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RESEARCH PAPER

A Systematic Two-Phase Study of COVID-19 Pandemic Impact On Sustainable Development Goals: A Case Study of Iran

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ABSTRACT

To respond to the urgent call for preventive action against COVID-19 pandemic implications for societies, this research is carried out. The main aim of our research is providing a new insight for the effects of the newly emerged restrictions by COVID-19 on the SD Goals (SDGs). This research, for the first time applied a two-phase qualitative approach for supporting the SDGs achievement post-COVID in Iran, as a developing country in the Middle East. In the first phase, using a fuzzy Delphi method, the SDGs affected by COVID-19 were identified. In the next phase, a fuzzy cognitive map, as a qualitative system dynamics modeling, was conducted to specify the key interconnections among the SDGs post COVID-19. Finally, three strategies including focus on people in vulnerable situation, support for industrial units and small and medium-sized enterprises, and national aggregation to Fight COVID-19 were examined. As a result, different scenarios associated with the three proposed strategies were tested based on the identified interconnections among the SDGs to reduce the potential negative effects of COVID-19 crisis on the achievement of the SDGs. The results provide a decision support for stakeholders and policy makers involved in SD action plan.

KEYWORDS: *COVID-19; Sustainable development goals; 2030 agenda for SD; Fuzzy cognitive map; Fuzzy delphi method; Scenario analysis.*

1. Introduction

The 2030 Agenda for Sustainable Development (SD) was adopted by the United Nations (UN) General Assembly in 2015 as a shared plan of action including 17 SD Goals (SDGs) for peace and prosperity [1] which works for both people and the planet. The 17 SDGs consist of 169 specific targets can be clustered in three main pillars of sustainability including economic (SDGs 1-3 and SDGs 8-9), social (SDGs 4-5, SDGs 10-11, and SDGs 16-17), and environmental (SDGs 6-7 and SDGs 12-15) [2]. Due to the serious restrictions imposed by COVID-19 on the global community, the complexity of interacting SDGs has become more complicated. Not only health, but almost all sectors of the global community such as economy, education, tourism, energy, manufacturing, transportation, food, environment, and agriculture, have been significantly affected by the COVID-19 and have seriously challenged the achievement of the SDGs. Therefore, long-term effects of the pandemic period should be analyzed and managed properly in an appropriate time towards SD mission. In consequence, the role of decision and policy makers in the different sectors of the society for implementing the 2030 Agenda for SD has become much critical.

Accordingly, throughout the COVID-19 pandemic, research on sustainable development has shown an upward trend. The effect of the pandemic on sustainable development has been investigated by many researchers in a wide range of science areas like SDGs [3,4], healthcare systems ([5,6], education [7,8], social media [9,10], food industry [11,12], tourism [13,14], sustainable transition [15,16], environmental pollution [17], energy [18,19], climate change [20], strategic management [21,22], supply chain disciplines [23,4,25] and waste management [26,27].

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However, the majority of previous studies have observed a specific field or focused just on one dimension of sustainability affected by the COVID-19 [28]. There are limited researches conducted on the SD 2030 Agenda. Developed countries contribute the main body of the research, while research on the impact of COVID-19 on sustainability in developing countries is more needed because of their vulnerability[29]. The literature also indicates that developed countries focus more on education sustainability, while developing ones concentrate on economic sustainability. Alibegovic et al. in 2020 provided a qualitative research work that showed that SDGs1 (No poverty), 4 (Quality education), and 8 (Decent work and economic growth) are most affected by pandemic-19 in Italy [30]. Barbier and Burgess in 2020 suggested subsidy swap and tropical carbon tax on fossil fuel post COVID-19, as a policy for SDGs survival with special attention on energy sector in developing countries [31]. In a theoretical analysis, Yoshino et al. in 2020 studied the importance of the government support and optimal portfolio allocation for progressing SDGs 2030 Agenda post COVID-19 [32]. Fenner and Cernev in 2021 highlighted the consequences of the COVID-19 pandemic on five critical SDGs which are foundational for progressing in the others (SDGs 1,3, 14 and 15). They explored the impact of four post pandemic scenarios on SDGs, namely Global well-being prioritized (Scenario 1), World trade recovers (Scenario 2), Poverty gaps widen (Scenario 3) and Earth systems in danger (Scenario 4). They concluded the necessity of refocusing on planetary and human health [33]. For more detailed literature on SD and COVID-19 see the work of Ranjbari et al. in 2021 which provided a systematic review to analyze the effects of COVID-19 on the triple bottom line of sustainability to support the future SD research direction. Wang and Huang in 2021 published another review paper on the impact of COVID-19 pandemic on SDGs [28]. In our recent paper a Fuzzy Cognitive Map (FCM) was developed to specify interdependency of SDGs in Iran in presence of COVID-19 pandemic. Then five scenarios were developed and tested to identify the long-term implication of pandemic on meeting 2030 Agenda [34].

The reviewed literature indicates that the achievement of SD 2030 Agenda lacks a comprehensive study considering the COVID-19 long-term implications for interconnections among SDGs. Moreover, according to the different levels of COVID-19 restrictions in each country as well as the different economic, social, environmental, and technological capabilities to respond to that restrictions, 2030 Agenda for SD deserve to be studied and customized under emerging circumstances in each country. Most of researches in this area are held in developed countries, although the pandemic cause significant challenges to the SD of developing countries than of developed ones. Iran, as a developing country in the Middle East, is the study area of our research, which has been infected dramatically by COVID-19. On the other hand, the qualitative methods, especially expert-based ones, received more attention due to the lack of data especially in developing countries and also absence of adequate historical data on SDGs during COVID-19 pandemic and its long-term effects.

This research is the first to employ a qualitative systematic two-phase FDM [2] -FCM study to identify the SDGs which are more at risk of COVID-19 pandemic in Iran and then to map strength of the interactions between these SDGs. Finally, scenario analysis is implemented and long-term effects of the strategies, which are applied by the government during pandemic, on the most vulnerable SDGs are studied. This research presents a new insight for meeting the 2030 Agenda for SD post COVID-19 in Iran as a case among developing countries. Based on the obtained results from simulating three different governmental strategies, a holistic insight is provided to analyze the consequences of these actions on multi-dimensional SDGs, not only targeted ones. To do this, the main three questions of the research are formulated as follows. (1) Which SDGs are significantly at risk of COVID-19? (2) How do at risk SDGs as well as pandemic affect each other? And (3) What are the consequences of performed strategies on 2030 Agenda for SD? The first question will be answered using a Fuzzy Delphi Method (FDM) informed by a panel of experts and Fuzzy Cognitive Map (FCM) modeling will be used to address the next two questions.

The paper is structured as follows: Section 2 explains the methodology including fuzzy Delphi method and fuzzy cognitive map. Section 3 analyses the results of the FCM scenarios and discusses the key finding. Finally, section 4 concludes the research and presents the future research recommendations.

[2] Fuzzy delphi method

2. Research Design and Methods

A mixed method approach including two main steps, is taken in this research as shown in the research framework in Fig. 1. In the first phase of this research, a FDM is used to identify the mostly affected SDGs by COVID-19. In the second phase, a FCM is applied to determine the interconnections among SDGs regarding COVID-19. Different scenarios are generated and insights about consequences of the proposed strategies are provided to policy makers.

2.1.Fuzzy delphi method

To improve the efficiency and reliability of data gathered from experts by solving the fuzziness of their opinions [35], Ishikava [36] introduced FDM by integration of traditional Delphi method and fuzzy set theory to reach a group decision [37]. FDM has been widely used in different SD domain [38,39].

In the first phase of our research a FDM is used for gathering opinion from our expert panel to identify the SDGs whose achievement affected by COVID-19. The steps of FDM in our research, adopted from [40], are as follows.

Step 1. Designing a Fuzzy Delphi questionnaire: At this step, a five-point scale questionnaire is designed to evaluate the magnitude of COVID-19 effect on each of the SDGs through linguistic terms, including "non/negligible", "low", "middle", "high" and "extremely high".

Step 2. Creating triangular fuzzy numbers (TFN): Each of the linguistic terms is transformed into a TFN in the range [0,1], as mentioned in Table 1. Based on the method presented by Klir and Yuan [41], the weight of SDG j affected by COVID-19, demonstrated by the i th expert among n experts, is set as $\widetilde{w_{ij}} = (a_{ij}, b_{ij}, c_{ij})$, where $i = 1,2,\dots,n$ and $j = 1,2,\dots,m$. Then, the fuzzy weight of the j th SDG is calculated as $\widetilde{w_j} = (a_j, b_j, c_j)$, where $\mathrm{a_j} = \mathrm{Min_i}\{\mathrm{a_{ij}}\}$, $\mathrm{b_j} = \frac{1}{\mathrm{n}}\sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{b_{ij}}$, and $\mathrm{c_j} = \mathrm{Max_i}\{\mathrm{c_{ij}}\}$.

Step 3. Defuzzifying the TFN: In order to defuzzify $\widetilde{w_j}$ into the crisp value S_j, the approximation of the three-parameter beta distribution is used where $\mathrm{S_j} = \frac{\mathrm{a_j}+4\mathrm{b_j}+\mathrm{c_j}}{6}$, $\mathrm{j} = 1,2,\dots,\mathrm{m}$.

Step 4. Screening the weights and providing the results: The threshold $\alpha = 0.1$ is considered to select the considerably affected SDGs from COVID-19. To make this segregation, if $S_\mathrm{j} \geq \alpha$, the jth SDG is considered as an affected factor and to be used in the next phase.

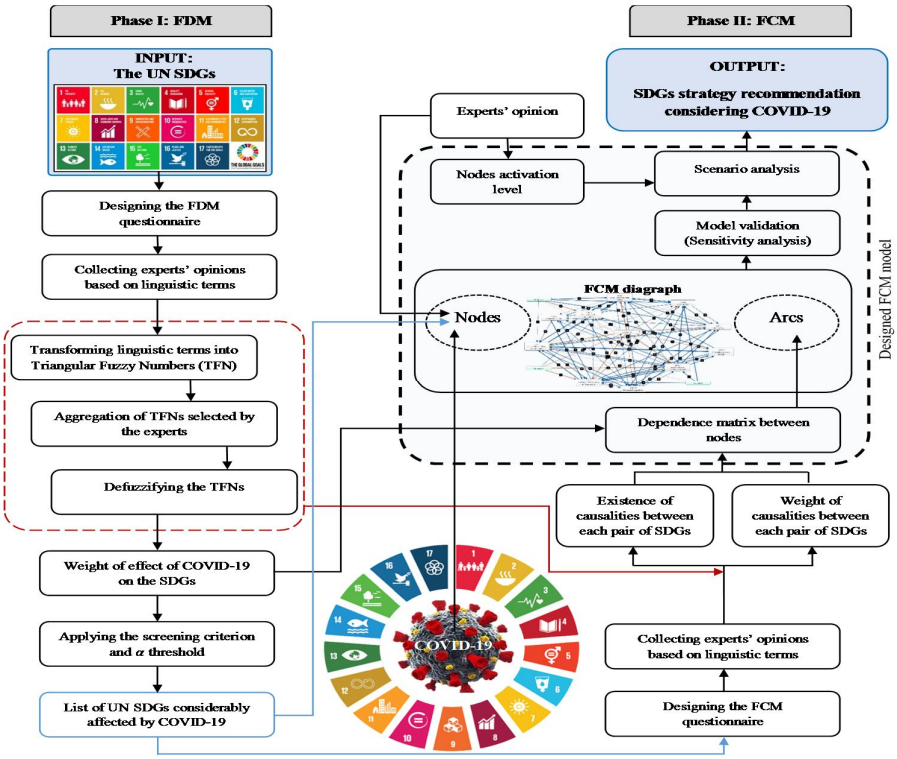


Fig. 1. Research framework

2.2 Fuzzy cognitive map

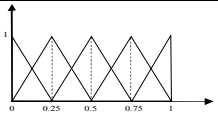
Due to the lack of adequate and reliable data

related to COVID-19, the application of participatory methods informed by a panel of experts has become much highlighted in the research conducted. FCM is an appropriate tool in the case of data insufficiency and has been applied in several research. FCM is a graphical representation of concepts as nodes, which affect each other and weighted links or arcs representing interconnection between concepts within a system as a whole [42]. A set of variables and their relevant interconnections, which come from the knowledge and experience of experts, are two main pillars of a FCM model as a qualitative system dynamic modelling approach [43]. FCM has been utilized in the different areas of sustainability context [34], [44-48]. Regarding the complex nature of interconnection between SDGs, FCM is applied in our research to draw the causality between the SDGs considering the COVID-19 effects. The main steps of FCM modeling in our research are as follows.

Step 1. Concept (nodes) selection. The identified SDGs in the previous phase, as well as COVID-19 are imported as nodes in the FCM model, presented by $C = \{c_1, c_2, \dots, c_n\}$.

Step 2. Fuzzy FCM questionnaire. A questionnaire is designed to capture the opinions of the experts for the existence and the weight of causal relationships between each two nodes, by a seven-point scale, including "no effect" and "high", "medium", "low" degrees in either positive or negative directions.

Tab. 1. Transferring linguistic terms of experts' opinions to corresponding TFN

Linguistic term	Corresponding TFN	TFN for the considered five-point scale questionnaire
None/negligible	(0, 0, 0.25)	
Low	(0, 0.25, 0.5)	
Middle	(0.25, 0.5, 0.75)	
High	(0.5, 0.75, 1)	
Extremely high	(0.75, 1, 1)	

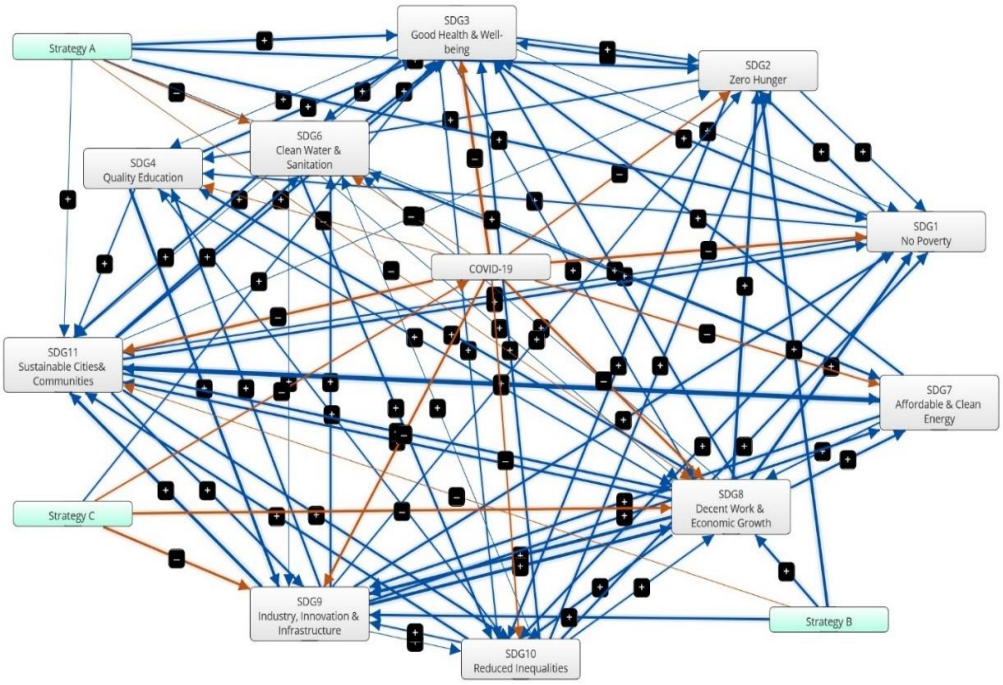


Fig. 2. The designed FCM diagraph

Step 3. Building the diagraph and the dependence matrix. The linguistic terms regarding the strength of the relationships were translated into TFNs, defuzzified into crisp values according to steps 2 and 3 of the FDM, and used to build the dependence matrix.

Step 4. Analyzing the scenarios. For each component, the activation level is illustrated by L^0 ; a number in the interval [-1,1]. Fully inactive level is denoted by 0, while -1 and 1 show fully active level with negative and positive relative change, respectively. An activeness

vector, is applied as an input and simulation is started to calculate the component values. The simulation process is conducted repeatedly for each scenario by changing the activation level of the nodes.

According to the wide range of the SDGs, 47 potential experts from different fields of activity, whose characteristics are reported in Table 2, were invited to the research. The responses were gathered through two different questionnaires for the FDM and the FCM phases.

3. Implementation and Results

Tab. 2. Characteristics of expert panel participated in the research

Field of activity	FDM and FCM participants						Total number of experts	Average years of work experience
	Academia	Research center	industry	Social media	Government sector	NGOs		
Environment	1	1	1	1		2	6	5.2
Energy	1		1		2		4	9.7
Social science	2	2		1			5	10.8
Economy		3	1	1	1		6	11.2
Education	1	2			1	1	5	8.5
Women's rights		1				1	2	6
Law	1	1			2		4	15.8
Total no. of experts	6	10	3	3	6	4	32	

In this phase, data was collected to weight the effect of COVID-19 on each of the SDGs. S_j value for all SDGs was computed and compared with the threshold $\alpha = 0.1$, and the ones with $S_j \geq 0.1$ were entered into the second phase, see Tab. **3**. The SDGs which are significantly at risk of COVID-19 are illustrated by word "**Yes**" in the last column of in Table 3. The fuzzy weights of the arcs, stated by the experts in the questionnaire, were defuzzified and used to construct the FCM dependence matrix. Then, COVID-19 and three strategies proposed by a group of three experts were added to the model as driver components.

Figure 2 illustrates the FCM diagraph constructed in the MentalModeler software. The blue\red arcs with '+'\'-' signs demonstrate the positive\negative magnitude in the causal relationship between the nodes. Moreover, the thicker the arc, the higher the relationship weight. In order to validate the model, sensitivity analysis was conducted by presenting the output results for different activation levels of COVID-19, SDGs and the strategies, to and confirmed by a group of three experts. Then, various scenarios were simulated by changing the activation level of the nodes.

Tab. 3. Aggregated opinions of the experts regarding the strength of the COVID-19 effect on the SDGs

SDG no.	SDG description	Defuzzified numbers (S_j)	$S_j \geq 0.1$
SDG 1	No poverty	0.807	Yes
SDG 2	Zero hunger	0.302	Yes
SDG 3	Good health and well-being	0.958	Yes
SDG 4	Quality education	0.130	Yes
SDG 5	Gender equality	0.089	No
SDG 6	Clean water and sanitation	0.125	Yes
SDG 7	Affordable and clean energy	0.255	Yes
SDG 8	Decent work and economic growth	0.802	Yes
SDG 9	Industry, innovation and infrastructure	0.688	Yes
SDG 10	Reduced inequality	0.167	Yes
SDG 11	Sustainable cities and communities	0.510	Yes

SDG 12	Responsible consumption and production	0.094	No
SDG 13	Climate action	0.089	No
SDG 14	Life below water	0.042	No
SDG 15	Life on land	0.094	No
SDG 16	Peace and justice strong institutions	0.089	No
SDG 17	Partnerships to achieve the goal	0.042	No

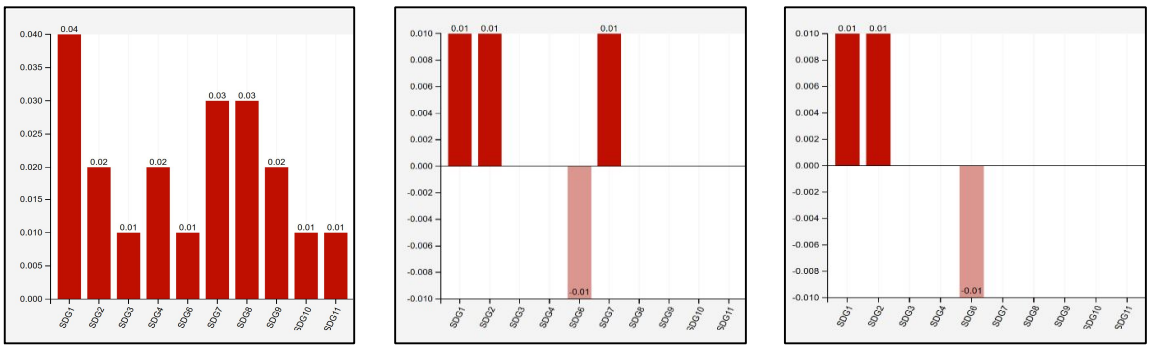
3.1. Scenario analysis and discussion

Based on the constructed FCM model, three strategies implemented by government to mitigate the impact of COVID-19 on vulnerable people, businesses and health, were tested. Three governmental strategies are as follows:

- Strategy A: focus on people in vulnerable situations
- Strategy B: Support for industrial units and small and medium-sized enterprises
- Strategy C: National aggregation to Fight COVID-19.

3.1.1. Strategy A: focus on people in vulnerable situations

This strategy refers to the financial and non-financial support for people living in vulnerable situations suffering from the economic pressure imposed by the pandemic. Financial support to the people living in poverty is one of the main components of this strategy. This financial support may cover a part of the financial needs of the people living in poverty that cannot be satisfied by themselves during the pandemic period. Extending the deadlines for the payment of utility bills and providing loans for the payment of mortgages are other considerations for financial support. Providing grocery bonuses can be considered as another option. Besides, providing the pregnant women and the elderly living in poverty with free sanitation packages is considered as another component of this strategy.



(a) COVID-19 $L^0 = -0.5$ (Improving the pandemic situation)

(b) COVID-19 $L^0 = 0$ (Current pandemic situation)

(c) COVID-19 $L^0 = +0.5$ (Worsening the pandemic situation)

Fig. 3. Relative changes of SDGs for different COVID-19 activation levels, Strategy A, $L^0 = +1$

Activation of this strategy in the designed FCM model for three different activation levels of COVID-19 leads to obtaining figures (a), (b) and (c) in Figure 3. Section (a) in this figure, shows the relative change of the SDGs if there is a medium relative improvement in the pandemic situation. As can be seen, SDG 1 experiences the highest relative change in the positive direction by implementing strategy A if the pandemic situation improves. The second position of positive relative change refers to both SDGs 7 and 8, followed by SDGs 2, 4 and 9 in the third position.

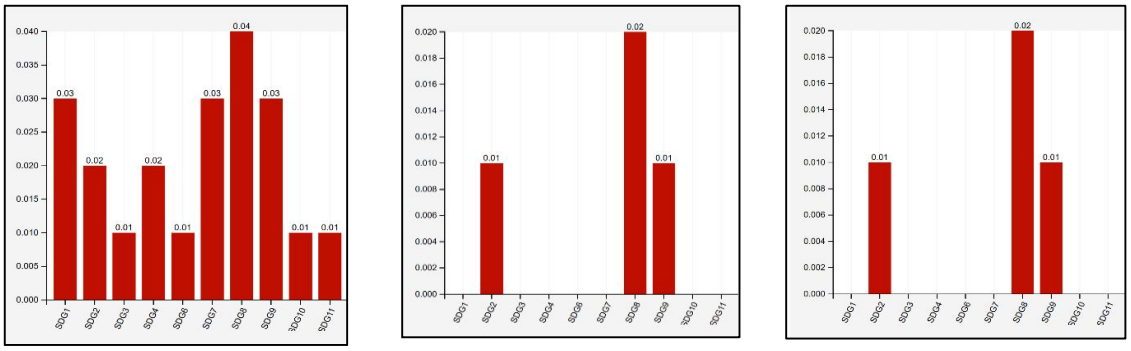
Activation of this strategy, considering activation levels $L^0 = 0$ and $L^0 = +0.5$ for COVID-19, portrays the relative change of the SDGs as illustrated in sections (b) and (c) in Figure 3. As illustrated, implementing strategy A would have the same effect on SDGs 1, 2 and 6 if the pandemic situation remains the same as the current situation or experiences a medium negative change. In both cases, SDGs 1 and 2 would have a relative positive change equally, and SDG 6 experiences the same level of relative change, but in a negative direction. This implies that although poverty and hunger in Iran

experience a slight improvement by implementing this strategy, the situation of clean water and sanitation becomes worse. Moreover, if the pandemic situation remains the same in the country, applying strategy A not only affects the mentioned SDGs, but also causes a relative positive change in SDG 7 in Iran.

3.1.2. Strategy B: support for industrial units and small and medium-sized enterprises

This strategy concentrates on providing support for the industrial and agricultural sectors, and the knowledge-based institutes. Among the main component of this strategy, we can mention devoting financial support for respecting health protocols in the agricultural sector to ensure reliable export of agricultural products, upgrading the infrastructures to establish online medical consultation and door examination systems and to boost online businesses. Lowering loan interest rates, extending the deadlines for loan repayments, and considering tax discounts for businesses and industrial units are some of the other recommended components in this strategy. To help SMEs, start-ups and knowledge-based companies survive, it is suggested that the government exempts them from paying rent, extends their contracts, and defers their checks and installments. Moreover, to support complementary units in the food production chain, which comprises of SMEs, it is recommended to put their products in the vulnerable households' consumption basket.

Implementing this strategy, assuming that the pandemic situation improves at a medium level, leads to relative changes in the SDGs as illustrated in section (a) of Figure 4. In such a situation, all the SDGs would experience a positive relative change, among which SDG 8 would face the highest level of change, followed by SDGs 1, 7 and 9. Moreover, applying this strategy in the current level of pandemic and in case of worsening the situation, as illustrated in sections (b) and (c) of Figure 4, respectively, would only affect the relative changes in SDGs 2, 8 and 9. Among the three positively changed SDGs in both cases, SDG 8 would experience a higher relative change.



(a) COVID-19 $L^0 = -0.5$ (Improving the pandemic situation)

(b) COVID-19 $L^0 = 0$ (Current pandemic situation)

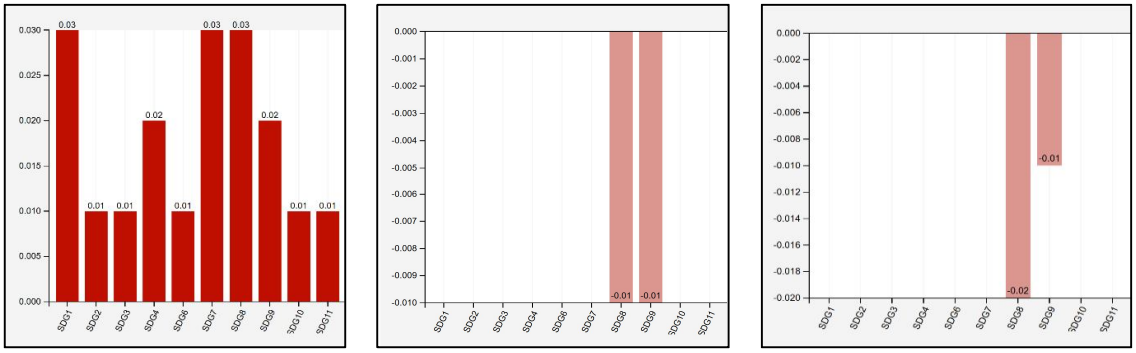
(c) COVID-19 $L^0 = +0.5$ (Worsening the pandemic situation)

Fig. 4. Relative changes of SDGs, different COVID-19 activation levels, strategy B, $L^0 = +1$

3.1.3. Strategy C: national aggregation to fight COVID-19

This strategy targets the reduction of COVID-19 infection rate and improving the capacity of the healthcare system for the treatment of infected people. A critical component of this strategy is limiting and closure of gatherings and social activities. People should be convinced not to take part in the social activities that increase the possibility of their infection to the novel COVID-19 and proper entertainment and engagement should be provided for them to encourage them stay home as much as possible and practice home isolation. Social distancing should also be promoted and tried to be well practiced in the society to reduce the infection rate. Providing the required infrastructure for e-learning at all educational levels is also important to keep many of the people home, conducting their learning activities in isolation but at the same time, by keeping their contact with other people through e-communication. In addition, working hours can be reduced or shifting working hours can be considered for the industrial units. A large part of the office activities can be conducted through telecommuting and hence, both the workers and customers can have their work done without being at the exposure of COVID-19 infection.

However, some of the activities and occupations cannot be stopped. Moreover, appropriate budget and effort should be spent by the government to prepare all the medical equipment required by the hospitals for the treatment of affected people. Setting up laboratories and diagnostic centers and freeing up diagnostic tests for COVID-19 are some of the other important components of this strategy.



(a) COVID-19 $L^0 = -0.5$ (Improving the pandemic situation)

(b) COVID-19 $L^0 = 0$ (Current pandemic situation)

(c) COVID-19 $L^0 = +0.5$ (Worsening the pandemic situation)

Fig. 5. Relative changes of SDGs, different COVID-19 activation levels, Strategy C, $L^0 = +1$

Since this strategy deals with the health of the people in the society, regardless of their social or economic level, the outcome of implementing this strategy would affect not only the vulnerable people, but also everyone in the society.

As can be seen in section (a) of Figure 5, by implementing strategy C while the pandemic situation experiences a medium improvement, all the SDGs affected by COVID-19 would face a positive relative change. This relative change is the highest for SDGs 1, 7 and 8, followed by SDGs 4 and 9. SDGs 2, 3, 6, 10 and 11 would face a rather smaller relative change compared with the other SDGs involved.

As can be seen from section (b) in Figure 5, if the pandemic situation does not change in Iran, applying strategy C can make SDGs 8 and 9 experience a negative relative change, while the status of other SDGs does not change. Besides, section (c) of the figure indicates that the same SDGs would be affected by implementing this strategy if the pandemic situation becomes worse. However, the level of the negative relative change that SDGs 8 and 9 experience in these two scenarios are different. While there would be an equal relative change for these two SDGs in scenario (b), SDG 8 faces a stricter negative change in scenario (c). We also suggest to see the work of Jalali Sepehr et al. in 2019 which evaluates the OECD countries' healthcare system from the sustainable development perspective and provides another viewpoint [49].

3.1.4. Strategies integration

In this section, strategies A, B and C are put together, and a combination of these strategies are analyzed. To do this, the activation level for all the three strategies were set to be $L^0 = +0.5$. The implementation of all these strategies were tested in three scenarios for different levels of pandemic activation. The results indicate that no relative change is made to the SDGs when considering $L^0 = 0$ and $L^0 = +0.5$ for COVID-19. However, if $L^0 = -0.5$ is set as the activation level of the COVID-19 node to show medium relative improvement in the pandemic situation, relative changes made in the SDGs affected by COVID-19 would be as shown in Figure 6.

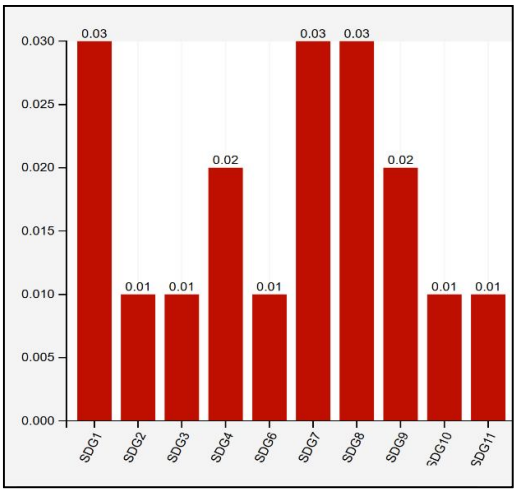


Fig. 5. Relative changes of SDGs for COVID-19, $L^0 = -0.5$, strategies integration

As illustrated in Figure 6, all the SDGs would experience a positive relative change, and they would be organized in three levels regarding their positive relative change. SDGs 1, 7 and 8 stand in the highest position in terms of positive relative change experienced. SDGs 4 and 9 stand in the second position and SDGs 2, 3, 6, 10 and 11 are in the third position regarding the relative positive change experienced.

3.2. Discussion

Table 4 summarizes the relative changes of SDGs affected by COVID-19 in the scenarios analyzed in this research. Results show that if the pandemic situation improves in the country, applying any of the strategies A, B, C or a combination of all of them would lead to positive relative changes in all the vulnerable SDGs affected by the pandemic. If the pandemic situation remains the same as the current situation or worsens, each of the three considered strategies would affect the relative change of only a few SDGs, while applying the combination of all the three strategies would have no effect on them.

SDG 1 (no poverty) experiences the highest relative change in strategy A assuming an improvement in the situation. This SDG is also among the SDGs with the highest positive change while implementing strategy A in the current situation of pandemic or in a worsen situation. Moreover, SDG 8 (decent work and economic growth) experiences the highest relative change if strategy B is applied in an improved situation of pandemic.

SDG 4 (quality education) would have the same level of relative change by implementing each of the strategies A, B, C or their combination under each of the three activation levels of COVID-19. In fact, if the pandemic situation improves, SDG 4 experiences a positive relative change of +0.02, and otherwise, it will remain unchanged. SDGs 3 (good health and well-being), 10 (reduced inequality), and 11 (sustainable cities and communities) follow the same route, but their positive relative change in case of the improvement in pandemic would be +0.01. Besides, SDGs 6 (clean water) and 7 (affordable and clean energy) are indifferent in applying any of the strategies or their combination if the pandemic situation improves, as they experience the same level of relative change in all the scenarios. However, their relative change is diverse if the pandemic remains as the current situation or worsens.

Moreover, although the implementation of strategy C in the situation of improvements in pandemic returns positive relative changes in all the involved SDGs, this strategy causes a relative negative change in SDGs 8 and 9, and keeps the other SDGs unchanged if the pandemic does not change or worsens. These negative relative changes can be explained by applying some of the components in this strategy, including the reduction or change of working hours and also the budget spent on healthcare instead of industrial and business activities that affect the industrial activities and the economic growth. However, since this strategy deals with the health of the society and is necessary to be considered during the pandemic, the government and authorities should take care of the negative effects of implementing this strategy on the industry and economy in case of applying it in the current situation of pandemic or a worse situation.

Applying a combination of the three considered strategies in the situation of pandemic crisis imposes positive relative change in the SDGs only if the pandemic situation improves. Therefore, the combination of these strategies is not suggested to be applied in other situations. Besides, as Table 6 shows, if the pandemic crisis improves, implementing any of the three considered strategies or their combination would improve the achievement of the involved SDGs compared with the case of not implementing any of the strategies. Nevertheless, the effectiveness of these strategies or their combination reduces clearly if there is no improvement in the pandemic situation or it worsens.

Tab. 4. Summary of the SDGs relative changes in the analyzed scenarios

SDGs more at risk of COVID-19	COVID-19 $L^0 = -0.5$				COVID-19 $L^0 = 0$				COVID-19 $L^0 = +0.5$			
	Strategy A	Strategy B	Strategy C	Strategies A, B and C	Strategy A	Strategy B	Strategy C	Strategies A, B and C	Strategy A	Strategy B	Strategy C	Strategies A, B and C
SDG 1- No poverty	+0.04	+0.03	+0.03	+0.03	+0.01	0	0	0	+0.01	0	0	0
SDG 2- Zero hunger	+0.02	+0.02	+0.01	+0.01	+0.01	+0.01	0	0	+0.01	+0.01	0	0
SDG 3- Good health and well-being	+0.01	+0.01	+0.01	+0.01	0	0	0	0	0	0	0	0
SDG 4- Quality education	+0.02	+0.02	+0.02	+0.02	0	0	0	0	0	0	0	0
SDG 6- Clean water and sanitation	+0.01	+0.01	+0.01	+0.01	-0.01	0	0	0	-0.01	0	0	0
SDG 7- Affordable and clean energy	+0.03	+0.03	+0.03	+0.03	+0.01	0	0	0	0	0	0	0
SDG 8- Decent work and economic growth	+0.03	+0.04	+0.03	+0.03	0	+0.02	-0.01	0	0	+0.02	-0.02	0
SDG 9- Industry, innovation and infrastructure	+0.02	+0.03	+0.02	+0.02	0	+0.01	-0.01	0	0	+0.01	-0.01	0
SDG 10- Reduced inequalities	+0.01	+0.01	+0.01	+0.01	0	0	0	0	0	0	0	0
SDG 11- Sustainable cities and communities	+0.01	+0.01	+0.01	+0.01	0	0	0	0	0	0	0	0

4. Conclusion

Achieving 2030 Agenda for Sustainable Development (SD), needs providing a comprehensive and systematic insight to decision makers. Regarding the substantial effect of the COVID-19 pandemic on the 2030 Agenda, this study was conducted to simulate long-term consequences of governmental strategies implemented during pandemic in Iran. Applying a qualitative systematic two-phase method, the following steps were completed. (1) the SDGs significantly affected by COVID-19 were identified and weighted using Fuzzy Delphi Method (FDM); (2) interconnections among the SDGs during COVID-19 were determined and weighted using Fuzzy Cognitive Map (FCM) modeling; (3) three governmental strategies during pandemic including focus on people in vulnerable situation, support for industrial units and small and medium-sized enterprises, and national aggregation to Fight COVID-19 were tested under three scenarios regarding the different levels of COVID-19 effects. Simulations showed that applying each of the three strategies or their combination would have the highest positive effect on the survival of SDGs in case of the improvements in the pandemic situation. The outcome of applying these strategies would be much diverse in case the pandemic crisis remains the same or worsens. The results of our study, illustrates the effects of implemented governmental strategies on each SDG by detail which is a necessity to observe if the current action plans are helping the achievement of 2030 Agenda or not, and which SDGs need more specific strategies to improve. The qualitative systematic approach of this research can be applied to observe any suggested or implemented strategy as well. This research was conducted focusing only on the 17 SDGs level within the 2030 Agenda for SD. Further research can be done on the targets and indicators

levels, as well. Second, the same research for the other countries using different panels of experts is recommended. Third, the SDGs analysis considering COVID-19 can be studied with respect to other aspects of sustainability given in the literature for health systems.

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