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Research Article

Systems Dynamics Model of SDGs: A Case Study of Iran

Mojgan Chapariha

Lisbon School of Economics and Management (ISEG), University of Lisbon, Lisbon, Portugal

* Corresponding author: mojgan@phd.iseg.ulisboa.pt

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Abstract: This paper investigates on the implementation Sustainable Development Goals (SDGs) in Iran. It generates a systems dynamics model for exploring possibilities for achieving four SDGs: SDG-1 (eradicating poverty), SDG-8 (economic growth and decent work), SDG-12 (sustainable production and consumption), and SDG-13 (climate action) in Iran. The model is used to generate four possible stories about the implementation of measures to achieve these SDGs in the future of the Iranian economy from 2020 to 2050: 1) the Scenario of *Business as Usual* continues current trends and projects them into the future, 2) the Scenario of *Inclusive Growth* is designed to simulate more income equality and faster economic growth, 3) the Scenario of a *Steady State* introduces measures to improve social, and environmental aspects while having zero economic growth, and 4) the Scenario of *Well-being* for *People and Planet* is designed to improve socio-economic and environmental aspects of the Iranian economy to achieve the four SDGs in Iran. The performance of the Iranian economy for progressing towards the SDGs is monitored through four SDG indexes which are measured based on the arithmetic mean of selected indicators for each SDG, and a Combined Index of SDGs which is measured based on the arithmetic mean of the four SDGs indexes. The results of the simulations of the SDGs model of Iran shows that the transformational scenarios (*Steady State*, and *Well-being* for *People and Planet*) provide better pathways in comparison to conventional scenarios (*Business as Usual* and *Inclusive Growth*) for achieving the SDGs. Moreover, this study find that transformational policy changes and extraordinary efforts are required for progress in achieving SDGs in Iran.

Keywords: Ecological Macroeconomics; Human and Ecological Well-being; Iranian economy; SDGs

1. Introduction

Discussions on SDGs illustrate that they are important development agenda for achieving sustainability, human and ecological well-being. Costanza et al. (2016) argue that “The SDGs represent a major potential tipping point in the future of humanity” [1]. It is necessary to have global goals such as SDGs; however, implementing and achieving SDGs is another important factor. The implementation of SDGs can be challenging in different aspects, especially in developing countries. As Bhattacharya et al. (2016) identify five major challenges to implementing SDGs in developing subnational, and local levels of SDGs; establishing institutional systems to implement them; limited financial resources; monitoring and evaluation of progress of the SDGs through improving availability of data; and developing partnerships [2]. Therefore, this study deepens our knowledge of implementing SDGs in the developing country of Iran.

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Monitoring the progress in achieving SDGs is important for analysing best possible pathways for achieving them. In this regard, Randers et al. (2018) constructed an integrated "Global Systems Model", Earth3, which links socio-economic and biophysical systems and then simulates the implementation of 17 SDGs within 9 planetary boundaries [3]. Earth3 produces four scenarios of Business as Usual, Accelerating Economic Growth, Stronger Efforts on All Fronts, and Transformational Change which measures the number of SDGs achieved for seven World regions in the period of 2018 to 2050 [3]. Similarly, this research considers two categorizes of scenarios: *conventional* and *transformational*. However, the scenarios of the SDGs model are written for the specific case study of Iran to enhance our perception about the situation of SDGs in Iran.

Most of the research on SDGs in Iranian literature has focused on SDG-3. For instance, Mohammadi et al. (2019) analyzed the interactions between SDG-3 and other SDGs in Iran, from which they realized that considering health in the context of sustainable development helps to improve social, economic, and environmental determinants of health [4]. Therefore, this research enriches our understanding of the implementation of SDGs in Iran by providing a unique measurement of progress in implementing four SDGs through systems dynamics modelling in Iran: SDG-1, SDG-8, SDG-12, and SDG-13.

This paper designs four scenarios for the implementation of selected SDGs in Iran from 2020 to 2050: two *conventional* scenarios (Business as Usual and Inclusive Growth) and two *transformational* ones (Steady State Economy and Well-being for People and Planet). It then contributes to research and policy by designing the first systems dynamics model of SDGs and applying it to provide an understanding of where Iran stands in terms of implementing the SDGs under different scenarios from 2020 to 2050. Each of these scenarios has specific focus, which compares the role of the overarching goal of economy on achieving SDGs. The simulation of ecological macroeconomics model of the SDGs makes an original contribution to Iranian research and policy on such models.

Conventional scenarios analyse the role of conventional policy options on implementing SDGs in Iran. Scenario of "Business as Usual" is a projection of recent trends into the future. Scenario of "Inclusive Growth" considers socio-economic factors such as higher economic growth, income redistribution, and a higher level of population growth as its main objectives.

Transformational scenarios analyse the role of radical efforts on implementing SDGs. Transformational policy changes are required for improving sustainability [3,5]. We are living in a finite system; inevitably, the sub-systems of this system cannot grow infinitely [6]. This raises the issue of reshaping the economic system in a way that is in line with the finite ecological system [7,8]. Therefore, scenario of "Steady State Economy" is based on zero economic growth, income redistribution, a lower level of population growth, and a reduction in working hours, and is supported by environmental plans including a carbon tax and the redirection of income from the fossil-fuel industry to renewable energy investment. Studies illustrate that developed countries must move toward steady state economy. There is a literature gap in analyzing the role of Steady State Economy in developing countries [9]. Therefore, this research contribute to the discourse of steady state economy in Iran and global north countries. Scenario of "Well-being for People and Planet" is based on income redistribution, a medium level of population growth, and a reduction in working hours, but does not control the GDP growth rate. It also considers a progressive carbon tax and the redirection of income from the fossil-fuel industry to renewable energy investment.

This paper has eight main sections (including the introduction and conclusions). In Section 2, it explains the case study of Iran. Then in Section 3 it explains the structure of the Iran's Ecological Macroeconomics Model of SDGs. Then in Section 4, it describes four scenarios of the SDGs model categorized into *conventional* and *transformational* scenarios. Then in Section 5, it describes the policy changes of the scenarios. Next, in Section 6, it compares the results of simulations of the systems dynamics model of SDGs in Iran under the four scenarios. Then in Section 7, it will explain the limitations of the model that are outside of the control of author.

2. Case of Study of Iran

The Islamic Republic of Iran (Iran for short) is in the continent of Asia and the region of the Middle East. Iran, with an area of 1,628,760 square kilometres, ranks as the sixteenth biggest country in the world [10]. Iran shares borders with several countries, including Turkey, Azerbaijan, Armenia, Iraq, Pakistan, Afghanistan, and Turkmenistan. Also, Iran borders the Caspian Sea in the north and the Persian Gulf and the Gulf of Oman in the south. Figure 1 depicts a map of modern Iran. Iran has a population of around 81.8 million [11], which forms around 1% of the world's population. Iran's population increased from 21 million in 1960 to 82 million in 2018 [11].

Figure 1. Modern Iran [12].

Iran is facing with socio-economic and environmental issues. The IMF provides the Iran's inflation rate based on average consumer prices, which illustrate fluctuations between 4% and 50% in the period 1980 to 2020 [13]. Income inequality [14] has been fluctuating over years, however; in comparison to a level of 46 in 1979, it has declined to 40 in 2017 [15]. Poverty data reporting based on World Bank and Iranian sources are different. The World Bank reported that 11.6% of the population in 2016 were living below the poverty line [16]. However, an Iranian economist declared that in 2015, 40% of people were doing so [17]. This inconsistency among poverty data may be due to the use of different exchange rates, different poverty line definitions, and the use of data from different sources. The global unemployment rate was 5.5% in 2018 [18], while the total unemployment rate in Iran was 12% in 2019 [19].

Iran is among the top ten countries with the highest level of total CO_2 emissions. CO_2 emissions increased from 37,392 kilotons in 1960 to 649,480 kilotons in 2014 [20]. CO_2 emissions per capita increased from 1.7 metric tons per capita in 1960 to 8.38 metric tons per capita in 2014 [21]. Energy sector had highest contribution to CO_2 emissions in Iran which 90% of total CO_2 emissions in 2000 [22] and 88% in 2010 [23]. As the energy sector in Iran contributed to 86-90% of total GHG emissions in Iran, so, [24] recommended that for mitigating climate change in Iran it is required to focus on mitigation of GHG emissions in energy sector.

The ecological footprint measures our dependence and impact on the environment and the carrying capacity of nature [25]. The ecological footprint in Iran was measured at 3.2 global hectares per person in 2017, which exceeded the biocapacity of 0.7 global hectares per person. In Iran, the carbon footprint is 2.5 global hectares per person of the total ecological footprint (3.2), and is around 70% of the total ecological footprint of consumption [26].

As explained above, Iran is dealing with socio-economic issues such as poverty, income inequality, a high unemployment rate, and lack of decent work which these macroeconomic indicators are addressed in the SDGs model of Iran through simulating SDG-1 and SDG-8. Moreover, Iran is dealing with some environmental issues such as high levels of CO_2 emissions and ecological deficit which these environmental issues have been addressed in the SDGs model of Iran through simulating SDG-12 and SDG-13.

3. Structure of Iran's Ecological Macroeconomics Model of SDGs

3.1. Systems Dynamics Modelling

The model of this paper is developed based on systems dynamics approach. The systems dynamics model of this paper is built based on software of STELA Architect 1.8.2. The approach of systems dynamics models is to solve dynamic, long-term, and complex policy problems [27] such as sustainability. "Systems dynamics can address the fundamental structural causes of the long-term dynamic contemporary socio-economic problems" [27]. Systems dynamics models are based on a problem and purpose [27]. Therefore, they start from a problem to solve it [28]. Systems dynamics models are simulation models that include stock and flow variables [29]. Stocks variables can accumulate or deplete over time (e.g. population government debt) through flow variables, which add to or subtract from stocks. Therefore, flows directly flow in and out of the stocks (e.g. birth and death, government revenue, government expenses).

Models can have different purposes, such as to understand, quantify, visualize, predict, and simulate different aspects of the world. This model contributes to all these five aspects. Firstly, it illustrates the existing situation of Iran's economy for its ability to achieve the four goals of the SDGs. Then, it quantifies the progress of achieving these goals. Thirdly, it visualizes the achievement of the goals. Fourthly, it predicts progress in achieving these goals in the period 2020 to 2050. Finally, it compares the implementation of the SDGs in different scenarios. The scenarios of the model provide different possibilities and pathways for the future. Moreover, they illustrate the scope of goals that a country can achieve in a certain period. Each scenario includes specific actions consistent with the character of the scenario.

3.2. Overview of the Model

To transition toward sustainability, it is essential to consider the interactions of different systems of economy, society, and environment [30]. Conceptualizing the economy, society, and environment as nested systems is crucial for understanding the economy and its dependence on the wider world [31,32]. Ecological macroeconomics models provide situation to analyse systems of economics, society, and environment in an integrated way. Victor and Jackson (2020) developed a research agenda for ecological macroeconomics which they proposed that ecological macroeconomics must consider three spheres of modelling and metrics including the ecological sphere, the real economy, and the financial economy [33]. Also, Jackson and Victor (2019) constructed an ecological macroeconomics model, called LowGrow SFC, for Canada which includes three interrelated spheres of environment, real economy, and financial economy [34].

The intent of the SDGs is to develop a more integrated agenda, one that successfully combines three dimensions (economic, social, and environmental) of sustainable development, and one in which goal areas are interrelated [35]. It should successfully combine these three dimensions and recognize each goal area as interrelated [35]. Goals and targets are interdependent, and they must be pursued together; many of the indicators are related to more than one of the targets in the SDGs.

This research develops a systems dynamics models based on three integrated systems of economy, society, and environment to analyze implementation of SDGs for Iran. The SDGs model is inspired by concepts of strong sustainability and is designed to provide basis for measuring human and ecological well-being. It therefore helps respond to key existing critiques of the SDGs in terms of being based on the three-pillar model of sustainability and disregarding interactions between goals and targets. Figure 2 illustrates this integration of the three sectors of economy, society, and environment that lead to the achievement of human and ecological well-being.

Figure 3 gives an overview of the SDGs model of Iran. This model consists of exogenous and endogenous variables. Values for the exogenous variables are derived from real data. The values of the endogenous variables are the output of the model. The relationships among the variables in the model are explained in different parts of this paper. Then, the output of the model is used to measure four SDG indexes. Finally, these SDG indexes are used to measure a combined index to show the overall performance of each scenario.

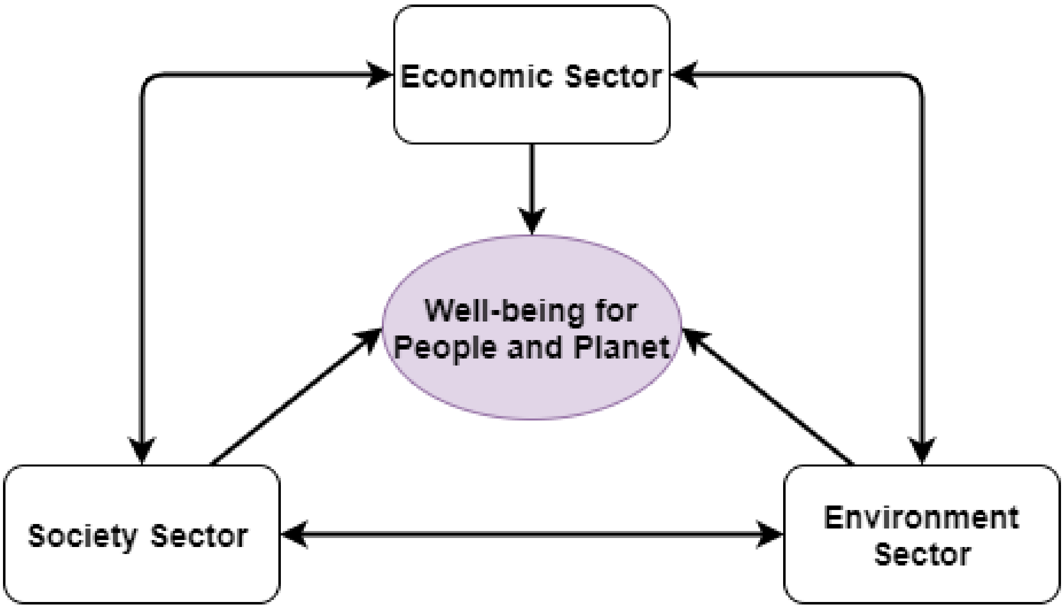

Figure 2. Three main sectors of the model.

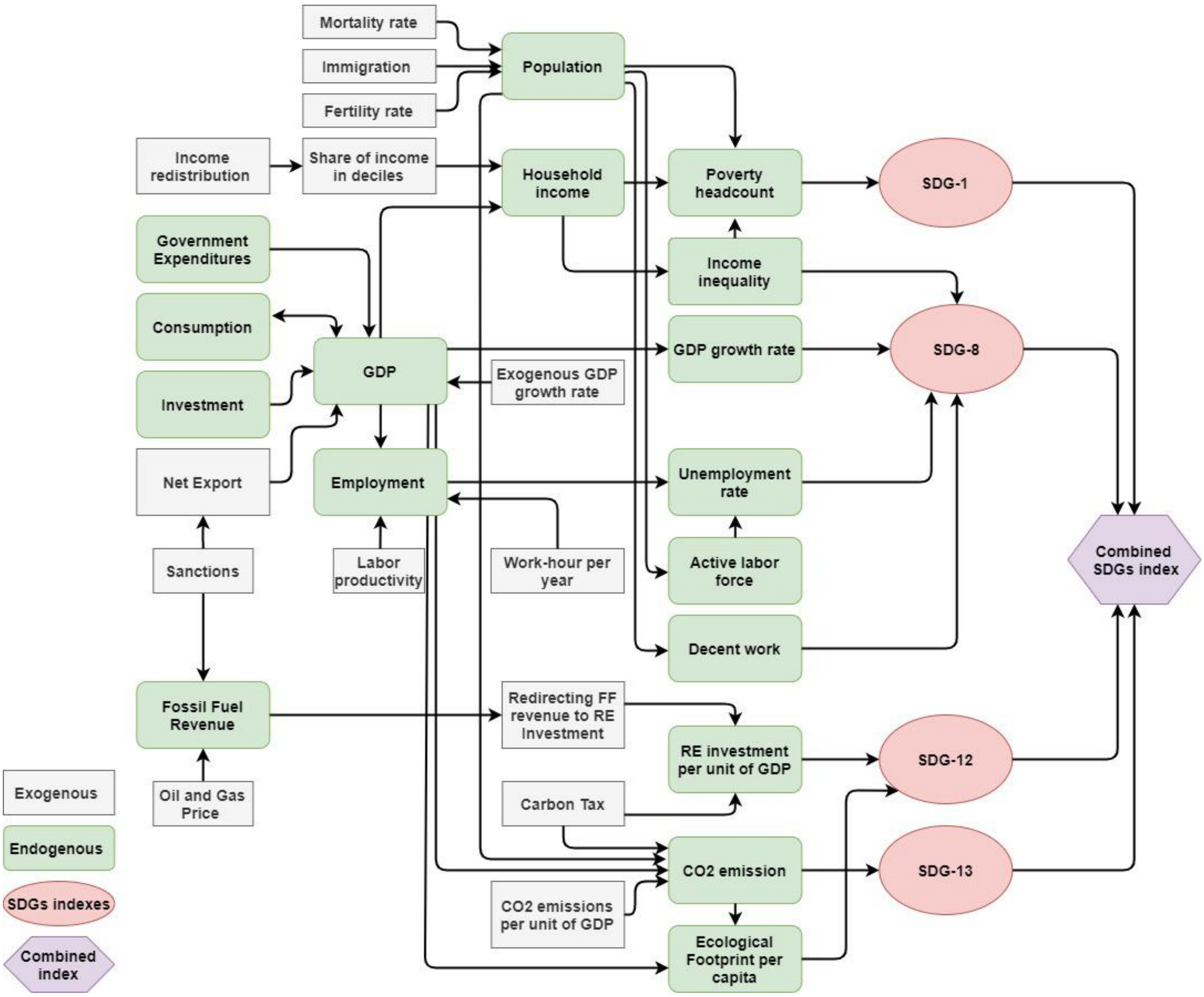

Figure 3. Overview of the SDGs model of Iran.

3.3. Sets of Indicators to Measure SDGs Indexes

The United Nations Statistical Commission, meeting in March 2016, adopted a global indicator framework consisting of 230 indicators for the 17 SDGs. In this paper, main indicators of SDGs in this model are defined based on the context of “The 2030 agenda for sustainable development” [36] and also “Global indicator framework for Sustainable Development Goals and targets of the 2030 agenda for sustainable development” [37]. This model generates many indicators that can be used to measure the SDGs indexes. The criteria used for selecting the indicators were: relevance to the targets of the SDGs, being compatible with the suggested SDGs indicators by the United Nations Statistical Commission (2016), broad availability of data for Iran and other countries, and the quality of the data. To measure the SDGs’ indexes, indicators that has been measured in the model are shown in Figure 4.

3.4. Measuring SDGs Index

Each of the indicators used to measure SDGs indexes have different units; therefore, it is required to convert them into a normalized index for them to be comparable to each other. The SDGs index is normalized to be in the range of 0 to 100, where 0 shows complete failure in achieving the SDGs and 100 means complete success. In other words, if the SDG index approaches 100, this means that Iran has achieved that goal. On the other hand, if the SDG index decreases, this means that the attempt to achieve that particular SDG is worsening. For indicators whose increase is assumed as implausible (e.g. poverty), Equation 1 has been used to normalize that index, while for indicators (e.g. the ratio of renewable energy investment to GDP) whose increase is assumed plausible, Equation 2 has been used to do so.

$$\text{Normalized } x = 100 - \frac{x - \text{Min}(x)}{\text{Max}(x) - \text{Min}(x)} * 100 \quad (1)$$

$$\text{Normalized } y = 100 - \frac{y - \text{Min}(y)}{\text{Max}(y) - \text{Min}(y)} * 100 \quad (2)$$

The minima and maxima of the Equations have been defined based on SDGs’ context or performance of other countries. If the ideal level of a target has been defined in the context of SDGs, then this number would be used as the ideal level of that indicator. Otherwise, the ideal level is defined based on the best performance of other countries. On the other hand, the worst level of an indicator is defined based on the worst case in the world. Table 1 shows the minima and maxima of the SDG indicators in the model.

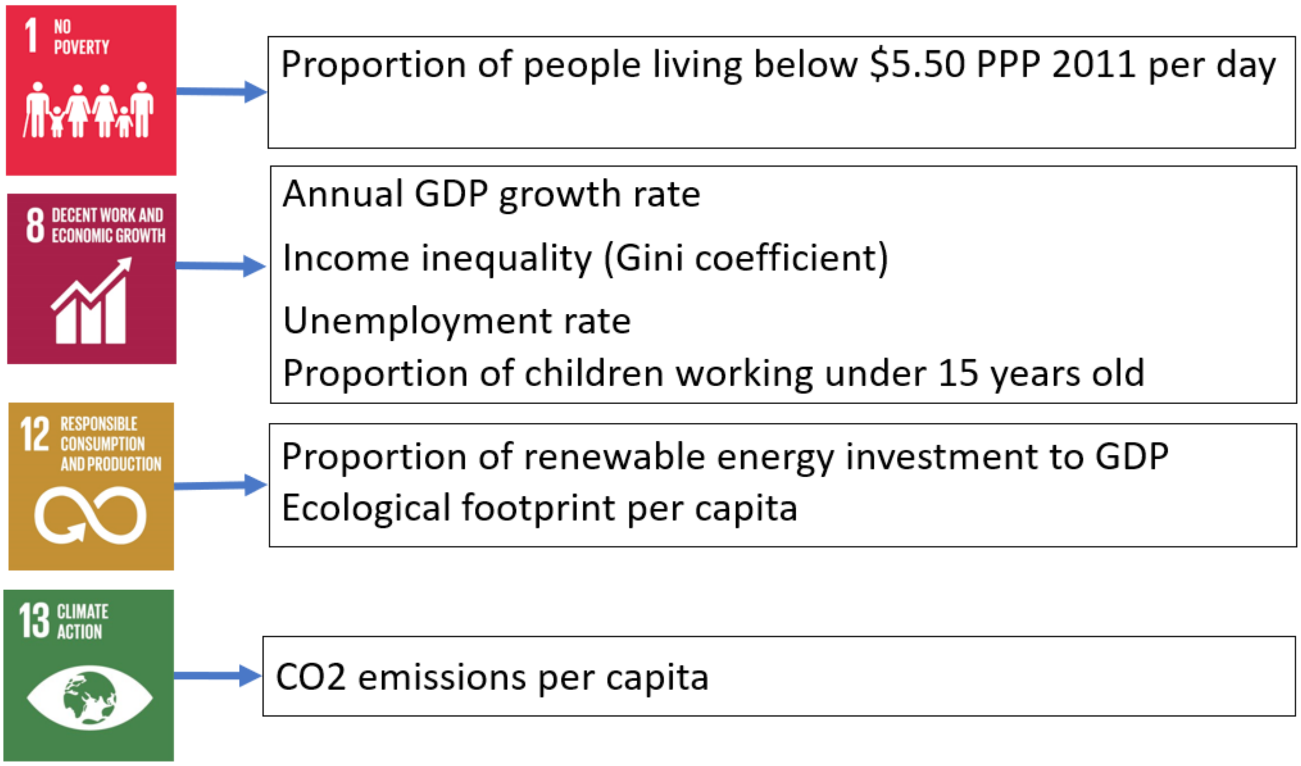

Figure 4. Sets of indicators to measure SDGs in the SDGs model.

Table 1. Traffic light system for ICS performance from different inspection levels in a group certification scheme. Sources: [a]World Bank, [b]Ecological Footprint Network [26], and [c]Wordometers [38].

SDGs	Modelled indicators	Minimum (worst case)	Maximum (Target)
SDG-1	Proportion of population living below 5.5 $ PPP per day	90.6% (Benin 2015)[a]	0%
SDG-8	GDP growth rate	-20.6% (Sierra Leone 2015)[a]	4%
	Gini coefficient	59.1% (Namibia, 2015)[a]	0
	Unemployment rate (total)	35%	<5%
	Proportion of child labor	15.39% (Colombia, 2015)[a]	0%
SDG-12	Ecological footprint per capita	14.5 gha per capita (Qatar, 2015)[b]	<0.7 gha (Iran's biocapacity)
	Percentage of renewable energy investment within GDP	0%	10% (South Africa and Chile)
SDG-13	CO_2 emissions per capita	37.91 metric tons per capita (Qatar, 2014)[c]	0

4. Four Scenarios of the Model

This model consists of four predefined scenarios: Business as Usual, Inclusive Growth, Steady State Economy, and Well-being for People and Planet. Scenarios of this model are predefined in a way to describe different possible pathways of implementing SDGs.

The first two scenarios of this study, Business as Usual and Inclusive Growth, are based on conventional policies. Scenario of Business as Usual continues the same conventional policies to 2050. Some of the economists suggested that accelerating economic growth and redistributing income among people could improve macroeconomic indicators. Therefore, economic growth has been a major policy objective in many western countries [31,32,39] and recently in many developing countries [40]. Therefore, scenario of Inclusive Growth tests this conventional idea that accelerating economic growth provide a better life for people.

Studies ([3,5,33,41]) show that for improving human and ecological well-being, transformational policies are required. Therefore, two scenarios of Steady State Economy, and Well-being for People and Planet are constructed based on transformational policies to help in achieving SDGs in Iran by 2050. The goal of Steady State Economy scenario is to achieve social justice and sustainability while managing economic growth. Finally, the last scenario of Well-being for People and Planet bridges the gap between human and ecological well-being. The main goal of scenario of Well-being for People and Planet is to improve human and ecological well-being through extraordinary efforts. Therefore, this scenario includes extraordinary socio-economic and environmental policy reforms. Figure 5 illustrate description of four scenarios.

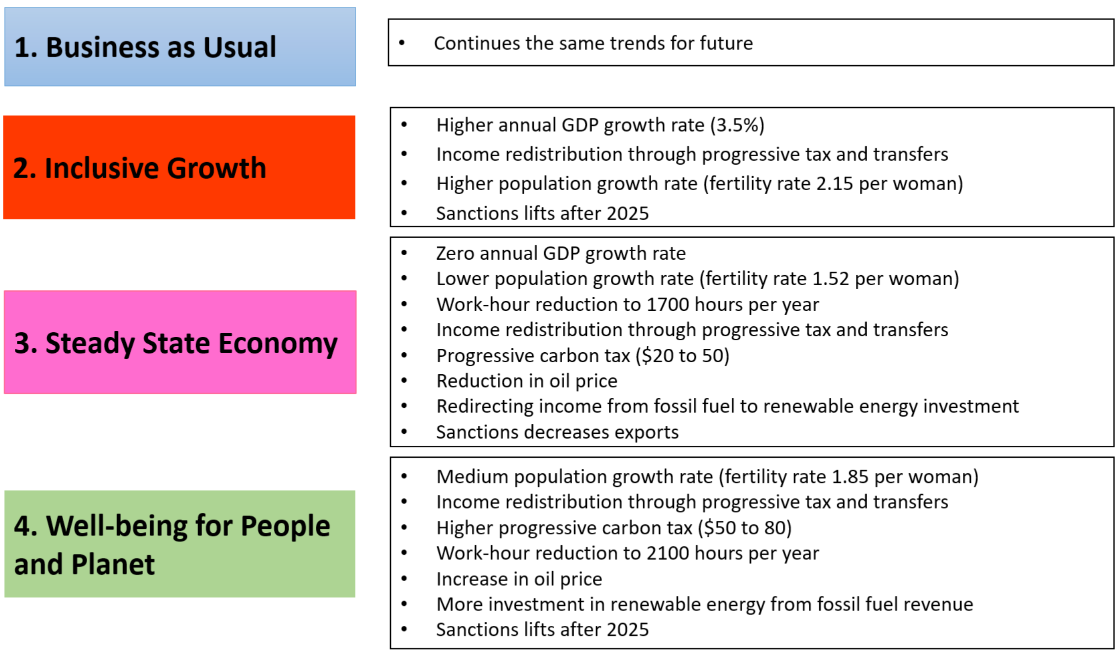

Figure 5. Four scenarios of this model.

5. Description of Policy Changes in Scenarios of the Model

5.1. Managing Economic Growth

This research considers GDP growth rate as one of the indicators of the model that varies in different scenarios. There are two extreme ideas about the role of GDP growth on well-being: 1) pursuing economic growth for improving human well-being, and 2) managing economic growth for improving human and ecological well-being in the context of sustainability.

Many writers and notable economists articulated that economic growth is important for a period of time to meet basic needs, supply basic infrastructure, and eradicate poverty, but it is not enough for a happy society, because significant factors of well-being go beyond economic growth [42]. Ecological economists have stated that meeting material needs is necessary for achieving well-being up to a certain threshold point, during which the benefits of economic growth exceed its costs [6,43,44]. After this threshold point, we are faced with "uneconomic growth" [45]. Therefore, well-being that is brought about by economic growth is achieved by social costs and sacrifices to society [46] and environmental externalities [31].

The De-growth Economy is an alternative paradigm to the Mainstream Economy. De-growth means "an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level, in the short and long term" [47]. Ecological economists believe that in developed countries they must manage economic growth. As Hickel states, rich nations must abandon economic growth as major policy objective to stay within planetary boundaries [48]. However, the implications of a de-growth economy in developing countries are largely neglected [9]. Therefore, in the Steady State Economy scenario of this model, it analyses the role of zero GDP growth rate on achieving SDGs in Iran.

In this model, different scenarios consider different ranges of GDP growth rate. The Inclusive Growth scenario considers 3.5% to be the GDP growth rate, while the Steady State economy scenario considers zero as the GDP growth rate. The two scenarios Business as Usual and Well-being for People and Planet do not consider the exogenous GDP growth rate. Table 2 shows the exogenous GDP growth rates in different scenarios. This helps to assess the role of GDP growth rate in different aspects of socio-economic and environmental.

5.2. Income Redistribution Through Tax Reforms and Transfers

Income inequality in developing countries can be an obstacle to raising growth and reducing poverty. Therefore, income redistribution can help to achieve more income equality, faster economic growth, and faster poverty reduction in developing countries [49]. Based on an OECD report, the tax and transfer system is still one of the fundamental policies for inclusive growth that shares economic growth among all people [50]. Tax and transfers are specifically useful when the benefits of growth fail to be distributed to all people equally [49].

Income tax is an example of direct tax, which is levied based on the individual's level of income and can be designed to take into account the circumstances of taxpayers [51]. Tax on personal income is 4.27% of GDP in Iran, while, in 2018, the average rate of tax on personal income in OECD countries was 8.28% of GDP [52]. In 2009, Iran's tax revenue proportion of GDP was 7% [53]. In other oil exporting countries in the Middle East, such as the United Arab Emirates, Kuwait, and Iraq, the proportion of tax revenue of GDP in 2015 was respectively 0.06%, 1.38%, and 1.24% [53].

In this research, the redistribution of income means transfer of income from some individuals to others through income taxation and cash transfers. In various scenarios of the model, progressive tax rates have been considered to reduce income inequality and poverty. Table 3 shows the income tax rates in different scenarios.

Social protection and cash transfers were effective in Iran to reduce poverty and income inequality [54]. Therefore, in the scenarios of Inclusive Growth, Steady State Economy, and Well-being for People and Planet, cash transfers to low-income households are used as a policy to reduce poverty and income inequality. Table 4 illustrates the percentage of income transfer rates in different scenarios. In these scenarios, transfers are designed in a way that the poorest household (decile 1) receives more income transfers rate than the richest (decile 5).

Table 2. Exogenous annual GDP growth rate in different scenarios.

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Annual GDP growth rate	-	3.5%	0	-

Table 3. Income tax rates (%) in different scenarios.

	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
Business as Usual	0	0	0	0	0
Inclusive Growth	10	10	15	15	20
Steady State Economy	5	5	10	15	20
Well-being for People and Planet	20	25	30	30	35

Table 4. Income tax rates (%) in different scenarios.

	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
Business as Usual	0	0	0	0	0
Inclusive Growth	10	5	5	5	5
Steady State Economy	10	5	5	5	5
Well-being for People and Planet	10	10	10	10	10

Table 5. Annual working hours per employee in different scenarios.

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Working hours per year	2,193	2,193	1,700	2,100

Table 6. Fertility rate under different scenarios of the model.

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Fertility rate per woman	2.11	2.15	1.52	1.85

5.3. Reduction in Working Hours

De-growing GDP means that a lower amount of paid work is required in a nation, which leads to a decrease in working hours. Therefore, a reduction in working hours can be implemented in those countries to support the de-growth of GDP. Reducing working hours has economic benefits such as reducing the unemployment rate, as argued by Victor (2008). It has also been argued that a reduction in paid working hours can contribute to decreasing the environmental impacts of the economy and help to achieve environmental sustainability [55]. Coote and Goodwin (2010) called for a gradual transition in reducing working hours to employ more workers and provide opportunities for workers to spend more time with their families [56]. Juliet B. Schor (2005) conducted a linear regression among 18 OECD countries to assess the relationship between the ecological footprint and working hours per employee which realized that hours of employment per worker is a significant predictor of the ecological footprint [55]. A reduction in working hours improves environmental sustainability and human well-being [57].

In economics, the number of employed people is calculated based on the equations below. Based on Equation 3, the total number of hours of employment per year is calculated by dividing GDP into labour productivity per hour. Then, in Equation 4, the number of employed persons is calculated by dividing the total number of hours of employment per year by the number of working hours per employee. Based on Equation 4, if the total number of working hours per employee decreases, then the number of employed persons increases, *ceteris paribus*. The unemployment rate is calculated based on Equation 5, which divides the difference between the number in the active labour force and the employed labour force by the active labour force.

$$\text{Hours of employment per year} = \frac{\text{GDP}}{\text{Labor productivity per hour}} \tag{3}$$

$$\text{Number of employed persons} = \frac{\text{Hours of employment per year}}{\text{Work hour per employee}} \tag{4}$$

$$\text{Unemployment rate} = \frac{\text{Active Labor Force-Employed Labor Force}}{\text{Active Labor Force}} * 100 \tag{5}$$

In OECD countries, the average of the annual working hours per employee has decreased from 1,945 in 1970 to 1,734 in 2018 [52]. The annual working hours in Iran have decreased from 2,550 hours in 2005 to 2,193 in 2017 [58]. The average annual working hours per employee in Iran are greater than those in OECD countries. Therefore, in the scenarios of the Steady State and Well-being for People and Planet, the annual working hours per year have been decreased to 1,700 and 2,100 respectively. Table 5 illustrates annual working hours per employee in different scenarios.

5.4. Managing Population Growth

Population is an important element of different aspects of the economy and the environment. Total population can influence different parts of the model, including unemployment rate, poverty, CO_2 emissions, ecological footprint, etc. If the population is growing and consumption per capita is not to decline, then GDP growth is essential [32]. Therefore, in the scenario of the Steady State Economy, with an economy which economic growth is zero, it is assumed that the fertility rate is less than in other scenarios. The fertility rate in Iran has declined from seven children per woman in 1960 to 2.11 in 2017 [59]. To project the total population in the scenarios of this model, the UN's projection of the population of Iran has been used. The UN has projected three levels of population, lower 95, median, and higher 95 for Iran by 2050: 96.6, 103, and 109.5 million respectively [60]. In the SDGs model, different fertility rates have been used to achieve these UN population projections for Iran. It has been assumed that in the Inclusive Growth scenario, the fertility rate is at its highest rate, 2.15, as a higher GDP growth provides the opportunity to have more children. It has been assumed that in the Steady State Economy scenario, which is based on a GDP growth rate of zero, population growth is based on the lowest projection of the UN; therefore, the fertility rate is 1.52. In the Well-being for People and

Planet scenario, population growth is based on the median of the UN's projection of population, for which the fertility rate is 1.85. Table 6 illustrates all the fertility rates that have been used in the SDGs model of Iran.

5.5. Sanctions

Economic sanctions significantly influence Iran's economy. Recent economic sanctions in Iran had six major effects on Iranian economy: 1) a trade ban on many goods [61]; 2) a decrease in oil exports and revenue [61,62]; 3) a sharp rise in the exchange rate [61]; 4) restrictions on the country's banking system with other countries [62]; 5) a significant impediment to economic growth [63]; and 6) positive significant influence on inflation through its effect on the exchange rate and government debt [64].

Because Iran's economy is based on exports of oil and gas, sanctions can therefore directly affect exports and, consequently, GDP. As it is not clear when sanctions will be lifted from Iran, therefore, in different scenarios different levels of sanctions have been considered. In all the scenarios, it is assumed that for the period of 2020 to 2025, the situation of sanctions would in the period of 2020 to 2025. Because of uncertainty about future of Iran's nuclear deal, it is assumed that in scenario of Business as Usual, continues the same trend and therefore, sanctions reduced exports to 13% of its value in the period of 2025 to 2050. In scenarios of Inclusive Growth and Well-being for People and Planet, sanctions are lifted in 2025. In scenario of Steady State Economy, it is assumed that sanctions will decline exports to 50% of their value from 2025. Moreover, it is not certain when and how sanctions will be lifted from Iran's economy. Table 7 illustrates the effect of sanctions on exports in different scenarios.

5.6. Carbon Tax

The carbon tax is a fixed price set by governments. Carbon taxes are designed to achieve carbon reduction targets; for example, Calderon et al. (2016) realized that carbon tax and abatement targets have significant effect on reducing CO_2 emissions in Colombia [65]. Carbon taxes are important because they correct market failures that cause negative externalities on the environment. The carbon tax is designed to internalize the externalities of fossil-fuel usage [66].

The International Energy Agency (IEA) (2018) [67] estimates fossil-fuel subsidies through the amount that is consumed directly by end-users as inputs to electricity generation. Iran gives huge amounts of subsidies to oil, gas, and electricity [67]. Eliminating fossil-fuel subsidies is one of the most efficient ways of reducing CO_2 emissions and mitigating climate change [67]. Achieving climate targets is impossible without the phasing out of fossil-fuel subsidies [68]. Based on the IEA figures, in 2018 Iran gave the highest amount of fossil-fuel subsidies to its citizens. The average subsidy rate was 79% which is equivalent to $844 per person [67]. After Venezuela, Iran has the highest average subsidy rate. The total amount of subsidies is equal to 15.3% of GDP [67].

In this model, the carbon price affects CO_2 emissions per unit of GDP through the price elasticity of demand on the carbon tax. In this model, in the Steady State Economy scenario, the elasticity of demand on carbon tax is 0.2 and in the Well-being for People and Planet scenario, it is 0.8. This means that in the Well-being for People and Planet scenario, the CO_2 emission per unit of GDP is more dependent on the carbon tax. Table 8 illustrates carbon tax in different scenarios.

Table 7. The effect of sanctions on exports in different scenarios.

	2020-2025	**2025-2050**
Business as Usual	Reduces exports to 13% of its value in base year	Reduces exports to 13% of its value in base year
Inclusive Growth	Reduces exports to 13% of its value in base year	Sanctions lifted
Steady State Economy	Reduces exports to 13% of its value in base year	Reduces exports to 50% of its value in base year
Well-being for People and Planet	Reduces exports to 13% of its value in base year	Sanctions lifted

Table 8. Carbon tax in different scenarios.

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Carbon tax (per tonne of CO_2)	-	-	\$20-50	\$50-80

Table 9. Oil Price in different scenarios. Source: IEO (2020) [69], CBI (2021) [70] and Fars News (2021)[71].

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Oil price (per barrel)	Continues oil prices [70]	\$40.7 [71] to \$100 [69] in the period of 2020 to 2050	Decreased to \$20	Oil price increases 1% every year [70]

Table 10. Redirecting Income from Fossil-Fuel Industry to Renewable Energy Investment in different scenarios.

	Business as Usual	Inclusive Growth	Steady State Economy	Well-being for People and Planet
Revenue redirected from fossil-fuel industry to renewable energy (%)	-	-	10% in 2020 to 60% in 2050	10% in 2020 to 90% in 2050

5.7. Oil Price

In this model, oil prices are varying in different scenarios. Oil price of 2020 is considered \$40.7 per barrel [71]. In the Inclusive Growth scenario, the oil price projection of International Energy Outlook (IEO) 2020 is used which they have forecasted that the oil price increases to \$100 per barrel in 2050 [69]. A decrease in the oil price is a climate action policy, which can be a nudge to motivate investment in renewable energy. Therefore, in the Steady State Economy scenario, the price of oil has been decreased to \$20 per barrel; this will decrease the fossil-fuel revenue of Iran. In the Well-being for People and Planet scenario, the oil price increases by 1% every year from 2020 to 2050. In Table 9 shows the fossil fuel prices in four scenarios.

5.8. Redirecting Income from Fossil-Fuel Industry to Renewable Energy Investment

Around 99% of the total energy consumption in Iran is based on fossil fuel [72], therefore, contribution of renewable energies in Iran is crucial for achieving sustainability [73]. Studies on renewable energy in Iran shows that some cities have high potential in investment on renewable energy sector. For example, Razmjoo et al. (2019) realized that investments on renewable energy sector including wind and solar is economically justified [74]. Moreover, Razmjoo et al. (2021) found that renewable energy investment has three potential benefits in Iran including CO_2 reduction, greater sustainable electricity generation, and economically justified investment in the renewable energy [75].

This policy is based on redirecting income from the fossil-fuel industry to renewable energy investment. Its aim is to provide revenue for clean energy investment to reduce CO_2 emissions and the ecological footprint. Therefore, in this model, the revenue from exporting fossil fuels (including oil and gas) to other countries is redirected to renewable energy investment. In the Steady State Economy scenario, 10% of revenue of fossil-fuel exports in 2020 has been redirected to renewable energy investment, increasing to 60% in 2050. In the Well-being for People and Planet scenario, 10% of fossil-fuel revenues in 2020 have been redirected to renewable energy investment, rising to 90% in 2050. Table 10 shows percentage of income redirected from fossil fuel industry to renewable energy investment.

6. SDGs Indexes in Iran

6.1. Index of SDG-1

Figure 6 demonstrates that in 2020, 7 million people are living below \$5.50 a day. In the Business as Usual and Steady State Economy scenarios, poverty increases rapidly from 7 million in 2020 to 10 million and 13 million people in 2050. In the Inclusive Growth scenario, and Well-being for People and Planet Scenario the number of people living below \$5.50 per day declines to 4 million in 2050. It can be concluded that in the Scenario of Business as Usual and Steady State Economy, poverty is increasing rapidly. In the Inclusive Growth and Well-being for People and Planet scenarios, poverty has declined rapidly. Therefore, Inclusive Growth and Well-being for People and Planet provide better pathway for reducing poverty.

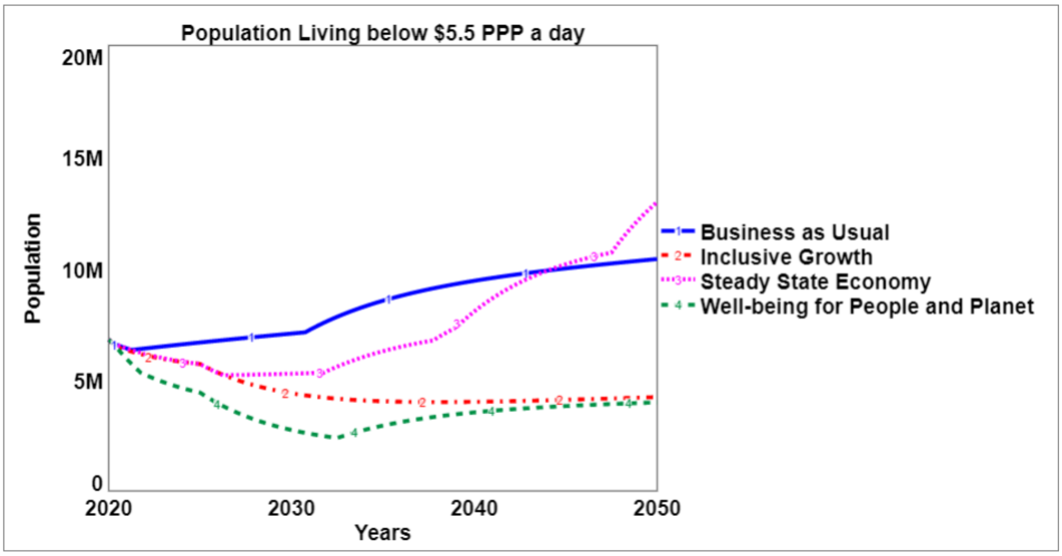

Figure 6. Population of people living below $5.50 a day.

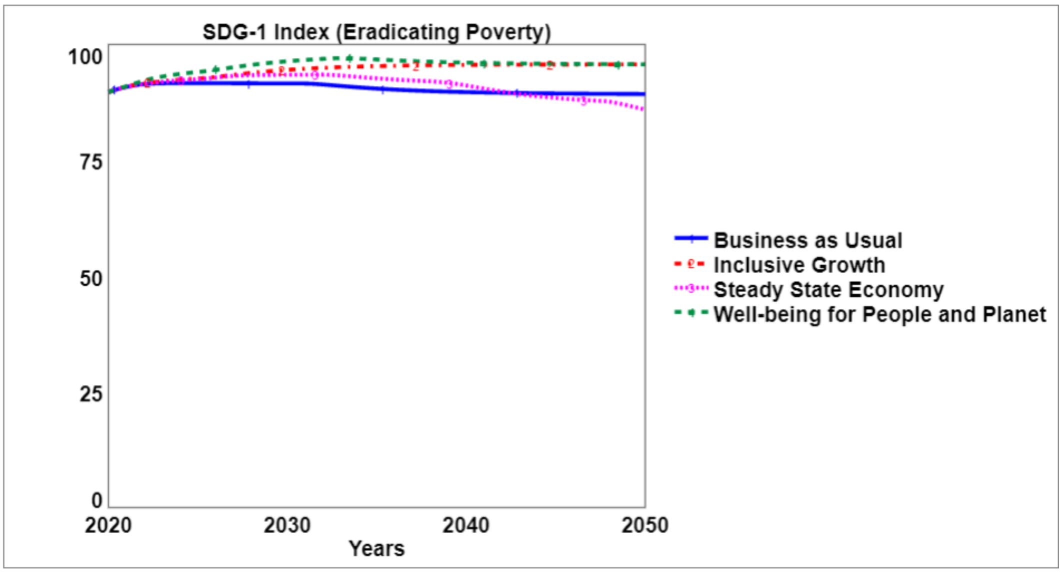

Figure 7. Implementation of SDG-1 in the four scenarios in Iran in the period 2020 to 2050.

Figure 7 compares the implementation of SDG-1 in the four scenarios. To interpret SDG-1, it is crucial to consider that if SDG-1 achieves 100, this means that the goal has been met, and if it is decreasing toward zero, it is getting worse.

In 2020, all the scenarios start at a level of 90 (out of 100). The trend while implementing SDG-1 in different scenarios gives different results. However, none of these scenarios lead Iran to achieve SDG-1 by 2050. The Well-being for People and Planet scenario gives the best results in achieving SDG-1 followed by the Inclusive Growth scenario. The worst scenario for SDG-1 are the Steady State Economy and Business as Usual.

Based on Business as Usual, in 2020 Iran's SDG-1 index is 90, which decreases to 89 in 2050. Therefore, Business as Usual does not illustrate progress in achieving SDG-1. Inclusive Growth, which considers redistribution policies, has better results in reducing poverty. Based on the simulation, SDG-1 achieves a level of 96 in 2050, which is better than the result of Business as Usual. The Steady State Economy demonstrates that SDG-1 declines to 86 in 2050. Based on the Well-being for People and Planet scenario, achieving SDG-1 has been the most successful among all the scenarios. Based on this scenario, SDG-1 achieves a level of 96 in 2050. This improvement in declining in poverty in the scenario of Well-being for People and Planet and Inclusive Growth is because of income redistribution policies and rise in GDP.

6.2. Index of SDG-8

In the Business-as-Usual scenario, GDP increases from 6 thousand trillion rials in 2020 to 9.7 thousand trillion rials in 2050. In the Inclusive Growth scenario, which is based on a higher GDP growth rate, GDP has jumped to 15.9 thousand trillion rials; while in the Steady State Economy scenario, which is based on a zero GDP growth rate, GDP remains at 6.7 thousand trillion rials from 2025 to 2050 [76]. In the Well-being for People and Planet scenario, it rises to 10.9 thousand trillion rials in 2050. This trend is illustrated in Figure 8(A).

Income inequality has different trends in each of these scenarios (see 8(B)). In the Business-as-Usual scenario, the Gini coefficient is around 0.4 and remains constant, because it continues the same shares of income among people. In the Inclusive Growth scenario, which is based on the tax and transfers system, the Gini coefficient has decreased from 0.4 in 2020 to 0.31 in 2050. In the Steady State Economy scenario, it has decreased to 0.32 in 2050. In the Well-being for People and Planet scenario, the Gini coefficient has been reduced to 0.21 in 2050.

Figure 8(C) illustrates the total unemployment rate in the four scenarios of the model. The unemployment rate is highest in the Business-as-Usual scenario: it rises from 10% in 2020 to 36% in 2050. The Inclusive Growth scenario is based on higher GDP growth; the unemployment rate decreases to reach 4% in 2050. In the Steady State Economy, the unemployment rate declines to 6% in 2030, and then it increases to 31% in 2050. In the Well-being for People and Planet, the unemployment rate is constantly increasing to reach 22%.

In this model, population of child work is dependent on the population growth. Therefore, in the Business-as-Usual scenario, the population of children rises from 1.16 million in 2020 to 1.21 million in 2050 (see Figure 8(D)). In the Inclusive Growth scenario, the population of children working rises to 1.22 million in 2050. In the Steady State Economy scenario, the population of children working declines to 945,000 in 2050, which is because of a decline in the population. In the Well-being for People and Planet scenario, the number of children in work declines to 1.08 million in 2050.

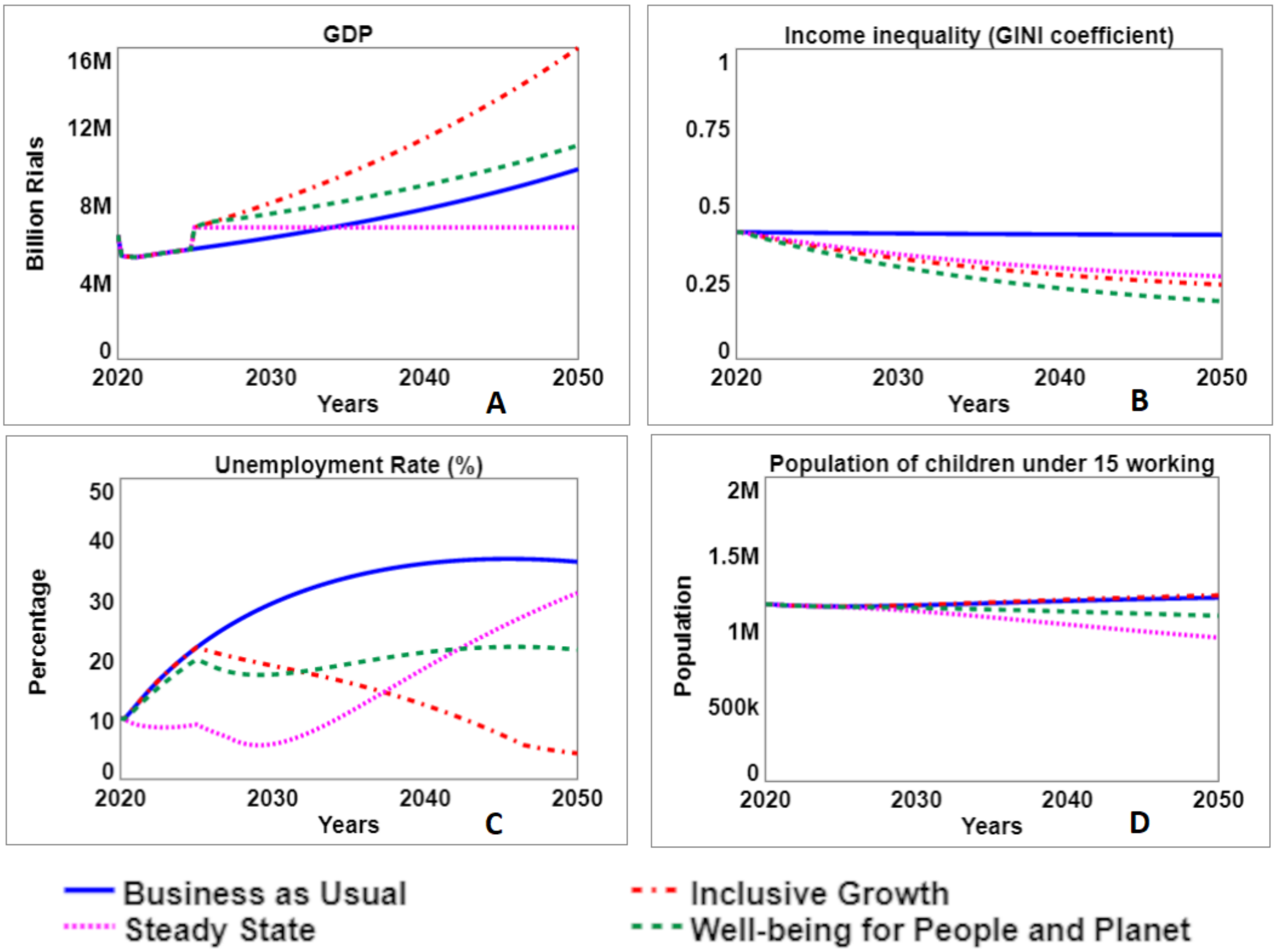

Figure 8. Indicators of SDG-8 in the model.

SDG-8 index in Figure 9 compares the progress of implementation of SDG-8 in the four scenarios. None of them achieve 100% of the goal of SDG-8. It is an interesting result that Business as Usual does not provide good progress in achieving SDG-8. In Business as Usual scenario, SDG-8 decreased gradually from around 49 in 2020 to 47 in 2050. However, in the Inclusive Growth scenario, SDG-8 increases from 49 in 2020 to 64 in 2050. Based on the Steady State Economy scenario, SDG-8 will slightly increase from 49 in 2020 to 60 in 2050. In the Well-being for People and Planet scenario, SDG-8 achieves its highest level among all the scenarios. It rapidly increases from 49 in 2020 to 63 in 2050.

6.3. Index of SDG-12

Steady State Economy and Well-being for People and Planet scenarios redirect fossil-fuel income to renewable energy investment (see Figure 10A)). Therefore, in the Steady State Economy, renewable energy investment reaches 6% of GDP in 2050. In the Well-being for People and Planet scenario, renewable energy investment increased to 10% of total GDP in 2050. Therefore, the scenario of Well-being for People and Planet almost achieves the target of SDG-12.2.

In the Business as Usual and Inclusive Growth scenarios, the ecological footprint per capita increases from 3.1 in 2020 to 4 and 4.5 respectively in 2050 (see Figure 10(B)). The Steady State Economy scenario has a lower ecological footprint which it reaches to 3.4 in 2050. In the Well-being for People and Planet scenario; it increases to 3.8 in 2050. Steady State Economy scenario has lowest ecological footprint in 2050.

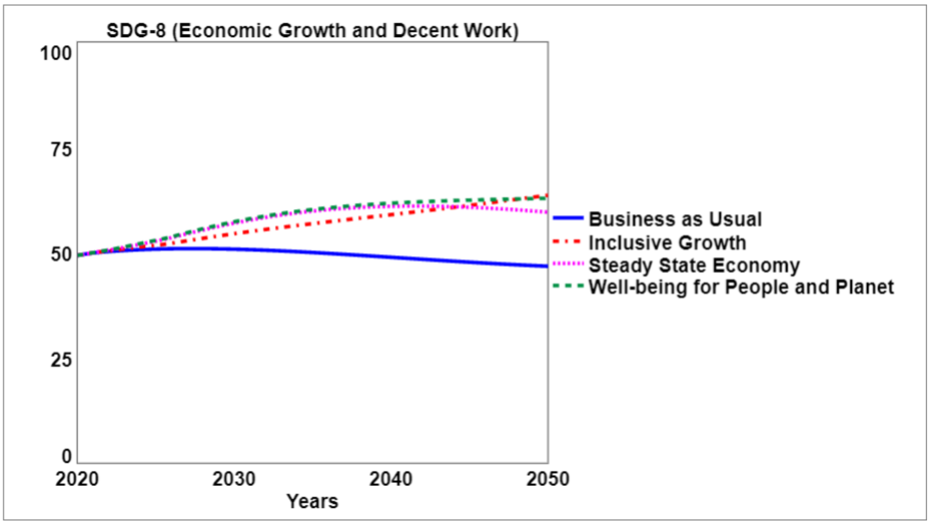

Figure 9. Implementation of SDG-8 in the four scenarios in Iran in the period 2020 to 2050.

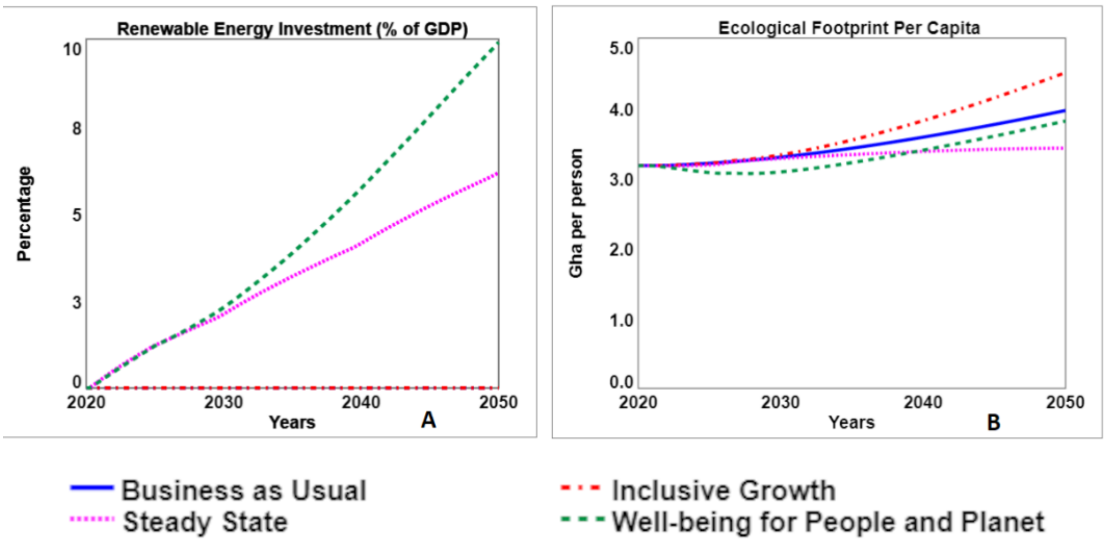

Figure 10. Renewable energy investment within GDP and ecological footprint per capita.

Figure 11 illustrates the implementation of SDG-12 in four scenarios. The SDG-12 index decreases in the conventional scenarios of Business as Usual and Inclusive Growth from 41 in 2020 to 38 and 36 respectively in 2050. However, the transformational scenarios of Steady State and Well-being for People and Planet show rapid improvement in achieving SDG-12 by 2050. In the Steady State Economy scenario, the SDG-12 index jumped to 71 in 2050 and in the Well-being for People and Planet scenario it increased to 88.

6.4. Index of SDG-13

In the Business as Usual and Inclusive Growth scenarios, CO_2 emissions per capita increase rapidly from 9.2 metric tonnes per capita in 2020 to 15.4 and 20.77 metric tonnes per capita in 2050 respectively (see Figure 12). However, in the Steady State Economy, where environmental policy changes have been considered, CO_2 emissions per capita have slightly increased to 9.8 in 2050 (see Figure 12). The Well-being for People and Planet scenario, in which more extraordinary environmental policies has been considered, performs the best among all scenarios in reducing CO_2 emissions per capita; they gradually decrease to 3.2 in 2050. The reason that CO_2 emissions in the scenario of Steady State Economy did not decline as much as the scenario of Well-being for People and Planet is that price elasticity on carbon tax is lower in the scenario of Steady State Economy.

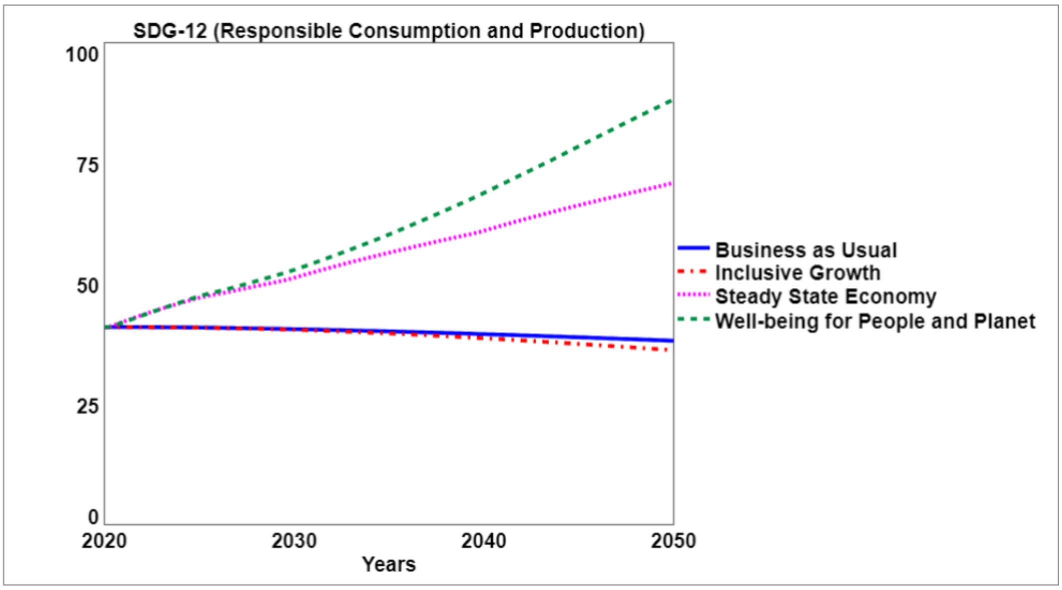

Figure 11. Implementation of SDG-12 in the four scenarios in Iran in the period 2020 to 2050.

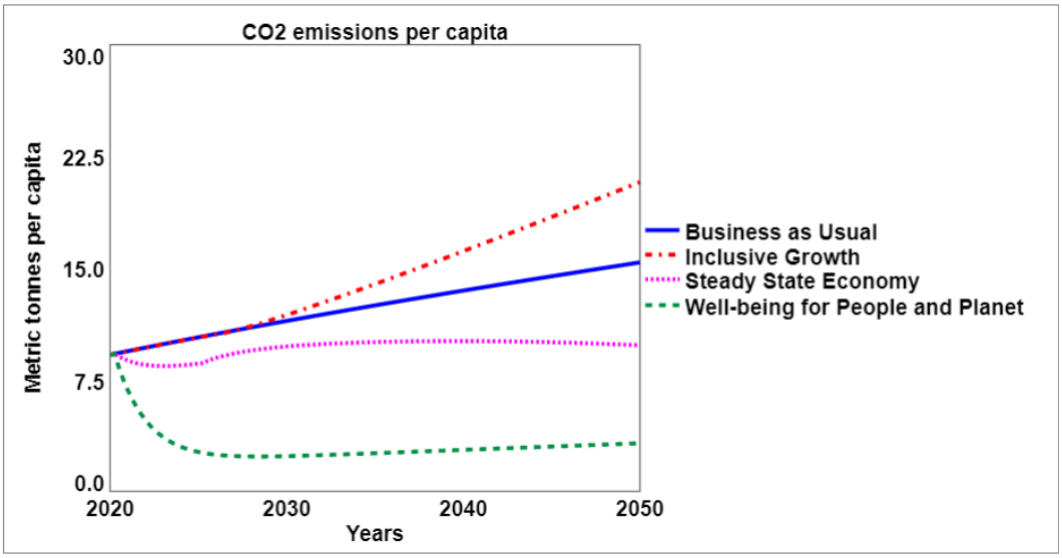

Figure 12. CO_2 emissions per capita in the four scenarios.

Figure 13 compares the achievement of SDG-13 in the four scenarios. In the Business as Usual and Inclusive Growth scenarios, the SDG-13 index decreases from around 76 in 2020 to 59 and 45 in 2050, respectively. In the Steady State Economy scenario, it slightly decreases from 76 in 2020 to 74 in 2050. Also, in scenario of Well-being for People and Planet, the index achieves 91 in 2050, which is a huge success in comparison with other scenarios. Therefore, in comparison to other scenarios, Well-being for People and Planet scenario provides the best results in achieving SDG-13.

6.5. Combined Index of SDGs

The combined SDGs index illustrates that, on average, achievement of the four goals of the SDGs in the Business as Usual and Inclusive Growth scenarios worsens in the period 2020 to 2050 (see Figure 14). On the other hand, the Steady State Economy and Well-being for People and Planet scenarios show improvement in achieving these four goals of the SDGs by 2050. Among all the scenarios, scenario of Well-being for People and Planet provides better pathway for achieving these selected four goals of SDGs. The result illustrates that the *conventional* scenarios are not appropriate for achieving the combined index of the four SDGs, while the *transformational* scenarios show improvement in doing so.

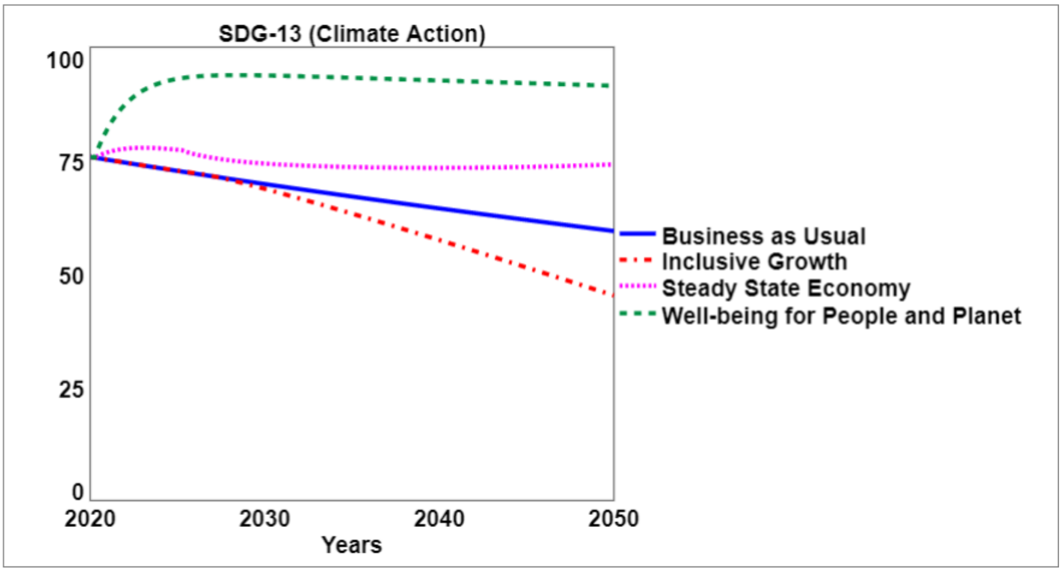

Figure 13. Implementation of SDG-13 in the four scenarios in Iran in the period 2020 to 2050.

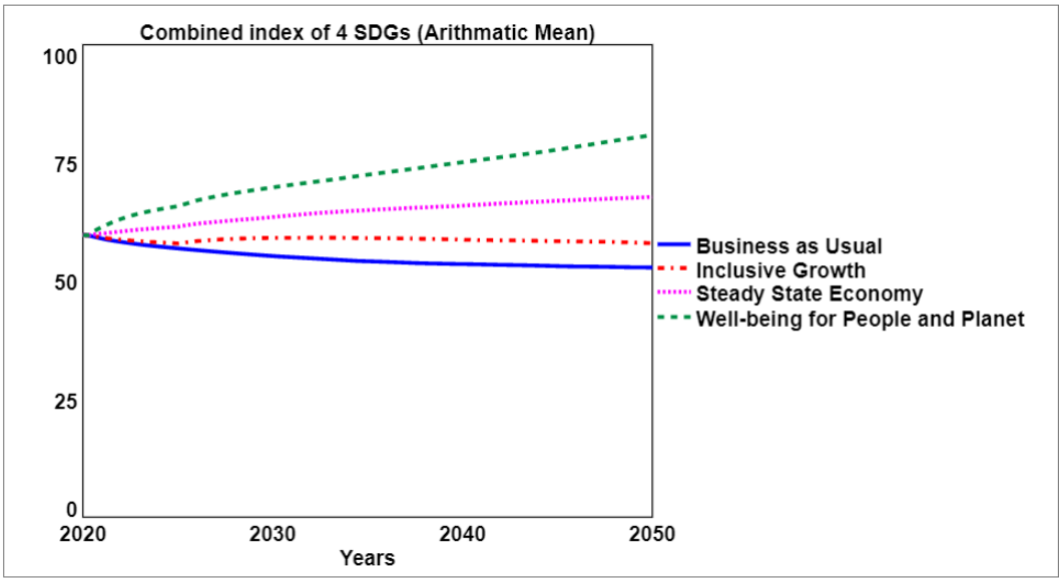

Figure 14. Combined index of SDGs in the four scenarios in Iran in the period 2020 to 2050.

7. Limitations of the Model

This model faces some limitations that are outside the control of the researcher. These limitations of the model are explained in the following to help further research in this field.

This model simulates implementation of four goals of the SDGs; however, it could be more interesting to consider a greater number of goals of the SDGs. However, considering a greater number of goals means considering a greater number of variables in the model, which would make the model more complex. As Barlas (2007) says: "As the number of variables increases, the complexity of the problem increases nonlinearly." Therefore, this model has considered four goals to eliminate any unnecessary complexity of the model.

In this model, four goals of the SDGs have been calculated by different indicators which have different units. Therefore, it is required to normalize the indicators of SDGs to a range of 0 to 100. To normalize the indicators, defining the minimum and maximum values of indicators is critical, because the result of the normalized index can be changed based on the levels of the minimum and maximum of the indicator.

In this study, to create a big picture of how well Iran is doing in achieving the SDGs, all four indexes of the SDGs have been combined to achieve a single number. Combining indexes to achieve a single number is a common approach in economics. This number illustrates the average of progress of four implemented goals of the SDGs. The advantage of combined index is analysing the big picture of achieving four goals. However, the disadvantage of is that it does not illustrate the progress or weaknesses in each of these SDGs separately.

8. Discussions and Conclusion

Currently, we are facing with series of crises such as climate change, inequalities, and economic issues which facing them needs a systemic plan. SDGs consist of different economic, social, and environmental dimensions that makes them important development agenda for achieving human and ecological well-being. Implementing these ambitious goals is one of the challenges for countries, especially developing countries with lack of financial resources, and infrastructure. This research develops a systems dynamics model of SDGs to analyse their implementation under four scenarios: Business as Usual, Inclusive Growth, Steady State, and Well-being for People and Planet for the period of 2020 to 2050.

The scenario of Business as Usual continues historical trends, therefore, there are no policy changes considered in this scenario. The results of implementing SDGs through this scenario in the model illustrates that all four SDGs are declining. Moreover, the combined index of SDGs is declining in the scenario of Business as Usual. Therefore, scenario of Business as Usual is not appropriate for achieving SDGs in Iran. This result is in line with the OECD (2020) which emphasizes that for meeting the needs of today's world, "Business as Usual" is not a solution [77].

The scenario of Inclusive Growth is mainly based on policies about the acceleration of economic growth and increasing income equality. The results of the scenario of Inclusive Growth illustrate improvements in achieving SDG-1 and SDG-8 in comparison to the base year of 2020, however, SDG-12, and SDG-13 are declining. In the scenario of Inclusive Growth, SDG-1 has increased from 2020 to 2050. Additionally, value of SDG-1 in the scenario of Inclusive Growth is higher than scenario of Business as Usual. In the scenario of Inclusive Growth, because of considering income redistribution policies and faster economic growth, SDG-8 index is improved in comparison to the Business-as-Usual scenario. On the other hand, in the scenario of Inclusive Growth, SDG-12 and SDG-13 are declining from 2020 to 2050. In the scenario of Inclusive Growth, the combined index of SDGs declines in comparison with the base year of 2020. Therefore, it shows that the Scenario of Inclusive Growth does not provide a proper pathway for achieving SDGs.

Many studies have been done on the role of alternative agendas (e.g. Steady State Economy) for achieving sustainability in Global North, however, there is few studies which analyzed the role of alternative agendas in Global South. Therefore, this paper contributes to the literature by assessing the role of *transformational* scenarios (Steady State Economy Scenario, and Well-being for People and Planet Scenario) in Iran as Global South country. The result of the model illustrates that *transformational* scenarios provide better pathway for achieving SDGs in Iran.

The scenario of Steady State Economy assesses the role of managing economic growth on transitioning toward an economy based on human and ecological well-being. This scenario contributes to the discourse on a steady state economy in Iran. Steady State Economy Scenario is mainly based on managing GDP growth, while considering some socio-economic and environmental policies to improve human and ecological well-being. The results of the scenario of Steady State Economy shows that SDG-8, and SDG-12 has improved from 2020 to 2050. In this scenario, the value of the SDG-1 and SDG-13 slightly declines. In the scenario of Steady State Economy, combined index of SDGs has improved in the period of 2020 to 2050.

The scenario of Well-being for People and Planet is designed in a way that promotes human and ecological well-being and makes a better contribution in achieving SDGs. This scenario is based on extreme policy changes and therefore, extraordinary efforts are needed to implement them. The results of this scenario contribute to analyzing transformational policy changes for achieving SDGs and improving human and ecological well-being in Iran. In the scenario of Well-being for People and Planet, SDG-1, SDG-8, SDG-12, and SDG-13 indexes are improving from 2020 to 2050. The results show that the combined index of SDGs in the scenario of Well-being for People and Planet provides a better pathway in comparison to the other scenarios.

To conclude, SDGs are ambitious goals and, therefore, achieving them by 2050 let alone by 2030 is very difficult, especially in developing countries. This has become even more challenging because of the COVID-19 pandemic which has been particularly hard on developing countries [78]. Because of the COVID-19 pandemic, middle- and low-income economies will suffer from a more serious lack of international funds for achieving the SDGs [79] than when they were first adopted. It remains to be seen whether developed countries will provide them.

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