

## SYSTEM DYNAMICS MODELING FOR NATIONAL AGRICULTURAL SYSTEM WITH POLICY RECOMMENDATIONS: APPLICATION TO IRAN

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Using system dynamics (SD) approach, this paper develops a simulation model to study the behaviors and relationships within the agricultural system at national level and analysis the future scenarios. The proposed model considers three major sub-systems: demand side (population and income), supply side (land use, water resources, and productivity), and regulatory side (barriers, incentives, and support). Iranian agricultural system is modeled using this approach and the future conditions are simulated under three if-then scenarios up to 2040. The results show that under the policies as current conditions, the demand for the agricultural products will rapidly increase due to the population growth and economic development. However, agricultural land use and domestic supply does not experience much growth because of crucial limitations in the climatic conditions, available water resources, and rather low productivity; therefore, the gap will be compensated through an ever increasing import. The suggested SD model helps policy makers to identify the bottleneck points in the system based on simulation results and then, improvement policies can be made according to these bottlenecks. Some improvement policies for supply side have been proposed and effectiveness of them on increase in production and agricultural land use development has been demonstrated. By improving supply side policies alone, the Iranian government's goal of agricultural self-sufficiency is not likely to be achieved and it is essential to improve the demand side policies in this regard. The suggested model has proven to be useful for Iranian agricultural system, and its methodology could be used as a decision support tool for land use planning, policy making and managements of agricultural sector.

**Keywords:** Agricultural system, simulation model, system dynamics, system improvement, scenario analysis

### INTRODUCTION

Agricultural development is the basis of human survival. However, critical resources for food production, including land and water are significantly under pressure of factors like population growth and economic development as well as ecological changes. Therefore, future farmers must produce a greater amount of agricultural products using fewer resources. As a result, an appropriate insight into the future developments of the agricultural sector is significantly important for both whole society and policy makers, reaching to which requires scientific and comprehensive models (Schneider *et al.*, 2011).

In recent years, agricultural systems have been widely studied and there are numerous researches which have discussed the interaction between different drivers and variables on global scales (Verburg *et al.*, 2013; Schaldach *et al.*, 2011). Some studies have revealed the implication and prospect of agriculture from an engineering and technical point of view, and some research has used economic assessments (Stoorvogel *et al.*, 2004). Meanwhile, biophysical and geographic evaluations (Hu *et al.*, 2014; Titttonell *et al.*, 2009) are mainly based on different conditions of production and its consequences. In this regard, those studies which have merged the ecological, economical

and technological aspects together are known as the integrated evaluations (Bouwman *et al.*, 2006). With clear advantage on single-factor studies, these comprehensive studies are simultaneously able to measure the effects of a set of drivers and factors such as the economic development, population growth, environmental changes, technological progress and possible policy pathway (Schneider *et al.*, 2011).

In spite of the advantages of the integrated models, they incorporate some complexities. Senge (1994) introduces two types of complexity as below: (1) details, and (2) dynamics. Complexity of the details is associated with systems which have many components, while the complexity of the dynamics is related to those having effects which are separated by time and/or space (Zarghami and Akbariyeh, 2012). What is usually seen in the agricultural systems is the dynamic complexity which causes significant problems for agricultural management. This is because one cannot generally establish a relationship between their causes and effects which are removed during time or distance. To solve this type of complexity, the approach of system dynamics enables us to perform multi-scenario and multi-characteristic analyses, and to conduct relative comparisons among several competitive management strategies during the time (Sehlke and Jacobson, 2005). The SD method is based on

cybernetics, system theory and information theory, which its main characteristic is its ability to reflect the interactions between structures and behaviors of complex dynamic systems, real dynamic simulation, and estimating the behaviors of the system under different scenarios (Sterman, 2000). A great deal of research work has shown that the SD method can be used in many areas, including agricultural systems (Saysel *et al.*, 2002; Teimoury *et al.*, 2013), environmental management (Turner *et al.*, 2013; Mashayekhi, 1990), ecological modeling (Kopainsky, 2015; Wu *et al.*, 1993), water resource planning (Aivazidou *et al.*, 2015; Niazi *et al.*, 2014), and can be regarded as a useful tool for scenario analysis in the land use researches (He *et al.*, 2005; Rasmussen *et al.*, 2012; Liu *et al.*, 2013). Despite numerous studies in recent years in the field of agricultural land use change modeling using system dynamics technique (Shi and Gill, 2005; Luo *et al.*, 2010; Rozman *et al.*, 2013), but there is still research gaps on SD models using macro socio-economic driving factors in an open economy and at national level to predict the future agricultural land use change and assess the effects of improvement policies.

Iran is a country with a population of almost 80 million, the policy makers of which have recently emphasized on abandonment of the birth control policies. The demand for food and agricultural products is increasing due to population growth. The arid climate together with some imposed sanctions has added to concerns regarding the food security in Iran. Existed gap between demand and supply of agricultural products needs more effective application of the resources, especially water, land, and of course, management tools. Therefore, modeling of scenarios which address how to develop the agricultural land use and evaluate its mutual effect with the demand and supply of the agricultural products in Iran is of clear theoretical and practical importance.

Taking the aforementioned gaps in the literature and the case of Iran into account, a system dynamics model for agricultural system is developed here to evaluate future development of agriculture at the national level. Having calibrated the model based on the historical data (1980-2011), three scenarios were designed on the basis of population growth and economic development. According to the different system conditions, the area of the land use and the amount of demand, supply and trade of the agricultural products are discussed under each of the scenarios, in addition to their economic and technical consequences during the next 25 years in Iran. The improvement policies are explained based on the analysis carried out on the system and the effectiveness of these policies has been proven. Although this method is proposed in order to analyze the agricultural system in Iran, it is still applicable for analysis of the other variables and agronomic systems, especially in other developing countries.

## MATERIALS AND METHODS

**System dynamics method:** The system dynamics method was created by Professor Forrester (1958) and after decades, this modeling process has been widely used in the study of complex systems, as mentioned above. The main characteristics of this method are the existence of complex systems, the change of system behavior, and the existence of the closed-loop feedback to describe the new information about the system conditions that will yield the next decision (Li *et al.*, 2012). Sterman (2000) has developed steps to create system dynamics (Suryani *et al.*, 2010):

**Step 1:** Problem articulation: in this step, we need to find the real problem, identify the key variables and concepts, determine the time horizon and characterize the problem dynamically for understanding and designing policies to solve it.

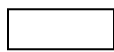
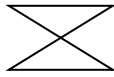

**Step 2:** Dynamic hypothesis: modelers should develop a theory of how the problem arose. In this step, we need to develop a causal loop diagram that explains causal links among variables and convert the causal loop diagram into the flow diagram, which consists of three variables as depicted in Table 1.

**Step 3:** Formulation and deployment in software: In this step, we should translate the system description into levels, rates and auxiliary equations. We need to estimate some parameters, behavioral relationships, and initial conditions.

**Step 4:** Testing: the purpose of testing is to compare the simulated behavior of the model to the actual behavior of the system.

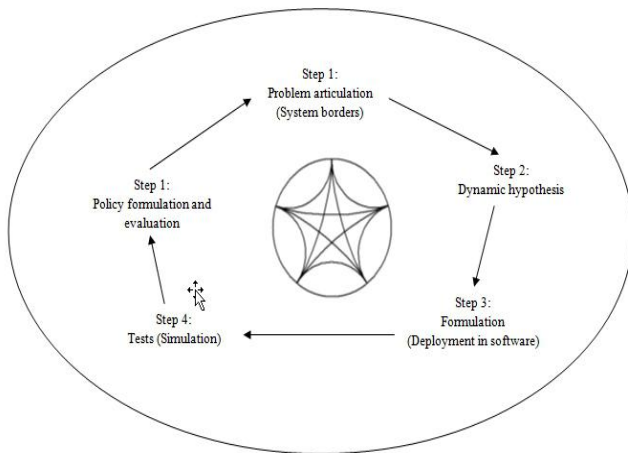
**Step 5:** Policy formulation and evaluation: We can utilize the valid model to design and evaluate policies for improvement.

**Table 1. Some variables in system dynamics**

Variable	Symbol	Description
Level		A quantity that accumulates over time, changing its value by accumulating or integrating rates
Rate		Change the values of levels
Auxiliary		Arise when the formulation of a level's influence on a rate involves one or more intermediate calculations

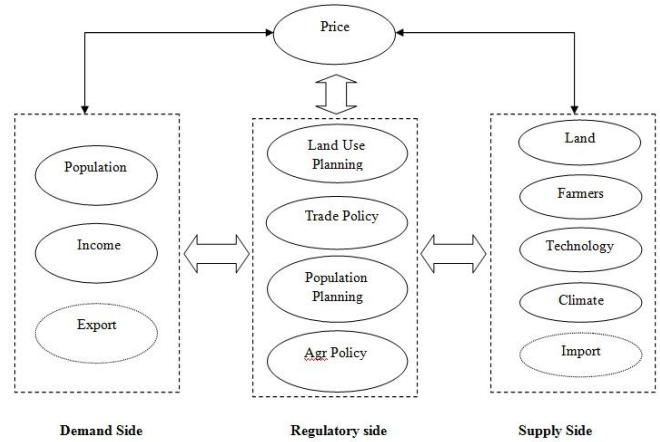
**Logical framework of the model:** The agricultural system can be considered including the three following subsystems: demand, supply and regulatory. The demand subsystem mainly includes two elements of population and economy. Thus, performance of this subsystem, demand for the agricultural products will increase. This demand stimulates the supply subsystem via price mechanism. The supply subsystem includes available agricultural land, farmers, climate and technology. In addition, in an open national

economy, some demand for export exists and some portion of supply imported from foreign. A part or all of the demand will be satisfied with the interaction of supply side elements. A shortage emerges when the demand exceeds the supply, while the resources will be wasted when the supply is more than the demand. To regulate this imbalance, in the regulatory subsystem, a decision maker may adopt optimization policies to interact between the demand subsystem and the supply subsystem. In order to create an equilibrium and sustainable development in the whole agricultural system, these policies include: trade policies, land use planning, population planning and other agricultural policies for example supportive policies in this sector (Fig. 1).



**Figure 1.** Five steps for System dynamics modeling

**Stock-Flow diagram (SFD):** Stock-flow diagram is the core of SD model, and is the process of quantization and materialization of causal loop diagram (Li *et al.*, 2012). Figure 2 represents the whole stock-flow diagram of the model designed in Vensim software (licensed). In this figure, the sign "+" indicates a positive feedback relation, while the sign "-" indicates a negative one. Additional details about the simulation procedures are available from the authors. To facilitate discussion, the model can be divided into four parts as below.



**Figure 2. Logical framework of the model**

**Part 1. Demand:** This loop addresses the changes in demands for the agricultural land use and agricultural products and also urban land use. It includes five variables, namely: population, GDP, urban land area, price, and demand. In the demand part, the amount of population and GDP with positive effect and the price level with negative effect form the whole demand for the agricultural products (Eq. 1-2). Increased demand leads to higher price, which in turn leads to smaller demand by triggering the supply in a negative loop. Meanwhile, increased population and GDP results in greater demand for the urban land use (i.e. residential, industrial and commercial) and thereby, lead to encroachment to the agricultural lands and acts as a pressure factor to change agricultural land use.

$$Demand(t) = \int (Change\ in\ demand) dt + Initial\ demand(0) \quad (1)$$

$$Change\ in\ demand = (GDP * Population) / (Price) \quad (2)$$

**Part 2. Supply:** This part reflects the effective mechanisms on production and supply of the agricultural products. It has six main variables, namely: price, production, agricultural value added per worker, agricultural land use, water resources and productivity. Increased prices lead to increased value added per worker and thus encourage farmers to develop agricultural land area. The amount of production increased along with development of the agricultural land so that the prices decrease and get equilibrium (negative loop). On the other hand, an increase in production positively affects farmer income and it has significant influence on increasing the agricultural value added per worker (Eq. 3-6). In addition to agricultural land area, productivity is another factor which has positive effect on the amount of production. Irrespective of the positive effect of technology growth on productivity, an increase in the land area and consequently using more water, reduce the available water resources per unit area of the land which altogether reduce the productivity (Eq. 7-10). In fact, limitation of the water resources which is mainly determined by climate conditions is a limiting factor for agricultural lands and productions development.

$$\text{Agricultural land area}(t) = \int (\text{Change in ALA}) dt + \text{Initial ALA} \quad (3)$$

$$\text{Change in ALA} = \text{Value added per worker} / \text{Urban land area} \quad (4)$$

$$\text{Value added per worker} = \text{Farmer income} * \text{Price} * \text{Subsidy} \quad (5)$$

$$\text{Production} = \text{Agricultural land area} * \text{Productivity} \quad (6)$$

$$\text{Productivity} = \text{Technology} * \text{Available water resources} * \text{Water productivity} \quad (7)$$

$$\text{Technology}(t) = \int (\text{Increase in technology}) dt + \text{Initial technology} \quad (8)$$

$$\text{Increase in technology} = \text{Capital stock} \quad (9)$$

$$\text{Available water resources} = (\text{Precipitation} * \text{Capital stock}) / \text{ALA} \quad (10)$$

**Part 3. Agricultural sector support:** This part reflects the government and private sector support from agriculture, comprising of four variables: GDP, government expenditures in agriculture, subsidies allocated to agricultural sector and rate of investment in agriculture. By increasing of the domestic income, the government gets greater income to invest in the agriculture. A part of this appears as investment and other part emerges as subsidies; these consequently, compensate some costs for farmers. Moreover, beside consumption, a part of incomes is always spent on investment. Thus growing economy and income makes the private sector able to accumulate more capital in the agricultural sector. This increased investment results in productivity and production enhancement as discussed in part 2 (Eq. 11-14).

$$\text{Capital stock}(t) = \int (\text{Investment}) dt + \text{Initial capital stock} \quad (11)$$

$$\text{Investment} = \text{GDP} * \text{Investment rate} \quad (12)$$

$$\text{Subsidy} = \text{Government expenditure} \quad (13)$$

$$\text{Government expenditure} = \text{GDP} \quad (14)$$

**Part 4. Trade:** The difference in the amount of domestic demand and supply of the agricultural products lead to agricultural trade mechanisms which are shown in this sector. This sector includes six variables: domestic price, world

price, trade barriers, trade incentives, import, and export. Overtaking of the demand to the production of a product adds to its prices and makes import economically justified. Therefore, the trade barriers decrease and more import results in domestic price reduction and balance between the supply and the demand by satisfying a part of the demand through import. Furthermore, when the domestic price of a product is less than from its world price, there would be motivation to export it. Export raises the domestic price and establishes equilibrium between the domestic price and the world price (Eq. 15-19). In fact, trading of the agricultural products creates equilibrium between the domestic price and abroad.

$$\text{Price}(t) = \int (\text{change in price}) dt + \text{Initial price} \quad (15)$$

$$\text{Change in price} = \text{Price} * (1 + \text{Inflation rate}) \quad (16)$$

$$\text{Inflation rate} = (\text{Demand} * \text{Export}) / (\text{Production} * \text{Import}) \quad (17)$$

$$\text{Import} = 1 / \text{Trade tariff} \quad (18)$$

$$\text{Export} = \text{Trade incentive} \quad (19)$$

**Parameter estimation and calibration:** To study the behavior of the system over time, we need to instruct mathematical equations and estimate the parameters and coefficients. Calibration is the process of parameter estimation by using historical data or observation from a system. The described model includes a certain number of parameters and coefficients which their values have been calculated by estimation techniques. The estimation of parameters in stock-flow diagram can be obtained from different sources. e.g., proven equations of previous researches, statistical analysis of time series, and weighting ratio changes between variables based on experts knowledge. A large amount of data is used in this research (Table 2). Some of these data were input directly into the SD model for future simulation and some were used only for calibration of

**Table 2. Datasets used in this study**

Variable name	period	Level of details	Data sources
SD model			
Population	1980-2014	Country	WB (data.worldbank.org)
	2015-2040	Country	World population prospects
Economic growth rate	1980-2014	Country	WB (data.worldbank.org)
World agricultural price index	1980-2014	Middle East	FAO statistical database (http://faostat.fao.org/)
Precipitation	1980-2014	Country	Iran Meteorological Organization (http://www.irimo.ir/)
Agricultural land area	1980-2013	Province	Annual Agricultural Statistics of Iran (http://amar.maj.ir/)
	2015-2040	Province	Simulation by SD model
Model calibration & validation			
FAO statistical database	1980-2014	Country	FAO statistical database
World bank (WB) database	1980-2014	Country	WB (data.worldbank.org)
Statistical center of Iran (CBI) database	1980-2014	Country	CBI (http://www.amar.org.ir/)
Ministry of agriculture jihad database	1980-2014	Province	MAJ (http://amar.maj.ir/)

the model.

**Model validation:** System dynamics models, which are classified in the class of causal mathematical models, can be validated by collected data and available literature. Then these models develop tools to test scenarios and make different simulations. Two types of validation in this regard include: structural validation and behavioral validation. Structural validation is the process of determining whether the theories and assumptions underlying the conceptual

model are correct, reasonable, and sufficient. Behavioral validation or verification is the process of determining whether the model behaviors accurately represent the conceptual framework of the model.

Since we developed the proposed model based on expert knowledge and available literature, structural validation of the proposed model in this paper has been approved in several focus groups in academic centers related to agricultural and economic studies. Behavioral validation of the model has been done by several ways which the most important ones below.

*Verification with historical data:* The developed model is verified using the data during the time horizon from 1980 to 2011. According to Barlas (1996), a model will be valid if the error rate is smaller than 5% (Eq. 20), where denotes the average of the simulation result, and denotes the average of the historical data.

$$\text{Error rate} = \frac{|S-A|}{A}$$

In this research, the examined variables include demand, production, import, and agricultural land area. Table 2 shows the verification results. Based on results, all the error rates are smaller than 5%, which confirms that the proposed model is valid. The detailed comparison between simulation results and historical data are given in Figure 3.

**Sensitivity analysis:** The results of sensitivity tests also confirmed the validity of the model. Due to the limitation of

space, the paper only chooses the investment rate, a rather more important factor. For example, if investment rate increases by 10%, it is expected that production and agricultural land area will gradually increase and import amount will slowly decrease. After simulation, model outputs confirmed this prediction (Fig. 4).

## RESULTS AND DISCUSSION

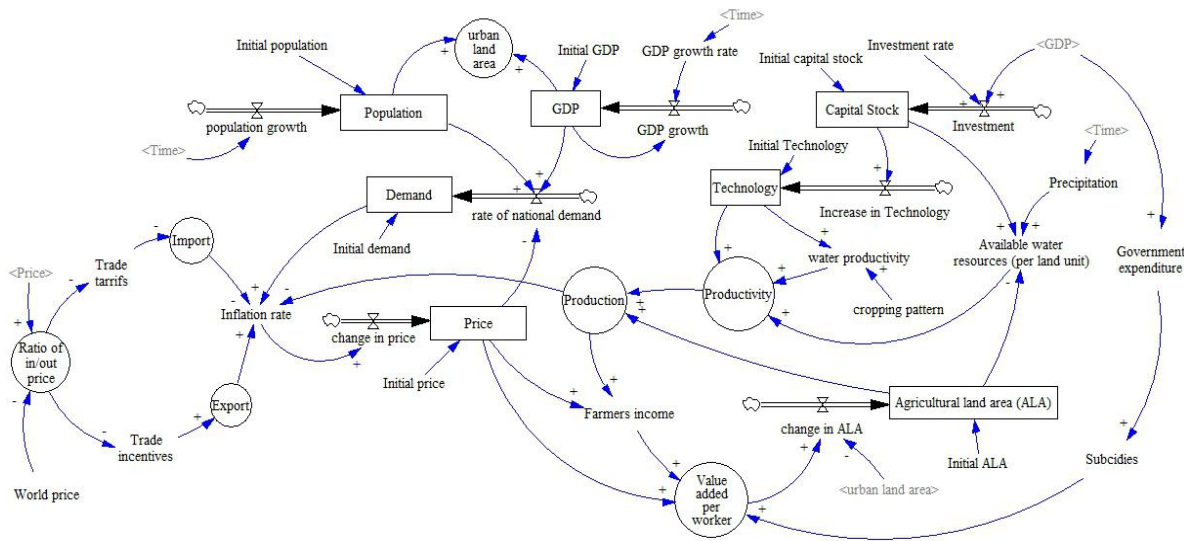


Figure 3. The stock-flow diagram of the model

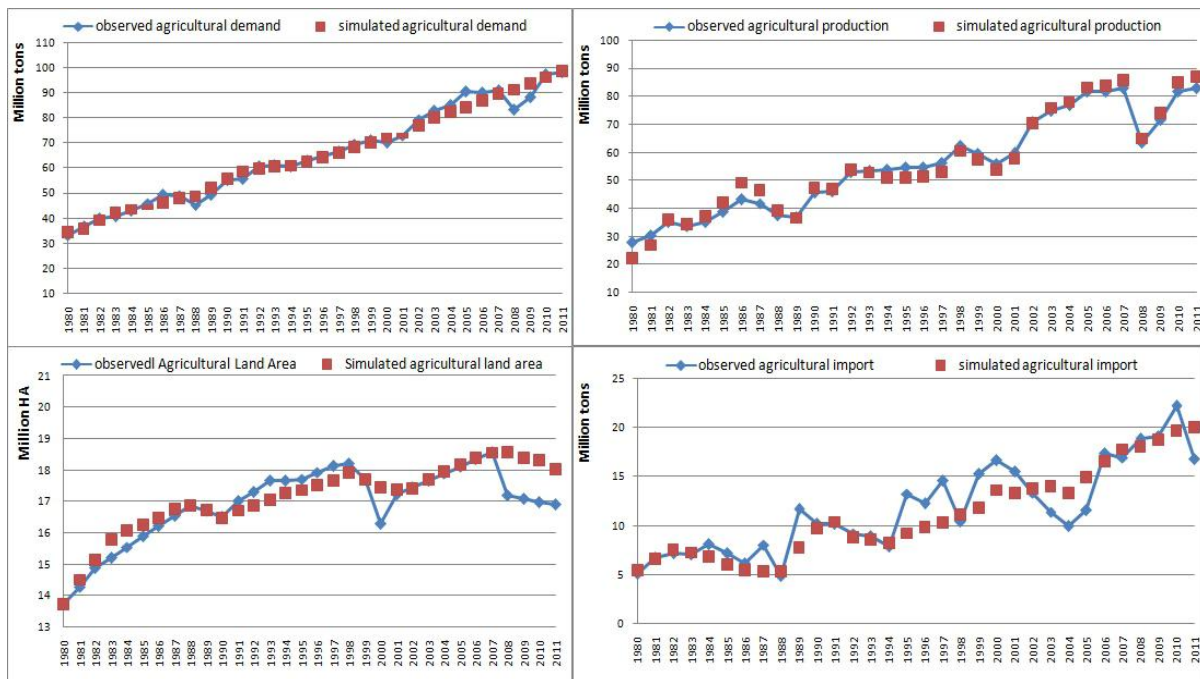


Figure 4. Comparison between simulated results and observed data



**Study area:** Iran is the second largest country in the Middle East with a population of approximately 80 million people. From its total area of 1,648,000 km<sup>2</sup>, just one-third is agriculturally usable land. Again, only 15% of the land is dedicated to agriculture due to the unsuitable soil, lack of water and unfavorable distributed precipitation (Ehlers, 2014). Agriculture in Iran is heavily dependent on rainfall and the limitation of water resources and unfavorable climatic conditions can be considered as the major crisis of future in the field of agriculture. Other significant problems involve unproductive methods, inappropriate distribution system, desertification and encroachment of industrial activities and urbanism to rural areas and agricultural lands. Although food security index in Iran is high, but the above mentioned issues together with the imposed economic and commercial sanctions on this country have arose concerns for the future.

Management of the agricultural sector needs to be promoted in order to maintain the food security. Iran government is currently studying and implementing the strategies for agricultural self-sufficiency. Thus, in this part, identification of the main effective factors in development of the agricultural sector and modeling the change scenarios is being investigated using the system dynamics approach.

**Scenario development:** Based on the prediction scenarios of UN for the population of Iran until 2040 and also on the basis of the statistics extracted from regional and national variables of Iran from 2002 to 2012, three combinations of exogenous variables including population, economic growth and precipitation have been designed for the future 25 years. Three scenarios are defined for the future in accordance with this combination (Table 3). The first scenario is based on high fertility rate and economic growth greater than the average value of previous years. The second scenario is based on average fertility rate and economic growth equal to previous years, while the third scenario is based on low fertility rate and economic growth smaller than recent years. In addition, it is assumed that the annual precipitation in all

scenarios is similar to the average of the past years.

Although we build above scenarios based on some proven assumption about positive correlation between economic development and population growth, but other scenarios based on different parameter setting could be designed and evaluated in future studies.

Using the model, the probable evolution trends of the agricultural system variables including demand, production, trade, and land area between 2015 and 2040 under three above scenarios are simulated and analyzed (Fig. 5).

**Demand:** Simulation results indicate that the demand for food and other agricultural products will increase significantly. Demand will grow based on the population growth rate. Especially in the first scenario which incorporates the maximum population growth rate; the demand for the agricultural products will reach 230 million tons from the current 100 million tones until 2040. If the growth in supply or trading of the agricultural products is not this much, the food security will be threatened in the next years.

**Agricultural land area:** As observed results indicate, trend of changes in the agricultural land area will almost be the same in all of the three scenarios. Based on the simulation results, the agricultural lands until 2025 will gradually increase from the current 16.7 million hectares to 19.5 million hectares, and then remain almost constant. Arid and semi-arid climate, and lack of water resources and decreasing trend of groundwater during the coming years, will act as the main limitation in development of the agricultural lands in Iran. Meanwhile, the increased population and demand for the urban land use and encroachment to the existing agricultural lands are other factors which prevent agricultural lands from development.

**Table 3. The average value of the simulation results (S) and historical data (A)**

Variable	Simulation ()	Historical data ()	Error rate
Demand (tons)	65174156	65156740	0.02 %
Production (tons)	55980859	55632946	0.60 %
Import (tons)	11342531	11662661	2.74 %
Agricultural land area (1000 Ha)	16999	16910	0.50 %

**Table 4. Designed scenarios based on the growth of population and economic development within 2015-2040**

	2002-2012	Scenario 1	Scenario 2	Scenario 3
Fertility rate		High*	Medium*	Low*
GDP growth rate	4.9 %	High (5.9%)	Medium (4.9 %)	Low (3.9 %)
Annual precipitation	212 mm	212 mm	212 mm	212 mm

\* U.N World Population Prospects: The 2012 Revision

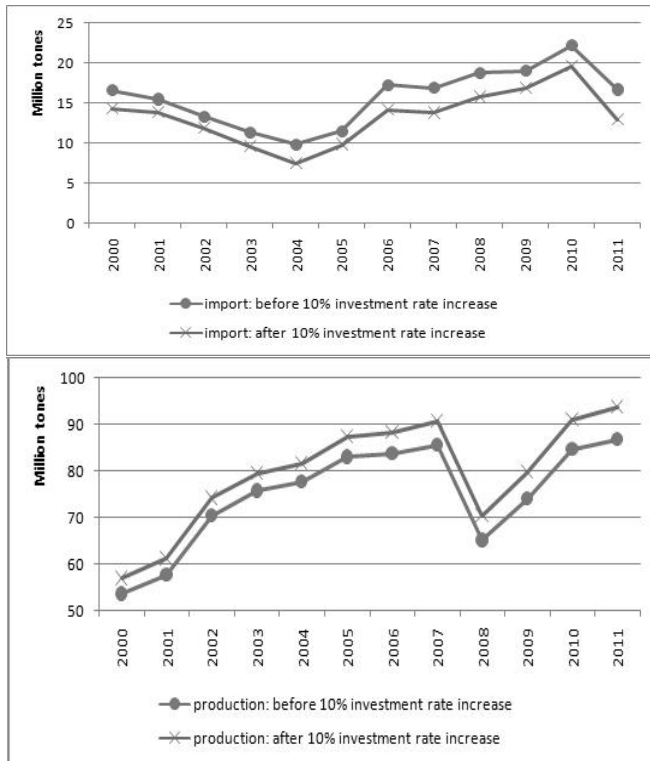


Figure 5. Sensitivity analysis of the model

**Production:** In spite of considerable growth in the demand, agricultural production will experience little growth in all the three scenarios. Actually, Iranian agriculture is faced to serious limitations including shortage of the water resources and low productivity, which are barriers to a significant increase in production. Assuming that current policies are followed without any other action to deal with the above mentioned limitations, the gap between the demand and supply of the agricultural products will drastically increase during the coming years, such that this gap will reach 200 million tons from the current 15 million tons in the third scenario until 2040.

**Trade:** The results from implementation of the model reveal that the agricultural products trade will incorporate different behaviors in import and export. Although export of the agricultural products will slowly grow, the positive trend of import is significant in all of the three scenarios. In fact, without growth of the production, the export will not grow much accordingly. However, taking into consideration the increased gap between the demand and supply, this gap will be compensated via import. Thus, continuing of current agricultural system's trend, Iran must be considered as a country which is heavily dependent on importing of the agricultural products in order to satisfy its demands in future.

**Improvement policies and prediction of effects:** Using the SD technique and developed model, in addition to the simulation and prediction of the possible future scenarios

based on previous trends and current conditions, we can also simulate system changes under the conditions of policy making. The improvement policies will change some functions and variables in the model and then, the effects of these changes on the trend of other variables will be shown.

As simulation results indicate, due to limitations in agriculture development, Iran will be forced to supply almost half of its demands by importing from foreign in next year's. There are numerous studies which have suggested the agricultural policies which should be included into national policy framework in Iran (Fami *et al.*, 2007). With regard to these researches and considering the arid climate and the lack of water, increasing the productivity of land and water resources is the last and only chance to conserve the agriculture in Iran. Required actions to attain this aim have been discussed in the following along with the effects of them. It should be noted that all of these policies are related to supply side to increase production and we leave demand side policies to future studies.

#### Improvement policies

- 1) Reallocation of the agricultural land use: The government should redesign location of the agricultural lands with respect to limitation of the water resources. Thereby, the cultivated area must be reduced in some areas, and must be increased in others.
- 2) Optimization of the cropping pattern: The government should carry out adjustment and incentive policies to change the cropping pattern considering the land capabilities and water consumption in the country.
- 3) Revising the irrigation system: The government should adopt a rationing system for the underwater resources and revise the irrigation system to increase efficiency of the agricultural water consumption.
- 4) Improvement of productivity via investment: Both the government and the private sector should take any necessary action to increase the investment in the agricultural sector for further mechanization. The government should also raise percentage of expenditures in the agricultural sector to support the farmers. In addition to domestic investment, the government should adopt to attract foreign investment and support of international organizations like FAO. This investment will eventually contribute to increase productivity of the land and water.

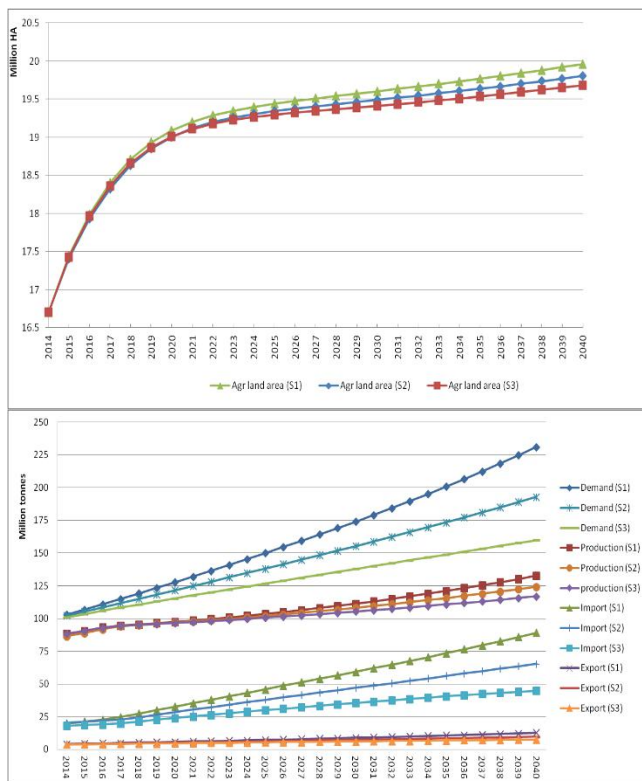
**Changes in the model:** The percentage of GDP which is invested in the agriculture is increased, and then the available investment in this sector (the capital variable) will also increase. This increase is reflected in terms of increased amount of the technology and productivity variables and thus increased amount of the production per land unit. Furthermore, by an increase in the government expenditures, subsidies will increase and this will provide an incentive for farmers to develop the agriculture. Optimal reallocation of the agricultural lands reduces the negative impact intensity



of land area development on available water resources. Therefore, it is possible to say that greater areas of the lands can be cropped for a certain amount of water. Meanwhile, changing the cropping pattern and modifying the irrigation system, increase water productivity and consequently will increase the productivity through another path.

**Prediction of influences:** The results of simulation indicates that having applied the improvement policies, production will significantly grow due to increasing of the productivity (volume produced per land unit), while the import will decrease accordingly. However, due to the arid climate and the seriously limited water resources, agricultural land area will not develop remarkably.

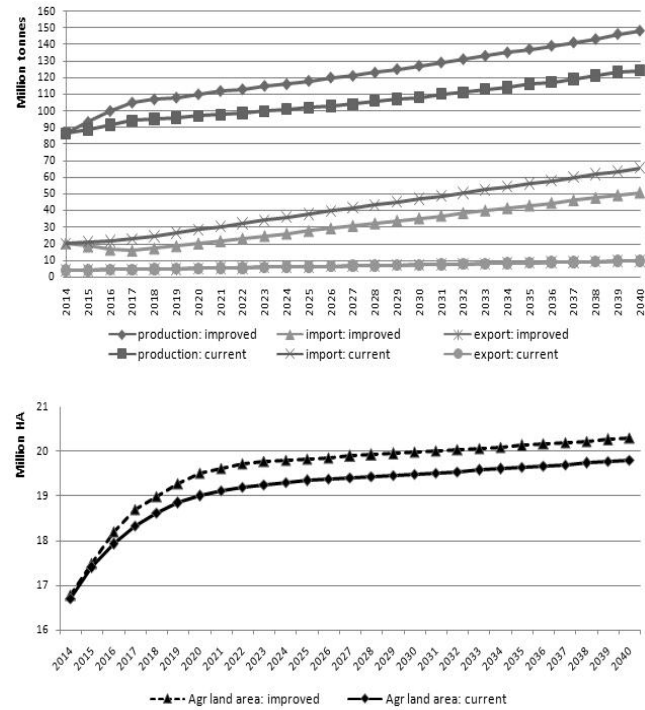
For example, in case of scenario 2, the productivity index will reach 7.2 from its current 4.5 until 2040. In spite of the insignificant change of the agricultural land area, production will grow up by 62 million tons in 2040 compared to 2014 (i.e. 80%) due to the increased productivity. With more production, the slope of import growth will be gentler and finally reach 50 million tones until 2040 which cover something around one-third of the local demand (Fig. 6).



**Figure 6. Simulation of agricultural variables during 2015-2040 under 3 scenarios**

The results show that even in case of improvement in the policies of the agricultural supply side and taking into account the trend of population growth and economic development, Iran will face increasing import needs for the

agricultural products to satisfy the domestic demand. In fact, the government's goal of agricultural self-sufficiency is unlikely to be achieved and then, finding sustainable resources of the agricultural products in other regions of the world and trade facilitation will thus be of critical importance for the purpose of food security. Meanwhile, adopting the improvement policies on the demand side and modifying of consumption pattern can reduce the gap between supply and demand, investigating the type and effects of which can be deemed as future studies.



**Figure 7. Simulation of agricultural variables under conditions of using improvement policies (scenario 2)**

**Conclusion:** Here a system dynamics model was proposed for simulation, analysis and improvement of the agricultural system. The proposed model shows the interactions of the influential variables in three sub-systems of supply, demand and policy making. On the basis of the developed model, causal feedback loops and effects of agricultural variables on each other could be analyzed. In addition to analysis of future scenarios, the model provides the conditions for diagnosing the improvement policies and also testing the influence of the improvement policies via simulation.

Iranian agricultural system was analyzed as a case study by using this approach. Based on the simulated results, future situation of the Iranian agriculture in the case of adopting current policy trend was addressed in terms of three population-economic scenarios. The growth of population and economic development will rapidly increase the demand,

while supply does not experience much growth because of crucial domestic limitations in the agricultural system. Lack of water resources and rainfall, low efficiency of water resources, unproductive agricultural methods, inappropriate distribution system, desertification and encroachment of industrial activities and urbanism to rural areas and agricultural lands, are some major limitations in this regard. Therefore, under business as current conditions, a significant portion of demand will satisfy through an ever increasing import.

Aims to reduce the gap between supply and demand, the improvement policies were made based on the identified bottleneck points in the supply side: (1) agricultural land use reallocation; (2) cropping pattern optimization; (3) irrigation system revising; (4) productivity improvement via investment. By using the SD model, the results of implementing these policies on growth of the production and productivity were shown. The offered improvement policies can be an appropriate reference for management and development of the agricultural system in Iran. The results show that improving supply side policies alone cannot lead to the government's goal of agricultural self-sufficiency. As can be seen in simulated future trends, the rate of increase in demand in the face of population growth is very high. This may be the result of incorrect consumption pattern and high rate of waste in agricultural products. Some policies that could be followed in this regard are: (1) Modifying the individual, social, and organizational consumption culture through education and promotion; (2) reform in pricing system especially in energy; (3) redirecting subsidies toward production rather than consumption. Implementing these demand side policies can help to achieve government's goal; we leave further analysis of them to future studies.

Finally, the characteristics of the proposed model turn it into a useful tool for analysis of the agricultural system and helping to the decision makers to take optimal policies. As a general conclusion, this model not only can be utilized as an effective decision support system for the land use planning and management of the agricultural sector, but also can be an appropriate basis and reference to develop rather complicated models for studying eco-agricultural and agronomics systems.

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