57-70.

Tema Foundation. (2018). Tema Vakfı 2018. Ekosiyaset Belgesi. Retrieved 09 February 2020 from http://www.tema.org.tr

Thapa R.B. & Murayama Y. (2008). Land evaluation for peri-urban agriculture using analytical hierarchical process and geographic information system techniques: A case study of Hanoi. Land use policy, 25(2), 225- 239.

TRGM. (2002). Organik Tarımın Esasları ve Uygulanmasına İlişkin Yönetmelik.

TRGM. (2008) Toprak ve Arazi Sınıflaması Standartları Teknik Talimatı ve İlgili Mevzuat.

Turkish State Meteorological Service. (2020). Uşak Merkez İstasyonu 1990-2018 yılları arasındaki Uşak kenti tüm Parametreler Bülteni.

TURKSTAT. (2020). Retrieved 06 March 2020 from http://www.tuik.gov.tr.

Türker, H. B., Gül, A., Anaç, İ. & Gül, H. E. (2021). The Role of Urban Agriculture in Adapting to Climate Change for Sustainable Cities. 2nd International City and Ecology Congress within the Framework of Sustainable Urban Development (CEDESU 2021), Proceedings Books, Ertan Düzgüneş and Öner Demirel (Eds.), 2- 3 December, Trabzon-Türkiye, 222-227.

United Nations. (2018). The World's Cities in 2018.

United Nations. (2019). World Population Prospects.

Usak Municipality. (2020). Retrieved 06.March,.2020 from https://www.usak.bel.tr/sayfa/genel-bilgi.

Van Veenhuizen, R. & Danso, G. (2007). Profitability and sustainability of urban and peri-urban agriculture. FAO Agricultural Management, *Marketing, and Finance Occasional* Paper No.19, 95p, Rome. V.

Yenigül, S. B. (2016). Büyükşehirlerde tarımsal alanların korunmasında kentsel tarım ve yerel yönetimlerin rolü. *Megaron,* 11(2), 291-299.

Voicu, I. & Been, V. (2008). The effect of community gardens on neighboring property values. *Real Estate Economics*, 36(2), 2414–2263.

Zengin, M. (2017). Peyzaj planlamada TOPSİS yöntemi ve Erzurum örneği. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 7(1).