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A cost-benefit analysis of applying urban agriculture in sustainable park design

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ABSTRACT

There are ideas that urban agriculture could assist in creating sustainable cities. However, little information is available on its financial benefits. Integrating Value Engineering (VE), Risk Management (RM) and Multi-Criteria Decision-Making (MCDM) techniques in this research improved the design and economical aspects of a city park based on urban agricultural development. This research was carried out on a part of Chehelbazeh Park in Mashhad, Iran. The base plan was designed based on conventional park design approach, and the proposed agricultural plan was designed by applying urban agricultural approach. In this study, based on the cost-benefit value index, the index of the base conventional plan was 0.86, which is considered uneconomic, and that of the proposed agricultural plan was 4.08. According to the results of this study, using urban agriculture in city landscapes can have high profitability and low risks. In general, VE, RM, and MCDM techniques can be used collectively as valuable tools in the design and maintenance of urban parks to achieve sustainability while making efficient use of the budget. The methodology of this study provides a decision-making framework for urban landscapes and can help policymakers, urban planners, and researchers on planning or designing urban parks in other countries. Also, it makes it easier for urban landscape managers and decision-makers to understand the importance of using fruit trees, vegetables, and other productive plants in urban landscaping.

1. Introduction

Sustainable development is one of the most important strategies to respond to social, economic and environmental problems, and urban green spaces (landscapes) and parks have important contributions to sustainability (Engestrom and Gren, 2017).

Green spaces have significant positive tangible and intangible effects on urban environments (Lovell and Taylor, 2013; Kazemi and Mohorko, 2017). Effects such as air and water purification, food production and reducing environmental problems are more tangible (TEEB, 2010; Kazemi et al., 2010, 2011) but their effects on increasing health (Hartig and Kahn, 2016; Hartig et al., 2014), reducing stress, and increasing psychological wellbeing and public preferences (Grahn and Stigsdotter, 2003; Nazemi Rafi et al., 2020), reducing heart diseases and early death (Mitchell and Popham, 2008), increasing the awareness of children with attention-deficit (Taylor and Kuo, 2009), and increasing physical activities (Kaczynski and Henderson, 2007) are less tangible. Despite such important effects of green spaces in the cities, there are debates on the effects of their construction and development as they are considered as high consumers of the resources and budget consumers with limited productivity in a city environment (Kazemi et al., 2018).

Saving resources, which is one of the main concerns in urban park design and management, can be achieved by cost-effective and sustainable solutions for environmental protection. The economic impacts of urban parks and green spaces have been less studied compared with their social and environmental effects, and planners and researchers have been less able to measure the economic values of urban parks and how to maximize the use of funds in their design and management (Andrews et al., 2017).

To efficiently manage the costs of the design and construction of a project, VE can be applied (Shin et al., 2016). VE is a method or function to improve the value of a project that optimizes the prices to achieve the expected performance (Dell'Isola, 2003). VE optimizes the value of the outputs of a system by combining the functions and the costs. In most

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cases, this practice identifies and removes unnecessary costs, so the value increases (Janani et al., 2018). Calculating the life cycle cost is also a method used for comprehensive economic analysis. It measures initial investment options and identifies the options with lower lifecycle costs. Life-cycle costs are achieved by comparing the initial construction and maintenance costs and income over the lifetime of a plan (Kumaraswamy and Kumar, 2017).

RM is also a process aimed at reducing the harmful effects of activity by predicting unwanted events and planning to avoid them (Naderi et al., 2020; Viner, 2015). This method in our study could complement the VE method. The goal of using RM in our study is to achieve a successful project throughout the life cycle of the project. There are no risk-free projects, but risks can be identified, managed, or minimized or even accepted. Therefore, one of the most important benefits of RM is to increase the confidence of the designers and constructors in the appropriate conduction of the project (Vahedi et al., 2007). Some studies believe that to better achieve sustainability and increase the success chances of a project, integration of VE using MCDM and RM approaches is needed (Vahedi et al., 2007). One of the popular methods for prioritizing the criteria is the Analytical Hierarchy Process (AHP), which is one of the several decision-making methods developed by Saaty (1977). AHP is a weighting method that evaluates alternative scenarios and ultimately leads to the selection of the best alternatives (Saaty, 2004).

To the best of our knowledge, VE techniques, both at local and international levels, have not been used in public park design, and such techniques have been more often used in construction projects (Cheah and Kiong Ting, 2005; El-Alfy, 2010; Palmer et al., 1996; and Zhang et al., 2009), irrigation systems projects (Kamasei et al., 2016), and product development processes in automotive companies (Ibusuki and Kaminski, 2007).

With increasing urban development, agricultural lands have also been converted into residential areas and industrial estates. Rapid growth in urban land values and a decrease in their quantity will gradually cause many economic and social crises, which will increase motivation for the multipurpose creation of green spaces (Sadeghi and Sheibani, 2012). One of the ways that is increasingly being developed as a solution to food availability in cities is urban agriculture (Ackerman et al., 2014). Urban agriculture is a policy for linking productive plants and green spaces, which will increase the performance of urban open spaces (Sheibani and Chamanara, 2012).

Applying urban agriculture has its roots in the history of garden design. In the past, Persian garden designs were rich in horticulture and used productive plants (Abbas et al., 2016). Many trees in Persian gardens provide shade and are productive plants, and a low number of non-productive flowers and ornamental plants can be found in these gardens (Shah Cheraghi, 2013). Considering that Persian gardens have common cultural, social, environmental and economic criteria in urban planning, they can be considered as suitable platforms for urban agriculture (Esfandiari and Ansari, 2016).

Urban agriculture is beneficial both for developing cities and for industrialized and advanced ones because it is based on the three pillars of sustainability, including the economy, society, and the environment. The economic situation and food security are the reasons for the expansion of urban agriculture (Ackerman et al., 2014). However, urban agriculture cannot meet all the food needs of a city, but it will help create a green connection between the city and the local area and will contribute to self-sufficiency and sustainability.

Urban agriculture not only provides a healthy food supply but can also help households generate income and create jobs (Kazemi et al., 2018). In these gardens and green spaces, people come together and collaborate and often strengthen the social and cultural identity of the urban community, and ultimately urban agriculture can play an important role in the sustainability of the urban environment, and as a form of green infrastructure, they help reduce the effects of urban heat islands and water loss and energy consumption for food transportation (Ackerman et al., 2014).

This study, therefore, for the first time, examined how to integrate urban agriculture with VE, RM and MCDM in the design, construction and maintenance stage of an urban park. Our focus is on reducing life cycle costs of the green space of a park and increasing its life cycle incomes.

The study aimed to determine the financial benefits of using urban agriculture in urban park design in comparison with common conventional park design approach. As a practical example, this study demonstrates the long-term financial profitability of urban agricultural development, and it can help managers and decision-makers in future planning and design of urban parks using urban agricultural approach. Also, the combination of VE, RM, and MCDM methods can be used in future research as a comprehensive way to reduce unnecessary costs of park plans as well as to increase their financial benefits through new and efficient ideas in urban landscaping.

2. Methodology

In this study, we changed the planting design of an urban park (two zones of "Chehelbaze Park") from conventional design approach to urban agricultural approach. To provide a methodological framework for this new design approach toward sustainability, and to increase the efficiency of the research outputs, we used VE, RM, and MCDM methods during the design stage.

2.1. Case study and the overall method

The study site was in the city of Mashhad, located in North East of Iran with geographical coordinates of 59∘ 27' east longitude and 36∘ 20' northern latitude and 1100 m above sea level. Mashhad is the second biggest, and the second most populated city in Iran, after Tehran (Kazemi et al., 2018). In this research, the base conventional design site was the two zones of Iranian and Japanese gardens of "Chehelbaze Park" located in Mashhad municipality, district 11 (Fig. 1). The total area of Chehelbaze Park is 300 ha which consist of eight various zones. This park was designed previously by another company. After many meetings and discussions with members of the municipality of Mashhad, we decided to re-plan and re-design the planting of the two zones of this park, namely the Persian and the Japanese Gardens areas (3.5 ha), based on urban agricultural approach. This park has the potential to be one of the important tourist attractions for Mashhad in the future. In this study, the base design was prepared according to conventional park design approaches in Iran, which usually uses ornamental trees, flowers, and other non-productive plants in large scales. This design approach mainly focuses on the recreational and aesthetic aspects of the green spaces.

In this study, we compared the differences between the base conventional design (primary design of the same area of 3.5 ha) and our proposed agricultural design (secondary design based on the highest potential of applying urban agriculture) in terms of the costs of the construction, life cycle, maintenance costs, and incomes, using the VE, MCDM, and RM methods. These techniques were used to quantify the profits of urban agricultural approach. Therefore, the scope of this research was to determine the financial profitability of urban agriculture compared to conventional urban park design scenario, and does not include the profits of intangible benefits of urban parks and green spaces.

2.2. Value engineering process

VE has different stages which are shown in Table 1. The best stage of a project to apply VE is the conceptual stage which can bring the most savings (Rachwan et al., 2016). We also used VE before implementing the plan, in design stage of the project, because it is easier to make changes at this stage.

Pre-workshop is the preparation step in VE. At this stage, we provided the prerequisites and requirements such as project information,

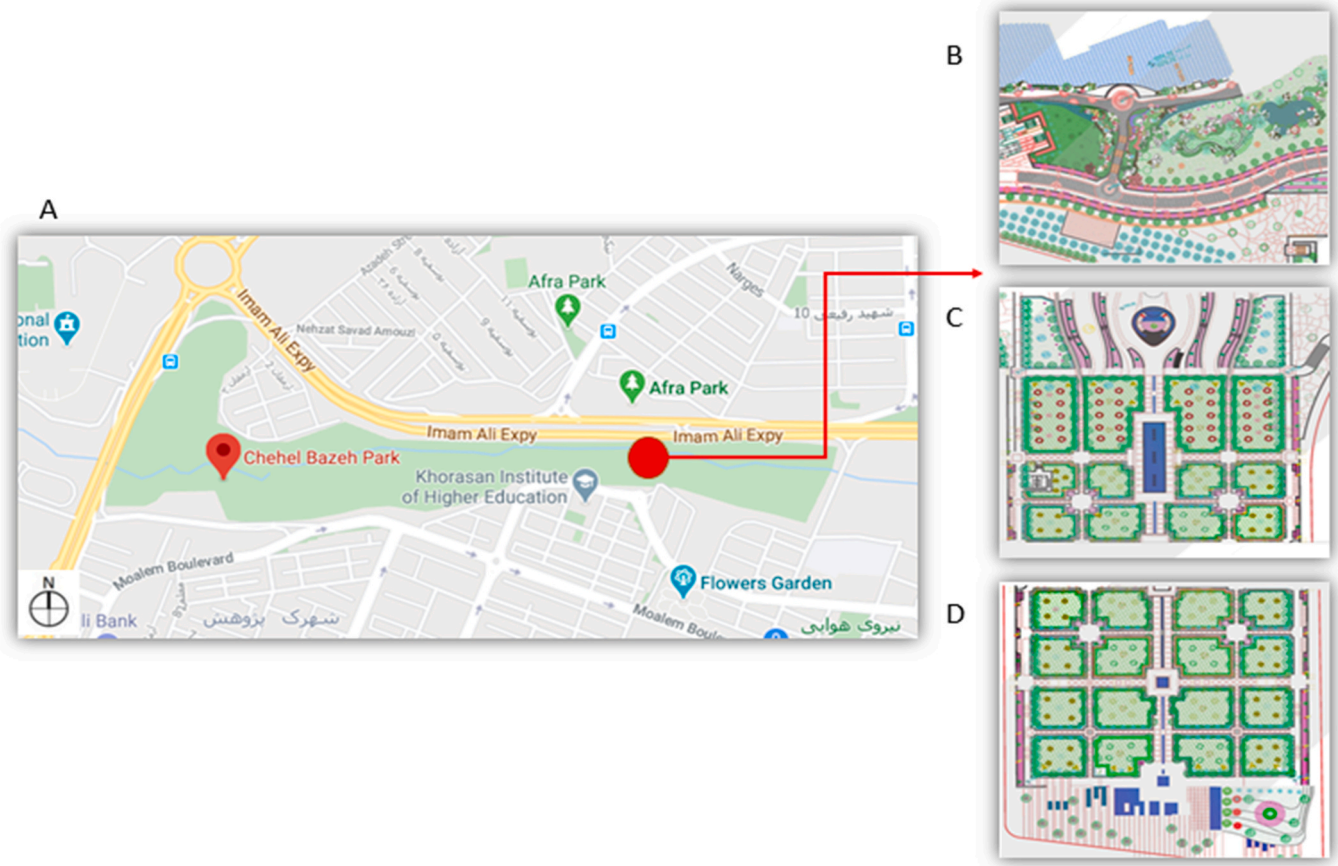

Fig. 1. A) Map of Chehelbaze Park from Google Maps; B) The plan of Japanese garden; C) The plan of northern portion of Iranian garden and, D) The plan of southern portion of Iranian garden, Mashhad, Iran.

Table 1
Different stages of value engineering method (Arab et al., 2010).

Stage	Steps
Pre-workshop	• Data collection • Determining the basics of the study (including the objectives of the project, objectives of the VE, identification of the stakeholders of the project, the project opportunities, determination of the employer's limitations) • Preparing the cost modeling • Determining the members of the study team
Main-workshop	• Information phase: obtaining general information on the case study • Functional analysis phase: determining the leverage functions and plotting its table • Creativity phase: achieving the new ideas • Analysis phase: evaluating the new ideas using the MCDM method • Development phase: developing the final ideas, implementing the RM and estimation of the costs and revenues • Presentation phase: reporting the results and presenting orally
Post-workshop	• Applying other suggested changes (if it is required based on unpredictable situations) • Track applying the changes (if it is required)

land uses, maps, approximate price estimates and Project Limitations and barriers. To begin the VE process, we selected the team members. The main workshop is a six-phase process including the information phase, functional analysis, creativity, evaluation and development phases (Rachwan et al., 2016). The post-workshop is the step that monitors the correct implementation of VE ideas after the implementation of the project or proposes some changes if needed. Therefore, in this study, we focused on the main workshop stage, which is the most important part of a VE study (SAVE International, 2007).

Since VE is a teamwork that requires team creativity, in this research, we gathered a group of 30 people to conduct this research, including representatives with expertise in landscape design and architecture (six people), urban planning (four people), civil engineering (five people), water resource management and engineering (four people), landscape horticulture (eight people), and economics (three people). These people were mainly stakeholders of the project as well. The key stakeholders of the project were from Mashhad Parks & Gardens organization, Mashhad Municipality, district 11, Mashhad Municipality Cultural & Amusement Organization, Mashhad Municipality Technical & Civil Organization, and the Mashhad Municipality Department of Urban Planning and Architecture.

The authors of this study acted as facilitators of the workshops and led the group to identify and solve the problems and increase the effectiveness of the group. To ensure the knowledge of the team members about the VE process, all sessions of the study were fully explained by the facilitators. Then the team facilitators determined the location and time of the meetings and made the necessary preparations, in consultation with the team members.

2.3. Analytical hierarchy process

In the evaluation phase of the main-workshop stage, the authors used the MCDM technique to select the best ideas of the team members for the appropriate changes in the base conventional plan. The VE team used AHP method, which is one of the MCDM methods, to analyze the weight of the criteria. Each idea was scored according to the effectiveness of the idea based on each criteria by the team members. AHP is a management tool that is used to deal with multiple criteria problems (Figueira et al.,

2005; Peng and Peng, 2018; Wong and Li, 2008). The purpose of the AHP technique is to select the best option based on different criteria by pairwise comparisons. This technique is also used to weight the criteria. The reason for using the AHP approach in this study was that the criteria were independent of each other, and there was a need for pairwise comparison of the criteria through the experiences of the experts and members of the VE team. This technique has been successfully applied in relatively similar situations in previous studies (Asgharpour, 2018).

For this reason, the VE team divided the ideas into three categories as our alternatives at this stage.

Then, four criteria for prioritizing the selected options were proposed. For weighting alternatives, 30 questionnaires were distributed among the team members to obtain everyone's opinion to be able to choose one of the alternatives. We used Expert Choice v.11.0 software to apply the AHP method and prioritize our alternatives and choose the best ideas for this urban agricultural park.

2.4. Risk assessment

In this study, we used risk assessment in the development phase, which is the most important phase of VE. Risk assessment is used in this phase because if the risk of a project is high, the project costs may increase due to poor decisions (Jannadi and Almishari, 2003; Babar et al., 2017). Since either of the secondary risks can be an opportunity or a threat (SAVE International, 2018), the advantages and disadvantages of each idea and their probability and impact of occurrence were identified by the team members in this phase. Then, the team determined the severity of each identified secondary risk. The use of a probability and impact matrix is one of the common tools for risk calculations (Project Management Institute, 2017). This stage was completed by filling 30 questionnaires by the team members. The team members scored the probability of occurrence between 10% and 90% and the impacts of the risks were scored between 5% and 80% in the questionnaires. These intervals were selected from the probability and impact matrix scaling in the Project Management Body of Knowledge (PMBOK) (2017) and Dumbrava and Iacob (2013). To assess the reliability of the questionnaire, Cronbach's alpha was calculated which was 0.802 and the impact intensity was 0.801. Therefore, the reliability of the study was confirmed.

A positive sign for each opportunity and a negative sign for each threat was given by the VE team and then the Severity (S), was translated into a mathematical language as follows:

$$S = I \times P$$

Where I= impact and P = probability (Dumbrava and Iacob, 2013).

$$EV = \sum S$$

Where EV= Expected Value that is the sum of the severities for each idea. In the next step, the Standard Deviation (SD or σ in probability theory) was calculated under the risk conditions ($\sigma = (\sum (P_j \times (I_j - EV)^2))^{0.5}$) to improve the accuracy of the risk measurement. The average of all the standard deviations is the Risk Assessment Factor (Williams et al., 1995; Mahdizadeh, 2010; Taghinezhad, 2010).

2.5. Financial calculations

The financial calculation process was used at the end of the development phase to examine the economic benefits of the proposed agricultural design and compare it with the base conventional design. These financial calculations were used to determine the Net Present Worth (NPW) of costs and incomes of the proposed agricultural and base conventional designs during their considered life span (20 years). Life cycle costing consists of all costs of a project, over a specified length of time (Mohammad Amin, 2015). The park's life span was considered 20 years according to the regulations of Iranian municipalities, and these calculations were made with the assumption of an average annual inflation rate of 15% and a Minimum Attractive Rate of Return of 15% based on the rates released by Central Bank of the Islamic Republic of Iran (Central Bank of the Islamic Republic of Iran, 2018).

The single-payment factor is:

$$P = F\left[\frac{1}{(1+i)^2}\right]$$

Where "F"= future worth and "P"= present worth for the "n" years and "i"= inflation rate (Oskounejad, 2016).

The Annual- payment present worth factor is:

$$P = A_1\left[\frac{1-(1+j)^n(1+i)^{-n}}{i-j}\right] \text{ if } i \neq j \quad p = \frac{n A_1}{1+i} \text{ if } i = j$$

Where "A"= Annual payment, "j"= Attractive Rate (Oskounejad, 2016).

There is a factorial table named compound interest tables as an appendix in many economic books (e.g. Halpin and Senior, 2009) that shows the factors with different inflation rates and different years and is shown in the standard form of (X/Y, I%, n), to avoid duplicate calculations of these factors. This factor is (P/F, I%, n) for a single-payment and (P/A, i, j, n) for annual payment and P=F (P/F, I%, n), and P = A (P/A, i, j, n) for both (Oskounejad, 2016; Mohammad Amin, 2015).

In this project, all the prices of the potential park design elements are provided as a list by the municipality on an annual basis and the list is called "the landscape price list" and this list is specific for each city and it is based on previous projects' experiences. To evaluate and compare all the cost aspects, including the costs of each practice in the construction stage, the costs of purchasing equipment, fertilizers, and plants, the costs of soil preparation and transportation, various maintenance costs such as irrigation, pruning, cleaning, and other costs were listed for either of the two park design plans using the annual price list of Mashhad.

Also, calculating the incomes of the parks in both plans was based on the incomes associated with selling the park products in the proposed design and the annual rent of the restaurant and coffee shop buildings, which is equal in both designs. In the proposed agricultural design, an area for daily markets and selling the products was also considered. Also, people can pick their own fruits and pay for them at specific counters. The prices of the products used in the proposed agricultural design were based on an assumption of quality. It was assumed that the urban agriculture park production would not meet the quality of commercial crops as they were not coming from professionally managed "monoculture" gardens. Therefore, our proposed prices in this project were slightly lower than the peak season market price from daily markets of Mashhad's municipality.

2.6. Monte Carlo simulation

Since fixed financial numbers are used in the formation of financial tables, and some of the parameters in these tables are related to the estimation of the future finance of the park, it is possible to be changed in the future. Therefore, more precise predictions should be made to achieve closer results to the realities in the future. To achieve such precise predictions, Monte Carlo simulation which is a method for generating random numbers concerning the distribution function of non-deterministic variables was used. This simulation type has been widely used in previous studies (e.g. Behbahaninia et al., 2022; Balezentis and Streimikiene, 2016; Arnold and Yildiz, 2015). For example, Balezentis and Streimikiene (2016) used it in the area of MCDM for ranking European Union (EU) energy development scenarios in order to check the robustness of the results and Arnold and Yildiz (2015) applied it to optimize the conceptual design of an investment project with respect to capital returns and risk. In this way, by generating random numbers in an Excel software package and adding the calculated costs and incomes of the construction of the proposed agricultural design using the annual landscape price list as described in the previous section

and also estimating the costs and incomes of the following years after the construction by applying the annual inflation rates of Iran and calculating the averages and standard deviations and also calculating NPW, we were able to simulate 1000 states and calculated the probability of failure within the 20-year life cycle of the proposed park.

3. Results

3.1. Information phase

In this phase, members of the VE team defined the current information and determined the goals of the project which were increasing the productivity and the profitability of the park. This stage was including the information on the park location (See part 2.1).

3.2. Functional analysis phase

In this phase, the team members drew up the Functional Analysis System Technique diagram by identifying the desired functions to achieve the goal of sustainable development with the guidance of the facilitators. The facilitators' task at this stage was to provide the experts with a unified expression of the project and to move the discussion from the project components to the project functionalities. The project's functions were identified by the team members. These functions were reviewed and improved to achieve the objectives of the project (SAVE International, 2007). To draw the diagram of this stage, team members drew up functions on cards and the facilitators glued them to the base chart drawn on the board. They displaced or substituted the functions on the diagram until the team members came to a single view. After that, they were able to prepare the final FAST diagram.

After drawing the diagram, the functions with high-risk characteristics, high opportunities, and high costs were determined by the team, and the team used them in the creativity phase. A FAST diagram has been used to improve the functions of projects to achieve goals in previous studies (e.g. in Ibusuki and Kaminski, 2007 and Al-Anzi et al., 2017).

Figs. 2 and 3 illustrate two types of FAST diagrams, the Technical FAST, and the Customer-Oriented FAST drawn for this research work. Both diagrams were drawn using the team members' opinions, respectively. Customer Oriented FAST is more hierarchical and lends itself to allocating costs, resources, and customer attitudes easily (Fowler, 1990; Blumstein, 1996).

3.3. Creativity phase

In this phase, the team members presented their ideas based on the leverage functions (high risk, high opportunity, and high cost), which were featured in the FAST diagrams, in the Function Analysis Phase. The team members used a brainstorming method (Ibusuki and Kaminski, 2007) to get the ideas, and ultimately 39 ideas were achieved.

3.4. Evaluation phase

In this phase, the proposed ideas were evaluated by the team, and those ideas that could improve the potential value in the direction of achieving the desired function of the project were selected (SAVE International, 2007).

In the first step, the ideas were evaluated qualitatively, and the individuals described their ideas, and the defenders and opponents gave their opinions, and then the types of ideas were defined.

The types of ideas included the scoring ideas, which were the ideas that went into the development phase; recommended ideas, which were

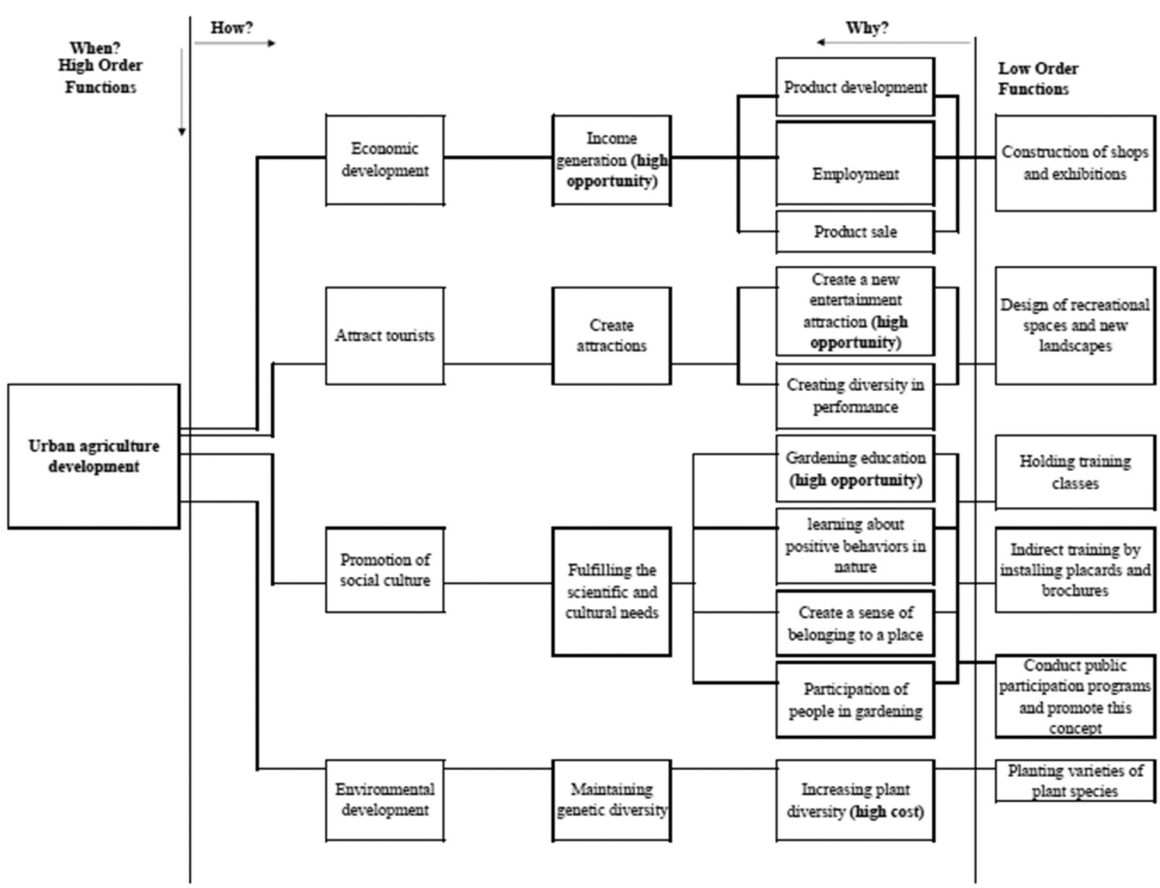

Fig. 2. Technical FAST diagram.

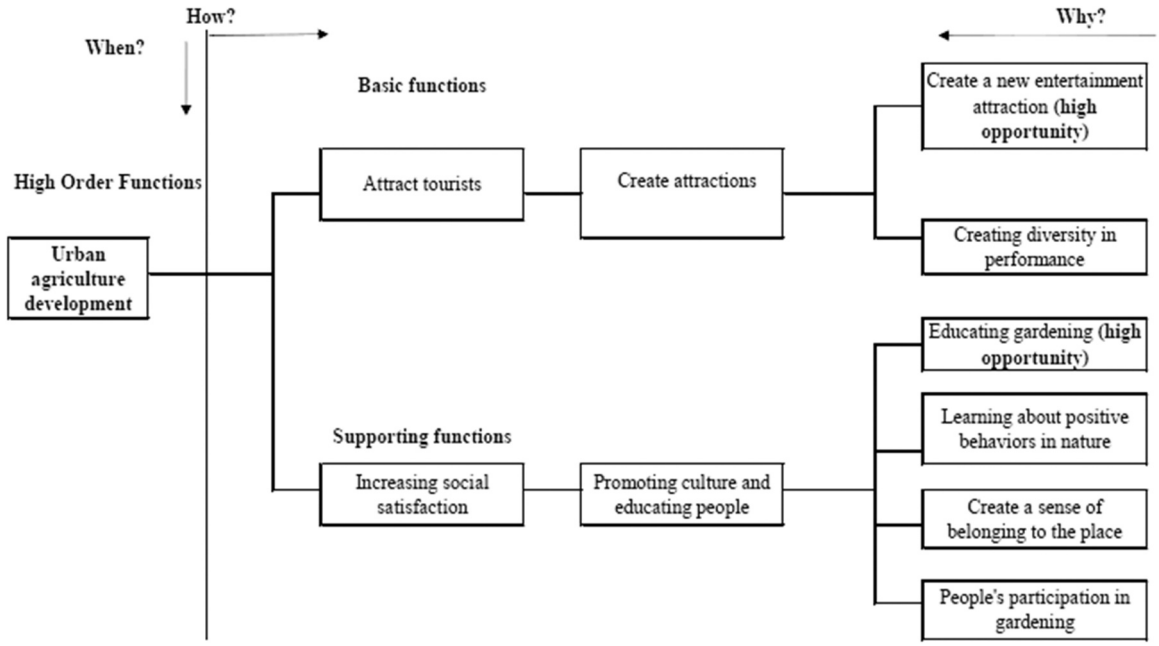

Fig. 3. Customer oriented FAST diagram.

the ideas that will be used in the future; compilation ideas, which were ideas that had many contributions and could be combined; duplicate ideas, which were ideas similar to the ideas used in the base conventional design; and disclaimer ideas, which were ideas that the team members dissuaded for various reasons for example because of being far from the main idea or having high prices. Finally, 17 ideas were selected after a qualitative assessment of the whole group of ideas.

In the second step, which was a quantitative evaluation, the VE team used the AHP method. For this reason, the ideas were divided into three alternatives as shown in Table 2. The first category was the idea of planting fruit trees in an urban agricultural park. The second was the idea of planting vegetables in the urban agricultural park, and the third category was the idea of creating an urban farm park (focused on animal husbandry). As there was enough space for the construction of an edible mushroom production greenhouse, the team decided to add this high-potential item to the first and second alternatives. Also, many people are also interested in learning about producing mushrooms in their home in Iran. The third alternative also focused on animal husbandry and it was deemed there was not enough space for this activity in the park.

Table 2
Three alternatives to urban agricultural park ideas.

Alternatives	Ideas
1. Cultivation of fruit trees	Cultivation of pome and stone fruit trees, berries and sale of the products in the park Picking fruits by people Creating a zone for aromatic and medicinal plants and selling them Establishing places for the construction of camps, tents, and night events in the park Creating opportunities for people's participation in the maintenance of the park Constructing a greenhouse or indoor area for cultivating mushrooms and holding mushroom production training classes Teaching gardening and answering people's questions
2. Cultivation of vegetables	Planting vegetables and herbs and selling them Creating a collection of seeds of vegetables and herbs and selling them Educating people on how to use the facilities and harvest vegetables using guidelines and brochures Making and selling a variety of local and traditional cuisines and foods Constructing greenhouse for cultivating mushrooms and holding mushroom production training classes
3. Creating an urban farm (focused on animal husbandry)	Construction of a livestock breeding site Production of dairy products Building a farm Applying organic farming Construction of fish storage and selling the products Beekeeping

At this point, our criteria for choosing the best alternative were to reduce the life cycle costs, high- income capability, promote public education, and create new recreational opportunities for people.

As shown in Fig. 4 and Table 3, based on the results of the questionnaires filled with the team members and the outputs from the Expert Choice software, the first alternative was the cultivation of fruit trees.

After consulting with our team members, the following were found as the reasons for their preferences in the selection of the fruit trees and shrubs in the urban agricultural plan:

- Fewer costs of construction and maintenance of "cultivation of fruit trees" compared with "urban farms" as an alternative;
- In contrast to vegetables, which are usually annuals or biennials, fruit trees are perennials;
- Increasing the maintenance costs and increasing the growth of the income in "cultivation of fruit trees" compared with "cultivation of vegetables";
- Creating urban farms need a larger area according to our team members' opinion;
- Creating an "urban farm" is associated with some social constraints.

All of these reasons were based on the opinions of the team members. Based on these reasons, higher scores were given to the first alternative. At this point, choosing one alternative does not mean that the other alternatives are not efficient. It only shows the team members have selected one of the criteria as the best.

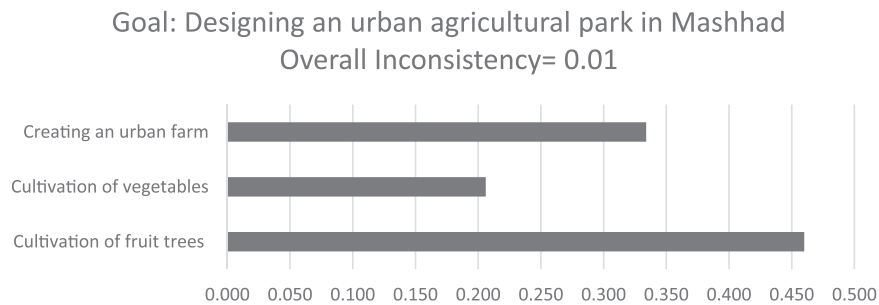

Fig. 4. The final result of the expert choice for choosing the best alternatives.

Table 3
The priority of alternatives based on the weight of the criteria.

Criteria	Alternatives	Priority
Creating new recreational opportunities (Weight: 0.318)	Cultivation of fruit trees	0.146
	Cultivation of vegetables	0.056
	Creating an urban farm	0.128
Income capability (Weight: 0.295)	Cultivation of fruit trees	0.136
	Cultivation of vegetables	0.032
	Creating an urban farm	0.114
Promotion of the public education and participation (Weight: 0.295)	Cultivation of fruit trees	0.136
	Cultivation of vegetables	0.108
	Creating an urban farm	0.085
Reducing the life cycle costs (Weight: 0.092)	Cultivation of fruit trees	0.042
	Cultivation of vegetables	0.011
	Creating an urban farm	0.007

3.5. Development phase

In this phase, the ideas were carefully examined and developed by the team members and the new secondary risks that may occur as the outcome of the implementation of these ideas were identified. One of the common activities in this phase is risk-based assessment and judgment (SAVE International, 2007). As can be seen in Table 4, the risk assessment for the proposed agricultural project is 14% with a positive sign that shows a 14% improvement in the project. One of the most important concerns about this project, according to Table 4, is the limited scientific and technical knowledge of the personnel of green space organizations (S= −0.19). This is because urban agriculture in Iran is almost a new approach and it needs educational training. Furthermore, one of the most significant benefits of implementing urban agriculture is the creation of multi-functional green spaces and the increased productivity of urban lands (S= 0.34).

After calculating the risk factor, the team members calculated the initial costs, the life cycle costs and life cycle incomes of the proposed agricultural and base conventional plan.

Tables 5 and 6 illustrate the costs of the construction and maintenance of the proposed agricultural design. The reason for the reduction in the price of the proposed agricultural design, compared with that in the base conventional design, is the removal of seasonal flowers and the use of permanent fruit trees and medicinal plants instead. In the base conventional plan, we had some types of permanent trees in limited numbers, but they were not fruit trees. Therefore, we increased the productivity of the park by substituting fruit trees in larger areas. Also, seasonal flowers should be replaced every year. Therefore, the removal of seasonal flowers in the park plan, which were used in a large area, reduces the costs of construction, maintenance, and irrigation of the landscape.

In the proposed agricultural scheme, we used fruit trees such as cherries, apricots, peaches, grapes, apples, cherries, plums, almonds, and hazelnuts. We also added a mushroom greenhouse to this park and used medicinal herbs such as barberry, chamomile, thyme, lavender, sage, rosemary, yarrow, brassica, lemon balm and peppermint in the proposed agricultural plan. By applying such a plan, the trees will be producing income after 3–5 years and the medicinal plants will bring incomes from the first year. The base conventional plan can only create income from the rent of a restaurant and coffee shop and these ideas have been included in the proposed agricultural plan too. By calculating the Net Present Worth of the incomes of the base conventional plan and the proposed agricultural plan, the total life cycle incomes for the proposed agricultural plan with the present worth of 2018 was US $2,717,697 and that of the base conventional plan was US$737,142.

To determine the value index of the base conventional plan and the proposed agricultural plan, the ratio of the benefits to the costs, which is used in many general-purpose projects, was used. If this ratio is less than 1, then the plan is uneconomic (Oskounejad, 2016). The value index of the base conventional design was 0.86 and that of the proposed agricultural design was 4.09. The ratio of the benefits to the costs for the base conventional plan was less than 1; therefore, this plan was considered as an uneconomic plan. Our risk assessment factor based on the secondary risks and probability and impact matrix was + 14%, which reflects an improvement in the proposed agricultural design.

Based on the results of Monte Carlo method, the probability of failure in the proposed agricultural scheme was 0.6%, and according to the probability and impact matrix, risks less than 5% can be ignored (Project Management Institute, 2017). This risk is based on changes in financial calculations and price changes based on inflation rates in Iran in the future.

3.6. Presentation phase

In this phase, the team leader presented a report. This phase ensured that the managers and the stakeholders have a good understanding of the methodological options.

4. Discussion and Conclusion

In this project, integrating VE, MCDM, and RM techniques confirmed quantitatively and qualitatively that an urban agriculture approach compared to conventional urban park design approach can be profitable by reducing the life cycle costs of the construction and maintenance, and also through increasing the life cycle incomes. In addition to financial benefits, some of the urban agricultural ideas of the VE team in this study also increased the environmental sustainability of urban parks compared to conventional park design schemes. However, our study had some limitations as well. One of them was that we did not calculate the

Table 4
Identifying the advantages and disadvantages of each idea and calculating the Standard Deviations (Risk Factor).

Ideas	Advantage	S	Disadvantage	S	Expected Value	Standard Deviation (Risk Factor)
Cultivation of pome and stone fruit trees, berries, vegetables and sale of the products in the park	Dual-use of urban green space for food production	0.34	Limited scientific and technical knowledge of the personnel of green space organizations	-0.19	0.25	0.29
	Access to a variety of native fruit trees for urban context for researchers and scholars	0.26	Likely increase in maintenance costs compared to the conventional design	-0.16		
Picking fruits and vegetables by people	Providing a relatively new platform for recreation	0.25	Increasing the likelihood of vandalism such as breaking tree branches	-0.16	0.36	0.08
	Increasing people's interest in farming and horticulture	0.27				
Creating a zone of aromatic and medicinal plants and selling them	Providing a relatively new platform for recreation	0.19			0.27	0.12
	Improving people's health using medicinal herbs	0.08				
Establishing places for the construction of camps, tents, and night-parties in the park	Providing a relatively new platform for recreation	0.15	It requires physical care of the space at nights	-0.15	0.47	0.15
	Integrating green space development, urban agriculture and tourism industry to use nature at days and nights	0.23				
	Creating more opportunities for gaining incomes	0.25				
Creating opportunities for people's participation in green space maintenance	Increasing people's interest in farming and horticulture	0.19	Lack of sufficient experience of the general public to maintain green spaces	-0.09	0.24	0.08
	Reducing labor costs	0.15				
Cultivation and sale of mushrooms and holding mushroom production	Providing a relatively new platform for recreation	0.20			0.49	0.21
Holding training classes	Creating more opportunities for gaining incomes	0.10				
	Providing a platform for education at various social levels	0.19				
Teaching gardening and answering people's questions	Creating an opportunity for people to interact with green spaces	0.11			0.26	0.04
	Providing a platform for education at various social levels	0.16				
Average					0.34	0.14
Risk Assessment Factor					0.14	

Table 5
The cost of the construction of the base conventional plan and proposed agricultural plan by applying the inflation rate of 15% based on US$.

year	The cost of constructing the base conventional plan with an inflation rate of 15% (US$)	The cost of constructing the proposed agricultural plan with an inflation rate of 15% (US$)
2017	197,491	169,342
2018	227,114	194,744

environmental benefits and health risks of Urban Agriculture. One of the problems that communities face with urban agriculture is that the authorities in developing countries prefer not to use this approach in their designs due to the environmental and health risks that are thought to be related to this concept (Kazemi et al., 2018). Some negative aspects of health and environmental issues such as contamination of products with pathogens, chemicals, and heavy metals (Lock and van Veenhuizen, 2001), soil degradation (Quansah et al., 1997), contamination of water with agrochemicals (Lock and van Veenhuizen, 2001), as well as the attitude of some researchers who believe that agricultural and horticultural activities are not suitable for urban environments have also been reported (Kalebbo, 1998).

In a study on 28 different urban parks, Bramwell et al. (2008) found that to reduce the health risks of soil contamination, urban agriculture can be compatible with these conditions in several ways, including: a. production of non-edible products such as the use of herbs for cosmetic purposes, b. selection of plants that do not accumulate metals in their edible parts (e.g., many fruit trees), c. use of plants whose edible parts are located higher than the contaminated soil (Bramwell et al., 2008). Another concern is the potential for pathogenic contamination due to the use of contaminated water resources from untreated sewage, the use of inappropriate fertilizers and compost, and the excessive use of fertilizers by low-expert farmers. Such problems can be managed in urban environments through holding workshops, and training experts in urban agriculture (Lovell, 2010).

Other limitations of the current study could be the differences in the type of the plant species and the number of their crops in different geographical locations, differences in the opinions of the experts in the weighting process according to their culture and geographical area, and also the differences in the prices and values of the currencies in different countries, which make it necessary to conduct the method in different regions and nationalities. Regarding the differences in currencies, however, due to having a comparative process in calculating the costs and incomes of the two schemes, the differences in the results of the regions might be small.

Generally, urban agriculture has been considered as one of the ways to provide part of the urban food supply in recent decades (Kazemi et al., 2018). The results of our current research show several advantages and disadvantages as a part of the risk assessment process. These results were similar to those obtained by Kazemi et al. (2018) about the development of urban agriculture in Mashhad. They achieved a strategic planning result using SWOT techniques. Similar to our current study, they emphasized that the multi-functionality of these types of landscapes, access to a variety of fruit trees and shrubs, and the high diversity of native plant species are the strengths and opportunities of this approach, while insufficient science and experience of personnel, lack of specialized and technical facilities in the harvest and postharvest stages of fruit trees, the possibility of social vandalism, and increasing organizational

Table 6
Calculation of the Net Present Worth of the construction costs, the maintenance costs and total cost of the base conventional plan and the proposed agricultural plan based on US $.

		Base conventional plan	Proposed agricultural plan
Net Present Worth of the construction	Conversion coefficient of the construction of the green space with a minimum attractive rate of 15%	(P/F,15%,1)= 0.86	(P/F,15%,1)= 0.86
	Net Present Worth of the construction costs of the green space, based on the inflation rate of 2018	US$195,318	US$167,479
Net Present Worth of the yearly maintenance	Conversion coefficient of the yearly maintenance cost with a minimum attractive rate of return of 15% and the inflation rate of 15% and worth calculation of 2019	(P/A,15%,15%,20) US$733,320	(P/A,15%,15%,20) US$421,423
	Conversion coefficient of the annual maintenance cost from 2019 to 2018 and worth calculation of 2018	(P/F,15%,1)= 0.86 US$630,655	(P/F,15%,1)= 0.86 US$362,424
Net present worth of the renovation costs	Conversion coefficient with minimum attractive rate of return of 15%	(P/F,15%,20)= 0.06	(P/F,15%,20)= 0.06
	Net present worth of the renovation costs	US$28,351	US$81,369
Net present worth of the renovation of the turfgrass replacement	Conversion coefficient with minimum attractive rate of return of 15%	(P/F,15%,10)= 0.24	(P/F,15%,10)= 0.24
	The net present worth of renovation of the turfgrass costs in the tenth year	US$2876	US$53,502
	Total life-cycle costs with the present worth of 2018	US$857,199	US$664,774

costs are the weaknesses and threats. Also, some other studies discussed the benefits of urban agriculture. For example, Duvernoy et al. (2005) defined that multi-functionality is multiple roles in the objectives of urban agriculture. Other studies said that one of the important points to note is that a large number of native fruit species are naturally occurring in Iranian vegetation regions and most of them are drought tolerant, like almonds, grapes, pistachios, jujubes, olives, wild olives, pomegranates, figs, and mulberries. Some other plant species, such as the Golab cultivar of apple, have already been adapted to the local urban conditions of Iran, so landscape development through urban agriculture can benefit from these variations of plants (Kazemi and Abbassi, 2016; Kazemi et al., 2018).

On the other hand, we can see that some studies have discussed the disadvantages of urban agriculture. For example, vandalism has been reported in some urban parks (Chiesura, 2004; Yavuz and Kuloglu, 2011), while another study reported that urban farms in Baltimore, United States, reduced the rate of crime in the neighborhood. This result contrasted with the results of our study, and the reason for it was the familiarity and intimacy of the residents with the labors of the farm (Poulsen and Spiker, 2014). Kazemi et al. (2018) addressed strategic solutions for the vandalism of urban agriculture, one of which was utilizing urban agriculture in specific landscape forms, such as theme parks and semi-public landscapes with more protection and supervision of the municipalities. In the current project, we also used this strategy to design the urban agricultural park in a Persian and Japanese garden park, which are considered theme parks and usually protected and surrounded with walls in Iranian culture. Considering the history of the Persian gardens, which has always been full of fruit trees, the cultivation of fruit trees in it was considered as an opportunity to revive the history of the Persian garden. Similarly, the Japanese gardens have usually been accompanied by therapeutic effects and relaxation. Therefore, in this research, the cultivation of medicinal plants in the Japanese section of the study site was considered to agree with the history and nature of this garden style. The fruit trees have beautiful blooms and attract birds and pollinators. Depending on the types of trees used, you can create remarkable beauty even in the winter. In Japanese gardens, cherry trees, almonds, peaches, apricots, and plums have always been noted for the beauty of their blossoms (Conan, 2000; Kazemi et al., 2018). Aesthetics is one of the important characteristics that should be considered when designing urban parks with any approach. Such attention could assist the planners and managers to satisfy people's preferences, hence, achieve social sustainability (Tweed and Sutherland, 2007). Currently, such modern agriculture theme parks have been built and popularly welcomed in the developed countries of the world, such as the United States (Schroder, 2011), Japan (Suga, 2017), and Russia (Chebanenko, 2018). Since urban agriculture is a significant part of Persian culture and tradition of horticulture, it is expected to be used as a hobby or job opportunity in the developed cities (Hobhouse, 2003). Brown and Jameton (2000) discussed another disadvantage of urban agriculture. They believed that some countries face economic challenges in the construction stage of urban agricultural landscapes, and this is in contrast with the result of our current study. Peng et al. (2015) also introduced urban agriculture as a multi-purpose green space approach in Beijing, China and examined it from the environmental, economic and social aspects using an Analytical Hierarchy Process (AHP). Similar to our study, they concluded that the economic performance of urban agriculture in different cities is more than its environmental and social aspects. The high cost of construction has always been one of the most important concerns of the experts. According to the results of this study, using the VE, RM and the use of the cost-benefit index, it was proved that the cost of the construction was almost unchanged and even reduced compared to that in the conventional park plan, while the park's profitability increased.

Several methods of urban planning can guide us in reaching a strategic plan for developing an urban agricultural concept in the cities. For example, Gal and Hadas (2013) found that experts considered food safety as the most important issue using SWOT techniques and examined the strengths, weaknesses, opportunities, and threats, and scored each of them by the stakeholders and the experts. Similar to our current study, they emphasized that agricultural lands should be preserved and urban agriculture should be expanded to increase sustainable urban development. Also, in research conducted in Zimbabwe, Kutiwa et al. (2010) introduced urban agriculture as a vital resource for the livelihood of urban households. Due to the increase in food prices, poor Zimbabweans are looking to urban agriculture as a solution to their food problems. In this study, the impact of urban agriculture on the reduction of food poverty and sustainable urban development is discussed.

In this study, using the VE technique, by collecting and choosing the best and most efficient ideas from a range of multidisciplinary specialists, and by reducing the life cycle costs and increasing the life cycle incomes, a project with 120,057$ of accumulated loss in its lifetime can become a profitable project with approximately 2052,921$ net income over its life span (incomes – costs). Similar to our current project, Al-Anzi et al. (2017) also used a VE approach and proposed a new water reservoir design by implementing a new water resource management technique to combat desertification and environmental contamination and compared it with the original design. In this study, the overall estimated saving in the proposed agricultural plan was 43.84%. Also,

Saeedi and Kavian pour (2017) used VE to design a power storage pump on the Chalus River in Siahbisheh, Mazandaran, Iran. In this plan, the engineering finance issue was not evaluated and only new ideas increased the quality of the design and increased its lifespan. Unfortunately, VE has not been used in urban green space projects yet.

Calculation of the cost-benefit is used as an indicator to show and compare the economics of the projects with their alternative scenarios. Barbier et al. (1989) recommended using the cost-benefit index calculation method to determine the weakness or robustness of sustainability in environmental projects. Furlong et al. (2017) in an integrated urban water management plan, formed a team of experts and stakeholders and, using the cost-benefit approach, assessed the value of the various proposed agricultural plans by the team to obtain the best proposal.

After the financial estimates, which can almost ensure the success of the plan, in our study, by applying the risk assessment technique, we multiplied this assurance and with this technique, we predicted the impact of the financial and non-financial risks on the project success. The risk assessment factor in this project was improved by 14%, by the new opportunities created. Various studies have shown that the risk is measurable and predictable. If the risk is identified correctly in a project, it will be closer to success in the next steps. RM is a process that can be continued before and even after the investment (Aminbakhsh et al., 2013). With Monte Carlo simulation of 1000 models, the probability of failure in the project was 0.06% by calculating the standard deviations of the costs and incomes.

Knowledge and skills for management of urban agricultural systems are necessary and it needs expertise in the environmental, social and cultural dimensions. It is hoped that the outcome of this research could provide enough evidence for applying sustainable urban agricultural park designs across the world. Also, VE and RM methods should be introduced and applied in future landscape projects to make a step forward to greater sustainability and profitability in urban landscape designs. Using the VE, RM, and MCDM methods as defined in this manuscript can be effective steps in the economic justification of many new approach in park designs that have already been investigated only for their environmental, social, and non-financial benefits. Such methodological development promises a step towards the implementation of future sustainable landscape design projects.

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