Original Research

Providing a System Dynamic Model to Predict Construction Status in Iran Using Sustainable Development Indicators

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Received: 2021-05-01 / Accepted: 2021-09-27/ Published online: 2021-11-04

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Abstract
In this paper, a system dynamic model (SDM) has been created to predict the construction status in Iran using sustainable development indicators (SDI). The aim is to create a model based on system dynamics that would understand the complexities of the sustainable development system, as well as predict the values of variables and indicators used in the model for years to come. Since sustainable development involves various economic, social, and environmental aspects, the model has been formulated Using ten-year available data in these areas. After that, the output results of the model have been validated with reference patterns, and then, various scenarios have been created for sensitivity analysis. Finally, based on this model, the construction status in the Next years has become predictable. According to the results of this study, there is a direct and significant relationship between the amount of construction and other indicators of sustainable development, such as the share of women working in the non-agricultural sector and the literacy rate of men aged 15-24.

Keywords - Construction; Causal Loops; Sustainable Development; System Dynamics

INTRODUCTION

Sustainability is commonly developed with three dimensions: economic, environmental, and social impacts (Shen, Tam, Chan, & Kong, 2002; Ugwu, Kumaraswamy, Wong, & Ng, 2006). First, sustainable development needs to be economically viable and minimize costs and maximize profit on construction projects. Second, sustainable development should have a positive and prolonged impact on the environment. The emergence of numerous management methods to educate construction partners on maximizing sustainable efficiency throughout a project life cycle has been prompted by an increasing understanding of environmental impacts. (Lingard, Graham, & Smithers, 2000; Shen & Tam, 2002). Sustainable peace study emphasizes proactive conflict mediation, while conventional sustainability science emphasizes social and economic growth and environmental stewardship. Despite their divergent foci, the two philosophical concepts have the same overarching central concern of advancing society and human well-being now and in the future. Environmental protection, ecosystem functioning, economic development, and peace and conflict management are necessary components of sustainability because they drive human well-being. To advance sustainability, we need advice on which improvements to the socio-ecological order to encourage, which types of destruction to avoid, and how to organize our social structures to be resilient and versatile enough to allow sustainable change (Blanc, 2015). Unfortunately, owing to the complexities of social-ecological processes, solutions to these issues remain elusive. We have only a rudimentary understanding of how the drivers of any sub-component of sustainability (peace, ecological structure, and economic development) work. We also recognize that these sub-components are intertwined in processes so that protecting the environment influences development, and access to natural resources influences the possibility of conflict. (Balint, Stewart, Desai, & Walters, 2011), However, we don't have a good understanding of how these interaction mechanisms work within frameworks. This is exemplified by the lack of societal and scientific agreement about whether and to what level climate change is caused by humans and what can be done to stop or reduce it. (Nordås & Gleditsch, 2007; Ozawa, 2006). Because of the confusion created by social-ecological complexity, as well as the absence of consensus, any recommendation or possible course of action is highly challenging. As a result, we need theoretical models that can deal with the social-ecological world complexities, as well as methods and resources to deal with the contradictions that emerge from ambiguity and complexity.

Over the last few decades, the field of complex systems has gained traction as an alternative, or even a supplement, to conventional science approaches with clear consequences for sustainability (Djuric & Filipovic, 2015). Due to this, a complex system can be described as a collection of elements that engage in linear and non-linear feedback processes over time and space. Emergent properties and dynamics arise due to these interactions, which influence the components and their interactions. (Nowak, Bui-Wrzosinska, Vallacher, & Coleman, 2012). Multiple facets of the physical and social environment have been analyzed using dynamic systems methods. Parallel to this, two sub-disciplines have arisen that are especially useful for the discussion of sustainability. The stability or coupled systems method, as well as dynamical systems theory (DST), are two of them. (P. Coleman, Vallacher, Nowak, & Bui-Wrzosinska, 2007; P. T. Coleman, Vallacher, Bartoli, Nowak, & Bui-Wrzosinska, 2011). Although both sub-disciplines are complementary, they have yet to be combined. A combination of the two, on the other hand, could provide a helpful context for understanding sustainability at the intersection of conflict, climate, and development. Environmental and energy issues have become so important in the last century that many researchers have worked on them (Arroyo M. & Miguel, 2020; Gu et al., 2020).

Literature Review

So far, sustainable development has been studied from the perspective of various stakeholders (Tangestani, Feizi, Bamdad Soufi, Tangestani, & Khatami Firouzabadi, 2020). The importance of sustainability in small businesses (Ukko, Saunila, Nasiri, & Rantala, 2021), Strengthen sustainable development in the education sector (Brechin, de Aguiar Dutra, & Guerra, 2021), managing sustainability in the automotive industry (Jasiński, Meredith, & Kirwan, 2021) and, Different theories in the field of resources (Corvellec et al., 2021), are among the most recent topics covered. Also, today, different modeling methods have been used in other parts of various industries (Dahia, Bellaouar, & Dron, 2021; Harati, Roghanian, Hafezalkotob, & Shojaie, 2021; Owlia, Roshani, & Abooei, 2020; Pradenas, Bravo, & Linfati, 2020). System dynamics is a good tool for investigating natural issues (Sokame et al., 2021; Sy et al., 2021). Different methods and strategies have been obtained using system dynamics (Gravelsins et al., 2018; Torres, Kunc, & O'Brien, 2017). The word of Sustainable development has different definitions and its concept is so challengeable. (Hopwood, Mellor, & O'Brien, 2005; Rassafi, Poorzahedy, & Vaziri, 2006; Redclift, 2005; Springett, 2005; Williams & Dair, 2007; Yanarella & Bartilow, 2000). Sustainability is also a concept related to dynamic systems which is a method to know relations between development and environment. (Fisher & Rucki, 2016). But in fact, all the meanings of sustainable development are focused on saving the earth. The result of the World Commission on Environment and Development in 1987 (Wced, 1987) shows that sustainable development must consider the world's poor people's expectations to live in a relatively comfortable manner. it must also consider current and future demands. WCED determines that sustainability is directly related to the society, environment, and the economy (Hall & Purchase, 2006).

All imagination must conclude creating welfare (Pearce, 2003, 2006). Not only individual ownership is a necessary component of welfare but also societal welfare is critical for sustainable development. Also benefit for the public good is a benefit for each member of society, so environmental issues arise from the policy choices (Dobson, 2007). As a result, it is obvious that the industries that contribute to development, such as transportation and construction, have an enormous capacity for achieving a sustainable future.

Sustainability has very feedback to all aspects of infrastructural development. Although very technological challenges are solved by human action using fossil fuels and processed resources, they are also regarded as a potential challenge to sustainability (Redclift, 2005). The construction industry is vital to people life's qualitative because it can facilitate their life economically and socially significant (Burgan & Sansom, 2006). Now, the environment has a lot of challenges consisting of social, and economic challenges. Construction produces greenhouse gas because of the energy used in crude material processing, distribution, construction, service, repair, and destruction. (Rwelamila, Talukhaba, & Ngowi, 2000; Sorrell, 2003). The construction business consumes the most oil and energy, and buildings need about half of all crude material consumption (Edwards & Hyett, 2005). An agreement, signed in 1997, wants developed countries to decrease greenhouse gas emissions during 4 years. Although most evidence shows the developing countries have a role in it, researchers agree that the effects are greater in emerging countries. (Industry, 2003).

Opposite to other sectors, the construction industry is unique in that it is long-term. An applied system has been used for how the Construction business works to the development (Sev, 2009). In developed countries, buildings have a long-life cycle time. structures, bridges, and other infrastructure dating back hundreds of years can be seen in many countries. This proves that construction would have a long-term impact on the structure's environmental efficiency. It is critical to implement sustainability concepts from the start of a project to achieve a more efficient, low-side effect framework. The energy sector and related policies in the construction industry and sustainable development have always been of interest (Laimon, Mai, Goh, & Yusaf, 2020; Mutingi, Mbohwa, & Kommula, 2017).

Although old methods focus on Money, functionality, and features, sustainability often considers resource conservation, less environmental destruction, the development of a safely built surround, and more well-being. Architectures and civil engineers must think of a project's whole life cycle, not just the basic fund.

Extra strain is being applied by common and political developments for all the more ecologically cognizant specialized arrangements. Organizations and offices currently understand that approaches like powerful waste and stock control, solid cycle and item plan, asset preservation, and reusing can be beneficial and naturally best. Moreover, new laws and orders are pushing organizations to control their natural expenses and contemplations better. Organizations should likewise carry out environmental checking and consistency cycles to conform to global necessities (Owens & Cowell, 2002).

Recently, a novel paradigm for transformational sustainable development was created that addresses the economic system's impacts on the industry while maintaining social and ecological embeddedness. (Trollman & Colwill, 2021). The problems faced by the Sustainable Development Goals for business players are addressed, both in terms of the opportunities for more sustainable and ethical activities and the limits to reform. (Scheyvens, Banks, & Hughes, 2016). Also, findings reveal a positive monotonic relationship between development and pollution (Fotis & Polemis, 2018). A study has been undertaken to look at the most relevant environmental features and how they impact the life-cycle costs of green buildings. (Weerasinghe & Ramachandra, 2020). Today, renewable and sustainable energy are opposed to fossil fuels (Hidayatno, Dhamayanti, & Destyanto, 2019; Saavedra M, de O. Fontes, & M. Freire's, 2018).

In conclusion, after reviewing the studies and opinions of thinkers, it can be concluded that the relationship between different dimensions of sustainable development and Construction is multilateral and complex in various economic, social, and environmental fields. Therefore, it is evident that the amount of construction and people's action in obtaining building permits will be affected by other social, economic and, environmental parameters, something that has been less focused on it so far.

METHODOLOGY

This research has presented an SDM (system dynamic model) based on mathematical relations to study and predict the construction status in Iran using SDI (sustainable development indicators). SDM helps the analyst a lot because it is quantitative, and this is something that many other modeling methods lack (Ebrahimi & Pilevari, 2021). The number of Building Permits issued in a year is a criterion for the amount of Construction. This variable called Construction is used in the model.

In designing dynamic models, the relationship between variables is necessarily obtained from several sources that are operating in almost all sciences. These sources include surveys (interviews), expert opinions, subject literature, direct observation, and databases (Charkhchi, Toloi, & alborzi, 2019). Therefore, the design of the system dynamic model of this research has been done with the help of the mentioned cases and a kind of expert judgment. The method of adding variables and problem details, both given the above and during the validation of the model structure, has been proposed. The research method and modeling steps are shown in the flowchart in Figure 1.

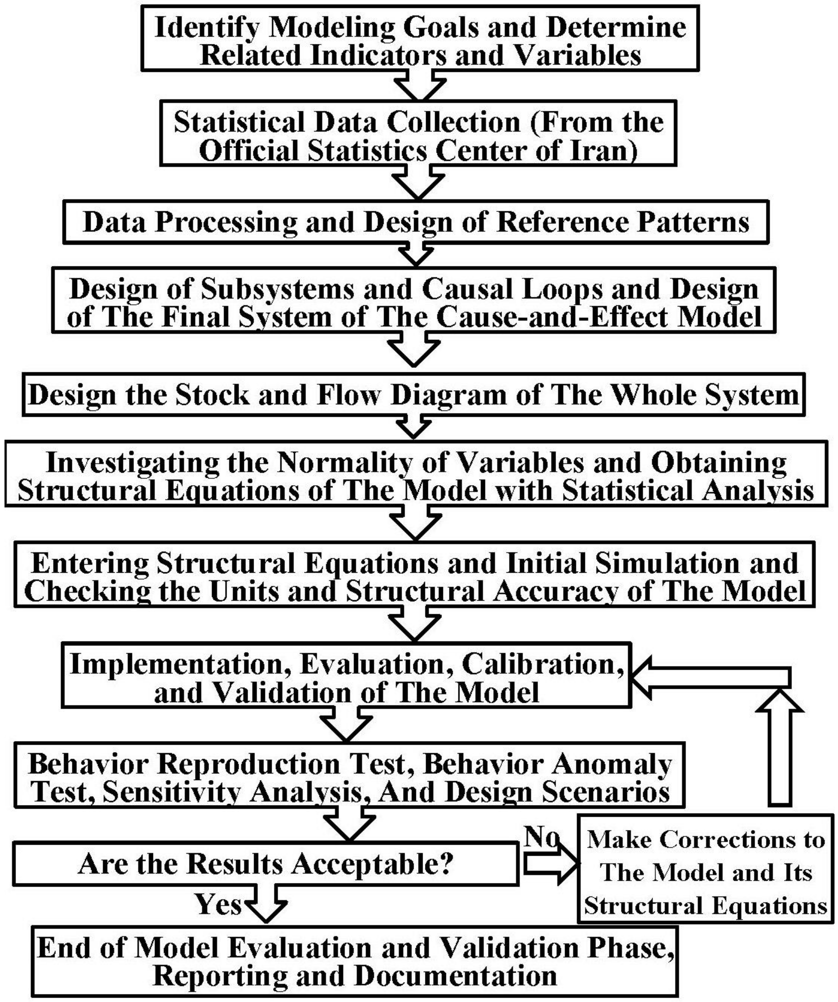

FIGURE 1
FLOWCHART OF RESEARCH METHOD

IDENTIFY MODELING GOALS AND DETERMINE RELATED INDICATORS AND VARIABLES AND COLLECT DATA.

The data based on the model of this research is related to ten years, so this model is designed to explain the behavior of variables in the model during these ten years. Also, it can predict the behavior of the variables in the model and especially the behavior of the variable amount of annual construction during about ten years after that. In total, the mentioned 20 years are considered as the modeling time horizon.

Table 1 lists the variables that were used in this study. Although some other documents, such as the 2030 Agenda, have proposed several different indicators for sustainable development, due to some political challenges in Iran, the data of the 2030 Agenda indicators have not been collected by official and reputable centers and are not available. Therefore, the data related to the years 2005-2014 have been considered for the indicators of the objectives of the Millennium Development Goals (MDG), which are the variables of this research (Palmer, 2015; Sachs, 2012). Ten-year data of these variables have been collected from the Statistics Center of Iran, an official government center (Iran, 2014). To facilitate the research and modeling process, these variables are named with the symbols in the "Index" column in Table 1.

TABLE 1
THE VARIABLES USED, INDICATORS OF THE MILLENNIUM DEVELOPMENT GOALS OF THE ISLAMIC REPUBLIC OF IRAN (2005-2014) (MDG)

Index	Indicators	Goals
MDG11	The Proportion of population below $1 (PPP) per day	Goal 1: Eradicate hunger and extreme poverty
MDG12	The Ratio of population below $2 (PPP) per day	
MDG13	Poverty gap ratio (based on $1)	
MDG14	Poverty gap ratio (based on $2)	
MDG15	Share of poorest quintile in national consumption	
MDG16	Frequency of underweight children under five years of age	
MDG17	The Proportion of population below minimum level of dietary energy consumption	
MDG21	Net enrolment ratio in primary education	Goal 2: Achieve universal primary education
MDG22	Literacy rate of 15–24-year-olds (Men)	
MDG23	Literacy rate of 15–24-year-olds (Woman)	
MDG24	The Proportion of pupils starting grade 1 who reach grade 5	
MDG31	The Ratio of girls to boys in primary education	Goal 3: Promote gender equality and empower women
MDG32	The Ratio of girls to boys in secondary education	
MDG33	The Ratio of girls to boys in tertiary education	
MDG34	The Ratio of literate women to men, 15-24 years old	
MDG35	The Ratio of seats held by women in national parliament	
MDG36	Share of women in wage employment in the non-agricultural sector	
MDG41	Under-five mortality rate	Goal 4: Reduce child mortality
MDG42	Infant mortality rate	
MDG43	The Ratio of 1-year-old children immunized against measles	
MDG51	Maternal mortality ratio	Goal 5: Improve maternal HEALTH
MDG52	Fertility Rate, 15-19 years old	
MDG53	The Proportion of births attended by skilled health personnel	
MDG61	Condom use rate of the contraceptive prevalence rate	Goal 6: Combat HIV/AIDS, malaria, and other diseases
MDG62	The Proportion of population in malaria-risk areas using effective malaria prevention and treatment measures	
MDG63	Prevalence rates associated with malaria	
MDG64	The Proportion of tuberculosis cases detected and cured under DOTS (internationally recommended TB control strategy)	
MDG65	Death rates associated with malaria	
MDG66	Prevalence rates associated with tuberculosis	
MDG67	Death rates associated with tuberculosis	
MDG68	HIV prevalence among pregnant women aged 15-24 years	
MDG69	The Proportion of school attendance of orphans to school attendance of non-orphans aged 10-14 years	
MDG610	Contraceptive prevalence rate, 15–24-year-olds (Woman)	
MDG611	Percentage of population aged 15-24 years with comprehensive correct knowledge of HIV/AIDS	
MDG612	Condom use at last high-risk sex	
MDG71	The Proportion of land area covered by forest	Goal 7: Ensure environmental sustainability
MDG72	The Ratio of area protected to maintain biological diversity to The surface area	
MDG73	consumption of ozone-depleting CFCs (ODP tons)	
MDG74	The Proportion of The population with sustainable access to an improved water source, urban and rural	
MDG75	The Ratio of The population with access to improved sanitation, urban and rural	
MDG76	Energy consumption (kg oil equivalent) per $1,000 GDP (PPP)	
MDG77	Carbon dioxide emissions per capita (UNFCCC, UNSD)	
MDG78	The Proportion of The population using solid fuels (Urban)	
MDG79	The Proportion of households with access to secure tenure	
MDG710	The Proportion of The population using solid fuels (Rural)	
MDG81	The Unemployment rate of young people aged 15-24 years, each sex, and total	Goal 8: Develop a global partnership for The development
MDG82	The Proportion of The population with access to affordable essential drugs on a sustainable basis	
MDG83	Telephone lines per 100 population	
MDG84	Cellular subscribers per 100 population	
MDG85	Debt sector as a proportion of goods and service exports	
MDG86	Internet users per 100 population	
MDG87	Personal computers in use per 100 population	
Construction	Variable of the number of building permits issued that indicates the amount of annual Construction	
Time	Variable related to time (year of data collection of variables)	

PREPARE, REVIEW, AND CONSIDER REFERENCE PATTERNS

According to the ten-year data related to the variables in Table 1, reference diagrams are obtained. The reference diagrams as a model behavioral pattern, on the one hand, help to validate the model and, on the other hand, by recognizing the behavioral pattern of essential variables and some stock variables in the process of modeling and selection of variables are so helpful. These Patterns are introduced during the modeling and validation steps. For example, the reference diagram for the construction variable, which indicates the number of building permits issued per year and is the primary variable of this model, is shown in Figure 2. According to this chart, 147096 building permits were issued in 2005, which is an indicator for Construction in this year; this number in 2014 has been reached 181000.

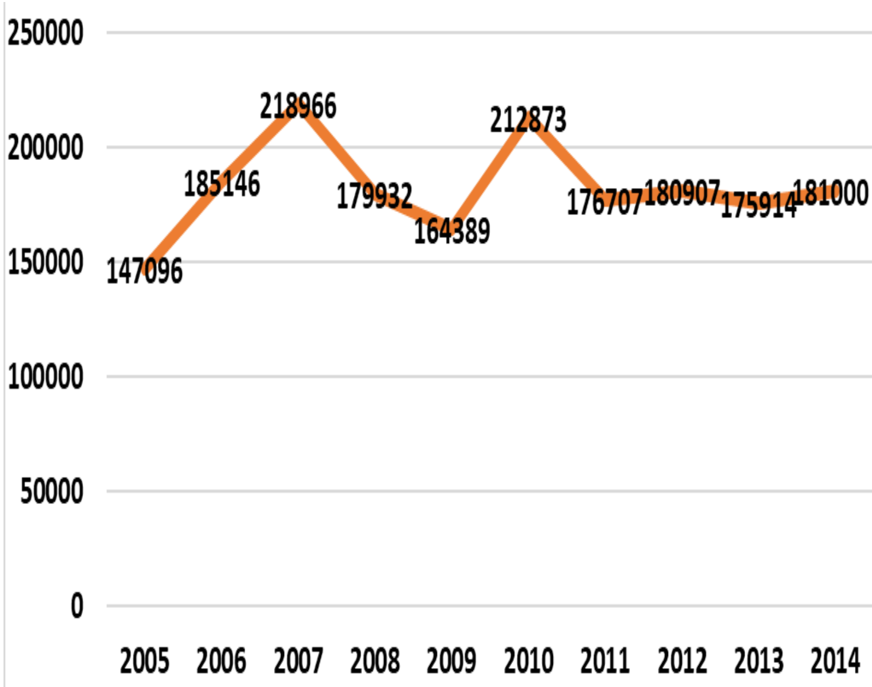

FIGURE 2
NUMBER OF BUILDING PERMITS ISSUED EACH YEAR

DESIGN OF SUBSYSTEMS AND CAUSAL LOOPS AND DESIGN OF THE FINAL SYSTEM OF THE CAUSE-AND-EFFECT MODEL

The logical relationship between the variables based on their effect on each other, and the extent to which the variables are used to define other variables as a tree structure, is shown in Figure 3. This series of connections form the cause-and-effect model subsystems. Based on this figure, a logical cause-and-effect relationship can be considered between the two variables with an apparent relationship. For example, the variable of the number of building permits issued per year, which is considered as an indicator of the amount of Construction (Construction), affects the variable (MDG79), which is the same percentage of households that have access to safe housing. This effect can be seen in the tree diagram of the use of variables, in other words, the relationship between these two variables can be logically considered, so, in the modeling process, the definition and Construction of the MDG79 variable from the Construction variable will be used.

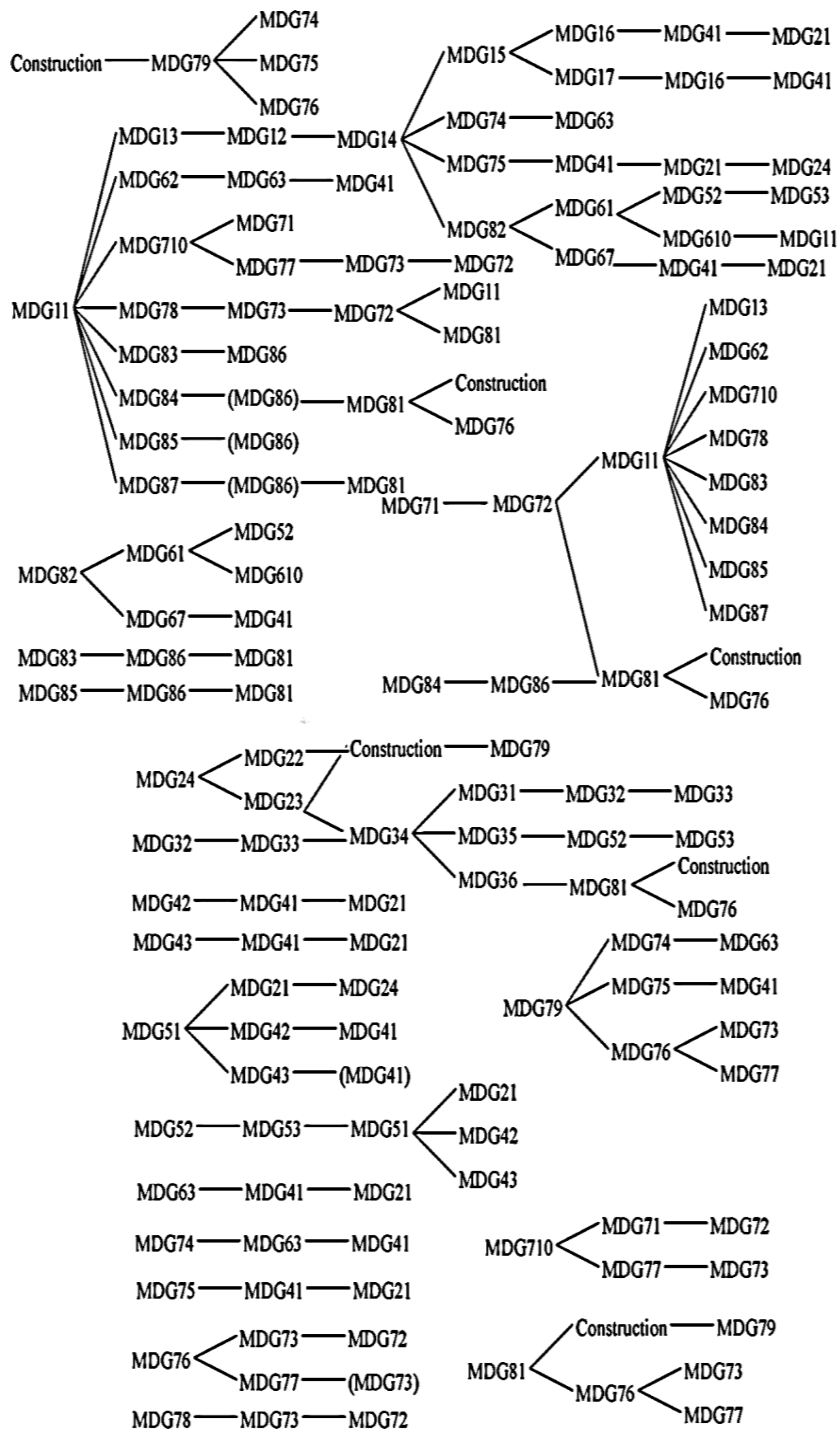

FIGURE 3
TREE STRUCTURE, THE USAGE OF VARIABLES IN MODEL COMPONENTS AND SUBSYSTEMS

According to the essential and influential indicators, causal loops were created, and after combining causal loops, a cause-and-effect model based on a mental model was designed. This model, shown in Figure 4, shows the relationships between sustainable development indicators that affect Construction. The number of building permits issued each year is also considered an indicator of Construction per year.

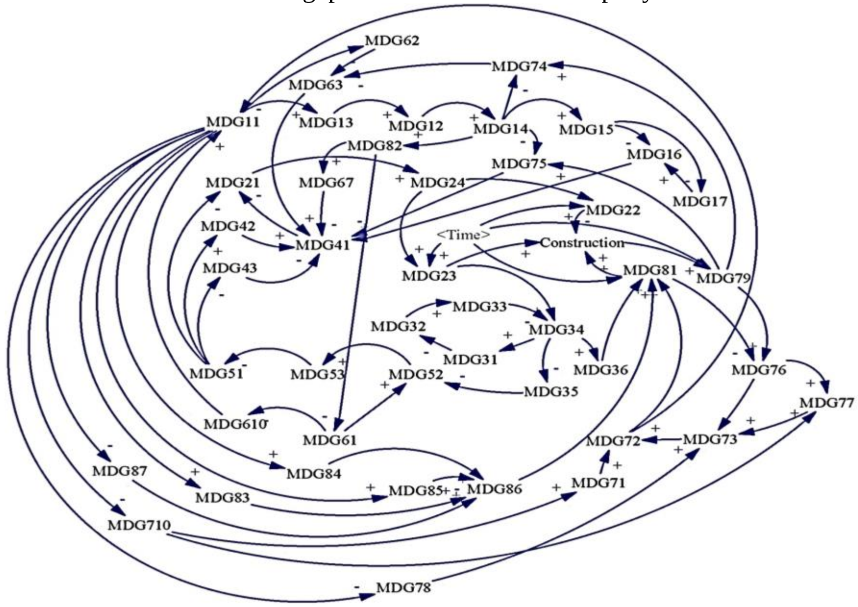

FIGURE 4
CAUSAL LOOPS DIAGRAM OF THE MODEL

DESIGN STOCK-FLOW DIAGRAM OF THE MODEL

After creating the causal loops and combining them, and conceptualizing the cause-and-effect system, it is time to formulate the model, including the Stock-flow diagram and the mathematical and structural equations of the model. The stock-flow diagram of the System Dynamic Model is shown in Figure 5. It is a dynamic model for estimating the number of building permits issued each year in the country, which indicates the amount of Construction.

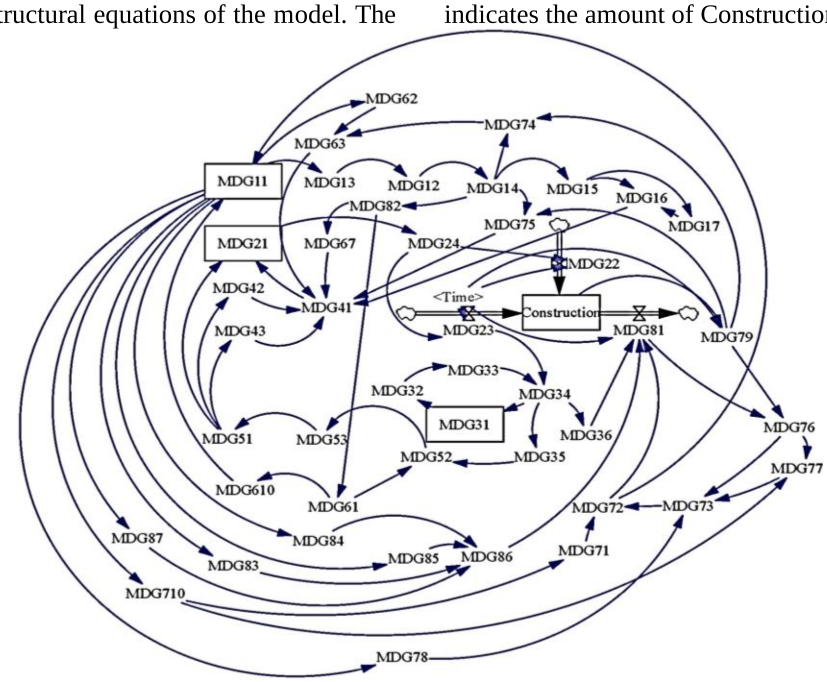

FIGURE 5
STOCK-FLOW DIAGRAM OF THE MODEL

INVESTIGATING THE NORMALITY OF VARIABLES AND OBTAINING STRUCTURAL EQUATIONS OF THE MODEL WITH RELEVANT STATISTICAL ANALYSES

To find the structural equations of the model and formulate the Stock-flow model and complete the dynamic model system, after collecting the available data for ten years from the Statistics Centre of Iran for the variables listed in Table 1, whereas the amount of data for each variable is equal 10. Therefore Shapiro-Wilk test was used to check the normality of the data of these variables.

Samuel Sanford Shapiro and Martin Wilk published the test in 1965. (Samuel Shapiro & Wilk, 1965; S. Shapiro, Wilk, & Chen, 1968). which is a more appropriate method for small sample sizes. Shapiro- Wilk test is conducted in the statistical software “SPSS” (analyze → descriptive statistics → explore → plots → normality plots with tests). Actually, For the test, the null hypothesis states that data are taken from a normally distributed population.

The null hypothesis is accepted when $P > 0.05$, and the data is said to be naturally distributed (Mishra et al., 2019; Villaseñor & González-Estrada, 2009). So, for this purpose, a significant level of 5% was considered for the Shapiro-Wilk test. All available data related to ten years from 2005 to 2014 for the variables listed in Table 1 were evaluated. The results are inserted in Table 2.

A significance level greater than 0.05 for each variable means that the data of that variable follow the normal distribution function.

TABLE 2

Shapiro _ Wilk Test Results

Hypothesis's	Index	The Null Hypothesis	Test	Sig[1]	Result
Hypothesis 1	MDG11	**DD**[2] is Normal, with an average of 0.11 and a standard deviation of 0.12111	Shapiro Wilk	0.081	CONH[3]
Hypothesis 2	MDG12	DD is Normal, with an average of 1.1135 and a standard deviation of 0.97823	Shapiro Wilk	0.243	CONH
Hypothesis 3	MDG13	DD is Normal, with an average of 0.0197 and a standard deviation of 0.01791	Shapiro Wilk	0.102	CONH
Hypothesis 4	MDG14	DD is Normal, with an average of 0.0396 and a standard deviation of 0.02248	Shapiro Wilk	0.503	CONH
Hypothesis 5	MDG15	DD is Normal, with an average of 0.05 and a standard deviation of 0.02401	Shapiro Wilk	0.434	CONH
Hypothesis 6	MDG16	DD is Normal, with an average of 5.6420 and a standard deviation of 1.57691	Shapiro Wilk	0.065	CONH
Hypothesis 7	MDG17	DD is Normal, with an average of 1.45 and a standard deviation of 0.30277	Shapiro Wilk	0.892	CONH
Hypothesis 8	MDG21	DD is Normal, with an average of 97.6950 and a standard deviation of 0.97310	Shapiro Wilk	0.448	CONH
Hypothesis 9	MDG22	DD is Normal, with an average of 98.1940 and a standard deviation of 0.07548	Shapiro Wilk	0.088	CONH
Hypothesis 10	MDG23	DD is Normal, with an average of 97.44 and a standard deviation of 0.40879	Shapiro Wilk	0.736	CONH
Hypothesis 11	MDG24	DD is Normal, with an average of 94.0898 and a standard deviation of 1.81877	Shapiro Wilk	0.513	CONH
Hypothesis 12	MDG31	DD is Normal, with an average of 0.9524 and a standard deviation of 0.03176	Shapiro Wilk	0.087	CONH
Hypothesis 13	MDG32	DD is Normal, with an average of 0.9617 and a standard deviation of 0.03666	Shapiro Wilk	0.951	CONH
Hypothesis 14	MDG33	DD is Normal, with an average of 99.0480 and a standard deviation of 9.17980	Shapiro Wilk	0.873	CONH
Hypothesis 15	MDG34	DD is Normal, with an average of 98.5915 and a standard deviation of 0.88073	Shapiro Wilk	0.064	CONH
Hypothesis 16	MDG35	DD is Normal, with an average of 3.3981 and a standard deviation of 0.87108	Shapiro Wilk	0.053	CONH
Hypothesis 17	MDG36	DD is Normal, with an average of 14.9173 and a standard deviation of 0.21482	Shapiro Wilk	0.142	CONH
Hypothesis 18	MDG41	DD is Normal, with an average of 20.6690 and a standard deviation of 2.92447	Shapiro Wilk	0.482	CONH
Hypothesis 19	MDG42	DD is Normal, with an average of 17.2170 and a standard deviation of 2.53706	Shapiro Wilk	0.181	CONH
Hypothesis 20	MDG43	DD is Normal, with an average of 98.2 and a standard deviation of 1.68655	Shapiro Wilk	0.118	CONH
Hypothesis 21	MDG51	DD is Normal, with an average of 23.1850 and a standard deviation of 3.61292	Shapiro Wilk	0.431	CONH
Hypothesis 22	MDG52	DD is Normal, with an average of 31.03 and a standard deviation of 1.15051	Shapiro Wilk	0.892	CONH
Hypothesis 23	MDG53	DD is Normal, with an average of 97.4665 and a standard deviation of 1.40688	Shapiro Wilk	0.085	CONH
Hypothesis 24	MDG61	DD is Normal, with an average of 12.6525 and a standard deviation of 2.12721	Shapiro Wilk	0.763	CONH
Hypothesis 25	MDG62	DD is Normal, with an average of 98.10 and a standard deviation of 1.87676	Shapiro Wilk	0.13	CONH
Hypothesis 26	MDG63	DD is Normal, with an average of 1.9139 and a standard deviation of 1.12698.	Shapiro Wilk	0.092	CONH
Hypothesis 27	MDG64	Percentage of TB cures, constant and equal to 100 over ten years	-	-	-
Hypothesis 28	MDG65	Malaria mortality rate constant and equal to 0 over ten years	-	-	-
Hypothesis 29	MDG66	DD is Normal, with an average of 27.9680 and a standard deviation of 9.19607	Shapiro Wilk	0.387	CONH
Hypothesis 30	MDG67	DD is Normal, with an average of 2.9183 and a standard deviation of 0.73778	Shapiro Wilk	0.509	CONH
Hypothesis 31	MDG68	Data is confidential and inaccessible	-	-	-
Hypothesis 32	MDG69	Data is confidential and inaccessible	-	-	-
Hypothesis 33	MDG610	DD is Normal, with an average of 77.6945 and a standard deviation of 0.79747	Shapiro Wilk	0.873	CONH
Hypothesis 34	MDG611	Data is confidential and inaccessible	-	-	-
Hypothesis 35	MDG612	Data is confidential and inaccessible	-	-	-
Hypothesis 36	MDG71	DD is Normal, with an average of 8.7470 and a standard deviation of 0.15160	Shapiro Wilk	0.195	CONH
Hypothesis 37	MDG72	DD is Normal, with an average of 8.9554 and a standard deviation of 1.53345	Shapiro Wilk	0.262	CONH
Hypothesis 38	MDG73	DD is Normal, with an average of 4853.352 and a standard deviation of 268.6722	Shapiro Wilk	0.474	CONH
Hypothesis 39	MDG74	DD is Normal, with an average of 97.5670 and a standard deviation of 0.59904	Shapiro Wilk	0.72	CONH
Hypothesis 40	MDG75	DD is Normal, with an average of 92.5397 and a standard deviation of 2.50030	Shapiro Wilk	0.083	CONH
Hypothesis 41	MDG76	DD is Normal, with an average of 0.2695 and a standard deviation of 0.00668	Shapiro Wilk	0.384	CONH
Hypothesis 42	MDG77	DD is Normal, with an average of 7092.0375 and a standard deviation of 561.9232	Shapiro Wilk	0.298.	CONH
Hypothesis 43	MDG78	DD is Normal, with an average of 0.0450 and a standard deviation of 0.01009	Shapiro Wilk	0.892	CONH
Hypothesis 44	MDG79	DD is Normal, with an average of 89.02 and a standard deviation of 6.98659	Shapiro Wilk	0.949	CONH
Hypothesis 45	MDG710	DD is Normal, with an average of 3.42 and a standard deviation of 0.84774	Shapiro Wilk	0.892	CONH
Hypothesis 46	MDG81	DD is Normal, with an average of 24.63 and a standard deviation of 2.21211	Shapiro Wilk	0.904	CONH
Hypothesis 47	MDG82	DD is Normal, with an average of 89.950 and a standard deviation of 0.0336	Shapiro Wilk	0.892	CONH
Hypothesis 48	MDG83	DD is Normal, with an average of 34.4490 and a standard deviation of 2.38779	Shapiro Wilk	0.812	CONH
Hypothesis 49	MDG84	DD is Normal, with an average of 56.6329 and a standard deviation of 27.08165	Shapiro Wilk	0.517	CONH
Hypothesis 50	MDG85	DD is Normal, with an average of 14.9665 and a standard deviation of 7.40404	Shapiro Wilk	0.273	CONH
Hypothesis 51	MDG86	DD is Normal, with an average of 16.5889 and a standard deviation of 11.81670	Shapiro Wilk	0.802	CONH
Hypothesis 52	MDG87	DD is Normal, with an average of 18.6350 and a standard deviation of 4.28244	Shapiro Wilk	0.892	CONH
Hypothesis 53	Time	DD is Normal, with an average of 1388.5 and a standard deviation of 3.02765	Shapiro Wilk	0.892	CONH
Hypothesis 54	CONSTRUCTION	DD is Normal, with an average of 217879.657 and a standard deviation of 6717.8	Shapiro Wilk	0.157	CONH

1- Significant Level 2- Data Distribution 3-Correctness Of Null Hypothesis

After determining the results related to the variables' normality, mathematical relationships between the variables used in the dynamic model were obtained based on statistical analysis, including regression analysis (Lindley, 1990). The structural equations of the model obtained in this way are given in Table 3.

TABLE 3

STRUCTURAL EQUATIONS OBTAINED FROM REGRESSION STATISTICAL ANALYSIS

Index	Equation
MDG11	INTEG(((-0.238733*MDG610)+(-0.138197*MDG72)+(19.8958))-MDG11)
MDG12	(36.8643*MDG13)+(0.387195)
MDG13	(0.077052*MDG11)+(0.011227)
MDG14	(0.004178*MDG12)+(0.034972)
MDG15	(0.138531*MDG14)+(0.044544)
MDG16	(-34.8692*MDG15)+(2.11483*MDG17)+(4.32014)
MDG17	(-11.7323*MDG15)+(2.037)
MDG21	INTEG(((-0.114572*MDG41)+(-0.020903*MDG51)+(100.548))-MDG21)
MDG22	(-0.020845*MDG24)+(0.022342*TIME)+(55.2593)
MDG23	(-0.127624*MDG24)+(0.168542*TIME)+(-229.236)
MDG24	(1.27382*MDG21)+(-30.3562)
MDG31	INTEG(((0.022832*MDG34)+(-1.29865))-MDG31)
MDG32	(-0.816105*MDG31)+(1.73894)
MDG33	(183.856*MDG32)+(-77.7625)
MDG34	(0.457851*MDG23)+(-0.058321*MDG33)+(59.755)
MDG35	(-0.613019*MDG34)+(63.8366)
MDG36	(0.030284*MDG34)+(11.9315)
MDG41	(-0.369344*MDG16)+(1.0135*MDG42)+(-0.167594*MDG43)+(0.001505*MDG63)+(0.841112*MDG67)+(-0.174631*MDG75)+(35.464)
MDG42	(0.105782*MDG51)+(14.7644)
MDG43	(-0.068693*MDG51)+(99.7927)
MDG51	(-0.549523*MDG53)+(76.7451)
MDG52	(0.108847*MDG35)+(0.565431*MDG61)+(23.506)
MDG53	(1.17356*MDG52)+(61.051)
MDG61	(-62.4259*MDG82)+(5627.86)
MDG62	(-1.69697*MDG11)+(98.2867)
MDG63	(-0.496156*MDG62)+(-0.272822*MDG74)+(77.2053)
MDG64	**
MDG65	**
MDG66	**
MDG67	(14.7*MDG82)+(-1319.35)
MDG68	**
MDG69	**
MDG610	(-0.371578*MDG61)+(82.3959)
MDG611	**
MDG612	**
MDG71	(0.172194*MDG710)+(8.15806)
MDG72	((3.06057*MDG71)+(0.003848*MDG73)+(-36.4901))-MDG72
MDG73	(-9856.02*MDG76)+(0.004431*MDG77)+(26168.8*MDG78)+(6300.18)
MDG74	(1.85599*MDG14)+(0.072947*MDG79)+(90.9997)
MDG75	(-5.24437*MDG14)+(0.335536*MDG79)+(62.8781)
MDG76	(0.000511*MDG79)+(-0.00104*MDG81)+(0.249596)
MDG77	(7324.27*MDG76)+(570.172*MDG710)+(3168.42)
MDG78	(-0.011111*MDG11)+(0.046222)
MDG79	(2.32126*TIME)+(1.1E-005*CONSTRUCTION)+(-4577.41)
MDG710	(-0.933333*MDG11)+(3.52267)
MDG81	(1.63277*MDG36)+(1.5239*MDG72)+(-0.421158*MDG86)+(1.26162*TIME)+(-2541.62)
MDG82	(0.193022*MDG14)+(89.9424)
MDG83	(0.439394*MDG11)+(34.4007)
MDG84	(-0.313998*MDG11)+(56.6674)
MDG85	(6.93544*MDG11)+(14.2036)
MDG86	(0.980708*MDG83)+(-0.231975*MDG84)+(-0.69047*MDG85)+(2.46514*MDG87)+(-39.662)
MDG87	(-4.71482*MDG11)+(19.1536)
Time	VARIABLE RELATED TO TIME (YEAR OF DATA COLLECTION OF VARIABLES, 2005-20014)
CONSTRUCTION	INTEG(((151873*MDG22)+(-22787.8*MDG23)+(2104.73*MDG81)+(-1.25703e+007))-(Construction))

** DUE TO THE LACK OF DATA RELATED TO THIS VARIABLE, THIS VARIABLE HAS NOT BEEN USED IN MODEL CONSTRUCTION.

ENTERING STRUCTURAL EQUATIONS AND INITIAL SIMULATION AND CHECKING THE UNITS AND STRUCTURAL ACCURACY OF THE MODEL

After Making the stock-flow diagram and formation the system dynamic model, and obtaining the structural equations of the model, it is time to enter the information of these equations in the designed model. The Academic version of Vensim software known as Vensim PLE has been used to design and build the model. Vensim PLE (Personal Learning Edition) is software that gets researchers started in system dynamics modeling and is free for educational use (Ventana Systems, 2015). This software can build models in an object-oriented and intuitive way. Also, it takes mathematical equations between variables from the user and, after defining the units of variables, performs the initial simulation. Therefore, this software checks the structural accuracy of the system dynamic model so that if a visual (graphical) relationship is established between the two variables, the mathematical relationship and the units must be defined based on logical-mathematical operators. The intuitive and visual characteristics of the model allow the modeler and the user to have a better understanding of the structure, components, and relationships between variables. Based on this, all the obtained structural equations were entered into the model. Except for the construction variable, measured in terms of number, many units of variables used in the model are percentages or percentage coefficients. All units were entered into the model; finally, the simulation and the accuracy of the model structure were measured. Also, the time horizon related to model structure from 2005 to 2025 has been considered and defined.

IMPLEMENTATION OF THE MODEL AND EVALUATION, CALIBRATION, AND VALIDATION OF THE MODEL

By running (Synthesym) the model, the calculations of all variables are automatically calculated for the considered years in the time horizon defined in the model. its output can be seen both graphically and in the form of data in the table. Just click on the desired variable in the intuitive model and select the output type, a table or chart, from the software tools. The model output is obtained for the construction variable, which indicates the number of Building Permits issued. This output of the model is a graph close to another graph related to the values of the number of Building Permits issued per year, which are collected based on actual data are given in Figure 6. By comparing the two graphs, the numbers are obtained in Table 4. This data range is related to the years in which the information is available and is known as the reference pattern. So, it is clear that the model has good accuracy. This means that the numbers predicted by the model with an average tolerance of 5% will reach the real numbers.

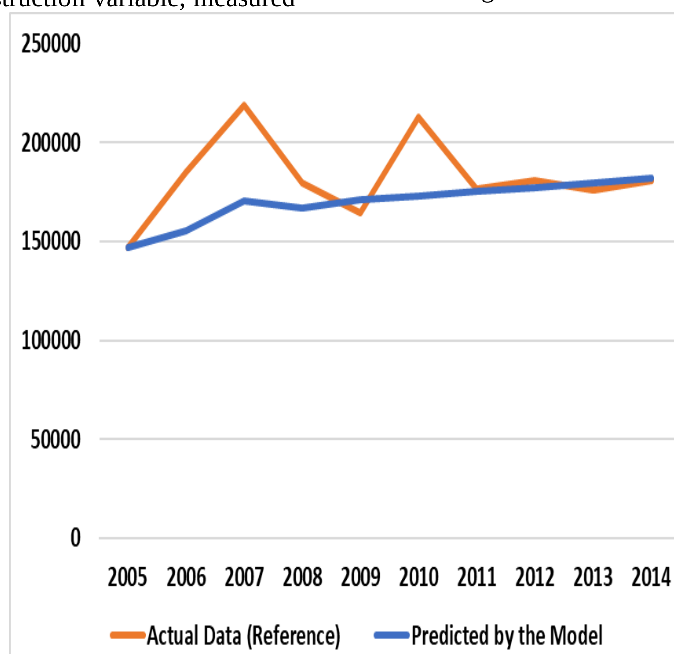

FIGURE 6
COMPARISON OF THE NUMBER OF ACTUAL ANNUAL BUILDING PERMITS ISSUED WITH THE NUMBER OF BUILDING PERMITS ISSUED ANNUALLY BY THE MODEL OUTPUT, FOR THE TEN YEARS FOR WHICH THE INFORMATION WAS AVAILABLE

TABLE 4 COMPARISON OF THE NUMBER OF ISSUED BUILDING PERMITS (MODEL OUTPUT WITH ACTUAL VALUE)

Year	Actual	Model	Difference	Percentage of difference
2005	147096	147096	0	0
2006	185146	155374	-29772	-16.08028259
2007	218966	170655	-48311	-22.0632427
2008	179932	167152	-12780	-7.102683236
2009	164389	171516	7127	4.335448236
2010	212873	172771	-40102	-18.83846237
2011	176707	175346	-1361	-0.77020152
2012	180907	177401	-3506	-1.938012349
2013	175914	179679	3765	2.14025035
2014	181000	181871	871	0.48121547
			AVERAGE =	5.9

Since it was found that the model is valid and the numbers obtained from it can be trusted, the output of some model variables that show the changes of variables over 20 years (model time horizon, 2005 to 2025) in Figures 7 to 10 is provided. The behavior of the construction variable, which is related to the number of building permits issued per year, is shown in Figure 7. Also, the erratic behavior related to the literacy rate of men aged 15-24 years is shown in Figure 8. The behavior related to the unemployment rate of young people aged 15-24 years is also shown in Figure 9. Figure 10 shows the erratic behavior associated with the literacy rate of women aged 15-24.

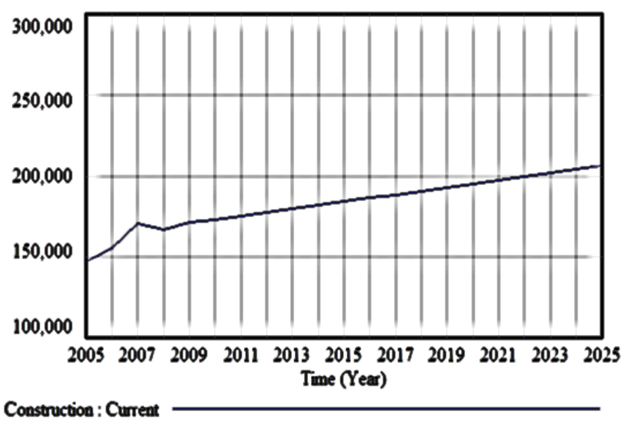

FIGURE 7
VARIABLE BEHAVIOR RELATED TO THE CONSTRUCTION (THE NUMBER OF BUILDING PERMITS ISSUED FROM 2005 TO 2025)

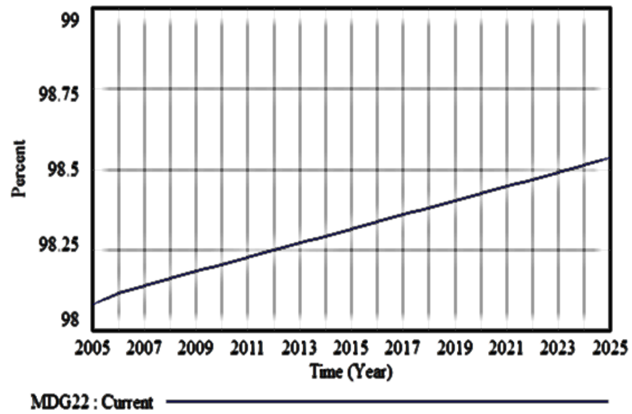

FIGURE 8
VARIABLE BEHAVIOR OF LITERACY RATIO OF MEN AGED 15-24 IN TERMS OF PERCENTAGE FROM 2005 TO 2025

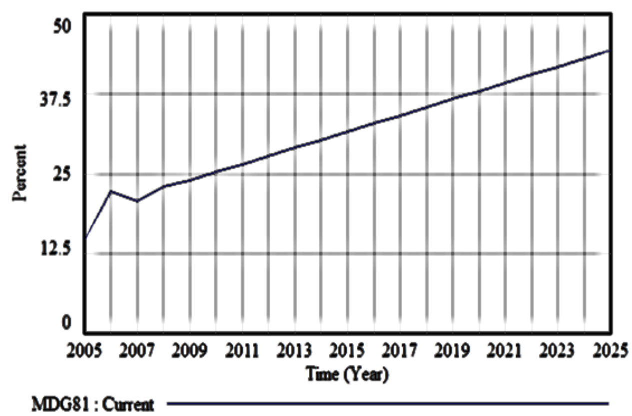

FIGURE 9
VARIABLE BEHAVIOR OF YOUTH UNEMPLOYMENT RATES IN THE AGES OF 15-24 YEARS IN TERMS OF PERCENTAGE FROM 2005 TO 2025

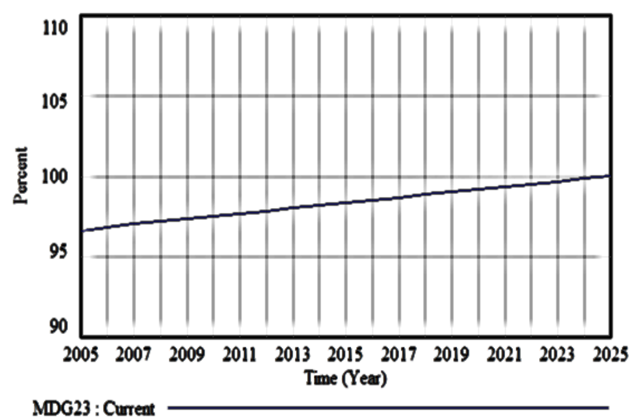

FIGURE 10
VARIABLE BEHAVIOR OF LITERACY RATIO OF WOMEN AGED 15-24 IN TERMS OF PERCENTAGE FROM 2005 TO 2025

BEHAVIOR REPRODUCTION TEST, BEHAVIOR ANOMALY TEST, SENSITIVITY ANALYSIS, AND DESIGN SCENARIOS

Some tests for Model Behavior Validation are Parameter Sensitivity Test, Structural Sensitivity test, Behavior reproduction test, Symptoms generation test, Behavior anomaly test, family-member test, Surprise behavior test, resilience test, and statistical test. These tests are for the fitness and consistency of Model Behavior. Validation methods in system dynamics are a relative concept which depends on the purpose of use. in the Behavior-Reproduction Test, the generated model behavior is judged with the historical behavior and their matches are observed. In Behavior-Anomaly Test Behavior conflicting with the actual system helps find apparent flaws in the model (Martis, 2006). Behavior reproduction tests and sensitivity analysis for the important variables in this study are presented below. Figure 11 shows the behavior reproduction test for the variable of youth unemployment rates in the ages of 15-24 years in terms of percentage from 2005 to 2025 (MDG81).

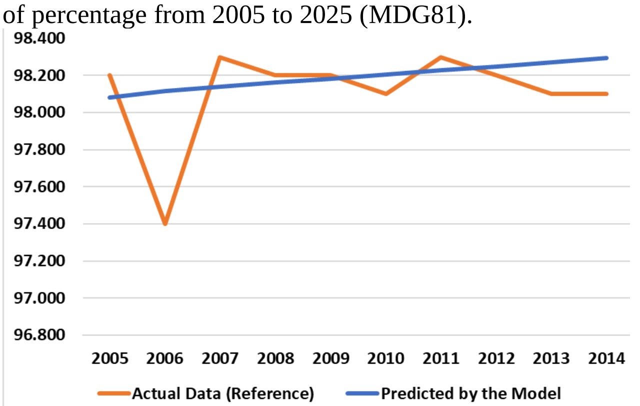

FIGURE 11
BEHAVIOR REPRODUCTION TEST FOR VARIABLE OF YOUTH UNEMPLOYMENT RATES IN THE AGES OF 15-24 YEARS IN TERMS OF PERCENTAGE FROM 2005 TO 2025 (MDG81)

Figure 12 shows the behavior reproduction test for the variable of literacy ratio of men aged 15-24 in terms of percentage from 2005 to 2025 (MDG22).

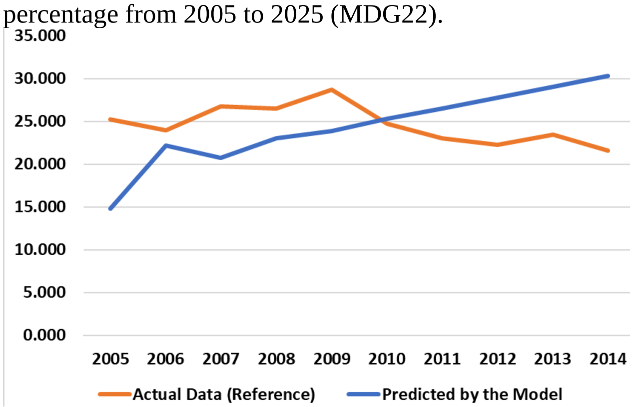

FIGURE 12
BEHAVIOR REPRODUCTION TEST FOR VARIABLE OF LITERACY RATIO OF MEN AGED 15-24 IN TERMS OF PERCENTAGE FROM 2005 TO 2025 (MDG22)

Figure 13 shows the behaviour reproduction test for the variable of literacy ratio of women aged 15-24 in terms of percentage from 2005 to 2025 (MDG23)

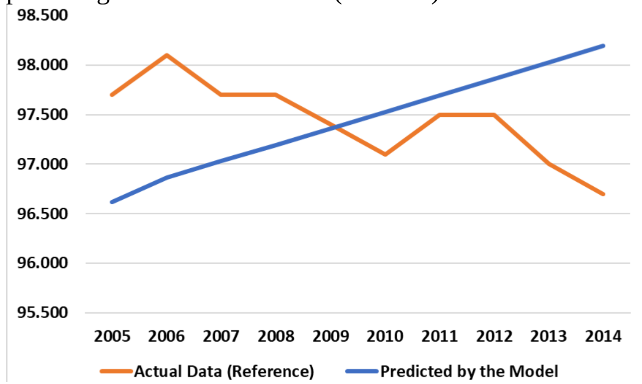

FIGURE 13
BEHAVIOR REPRODUCTION TEST FOR VARIABLE OF LITERACY RATIO OF WOMEN AGED 15-24 IN TERMS OF PERCENTAGE FROM 2005 TO 2025 (MDG23)

Figures 14 to 21 show the Behaviour Anomaly test for Some essential variables of this study.

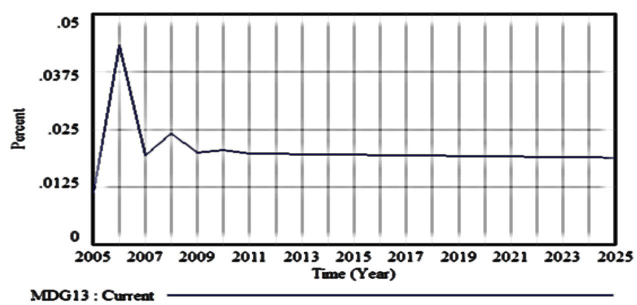

FIGURE 14
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG13

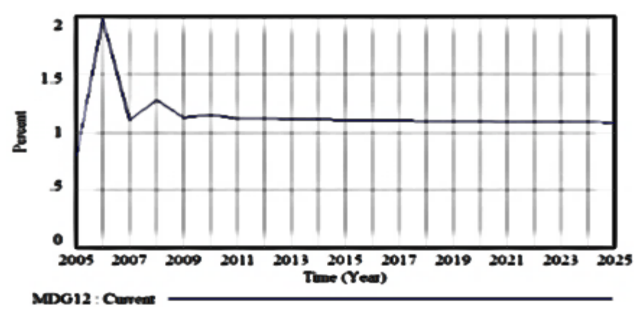

FIGURE 15
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG12

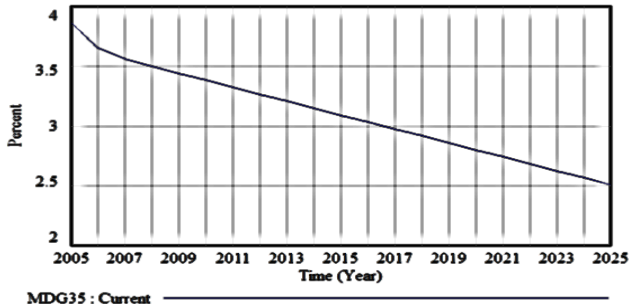

FIGURE 16
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG35

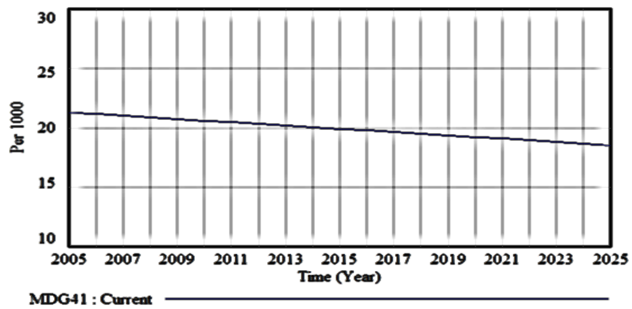

FIGURE 17
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG41

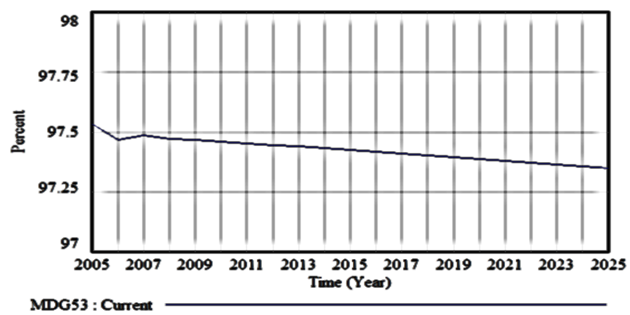

FIGURE 18
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG53

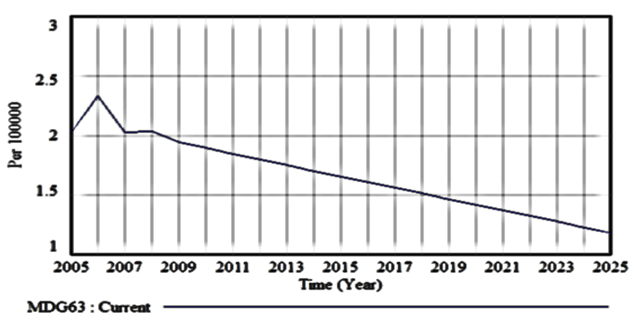

FIGURE 19
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG63

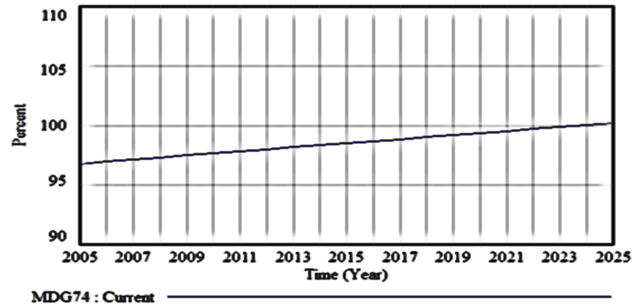

FIGURE 20
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG74

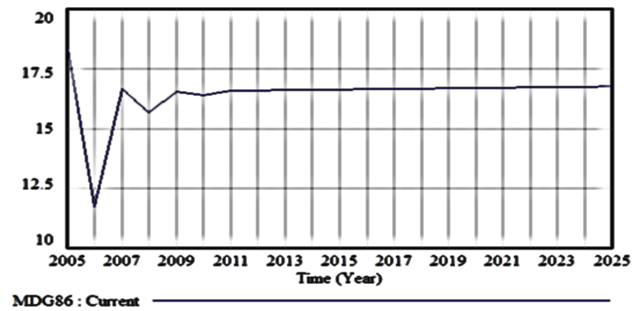

FIGURE 21
BEHAVIOUR ANOMALY TEST FOR VARIABLE MDG86

The first scenario calculates the construction variable in three different modes during the years 2005 to 2025. Once in the case where the MDG22 variable is at its lowest possible value each year, once in the case where the variable is at its maximum possible each year, and once in the case where the variable is usually following the trends defined in the model Have. Therefore, the difference between the results of these three modes can show the model's sensitivity to the MDG22 variable.

Figure 22 shows the sensitivity of the Construction variable to changes in the rate variable for literate men aged 15-24. According to this figure, it is clear that the higher the literacy rate of men aged 15-24, will Couse to the more construction, which confirms that young people active in the field of construction, including technicians and engineers, and even workers play such a significant role in the Construction industry that the lack of absolute literacy of men in this age range can even lead to the cessation of construction.

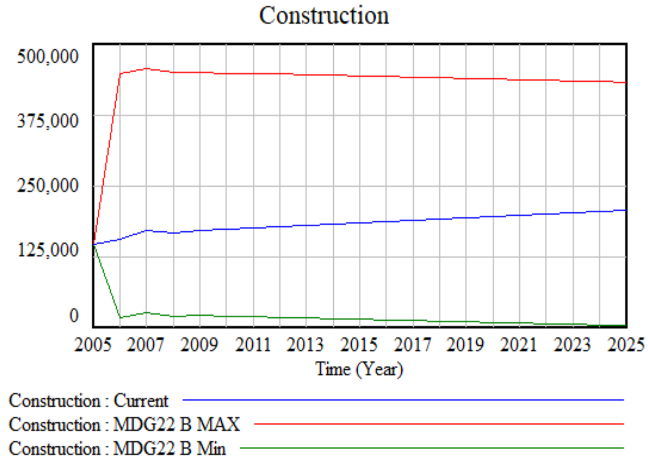

FIGURE 22
SENSITIVITY OF THE CONSTRUCTION VARIABLE TO CHANGES IN THE LITERACY RATE OF MEN AGED 15-24 YEARS

The second scenario calculates the construction variable in three different modes during the years 2005 to 2025. Once in the case where the MDG36 variable is at its lowest possible value each year, once in the case where the variable is at its maximum possible each year, and once in the case where the variable is usually following the trends defined in the model Have. Therefore, the difference between the results of these three modes can show the model's sensitivity to the MDG36 variable. Figure 23 shows the sensitivity of the Construction-related variable to changes in the variable related to the percentage of salaried women working in the non-agricultural sector. Given this figure, it is clear that the higher the share of salaried working women in the non-agricultural sector, the more construction will take place. It confirms that this group of women who are employed if instead of the construction industry turns to the agricultural sector, there will be more minor construction and vice versa.

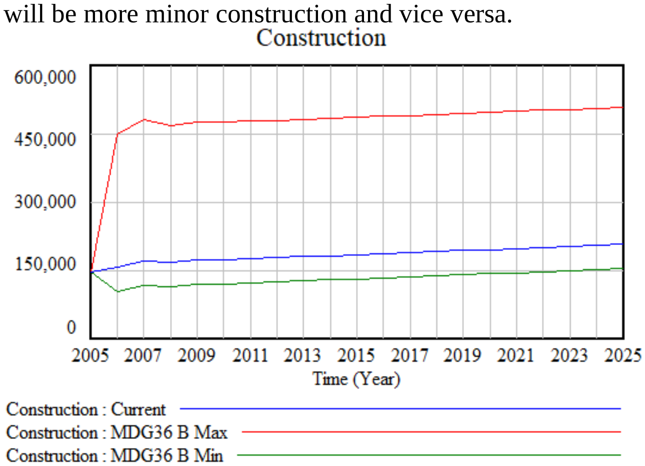

FIGURE 23
SENSITIVITY OF THE CONSTRUCTION VARIABLE TO CHANGES IN THE SHARE OF WOMEN WORKERS IN THE NON-AGRICULTURAL SECTOR

The third scenario calculates the construction variable in three different modes during the years 2005 to 2025. Once in the case where the MDG84 variable is at its lowest possible value each year, once in the case where the variable is at its maximum possible each year, and once in the case where the variable is usually following the trends defined in the model Have. Therefore, the difference between the results of these three modes can show the model's sensitivity to the MDG84 variable.

Figure 24 shows the sensitivity of the Construction-related variable to changes in the cellular subscribers per 100 population. According to this figure, it is clear that increasing this variable also causes more construction to be done, which confirms that the amount of communication and interaction in both the administrative process and the executive process of the construction industry. It has a facilitating and accelerating role, so the existence of new means of communication in the administrative process, supply chain, and housing production has an influential role. However, the effect of this variable is not as much as previous variables but has played a role.

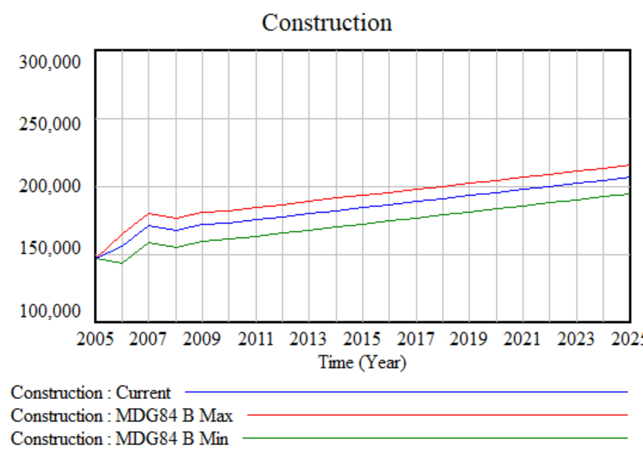

FIGURE 24
SENSITIVITY OF THE CONSTRUCTION VARIABLE TO CHANGES IN THE CELLULAR SUBSCRIBERS PER 100 POPULATION

CONCLUSION

As precise results of this research, the following can be mentioned:

Causal loops and causal relationships in the form of system dynamic and complex systems can be considered between the variables involved in sustainable development indicators (SDI), whether in social, economic, or environmental dimensions, so that the feedbacks affected by the change of variables on Other factors in this system will also change seemingly unrelated elements. As social indicators significantly change economic indicators. Changes, however small, can have far-reaching effects. These cause-and-effect relationships between the components of a system dynamic can have different behaviors, including the linear behavior between many variables in this study. Although the actual behavior may be slightly different, many of these behaviors can be well simulated. The more accurate and realistic the prediction of the behavior of the system dynamic components, the higher the accuracy of the implemented model and the lower the tolerance results. In contrast, any simplifying relationships and the simulation and formulation of behaviors can lead to far-fetched or highly approximated results.

Specifically, from the system dynamic model (SDM) created in this research, it can be concluded that with the current rate of change and with a tolerance of 5%, the number of building permits, which was equal to 147096 in 2005, will reach 206299 in 2025, and this shows the growth is about 40% in the construction industry. The unemployment rate for 15- to 24-year-olds is also projected to rise from about 14.8 percent in 2005 to about 44.3 percent in 2025, equivalent to a 300 percent increase in unemployment. Also, based on the findings of this study, it was found that the literacy rate of 24-15 years older men and the share of salaried working women in the non-agricultural sector will have a significant impact on the amount of construction and the number of building permits issued.

SUGGESTIONS FOR FUTURE RESEARCHES

It is suggested that the relationship between the amount of construction and economic indicators such as gross domestic product (GDP) or GDP per capita be examined and a model be prepared for it. The role of force majeure events such as the Corona pandemic in the construction process in the country can also be examined. Models can also be developed to investigate the status of buildings in terms of the number of floors or their area during different years and its relationship with other economic, social, and environmental variables of sustainable development and examine the complex and interrelated relationship between them. The impact of construction quality and its connection with ecological indicators is also an important issue that can be studied by other researchers.

REFERENCES

— Balint, P. J., Stewart, R. E., Desai, A., & Walters, L. C. (2011). Managing Wicked Environmental Problems. In P. J. Balint, R. E. Stewart, A. Desai, & L. C. Walters (Eds.), Wicked Environmental Problems: Managing Uncertainty and Conflict (pp. 207-217). Washington, DC: Island Press/Center for Resource Economics.

— Berchin, I. I., de Aguiar Dutra, A. R., & Guerra, J. B. S. O. d. A. (2021). How do higher education institutions promote sustainable development? A literature review. Sustainable Development, n/a(n/a). DOI: https://DOI.org/10.1002/sd.2219

— Blanc, D. (2015). Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. Sustainable Development, 23. DOI: 10.1002/sd.1582

— Burgan, B., & Sansom, M. (2006). Sustainable steel construction. Journal of Constructional Steel Research - J CONSTR STEEL RES, 62, 1178-1183. DOI: 10.1016/j.jcsr.2006.06.029

— Charkhchi, R., toloi, a., & alborzi, m. (2019). Designing a Dynamic Model for Strategic Evaluation of Innovation with a Multiple Scenario Approach. SMR, 25(72), 13-40.

— Coleman, P., Vallacher, R., Nowak, A., & Bui-Wrzosinska, L. (2007). Intractable Conflict as an AttractorA Dynamical Systems Approach to Conflict Escalation and Intractability. American Behavioral Scientist - AMER BEHAV SCI, 50, 1454-1475. DOI: 10.1177/0002764207302463

— Coleman, P. T., Vallacher, R., Bartoli, A., Nowak, A., & Bui-Wrzosinska, L. (2011). Navigating the landscape of conflict: Applications of dynamical systems theory to addressing protracted conflict. The non-linearity of peace processes: Theory and practice of systemic conflict transformation, 39-56.

— Corvellec, H., Hultman, J., Jerneck, A., Arvidsson, S., Ekroos, J., Wahlberg, N., & Luke, T. W. (2021). Resourcification: A non-essentialist theory of resources for sustainable development. Sustainable Development, n/a(n/a). DOI: https://DOI.org/10.1002/sd.2222

— Dahia, Z., Bellaouar, A., & Dron, J.-P. (2021). A dynamic approach for maintenance evaluation and optimization of multistate systems. Journal of Industrial Engineering, International, 17(1), 1-13. DOI: 10.30495/jiei.2021.1926554.1110

— Djuric, M., & Filipovic, J. (2015). Human and Social Capital Management Based on Complexity Paradigm: Implications for Various Stakeholders and Sustainable Development. Sustainable Development, n/a-n/a. DOI: 10.1002/sd.1595

— Dobson, A. (2007). Environmental Citizenship: Towards Sustainable Development. Sustainable Development, 15, 276-285. DOI: 10.1002/sd.344

— Ebrahimi, M., & Pilevari, N. (2021). System Dynamics Modeling and Simulation to Analyze the Role of Solar Energy in Secure Access to Sustainability. Journal of Industrial Engineering, International, 17(1), 63-77. DOI: 10.30495/jiei.2021.1924887.1102

— Edwards, B., & Hyett, P. (2005). The rough guide to sustainability: RIBA enterprises London.

— Farnam Nematkhah, Sadigh Raissi & Vahidreza Ghezavati (2017) An integrated fuzzy DEMATEL-fuzzy ANP approach to nominate diagnostic method and measuring total predictive performance score, Safety and Reliability, 37:1, 48-72, DOI: 10.1080/09617353.2017.1411676

— Fisher, J., & Rucki, K. (2016). Re-conceptualizing the Science of Sustainability: A Dynamical Systems Approach to Understanding the Nexus of Conflict, Development, and the Environment: Re-Conceptualizing the Science of Sustainability. Sustainable Development, 25. DOI: 10.1002/sd.1656

— Fotis, P., & Polemis, M. (2018). Sustainable development, environmental policy, and renewable energy use: A dynamic panel data approach. Sustainable Development, 26(6), 726-740. DOI: https://DOI.org/10.1002/sd.1742

— Gravelsins, A., Bazbauers, G., Blumberga, A., Blumberga, D., Bolwig, S., Klitkou, A., & Lund, P. D. (2018). Modeling energy production flexibility: system dynamics approach. Energy Procedia, 147, 503-509. DOI: https://DOI.org/10.1016/j.egypro.2018.07.060

— Gu, C., Ye, X., Cao, Q., Guan, W., Peng, C., Wu, Y., & Zhai, W. (2020). System dynamics modeling of urbanization under energy constraints in China. Scientific Reports, 10(1), 9956. DOI: 10.1038/s41598-020-66125-3

— Hall, M., & Purchase, D. (2006). Building or bodging? Attitudes to sustainability in UK public sector housing construction development. Sustainable Development, 14, 205-218. DOI: 10.1002/sd.265

— Harati, S., Roghanian, E., Hafezalkotob, A., & Shojaie, A. A. (2021). A Location-Routing-Inventory Model for Perishable Items Using Fresher First and Older First Inventory Management Policies. Journal of Industrial Engineering, International, 17(1), 32-41. DOI: 10.30495/jiei.2021.1918748.1075

— Hidayatno, A., Dhamayanti, R., & Destyanto, A. R. (2019). Model conceptualization for policy analysis in renewable energy development in Indonesia by using system dynamics. International Journal of Smart Grid and Clean Energy, 8(1), 54-58.

— Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable Development: Mapping Different Approaches. Sustainable Development, 13, 38-52. DOI: 10.1002/sd.244

— Industry, B. T. (2003). Sustainable building and construction: facts and figures. Ind Environ, 26(2-3), 5-8.

— Iran, S. C. o. (2014). Millennium Development Goals (MDG) - 2014 Report. https://www.amar.org.ir/english/MDG-2014.

— Jasiński, D., Meredith, J., & Kirwan, K. (2021). The sustainable development model for measuring and managing sustainability in the automotive sector. Sustainable Development, n/a(n/a). DOI: https://doi.org/10.1002/sd.2207

— Laimon, M., Mai, T., Goh, S., & Yusaf, T. (2020). Energy Sector Development: System Dynamics Analysis. Applied Sciences, 10(1), 134.

— Lindley, D. V. (1990). Regression and correlation analysis Time series and statistics (pp. 237-243): Springer.

— Lingard, H., Graham, P., & Smithers, G. (2000). Employee perceptions of the solid waste management system operating in a large Australian contracting organization: Implications for company policy implementation. Construction Management & Economics, 18, 383-393. DOI: 10.1080/01446190050024806

— Martis, M. S. (2006). Validation of simulation-based models: a theoretical outlook. The electronic journal of business research methods, 4(1), 39-46.

— Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. Annals of cardiac anesthesia, 22(1), 67-72. DOI: 10.4103/Aca.ACA_157_18

— Mutingi, M., Mbohwa, C., & Kommula, V. P. (2017). System dynamics approach to energy policy modeling and simulation. Energy Procedia, 141, 532-539. DOI: https://DOI.org/10.1016/j.egypro.2017.11.071

— Nordås, R., & Gleditsch, N. (2007). Climate Change and Conflict. Political Geography, 26, 627-638. DOI: 10.1016/j.polgeo.2007.06.003

— Nowak, A., Bui-Wrzosinska, L., Vallacher, R., & Coleman, P. (2012). Sustainable Peace: A Dynamical Systems Perspective. Psychological Components of Sustainable Peace, 265-281. DOI: 10.1007/978-1-4614-3555-6_14

— Owens, S., & Cowell, R. (2002). Land and Limits: Interpreting Sustainability in the Planning Process. Land and Limits: Interpreting Sustainability in the Planning Process, Second Edition, 19. DOI: 10.1016/S0264-8377(02)00043-1

— Owlia, M. S., Roshani, K., & Abooei, M. H. (2020). Interpretive Structural Modeling (ISM) of Intellectual Capital Components. Journal of Industrial Engineering, International, 16(4), 41-56. DOI: 10.30495/jiei.2020.678786

— Ozawa, C. (2006). Science and intractable conflict. Conflict Resolution Quarterly, 24, 197-205. DOI: 10.1002/crq.168

— Palmer, E. (2015). Introduction: The 2030 Agenda. Journal of Global Ethics, 11(3), 262-269. DOI: 10.1080/17449626.2015.1119928

— Pearce, D. (2003). The Social and Economic Value of Construction: the construction industry's contribution to sustainable development, CRISPR. London, available at.

— Pearce, D. (2006). Is the construction sector sustainable?: Definitions and reflections. Building Research and Information - BUILDING RES INFORM, 34, 201-207. DOI: 10.1080/09613210600589910

— Pourhassan, M.R., Raissi, S. and Apornak, A. (2021), "Modeling multi-state system reliability analysis in a power station under fatal and nonfatal shocks: a simulation approach", International Journal of Quality & Reliability Management, Vol. 38 No. 10, pp. 2080-2094. https://doi.org/10.1108/IJQRM-07-2020-0244

— Pradenas, L., Bravo, G., & Linfati, R. (2020). An optimization model for remanufacturing in a real sawmill. Journal of Industrial Engineering, International, 16(4), 32-40. DOI: 10.30495/jiei.2020.678785

— Rassafi, A., Poorzahedy, H., & Vaziri, M. (2006). An alternative definition of sustainable development using stability and chaos theories. Sustainable Development, 14, 62-71. DOI: 10.1002/sd.268

— Redclift, M. (2005). Sustainable Development (1987-2005) - An Oxymoron Comes of Age. Sustainable Development, 13, 212-227. DOI: 10.1002/sd.281

— Rwelamila, P. D., Talukhaba, A. A., & Ngowi, A. B. (2000). Project procurement systems in the attainment of sustainable construction. Sustainable Development, 8(1), 39-50.

— Saavedra M, M. R., de O. Fontes, C. H., & M. Freires, F. G. (2018). Sustainable and renewable energy supply chain: A system dynamics overview. Renewable and Sustainable Energy Reviews, 82, 247-259. DOI: https://DOI.org/10.1016/j.rser.2017.09.033

— Sachs, J. D. (2012). From millennium development goals to sustainable development goals. The Lancet, 379(9832), 2206-2211.

— Scheyvens, R., Banks, G., & Hughes, E. (2016). The Private Sector and the SDGs: The Need to Move Beyond 'Business as Usual. Sustainable Development, 24(6), 371-382. DOI: https://DOI.org/10.1002/sd.1623

— Sev, A. (2009). How Can the Construction Industry Contribute to Sustainable Development? A Conceptual Framework. Sustainable Development, 17, 161-173. DOI: 10.1002/sd.373

— Shahabi, A., Raissi, S., Khalili-Damghani, K. et al. Designing a resilient skip-stop schedule in rapid rail transit using a simulation-based optimization methodology. Oper Res Int J 21, 1691–1721 (2021). https://doi.org/10.1007/s12351-019-00523-y

— Shapiro, S., & Wilk, M. (1965). An Analysis of Variance Test for Normality. Biometrica, 52, 591. DOI: 10.1093/Biomet/52.3-4.591

— Shapiro, S., Wilk, M., & Chen, H. (1968). A Comparative Study of Various Tests for Normality. Journal of The American Statistical Association - J AMER STATIST ASSN, 63, 1343-1372. DOI: 10.1080/01621459.1968.10480932

— Shen, L. Y., & Tam, V. (2002). Implementation of environmental management in the Hong Kong construction industry. International Journal of Project Management, 20, 535-543. DOI: 10.1016/S0263-7863(01)00054-0

— Shen, L. Y., Tam, V., Chan, C. W. S., & Kong, S. Y. J. (2002). An examination of the waste management practice in the local construction site. Hong Kong Surveyors, 13, 39-48.

— Sokame, B. M., Tonnang, H. E. Z., Subramanian, S., Bruce, A. Y., Dubois, T., Ekesi, S., & Calatayud, P.-A. (2021). A system dynamics model for pests and natural enemies interactions. Scientific Reports, 11(1), 1401. DOI: 10.1038/s41598-020-79553-y

— Sorrell, S. (2003). Linking: Climate policy and the reform of the UK construction industry. Energy Policy, 31, 865-878. DOI: 10.1016/S0301-4215(02)00130-1

— Springett, D. (2005). Editorial: Critical Perspectives on Sustainable Development. Sustainable Development, 13, 209-211. DOI: 10.1002/sd.279

— Sy, C., Ching, P. M., San Juan, J. L., Bernardo, E., Miguel, A., Mayol, A. P., . . . Mutuc, J. E. (2021). Systems Dynamics Modeling of Pandemic Influenza for Strategic Policy Development: a Simulation-Based Analysis of the COVID-19 Case. Process Integration and Optimization for Sustainability. DOI: 10.1007/s41660-021-00156-9

— Tangestani, A., feizi, k., Bamdad Soufi, J., Tangestani, M., & Khatami Firouzabadi, S. M. A. (2020). A Pattern for Sustainable Development from Perspective of Stakeholders Theory. Journal of Industrial Engineering, International, 16(4), 57-67. DOI: 10.30495/jiei.2020.678789

— Torres, J. P., Kunc, M., & O'Brien, F. (2017). Supporting strategy using system dynamics. European Journal of Operational Research, 260(3), 1081-1094. DOI: https://DOI.org/10.1016/j.ejor.2017.01.018

— Trollman, H., & Colwill, J. (2021). The imperative of embedding sustainability in business: A model for transformational sustainable development. Sustainable Development, n/a(n/a). DOI: https://DOI.org/10.1002/sd.2188

— Ugwu, O., Kumaraswamy, M. M., Wong, A., & Ng, S. T. (2006). Sustainability appraisal in infrastructure projects (SUSAIP): Part 1. Development of indicators and computational methods. Automation in Construction, 15, 239-251. DOI: 10.1016/j.autcon.2005.05.006

— Ukko, J., Saunila, M., Nasiri, M., & Rantala, T. (2021). The importance of sustainability engagement in small businesses supplier collaboration. Sustainable Development, n/a(n/a). DOI: https://DOI.org/10.1002/sd.2224

— Ventana Systems, I. (2015). Vensim® Personal Learning Edition (PLE). from https://vensim.com/vensim-personal-learning-edition/

— Villaseñor, J., & González-Estrada, E. (2009). A Generalization of Shapiro–Wilk's Test for Multivariate Normality. Communications in Statistics—Theory and Methods, 38, 1870-1883. DOI: 10.1080/03610920802474465

— Wced. (1987). Report of the world commission on environment and development: our common future (the Brundtland Report). Med. Confl. Surviv, 4.

— Weerasinghe, A. S., & Ramachandra, T. (2020). Implications of sustainable features on life-cycle costs of green buildings. Sustainable Development, 28(5), 1136-1147. DOI: https://DOI.org/10.1002/sd.2064

— Williams, K., & Dair, C. (2007). A Framework of Sustainable Behaviours that can be Enabled through the Designs of Neighbourhood-Scale Development. Sustainable Development, 15, 160-173. DOI: 10.1002/sd.311

— Yanarella, E. J., & Bartilow, H. (2000). Beyond environmental moralism and policy incrementalism in the global sustainability debate: Case studies and an alternative framework. Sustainable Development, 8(3), 123-134.