The Role of Cotton Production in the Textile Supply Chain and the Study of the Amount of Pollution Production: A System Dynamic Study

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(Corresponding Author)

Zahra Faezi[1]
Azam Alikhademi[2]

[1,2]*Alzahra University, Tehran, Iran.*
[s]*Email: a_alikhademi@yahoo.com Tel: 09196090191*

ABSTRACT

Textile industry uses massive amounts of cotton annually and as the population of the world grows, the more people need textile, and the more cotton needs to be harvested. This study was an attempt to examine the impact of cotton production of the textile supply chain on people and the ecosystem. The data has been gathered from FAO, WHO, and other valid databases. Thirty participants were also asked to answer a questionnaire, who were proficient farmers acquainted with cotton cultivation. The questions were analyzed by System Dynamics (SD) Model to explore water, air and soil pollution, mortality and poisoning of humans and animals, and the use of pesticides. The findings of this study revealed that cotton production not only does have significant but also increasing repercussions for the environment and humans. These effects are especially worrying when 40% of this cotton is used in the enormous and ever-increasing textile industry, hence, in the end, suggestions have made on cutting down on them.

Keywords: *Cotton, System dynamic, Textile supply chain.*

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Highlights of this paper

- The impact of cotton production of the textile supply chain on people and the ecosystem.
- System Dynamics (SD) Model explores water, air and soil pollution, mortality and poisoning of humans and animals, and the use of pesticides.
- Cotton production not only does have significant but also increasing repercussions for the environment and humans.

1. INTRODUCTION

Cotton is an agricultural product made from the fibers that cover the seeds of the cotton plant (scientifically called Gossypium). Cotton is made up of soft, fluffy fibers that go into a capsule around the seeds of the cotton plant. These fibers are made of cellulose and due to their covering properties; they can take the plant seeds with them to distant areas and help the plant to spread. It is one of the uses of cotton in the textile industry (Chronology, 2020). Uses such as cotton fabrics, socks, underwear, baby clothes, towels, velvet fabrics, bedding, and the yarn used in crochet and knitting are also often made of cotton. Many fabrics are made entirely of cotton fiber. Some other fibers can also be mixed with cotton, thus adding other required properties to the fabric. For example, a mixture of rayon with cotton or a mixture of synthetic fibers such as polyester with cotton. Cotton yarn can also be mixed with stretched yarn to produce the knitwear needed for clothing such as jeans and knitwear (Cotton-Production, 2020). In addition to the textile industry, cotton is used in fishing nets, coffee and tea filters, explosives (nitro & cellulose), paper, and binding. The remaining cottonseed can be used to produce oil (after refining) like any other oil (Recognizing, 1986).

System dynamics developed in the mid-twentieth century by Forrester led to an understanding of systems behavior based on feedback control theory (Zhang, Calvo-Amodio, & Haapala, 2013). System dynamics can help to understand complex environments. System dynamics assumes that components are interconnected in a complex pattern and that the world is made up of rates, levels, and feedback loops, and the flow of information is more important. Nonlinearity and latency are important components of any system (Spector, Christensen, Sioutine, & McCormack, 2001). In fact, the system dynamics approach is based on the principle that the study of systems statically does not consider all aspects of phenomena alone, in this method, all variables are examined from different aspects (Shi & Gill, 2005). System dynamics not only helps to understand the structure of complex systems, but is also an accurate modeling method for constructing simulations of complex systems and effective organizational policy designs (Kibira, Jain, & McLean, 2009).

According to (Zhao & Tancrède, 2008) this research is aimed at analyzing the environmental and social impacts of China's cotton/textile Production and trade growth on global and domestic factors for policy recommendations in the Cotton/textile sector from a sustainable development perspective. The total cotton demand would be mainly for the domestic market by 2020. By then, all the

Production of domestic textiles and apparel will be used to meet domestic demand and the export is assumed at zero. Cotton imports will be more beneficial to environmental protection. And it will provide domestic employment for 3 million people and help to improve the income for100 million cotton farmers.

According to Beaudry (2020) the researcher stated globally, 35 million hectares of cotton are under cultivation. To control the numerous pests feeding on the cotton plant, farmers have long relied on the heavy application of insecticides, which leads to the pollution of surface and groundwater. In developing countries, half of the pesticides used in all of the agriculture are put toward cotton. Recent advancements in technology, including the ability to modify the cotton plant's genetic material, have made cotton toxic to some of its common pests. Though this has

reduced the use of insecticides, it hasn't eliminated the need. Farmworkers, particularly where the labor is less mechanized, continue to be exposed to harmful chemicals.

Based on Gold (2005) the researcher stated that conventionally grown cotton requires the use of large amounts of chemical pesticides to ensure a healthy crop, which may harm the soil and the surrounding environment. In 1995, pesticides were applied to 10 cotton fields in Alabama to combat a severe cotton worm infestation. It rained heavily afterward, and the run-off contaminated Big Nance Creek, killing 240,000 fish over about a 16-mile area. The pesticides used to grow cotton remain in the soil, where they can seep into the groundwater, and require the use of stronger fertilizers.

1.1. Research of the Study

The method of this research is quantitative. The type of research is based on the applied purpose and based on how to obtain the required data. The present research is descriptive and from the survey branch. The field method was used to collect information, to identify the indicators (research variables) affecting the formation of the branch by examining the research background, the indicators were identified, and then to complete these indicators and finalize them, a questionnaire was designed by the researchers. According to the final indicators and more extensive studies, the relationship between the final factors was determined and with the help of Vensim software, which is one of the system dynamics software, a causal diagram was designed (Khaki, 2000).

1.2. Vensim Model

System analysis course is one of the main courses in industrial engineering that is taught system dynamics is a method for studying and managing complex and feedback systems. The system dynamics approach is based on the principle that static systems examination does not consider all aspects of phenomena alone. A dynamic system approach is used to analyze and simulate large systems. For the simulation of software development at the undergraduate level. This course is known as the dynamics of systems (Ghobadi, 2006).

1.3. System Dynamics

Change is the greatest achievement of the new age. Rapid changes in technology, population, and economic activity have shifted our world from a simple, trivial state (for example, in the age of information technology to the use of the telephone) to a rich state (such as the effect of greenhouse gases on the world's climate). Sometimes these changes are surprising. Thus, some of these changes pollute our planet, make the human soul and psyche, and threaten human life. All of these changes challenge our old principles, habits, and beliefs. Most importantly, most of the changes the researchers are trying to understand a reflection of human actions. The confusing effects of rapid change are not new. One way to properly identify and understand these changes is to identify systems dynamics. System dynamics is to enhance learning in complex systems. Just as airlines use simulated flights to train pilots, the dynamics of systems identification are, in part, a way for ambitious simulators to develop management. Most computer simulation models help us understand the complexity of dynamics, sources of political resistance, and effective policies. Learning complex dynamic systems requires the creation of mathematical models rather than technological tools. The dynamics of the system are fundamentally internalized. Because the researchers consider the behavior of complex systems, system dynamics is based on the theory of nonlinear dynamics and the development of feedback control in the mathematical, physical, and engineering sciences. Therefore, the researchers use these tools for human behaviors such as physical and technical systems, so system dynamics is designed based on perceptual and social psychology, economics, and other social sciences. As we build system dynamics models to

solve important real-world problems, we need to learn how to work effectively with serious and active policymakers and how to accelerate continuous change in the organization. One of the most widely used software in systems dynamics is Vesim software. Vensim is simulation software designed by Vanata Systems. The system mainly supports system simulation and dynamics, with some discrete event and factor-based modeling capabilities. And is available as a "Personal Learning Tutorial" version. Vensim provides a graphical modeling interface with parabolic, flow, and loop diagrams, a text-based system of equations in a programming language. Vensim model files can be packaged and published in a format that is readable and can be accessed and executed by the reader. This allows interactive models to be shared with users who do not have the app or who do not want the model author to have access to the model code base (Ghobadi, 2006).

1.4. Sampling Method

This method uses a questionnaire that includes thirty questions and includes four options: very low, low, high, and very low, which was surveyed among 30 people.

1.5. The Validity of the Questionnaire

The validity of the questionnaires is a qualitative issue that the reliability of the questionnaire cannot be easily calculated. The validity of the questionnaire addresses the questionnaire scientifically and whether the questionnaire questions measure the desired or not. The questionnaire of this research initially included several initial questions that were provided by agricultural experts and the final questionnaire was designed by face-to-face interview as well as by providing initial questions and comments of experts' agricultural industry.

2. DATA ANALYSIS

The causal links of the model indicate that the population increases with increasing fertility rate and improved medical care. As the population grows, their need for income, jobs, water, medical care, and land increases. The increase of population due to the great need for cotton products, the amount of cotton cultivation increases, and the volume of water used in this sector increases. As the amount of water used increases, the amount of uncontrolled cultivation of cotton increases, and the amount of soil erosion and salinity increases due to uncontrolled cultivation, which reduces soil quality and reduces cotton production

In the next loop, with the increase in cotton production, the yield decline is also increased, which causes the use of droplets to increase and these toxins enter the soil and water. In the ring related to the entry of toxins into the water, it increases the number of people who are exposed to contamination and poisoning, and also causes aquatic creatures to be poisoned and destroyed. In the loop related to increasing soil toxins, these decreases reduce soil quality and reduce its fertility.

2.1. Model Delimitation

The following table (1) shows the framework of the drawing model includes the following boundaries:

*Water pollution.

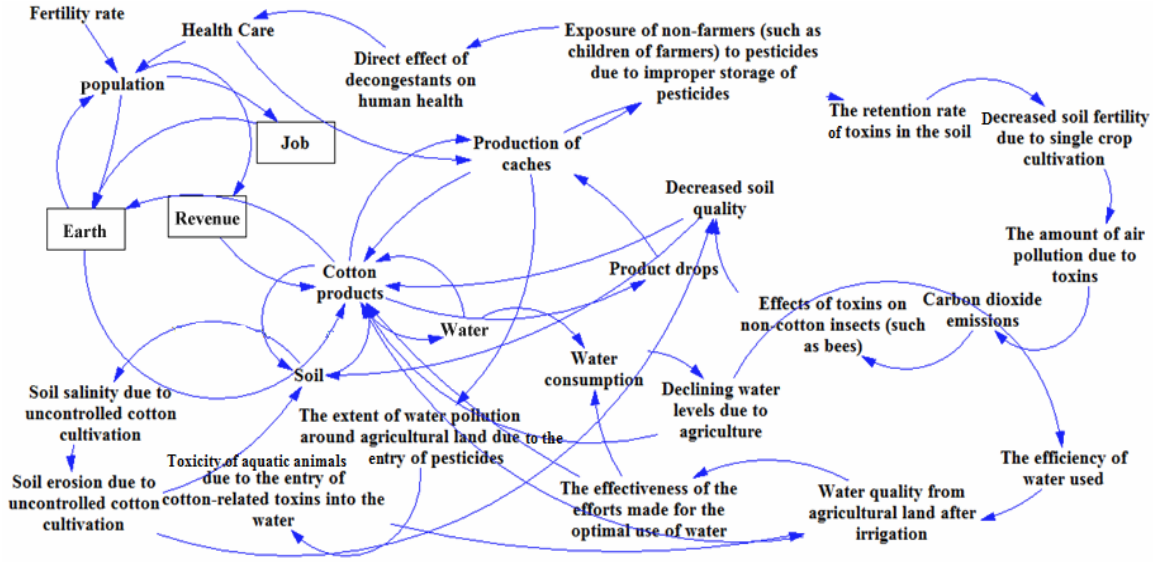
*Soil pollution.

*Air pollution.

*Human mortality and poisoning.

*Death and table poisoning of animals.

*Using drop caches.



Figuer-1. Causal loops related to cotton harvesting and its effect on environment and human.

Table-1. The consumption rate of water for cotton.

	Equations used
Increase per/100000-destroy per	Manufacturing
0.4*total cotton production volume	Reduction rate
Consumption of cotton water*water volume-consumption of pesticides for cotton*water volume-pollution*water volume*0.01	Rate rate

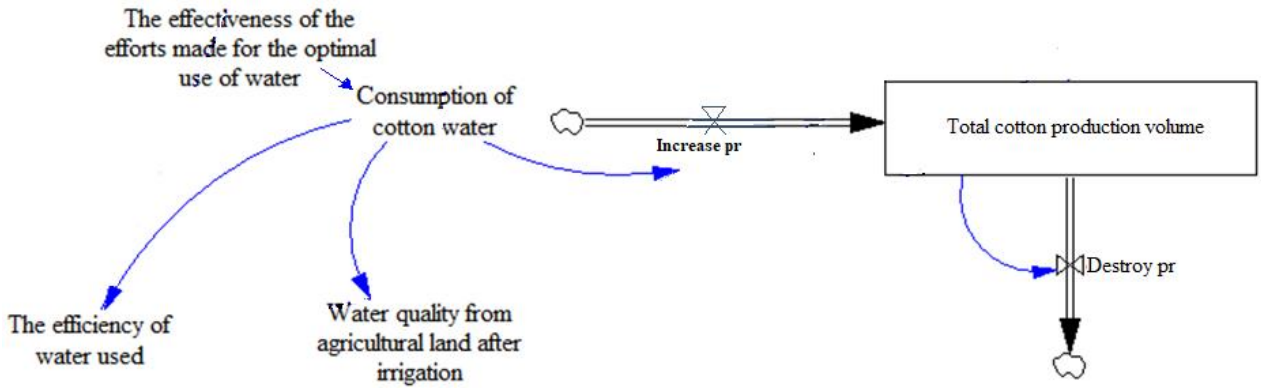


Figure-2. Flow diagram on the consumption rate of water for cotton.

Source: Based on statistical data gathered from proficient farmers.

According to the Figure 3, the amount of cotton produced from 2011 to 2021 has been studied. According to the recorded statistics, the amount of cotton production initially had an upward trend and then due to the problems caused by its uncontrolled cultivation; the cultivation rate of this crop is reduced. Then, with the improvement of conditions, the amount of cotton cultivation will increase again. However, this depends on creating optimal conditions and improving irrigation methods and proper use of pesticides.

2.2. The Amount of Fabric Produced

According to statistics in Figure 4, 40% of cotton production is spent on textile production. Based on this, the amount of fabric production has a process in accordance with cotton and has three different garlic. This course takes an uptrend and then turns into a downtrend and then takes an uptrend.

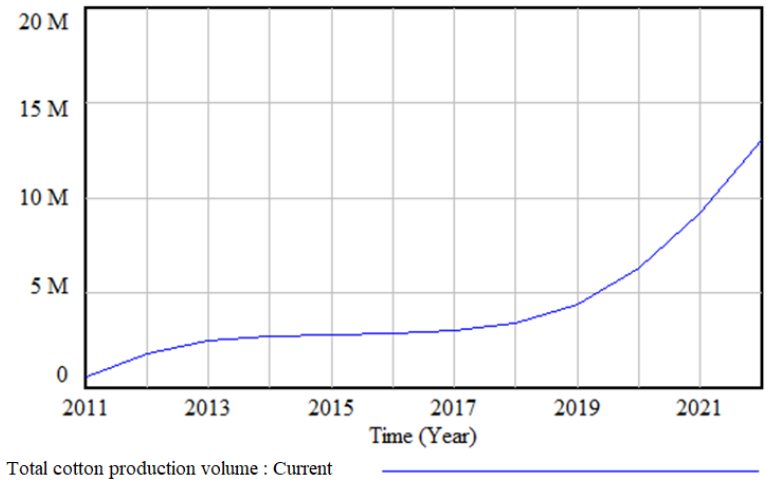
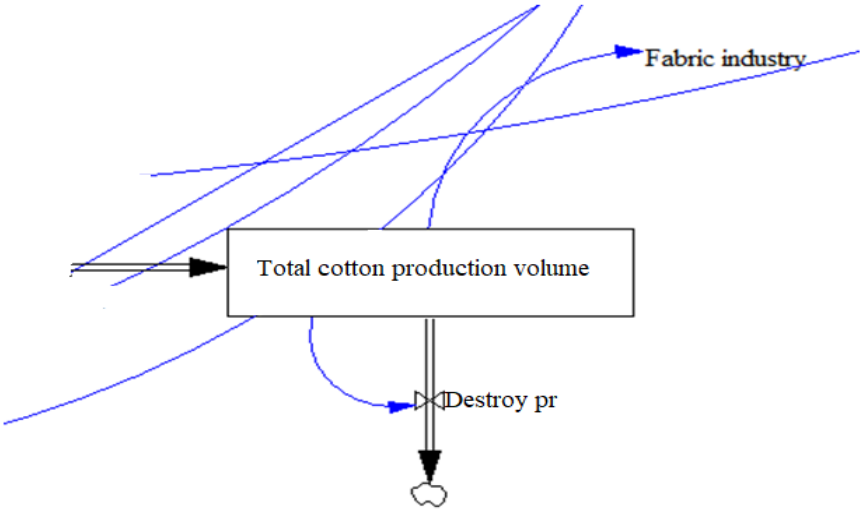
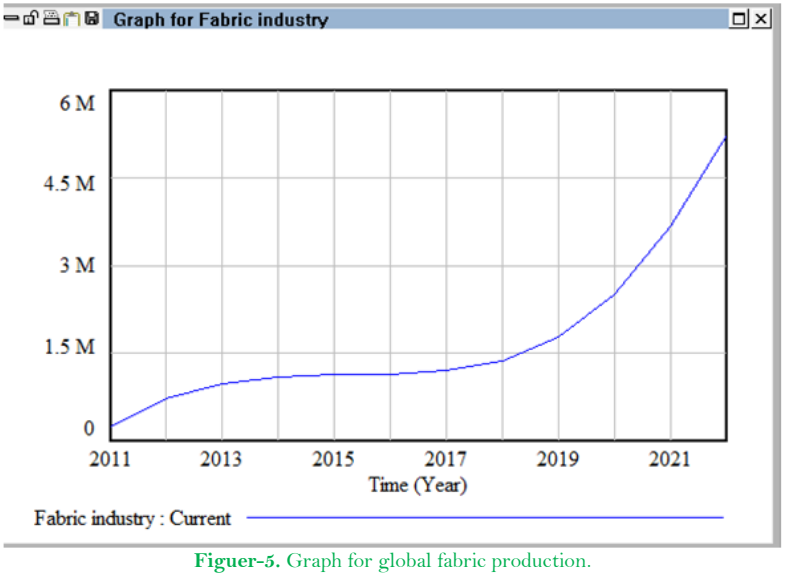


Figure-3. Graph for global cotton production.



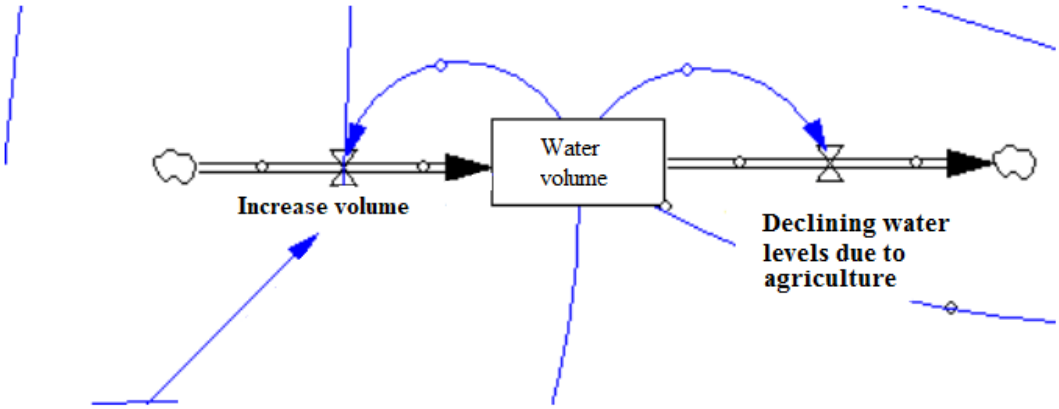
Total cotton production volume *0.4	Production equation

Figurer-4. Flow diagram of fabric industry.



Figuer-5. Graph for global fabric production.

Accordind to the Figure 5 and 6,the volume of water consumed for all agricultural activities has been compared based on the amount of water produced due to rainfall and the management of water consumption methods as well as the reduction of water volume. Accordingly, agricultural activities are increasing very sharply due to the increase in population, and accordingly, the amount of water consumption in this sector has also taken an upward trend.



Increase volume-declining water levels due to agriculture	Water volume
The effectiveness of the efforts made for the optimal use of water*water volume	The equation of increasing the amount of water
The efficiency of water used water quality from agricultural land after irrigation	Reduce the amount of water

Figure-6. Flow diagram on water volume.

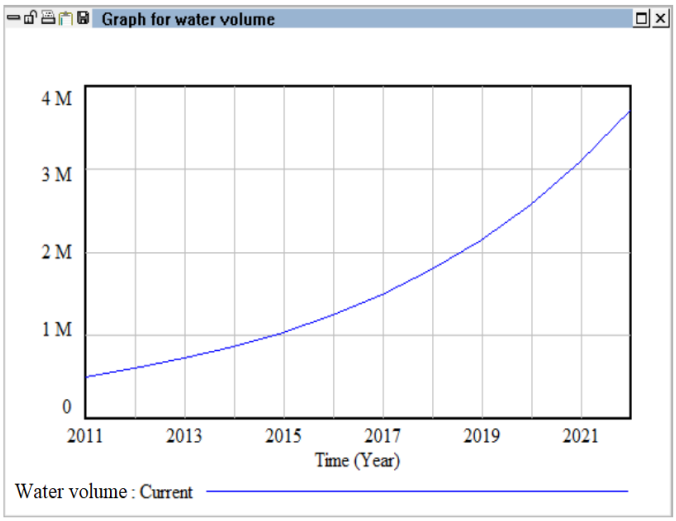
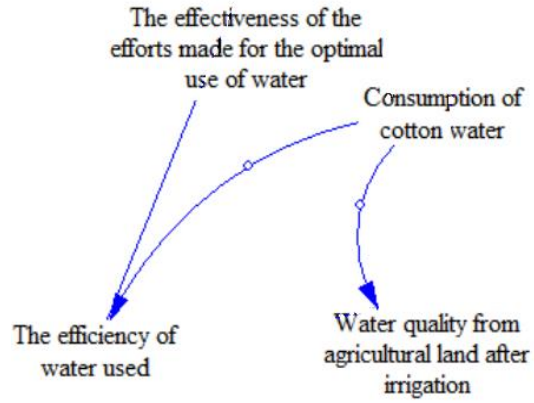


Figure-7. Graph for water volume.

2.3. The Amount of Water Consumed to Produce Cotton

According to the statistics obtained from the recorded data (Figure 8), the amount of water consumption in the annual periods has had an upward trend. This indicates that in periods when the amount of cotton is less cultivated, due to lack of proper water management and improper use; this rate has always been increasing.



*0.5Consumption of ctton water	Water efficiency
*0.3Consumption of cotton water	Consuming water
*0.3Consumption of cotton water	Water quality

Figure-8. Flow diagram of key variables in the waste of water and its quality.

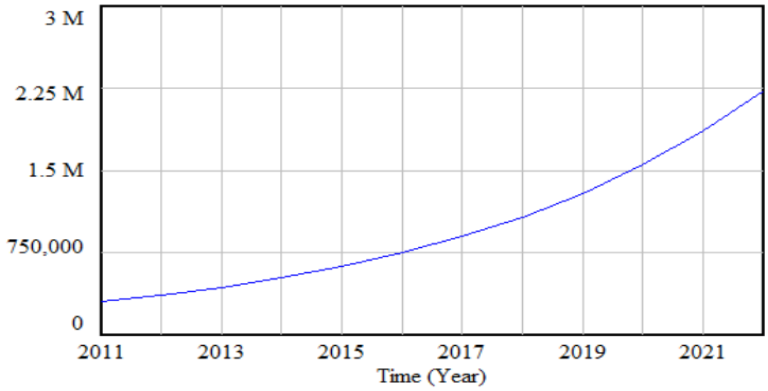
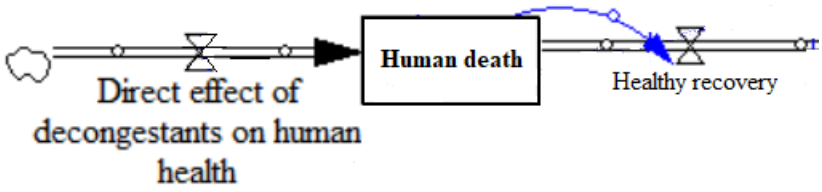


Figure-9. Graph for poor quality of water used.

Source: WHO.

According to Figure 10, the rate of poisoning and death and human descent due to the declines used for cotton According to FAO database statistics; Poisoning and death rates due to cotton swabs, which are extremely harmful to humans; Increases during cotton growing periods. This increases human poisoning. Due to the improvement of medical care, the rate of these poisonings and deaths has an upward trend with a lower slope.



Direct effect of decongestants on human health-healthy recovery	Mortality
Consumption of pesticides for cotton*"Exposure of non-farmers (such as children of farmers) to pesticides due to improper storage of pesticides (e.g. at home)"*0.0001	Direct effects

Figure-10. Flow diagram on human poisoning.

Source: Based on statistical data gathered from proficient farmers.

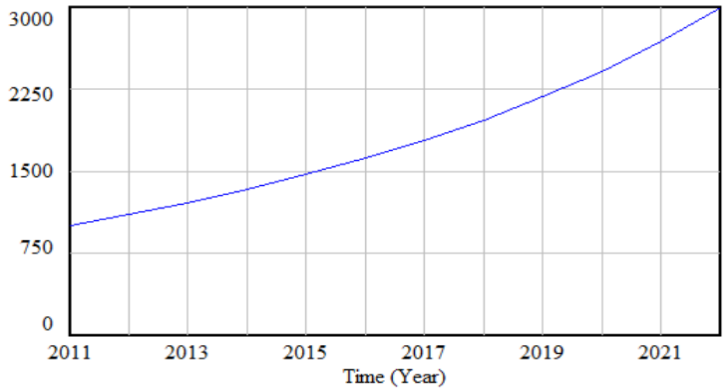
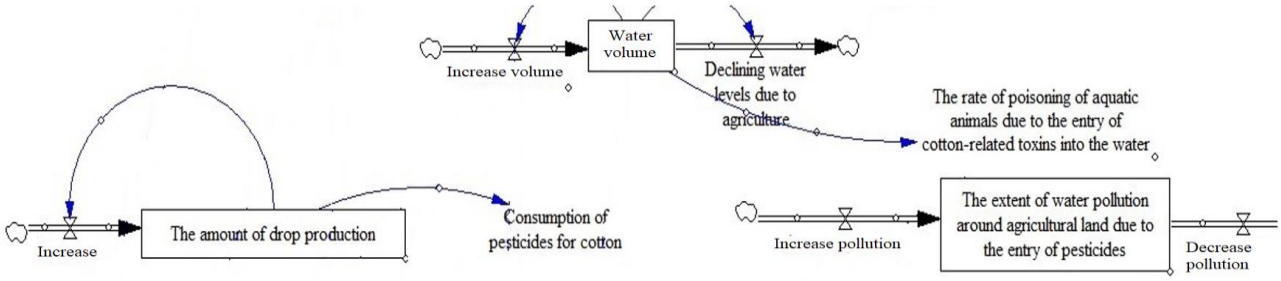


Figure-11. Trend for human death due to poisoning related to cotton.
Source: FAO.

2.4. The Total Amount of Pesticides Produced

As can be seen in Figure 12, the total amount of pesticides produced in the years under review has a strong upward trend. Because the world's population and consequently the need for agricultural products is high; As the amount of agricultural products increases, the rate of decline in these crops increases, and farmers' need for pesticides increases.



0.6*The amount of drop production	Water quality
Increase	Water quality
The amount of drop production*0.4	Consumption drop for cotton

Figure-12. Flow diagram of key variables in the pollution of water by pesticedes.
Source: Based on statistical data gathered from proficient farmers.

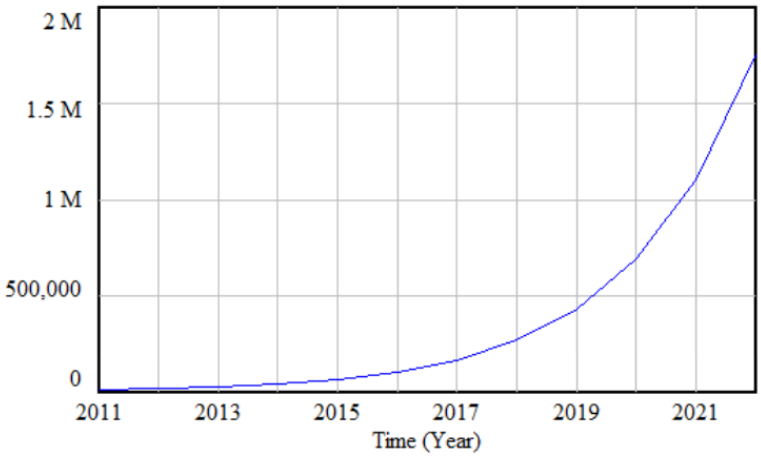


Figure-13. Graph for the total amount of drop prodction.
Source: FAO.

2.5. The Rate of Drop Used for Cotton

The Figure 14 indicates the use of decongestants for cotton shows that this trend has always been on the rise. As the amount of these pesticides increases, soils, air and water poisoning, and pollution increase with this trend, as well as in periods when cotton production was lower; The use of pesticides is still high, which indicates the lack of management of the use of these pesticides and the need for more training for farmers.

2.6. The Total Amount of Contaminants Created

According to the Figure 16, due to the upward trend in the use of pesticides and soil weakening and lack of management of water consumption and air pollution; the total amount of contaminants caused by cotton cultivation has increased. This variable has a fixed Saudi trend that requires intervention in the process of cotton production and cultivation.

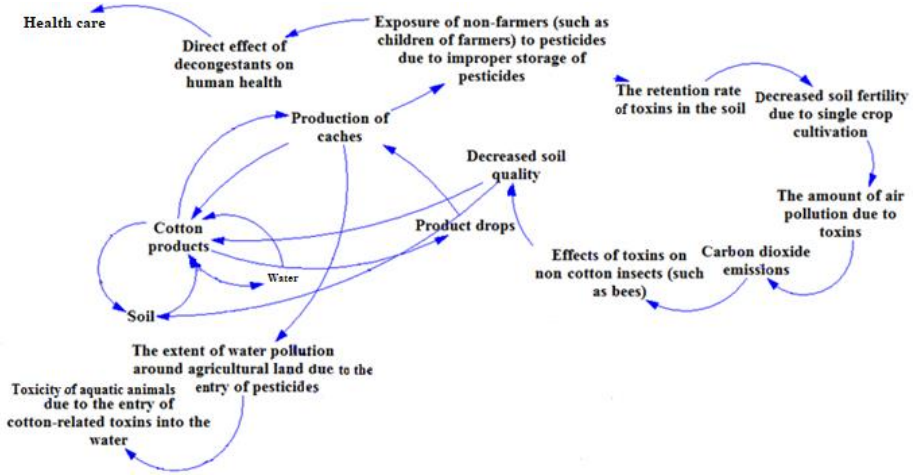


Figure-14. Flow diagram of the use of cotton decongestants.

Source: Based on statistical data gathered from proficient farmers.

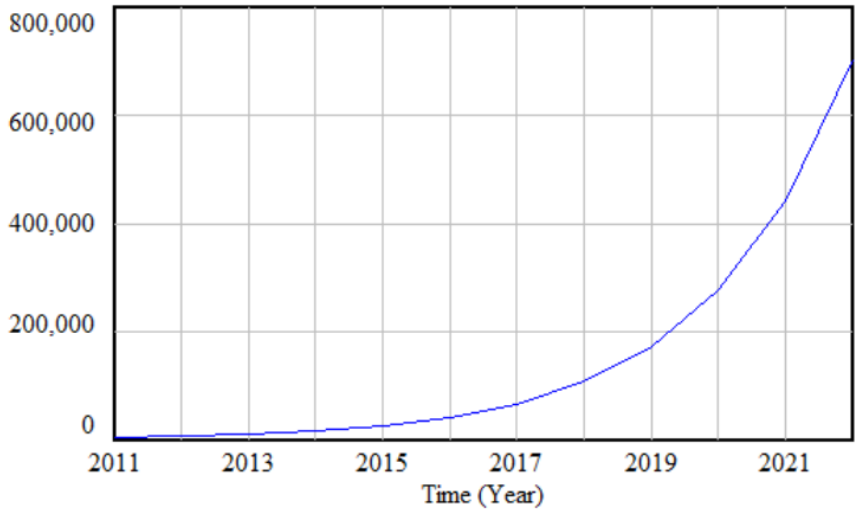
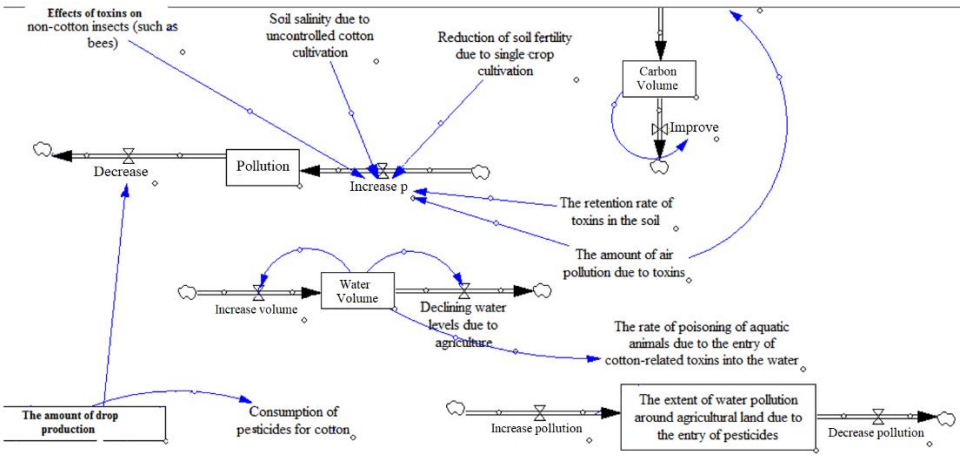


Figure-15. Trend for the consumption of pesticide for coton.

Source: WHO.



Increase p-decrease	Contamination created
Carbon dioxide emissions+ "Effects of toxins on non-cotton insects (such as bees)"+ "Exposure of non-farmers (such as children of farmers) to pesticides due to improper storage of pesticides (eg at home)"+Reduction of soil fertility due to single crop cultivation+ Soil erosion due to uncontrolled cotton cultivation+ Soil salinity due to uncontrolled cotton cultivation+ The amount of air pollution due to toxins+ The retention rate of toxins in the soil	Increase rate
The efficiency of water used+ Water quality from agricultural land after irrigation	Recovery rate

Figure-16. Flow diagram of key variables in **the** amount of contaminants.
Source: Based on statistical data gathered from proficient farmers.

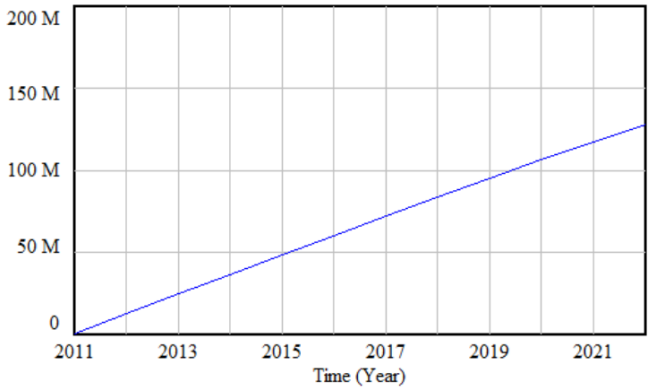


Figure-17. Trend for the amaunt of pollutants produced due to cotton.
Source: FAO.

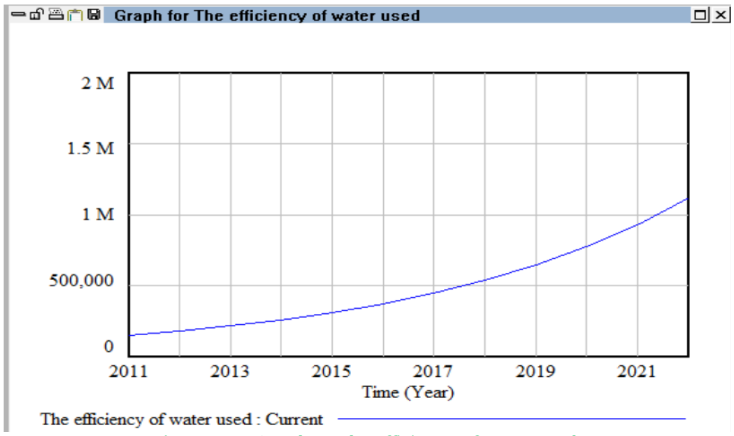


Figure-18. Graph on the efficiency of water used.
Source: FAO.

2.7. Water Pollution Rate

Figure 16 shows water pollution due to the increase in the use of Pesticides and wastewater from cotton processing plants has caused an upward trend for this variable during the years under study.

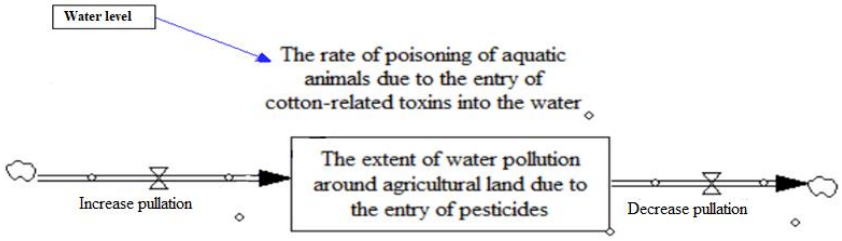
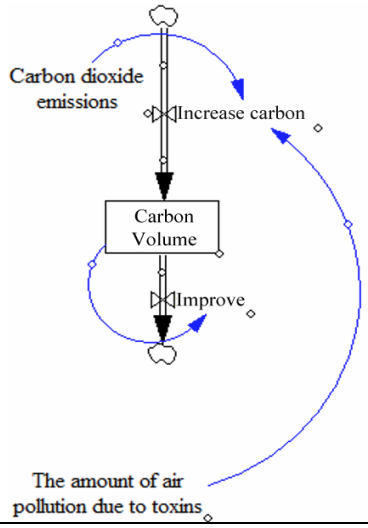


Figure-19. Flow diagram of key variables in deteriorated quality of water.
Source: Based on statistical data gathered from proficient farmers.

The following figure illustrates the amount of carbon dioxide and air pollution produced due to increased cotton production. The amount of carbon dioxide production in the early years has been increasing due to a lack of accurate monitoring of air pollution, but in recent years it has had a steady trend, which indicates to reduce pollution from cotton cultivation and processing. Reducing carbon dioxide also creates better conditions for agricultural production.



increase carbon-improve	Manufacturing
Carbon dioxide emissions+The amount of air pollution due to toxins	Increase rate
carbon volume*0.8	Reduction rate

Figure-20. Flow diagram of key variables in the amount of CO2 produced.
Source: Based on statistical data gathered from proficient farmers.

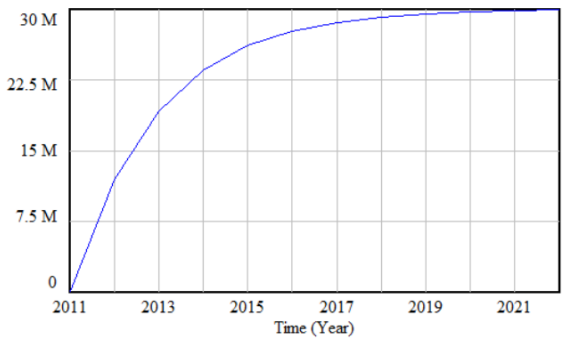


Figure-21. Trend for carbon volume in 10 years.
Source: FAO.

3. CONCLUSION

According to the obtained results, different models with different approaches can be considered that are in accordance with world design standards. This research showed that the Vensim method can be used for various researches, including planning strategy, environment, economic behaviors, biological modeling, software engineering, development of social theories, and natural sciences. This model examines mineral, instantaneous, and human resources based on human activities on earth. Based on the model and the opinion of experts, it is clear that the cotton crop has a negative effect on all environmental factors including water, air, soil, and biodiversity. Since 40% of the world's cotton is consumed in the textile industry, this impact is constantly increasing as the population grows and the need for textiles and fibers increases. On the other hand, the measures taken to control this adverse effect have been almost fruitless. As a result, not only should efforts be made to reduce global cotton consumption, but a serious plan should be put in place to reduce the impact of cotton on the environment.

REFERENCES

Beaudry, F. (2020). The environmental costs of cotton. ThoughtCo. Retrieved from: www.google.com.

Chronology. (2020). Chronology of Iranian history part 1 iranicaonline.org. Retrieved from: www.wikipidia.com.

Cotton-Production. (2020). Cotton production by country worldwide in 2017/2018, Statista, retrieved Jan 29, 2019.

Ghobadi, S. (2006). Dynamic system (Application of Systems Thinking). *Industrial Management Organization.*

Gold, R. (2005). *Why is cotton harmful to the soil?* : Leaf Group Ltd./ Leaf Group Lifestyle.

Khaki, G. (2000). *Research method in management* (1st ed.). Tehran: Science Publishing Center of Islamic Azad University.

Kibira, D., Jain, S., & McLean, C. (2009). *A system dynamics modeling framework for sustainable manufacturing.* Paper presented at the Proceedings of the 27th Annual System Dynamics Society Conference.

Recognizing. (1986). Recognizing the characteristics of the agricultural sector and determining the principles and principles governing its organization. *Administrative and Employment Affairs Organization of the Country*, 134.

Shi, T., & Gill, R. (2005). Developing effective policies for the sustainable development of ecological agriculture in China: The case study of Jinshan County with a systems dynamics model. *Ecological Economics, 53*(2), 223-246. Available at: https://doi.org/10.1016/j.ecolecon.2004.08.006.

Spector, J. M., Christensen, D. L., Sioutine, A. V., & McCormack, D. (2001). Models and simulations for learning in complex domains: Using causal loop diagrams for assessment and evaluation. *Computers in Human Behavior, 17*(5-6), 517-545. Available at: https://doi.org/10.1016/s0747-5632(01)00025-5.

Zhang, H., Calvo-Amodio, J., & Haapala, K. R. (2013). A conceptual model for assisting sustainable manufacturing through system dynamics. *Journal of Manufacturing Systems, 32*(4), 543-549. Available at: https://doi.org/10.1016/j.jmsy.2013.05.007.

Zhao, Y. C., & Tancrède, V. (2008). Global cotton and textile product chains: International Institute for Sustainable Development (IISD). Retrieved from: www.wikipidia.com.