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Application of System Thinking Approach in Identifying the Challenges of Beef Value Chain

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Abstract

In this study, the system thinking approach was used to explain the challenges of the beef value chain in Mashhad, Iran. Due to the complexity of the system and its dynamic nature, rich picture and CATWOE analysis were used to structure the problem. After structuring the problem, the relationships between the chain actors were drawn in the causal loop diagram. Then, the system archetypes were identified. Results showed that the dynamics of this value chain could be explained by limit to growth, fixes that fail and shifting the burden archetypes. The results indicated that the beef import policy has not been effective to regulate the domestic market. Also, it can be concluded that beef cattle production in Mashhad is largely dependent on sustainable supply of livestock feed. So, enhancing cattle production requires policy making to increase availability of livestock feed. Therefore, it is recommended to plan for increasing its production through changing irrigation system and using early maturing and drought-tolerant varieties of corn.

Keywords

Value chain, beef, rich picture, causal loop diagram, system archetype.

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Introduction

In recent years, study on food value chain management has attracted the attention of many researchers (Zarei et al., 2011). Responding to changing consumer demand for food, is only possible through agri-food value chain management (Naik and Suresh, 2018). The value chain of food is important to achieving food security in national and global policies (Neven, 2014). Investigating the challenges in the path of production and distribution of agricultural products requires recognizing the value chain, due to the importance of gaining competitive advantage and increasing the income of the actors. By identifying the strengths and weaknesses of the food value chain, policymakers and planners will be able to improve the efficiency of the value chain.

While patterns of food consumption have changed over time, meat remains a main meal component for consumers (Grunert, 2006). The major source of meat production is cattle. About 45 percent of the value added of agriculture is related to livestock and about 3 million people are directly involved in the livestock sector in Iran (Fatemi and Mortezaei, 2013). Consumption of red meat in Iran, particularly in rural regions and in low-income groups compared to developed countries, is undesirable (Rahimi et al., 2014). The average global per capita consumption of red meat is about 30 to 45 kg (FAO, 2015), whereas the per capita consumption of red meat in Iran is about 12.5 kg (FAO, 2016). However, the desired consumption of red meat in the 2025 horizon is considered to be 20.39 kg in Iran (Ebadi, 2015). The instability and fluctuations in the price of red meat and livestock feed have led to reduced domestic production and increased imports (Alijani and Saboohi, 2009). Based on the Ministry of Agriculture Jihad (2007), one of the most important factors influencing the price increase of red meat is the animal feed. Iran import of animal feed is about 3 billion dollar

every year (Iran feed industry association, 2017). Corn is the first imported product of Iran and is one of the most important items of livestock input, which due to low domestic production, considerable amount of it is imported every year (Ghasemi, 2016). Iran's economy is centrally planned, based on five year plans. It is specified by a large hydrocarbon sector, small scale private agriculture and services and significant government presence in large manufacturing and finance sectors (World Bank, 2010). Iranian government supports the agriculture sector in a several ways. For instance, the government allocates subsidized foreign currency to import forage like corn every year in order to decrease prices. Also, the government supports the consumers with allocating subsidized foreign currency to import beef. However, this subsidies have failed in decreasing prices, because importers and distributers sell imported beef and corn at several times the imported price. Therefore, they benefit from the difference between subsidized currency and free market currency, whereas, beef price and corn price do not decrease in domestic market. Unfortunately, there is no control over distribution of imported beef and corn. Due to the lack of proper market regulation policies by the government, the red meat market in Iran has often faced price fluctuations or shortages (Ministry of Agriculture Jihad, 2018). So that, meat producers are always dissatisfied with the low prices on the farm and consumers are also dissatisfied with the high retail prices (Hosseini and Shahbazi, 2010).

Management of animal production systems is difficult because they are dynamic and complex. In these systems, the performance of each level depends on previous level decisions and exogenous factors (Tedeschi et al., 2011). Grohs et al. (2018) stated that system thinking is an appropriate tool and framework for understanding complex and ambiguous systems and their related aspects.

Investigating the beef value chain requires the use of appropriate system thinking approaches, given that the beef value chain has a complex and dynamic nature and involves several actors; also, the relationships between these actors are not well known. Furthermore, the elements of this system are resistant to policies. In spite of the various policies implemented by the government in the past years, there has been no improvement in the beef value chain of Iran.

Khorasan Razavi province has appropriate conditions for livestock production. The total production of red meat in Iran was 835.2 thousand tons in 2017, this province ranked first in the production of red meat with 72.6 thousand tons (Ministry of Agriculture Jihad, 2018). Mashhad is the second largest population metropolis of Iran, which is located in this province. Mashhad has a population of 3 million people and 27 million pilgrims enter the city each year. Accordingly, there is a high demand for livestock products (Kharasan Razavi Provincial Government, 2016). Several studies have been conducted in the field of livestock and poultry supply chain, in the following, some of these studies are mentioned. Matulova et al. (2010) studied the dairy value chain using econometric analysis and concluded that a difference in the leverage of individual factors affecting the price at different levels of the milk value chain. Tedeschi et al. (2011) identified feedback loops for sheep and goat production systems and extracted system archetypes. Shamsuddoha and Nedelea (2013) modeled the Bangladesh poultry supply chain using system dynamics and examined the ability to recycle waste and create more employment. Piewthongngam et al. (2014) investigated the dynamics of Thai pork supply chain using system dynamics and analyzed the effects of various scenarios such as herd restructuring and changing in breeding rate on pork production and productivity. Setianto et al. (2014) applied soft system methodology (SSM) to structure the problematic situation of beef smallholders in Indonesia. They also drew the causal loop diagram (CLD) and extracted the system archetypes. They concluded that the unavailability of livestock feed and increased livestock sales were limitations for cattle production. Banson et al. (2018) identified the archetypes of Ghana's pork industry using system thinking and concluded that using causal loop diagram and system archetypes could help pig herders as well as policymakers understand the behavior of the whole system.

By reviewing previous studies, it can be concluded that the focus of researchers is more on the poultry industry, and the meat value chain, especially in Iran, has been neglected. Despite numerous challenges in the value chain of this product in Iran, no studies have been conducted to analyze the dynamics of the beef value chain considering the interaction among all actors. Therefore, in order to fill this gap, this study investigated the problems of beef value chain in Mashhad by using soft system methodology and causal loop diagram.

Materials and methods

Most people think that complexity is defined in terms of the number of elements in a system or the number of combinations that needs to be

considered in effective decision-making. Such problems have combinatorial complexity or detail complexity. In contrast, dynamic complexity which is the ability of a system to be able to develop into different states over time, can arise even in simple systems with low detail complexity. This kind of complexity is due to the interactions among agents over time (Sterman, 2000). Dynamically complex systems are policy resistant. So many evident solutions fail or aggravate the situation (Sterman, 2000). Complex systems generally have interconnected structures, so that behaviors and actions in one part of the system affect other parts of the system. They are specified by nonlinear and incomprehensible behavior; nonlinearity occurs when several factors influence decision making (Groff, 2013). Van Mai (2010) believes that system thinking is a powerful tool for addressing complex problems and identifying leverage points for intervention because of its capability to describe the interrelationships among economic, social and environmental subsystems. System dynamics as one of the most widely used and validated approaches in decision making is a way of applying system thinking in modeling that describes relationships among variables (Tedeschi et al., 2011). One of the most important features of system dynamics is the identification of system archetypes. They are the behavioral patterns of a system that are considered as generic structures or typical system outlines (Armendàriz et al., 2015). System archetypes consist of a set of loops that result from the interaction of all the factors that cause a problem. The most common system archetypes are balancing process with delay, limit to growth, shifting the burden, eroding goals, escalation, success to successful, tragedy of the commons, fixes that fail and growth and underinvestment (Zare Mehrjerdi, 2011).

The point of entry into the system dynamics is problem identification which is defined as problem structuring. This step is important in clarifying the purpose of the whole system dynamics process. However, the system dynamics approach has limitations at this step, because system stakeholders have different interests and there is no tool to consider multiple stakeholder interactions. To solve this problem, soft system methodology is used in the problem structuring step (Setianto et al., 2014). Soft system methodology as one of the system thinking approaches is useful to address problem situations from a systemic viewpoint (Phillips and Kenley, 2019). The soft system methodology which focuses on the learning process is in contrast to the hard system methodology which, is mainly goal-oriented.In hard systems, the effort is on making a mathematical model to achieve a specific goal and consider variables that seem to affect the problem, whereas soft systems look for key variables that determine system reliability (Jackson, 2007). The two main tools of the soft system methodology are the rich picture and CATWOE analysis that help the researcher to identify the actors involved in the system, their role and their relationships with each other.

Rich picture helps the researcher to better understand the actual situation when there are multiple relationships in the system (Checkland and Poulter, 2006). According to Checkland and Poulter (2006), using rich picture in the early stages of system identification can simplify problem understanding for all stakeholders and encourage them to become involved in the analysis process.

CATWOE analysis is another approach of soft system methodology that used to engage the stakeholders in analysis about the problematic situation (Hart and Paucar-Caceres, 2014). It helps researchers focus on six factors: customer, actors, transformation, weltanschauung, owner and environmental constraints. These factors are defined as follows (Bergvall-Kåreborn et al., 2004; Cox, 2014).

Customer: beneficiaries or victims affected by the transformation. Researchers recommended that replacing “Customers” by “Affectees”.

Actors: participants in the system who would carry out the transformation process.

Transformation: the purposeful activities which are necessary to convert input to output.

Weltanschauung: the worldview that makes the transformation process meaningful.

Owner: people or groups that have the power and responsibility for the system.

Environmental constraints: external and internal constraints which can affect the transformation process in the system.

CATWOE analysis is used to develop root definitions which are one or more sentences that describe the system, its goal and its actors (Mehregan et al., 2012). These root definitions help build a conceptual model that is later translated to the causal loop diagram (Setianto et al., 2014). The causal loop diagram represents the causal relationships among variables; it also demonstrates cause and effect behavior from a system perspective (Banson et al., 2018).

In this study, to structure the problem, beef value chain actors and their relationships are identified using rich picture and CATWOE analysis. After that, the root definitions are expressed. Then, the causal loop diagram is extracted. Finally, system archetypes are determined. To identify causal relationships, a series of interviews have been undertaken with a group of 60 cattle herders of industrial fattening farms in Mashhad. Also, another set of interviews was conducted with experts of Agricultural Jihad, industrial dairy and livestock farmers union, industrial dairy and livestock cooperative and slaughterhouse in Mashhad. Vensim software was used to build a causal loop diagram and Visio software was used to draw rich picture.

Based on the interviews, model assumptions are defined and reflected in the model structure. The local cattle production is modelled and analyzed. The production, breeding and slaughtering cattle and breeding stock is aimed to earn income from the herder's viewpoint. Part of the beef demanded quantity by consumers is responded by domestic production and the other part is responded by imports. Beef production involves cattle production through the fattening process and slaughtering breeding stock. Herders do not receive subsidies for livestock feed. They purchase livestock inputs from the free market. However, the government allocates subsidized foreign currency to import forage and beef every year in order to decrease prices.

Results and discussion

Rich picture and CATWOE analysis

Using the results of interviews with the beef value chain experts, rich picture of the beef value chain in Mashhad is drawn and shown in Figure 1. The main actors and their interests are shown in the rich picture. After drawing the rich picture, CATWOE analysis has also been

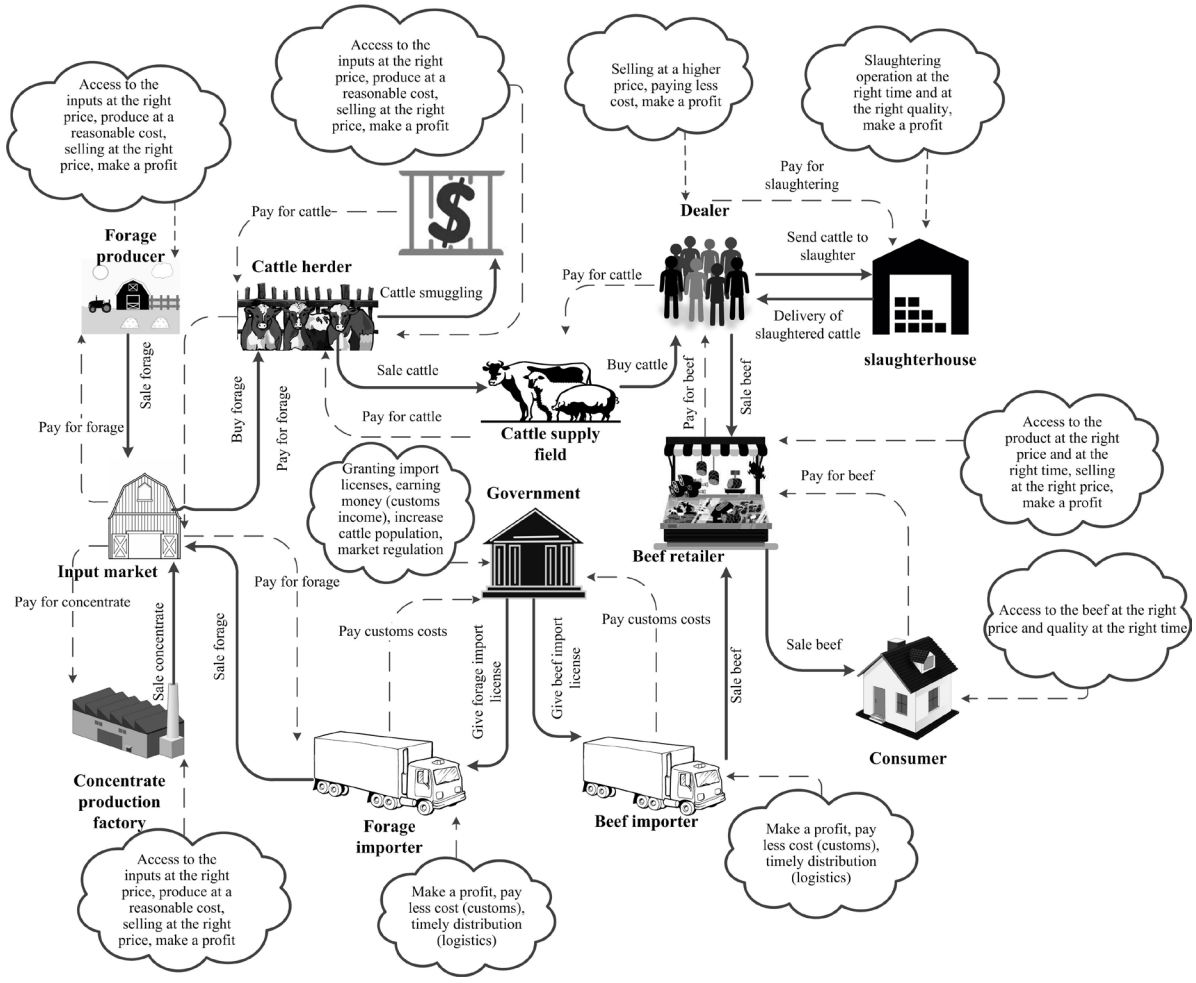

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Figure 1: Rich picture of the beef value chain in Mashhad.

performed to define the current farming situation. In the following, based on the rich picture and CATWOE analysis, root definition is expressed

CATWOE elements

Customer: herders, dealers, consumers, importers

Actors: forage producers, herders

Transformation: beef production with reasonable price to respond consumer's demand is not met >> beef production with reasonable price to respond consumers demand is met

Weltanschauung: beef production with reasonable price to have sustainable beef production and increase welfare of herders and consumers is feasible and desirable, it can be planned and organized

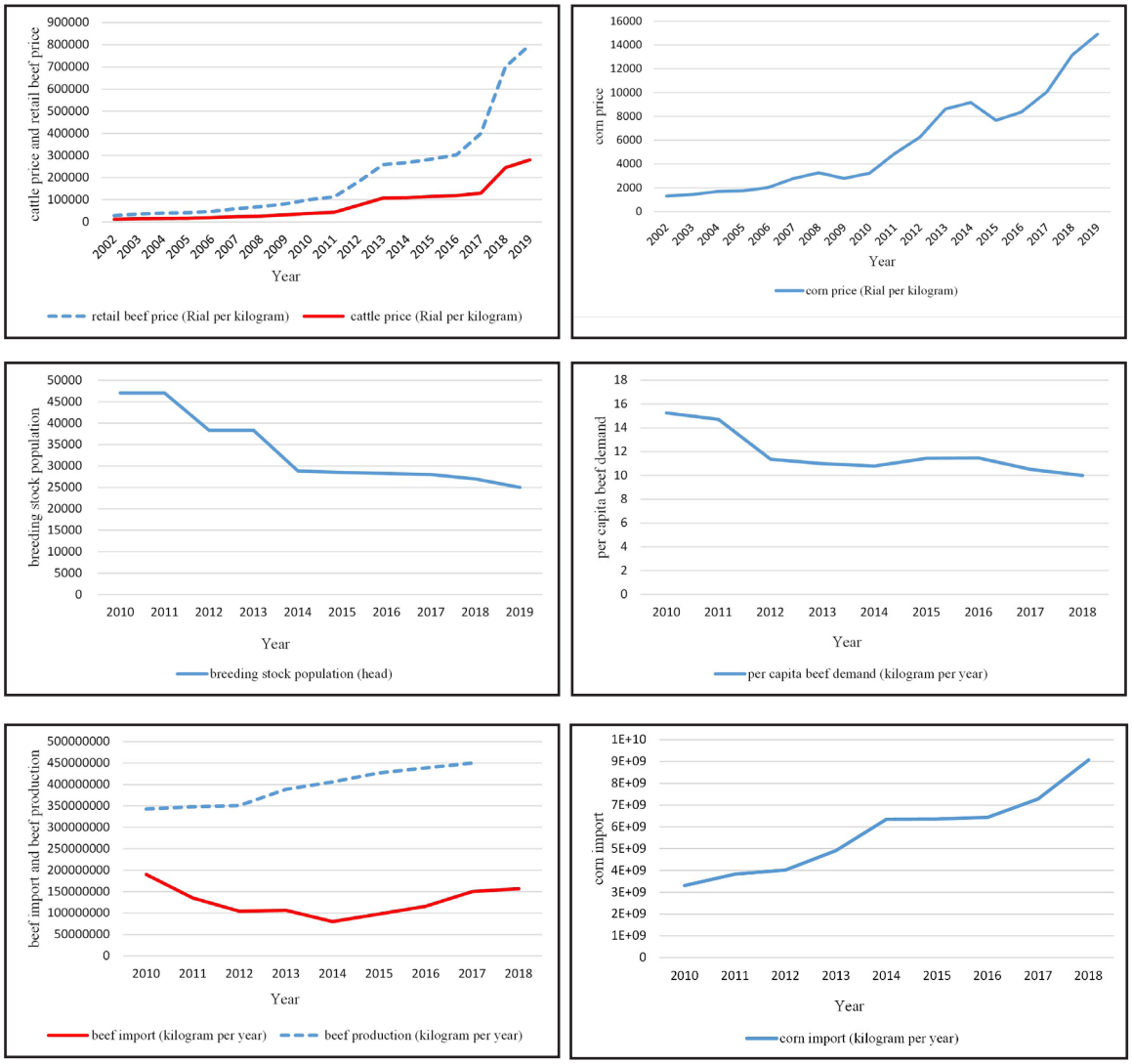
Owner: government, farmers' cooperatives

Environmental constraints: access to forage, access to market, forage price, beef price

Root definition: a value chain to ensure that beef production with reasonable prices to respond consumer's demand by herders and forage producers is met by government and farmers' cooperatives.

Reference mode diagram of the core variables of the beef value chain in Mashhad

The reference mode diagram of some important variables of the beef value chain in Mashhad is represented in Figures 2. As can be seen, the retail beef price has grown enormously in recent years whereas the cattle price has not grown much. So that, the gap between the retail beef price



Source: Ministry of Agriculture Jihad, 2018; Iran Customs Administration, 2018

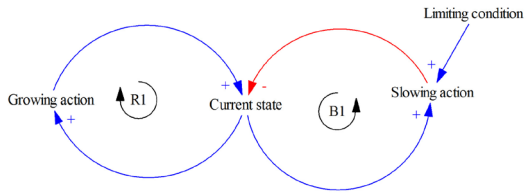
Figure 2: Reference mode diagram of the core variables of the beef value chain.

and cattle price has reached to its maximum value in 2019. However, since 2014, beef import quantity has also increased, this increase in beef import quantity has not been effective in decreasing the retail beef price. Additionally, increasing the retail beef price has reduced per capita consumption of this product in recent years. On the other hand, corn price which is the most important livestock feed, has increased significantly in recent years. Due to the sharp increase in livestock feed price and consequently, increasing cattle production costs and the slight increase in cattle price, the price cost ratio of cattle has reduced in recent years. This has led to an increase in slaughter of breeding stock; so, the breeding stock population has declined. Also, beef production has increased in recent years as a result of increased breeding stock slaughtering.

Causal loop diagram and identification of system archetypes

In this section, according to the results of the problem structuring based on rich picture and CATWOE analysis, a causal loop diagram is extracted and system archetypes are identified. System archetypes of the beef value chain in Mashhad include limit to growth, fixes that fail and shifting the burden which is described below.

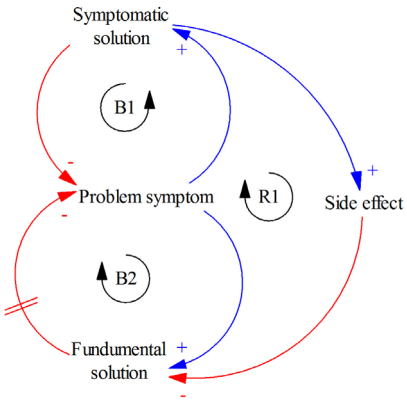
Limit to growth: this archetype shows a growth process (R1 loop) that faces a balancing process (B1 loop) in the following (see Figure 3).



Source: Senge, 2006

Figure 3: Limit to growth archetype.

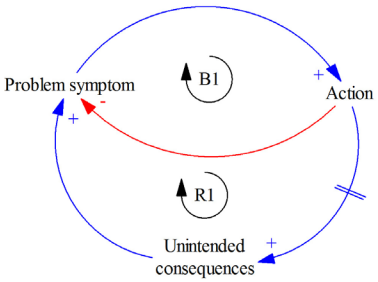
Shifting the burden: in this archetype, problem symptom is fixed using a short-term solution (B1 loop). Whereas, a fundamental solution can be used to solve the problem (B2 loop). Also, in this archetype a reinforcing loop is formed which results from becoming accustomed to using a short-term solution that leads to neglect taking the fundamental solution (R1 loop). So, the problem is getting worse (Posthumus et al., 2018). This archetype is shown in Figure 4.



Source: Posthumus et al., 2018

Figure 4: Shifting the burden archetype.

Fixes that fail: as shown in Figure 5, sometimes a corrective action can be effective in short-term (B1 loop). But it will have unintended consequences in the long-term (R1 loop). So over time, the problem symptom goes back to the previous level or becomes worse (Posthumus et al., 2018).



Source: Posthumus et al., 2018

Figure 5: Fixes that fail archetype.

The causal loop diagram of the beef value chain in Mashhad is shown in Figure 6, which represents 17 feedback loops including 8 reinforcing loops and 9 balancing loops. Each of these loops along with the identified archetypes are described below.

Consumer beef demanded quantity and cattle production capacity (shifting the burden archetype): as retail beef price decreases, beef demanded quantity by consumers increases. So, the gap between beef inventory and demand increases. In other words, inventory to demand ratio of beef decreases. To solve this problem, beef import increases. As a result, problem symptom (gap between beef inventory and demand) decreases in the short term (B1 loop). This easy and short term solution has two side effects that indirectly weaken the possibility to implement long term solution. These side effects happen through

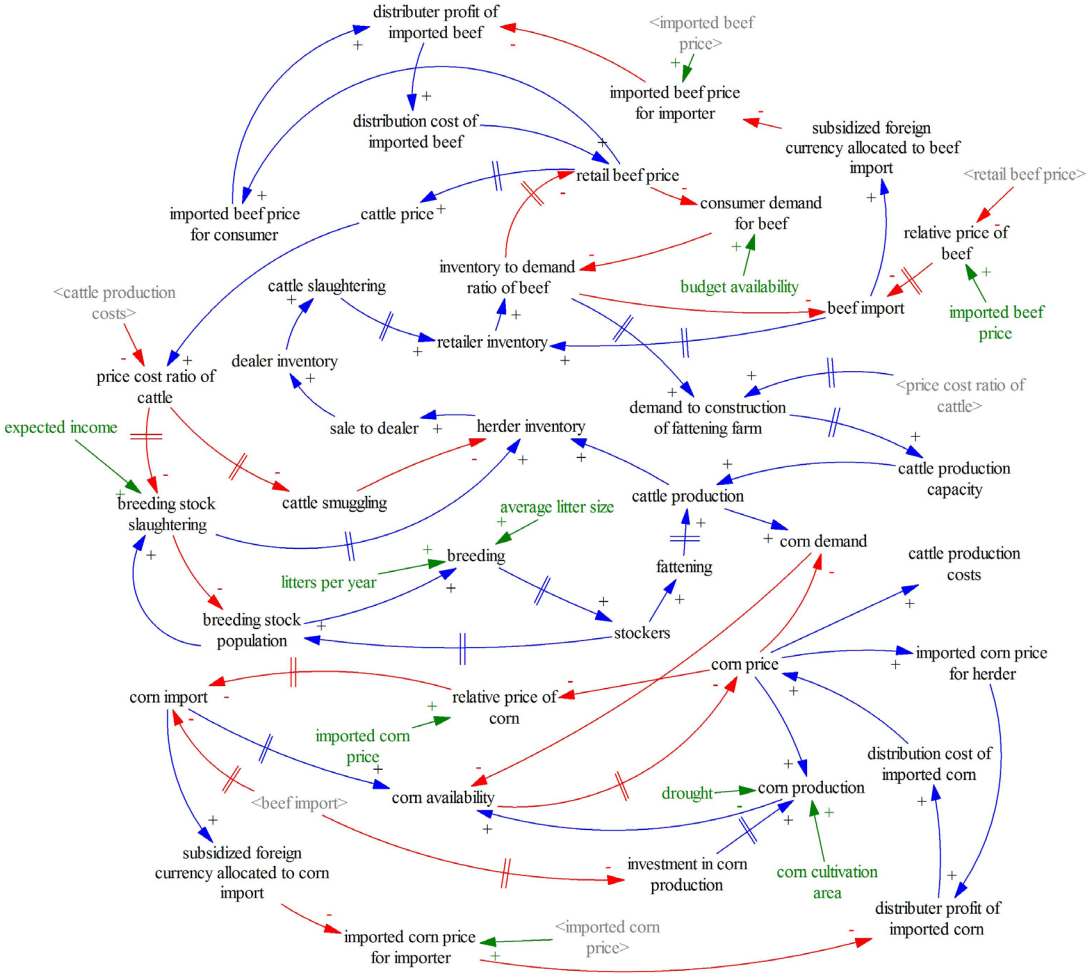


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Figure 6: Causal loop diagram of the beef value chain in Mashhad.

decreasing in corn import and decreasing investment in corn production which lead to decrease in cattle production capacity and cattle production, then decreases beef inventory and increases the gap between beef inventory and demand (see Figure 7, R1 and R2 loops).

The fundamental solution that can be used to solve this problem is to increase cattle production to respond the consumer demand for beef (B2 loop). This can be achieved through government intervention by supporting cattle herders to invest in the construction of new fattening farms. This finding is consistent with that of Parsons et al. (2011) stated that access to capital and sufficient area of land is essential to success in livestock production.

Breeding stock population loops (limit to growth archetype): as Figure 8 shows, with increasing the breeding stock population, breeding rate increases. Also, breeding rate is affected by average litter size and litters per year. Normally, average litter size of cattle is 1 animal/litter. Furthermore, litters per year for cattle is 1 litters/animal/year. Breeding produces stockers after 9 months gestation delay and 3 months of weaning period. With the assumption of 50 % chance of female, half of the stockers are allocated to breeding stock population after 9-12 months delay (R3 loop). This reinforcing loop leads to breeding stock population growth. However, there is a balancing loop which limits its growth (B3 loop). The limiting condition is "expected income". Herders need to slaughter their breeding cattle in order to earn income because they could not afford to feed all their livestock. As a result, breeding stock slaughtering exceeds the breeding rate, with the unintended and perverse outcome of a reduced rather than increasing breeding stock population. These loops together create limit to growth archetype. As Figure 2 shows, since 2010

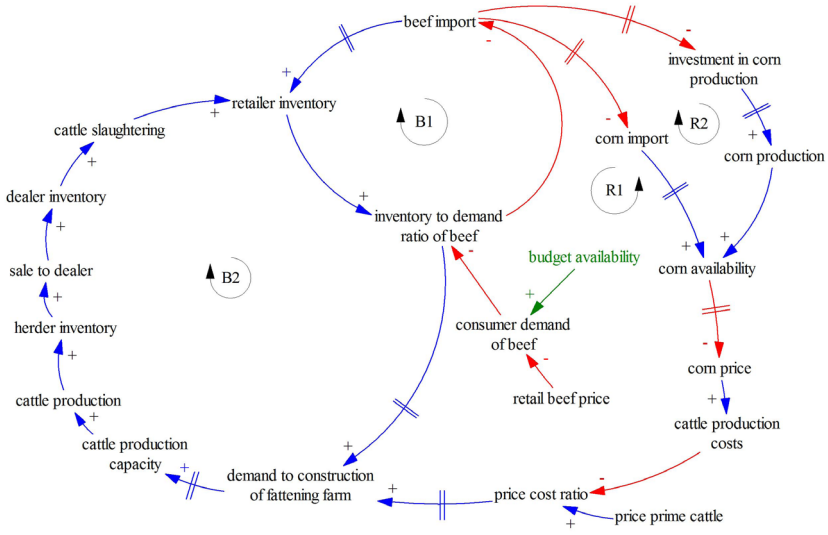

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Figure 7: Consumer beef demanded quantity and cattle production capacity (shifting the burden archetype).

breeding stock population has decreased. This is due to increase breeding stock slaughtering which limited the growth of breeding stock population. These results are consistent with that of Guimarães et al. (2009) and Tedesch et al. (2011) concluded that reproduction process should be considered in the analysis because it is related to the ability of a herder to develop his production. Additionally, Li et al. (2012) showed that the more rapid slaughter rate leads to decline the total number of beef cattle. Also, Mwanyumba et al. (2015) pointed out that if the government does not intervene to balance the herd dynamics to increase reproduction and decrease slaughtering, the livestock population will be annihilated over time.

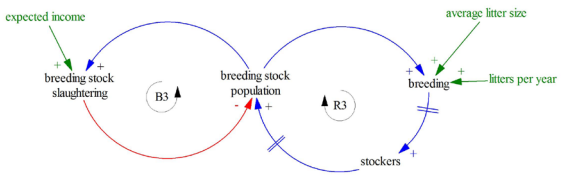

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Figure 8: Breeding stock population loops (limit to growth archetype).

Beef import loops (fixes that fail archetype): based on imperfect substitute model of trade, the relative price of import (import price to domestic price ratio) is one of the most important factors affecting imports of goods (Goldstein and Khan, 1985). Also, the relative price of beef (import price to retail price ratio) is an important factor affecting beef import in Iran. As shown in Figure 9, increasing retail beef price and decreasing beef relative price lead to increase beef import, which increases the retailer inventory and decreases retail beef price (B4 loop). On the other hand, with increasing beef import, subsidized foreign currency allocated to beef import also increases. This leads to decrease imported price of beef for importers. Therefore, importers buy imported beef at a lower price. This increases the profit of importers. So, distribution costs of imported beef rise and finally lead to increase the retail beef price (R4 loop). Also, importers pricing the imported beef for consumers based on the retail beef price, as retail beef price increases, they supplied imported beef at a higher price. It increases their profit and intensifies the reinforcing loop R5. In fact, imported beef should supply in domestic market at a lower price than domestic price to be effective in regulating domestic market. But unfortunately, there is no control over distribution of imported beef. So, the importers and distributers sell imported beef at several times the imported price. Consequently, these subsidies have failed in decreasing prices. This situation represents the archetype of fixes that fail. Actually, in this situation, beef import is increased to decrease retail beef price. But, this action is unsuccessful and the retail beef price is not decreased. As Figure 2 shows, since 2014 beef import has increased. However, retail beef price continued to rise. This result is consistent with that of Suryani et al. (2016) stated that beef import is unable to resolve the problems of shortage of beef production and higher prices. In this case,

monitoring on distribution of this product could be effective in decreasing beef price.

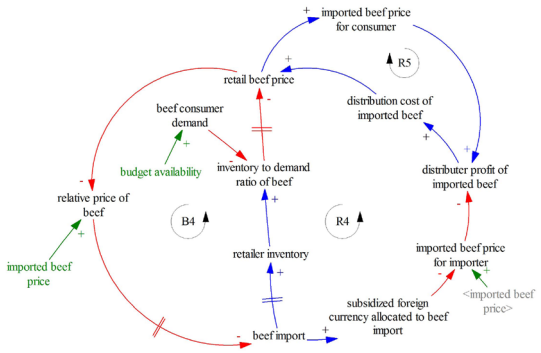

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Figure 9: Beef import loops (fixes that fail archetype).

Corn import loops (fixes that fail archetypes): as corn price increases, corn production increases with delay to balance the corn price (see Figure 10, B5 loop), but due to the water problem in Iran and corn cultivation area constraint, this negative loop has a weak effect in balancing the corn price. So, it needs to import corn to deal with high prices and corn shortage. Therefore, with increasing corn price and consequently decreasing relative price (import price to domestic price of corn), corn imports increase (B6 loop). On the other hand, with increasing corn import, subsidized foreign currency allocated to corn import also increases. This leads to decrease imported price of corn for importers. Therefore, importers buy imported corn at a lower price. This increases the profit of distributers. So, distribution costs of imported corn rise and finally lead to increase corn price (R6 loop). Also, importers pricing the imported corn for herders based on domestic corn price, as domestic corn price increases, they supplied imported corn at a higher price. It increases the profit of distributers and intensifies the reinforcing loop R7. Actually, imported corn should supply in domestic market at a lower price than domestic price to be effective in regulating domestic market. But unfortunately, there is no control over distribution of imported corn. So, the importers and distributers sell imported corn at several times the imported price. Consequently, these subsidies have failed in decreasing prices. This situation represents the archetype of fixes that fail. In fact, in this situation, corn import is increased to decrease domestic corn price. But, this action is unsuccessful. So, the corn price continues to rise. As Figure 2 shows, since 2010 corn import has increased. However, corn price continued to rise. The long-term solution is to change irrigation systems and irrigation management in corn production to increase water productivity. Also, using early maturing and drought-tolerant varieties of corn can improve corn yields. Additionally, given that reaching self-sufficiency in corn production in Iran is not possible and part of the corn demanded quantity is met through imports; it is necessary to closely monitor the import and distribution of this input to break the monopoly of importers and distributers. One solution is to hand over the distribution of imported forage to livestock farmers' cooperatives. This could be effective in reducing corn price and cattle production costs. Also, training the herders to improve feed utilization and reducing feed wastage could be effective in decreasing cattle production costs. This result corroborates the findings of Abdulla et al. (2016).

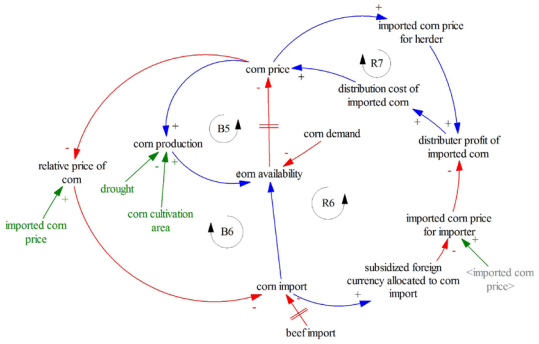

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Figure 10: Corn import loops (fixes that fail archetype).

Beef production loops: it should be noted that beef production (Figure 2) involves cattle production through the fattening process and slaughtering breeding stock. Figure 11 shows that as cattle price increases, the price cost ratio of cattle increases and demand to construct new fattening farms increases. This leads to increase in cattle production capacity and cattle production. Therefore, sale to dealer and dealer inventory increase. So, with increasing slaughtering, retail beef price decreases. As retail beef price decreases, also cattle price decreases with delay (B9 loop). On the other hand, with increasing cattle production, corn demand also increases and leads to decrease in corn availability. Also, corn availability is affected by corn production. Corn cultivation area and drought limit the corn production. Decreasing in corn availability leads to increase in the corn price. As corn price rises, cattle production costs increase. So, the price cost ratio of cattle decreases and leads to decrease in cattle production capacity and cattle production (B7 loop). Moreover, with increasing cattle price and price cost ratio

of cattle, cattle smuggling decreases. As a result, herder inventory increases and this loop continues as B9 loop (B8 loop). These negative loops balance the cattle production and herder inventory. Beside these balancing loops, there is a positive loop of breeding stock slaughtering which leads to herder inventory growth. As Figure 11 shows, with increasing in cattle production costs, the price cost ratio of cattle decreases. Since, herders unable to feed all their livestock, they send some of the breeding stocks to the slaughterhouse. As breeding stock slaughtering increases, herder inventory, sale to dealer and dealer inventory increase. This increases retailer inventory, which leads to decrease in retail beef price and consequently decrease in cattle price. So, the price cost ratio of cattle decreases again (R8 loop).

As Figure 2 shows, corn price has been rising during the time. This has limited cattle production. However, it can be seen that beef production has been rising since 2012. It is due to the reinforcing process of breeding stock slaughtering which increases herder inventory. So, the effect of reinforcing loop of breeding stock slaughtering overcomes the balancing loops that limit the cattle production. Therefore, beef production continues to rise. This leads to significant decrease in breeding stock population (see Figure 2). But it is clear that breeding stock slaughtering could not continue to growth limitlessly. Increasing breeding stock slaughtering decreases breeding stock population, which limits the breeding stock slaughtering growth (see B3 loop in Figure 8). Therefore, the combination of balancing loops B3, B7, B8 and B9 with reinforcing loop R8 can arise limit to growth archetype in the near future. So, balancing loops will limit the breeding stock slaughtering and herder inventory. It leads to decrease in beef production and increase in beef price. The limiting conditions are “drought” and “corn cultivation area”. These parameters affect the corn production. It could limit the herder inventory. Another limiting condition is “expected income” which limits the breeding stock population. It could limit the breeding stock slaughtering and consequently herder inventory. These results support the earlier research by Abdulla et al. (2016) indicated that low beef price cost ratio made worse the production. Given the high production costs of the fattening farms and due to this fact that more than 70% of production costs are related to livestock feed, providing forage at affordable prices for cattle herders could decrease production costs and cattle smuggling. To reach this goal, it is necessary for the government to invest in forage production by changing irrigation system and using early maturing and drought-tolerant varieties of corn. These results are consistent with that of Conrad (2004) which concluded that the low production cost is a preventative measure to protect cattle population and decrease beef price.

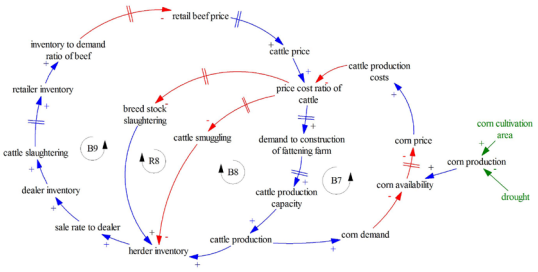

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Figure 11: Beef production loops.

Conclusion

In this study, the challenges of the beef value chain in Mashhad were investigated. Due to unstructured problems, dynamic nature and multiple factors, soft system methodology including rich picture and CATWOE analysis was used. By using these tools, the actors involved in this value chain and their relationships were explained. Then, the causal loop diagram and system archetypes were identified based on problem structuring in the previous step. In this value chain, 3 different generic archetypes were extracted including limit to growth, fixes that fail and shifting the burden. Fixes that fail and shifting the burden archetypes indicated that the beef import policy has not been effective to regulate the domestic market. This has only made the system accustomed to supply the required beef through imports and neglected fundamental solutions. Also, the corn import policy has not been effective in decreasing corn price and cattle production costs, given the lack of monitoring on imported corn distribution and distributing imported corn at a high price. The limit to growth archetype indicated dynamics of balancing loop of breeding stock slaughtering which limits the reinforcing loop of breeding stock population. Also, the results showed that the effect of reinforcing loop of breeding stock slaughtering overcomes the balancing loops that limit the cattle production. Therefore, beef production continues to rise. But breeding stock slaughtering could not continue to growth limitlessly. Therefore, combining the reinforcing loop of breeding stock slaughtering with negative loops which limited

the breeding stock slaughtering and herder inventory can arise another limit to growth archetype in the near future. It leads to decrease in beef production and increase in beef price. Based on the results, it is suggested that the government supports the herders to invest in the construction of new fattening farms in order to increase cattle production capacity. It can be concluded that beef cattle production in Mashhad is largely dependent on sustainable supply of livestock feed. So, enhancing cattle production requires policy making to increase availability of livestock feed. Since corn is one of the most important inputs in livestock production and given that rising its price in recent years led to a sharp increase in cattle production costs and beef price, it is necessary to plan for increasing its production by changing irrigation system and using early maturing and drought-tolerant varieties of corn. On the other hand, given that reaching self-sufficiency in corn production in Iran is not possible; it needs to closely monitor the import and distribution of this input to break the monopoly of dealers and distributers. This could be useful in reducing corn price and cattle production costs. Also, training the herders to improve feed utilization and reducing feed wastage could be effective in decreasing cattle production costs. This study showed that system archetypes could be used to identify problems in the livestock value chain. Because it would give a big picture of the system to planners and policymakers in order to decision-making in this sector. Since, system thinking and its tools are qualitative methods and they are the entry point to system dynamics modeling, it is suggested that future studies simulate the impacts of the proposed policies on the beef value chain system.

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References

[1] Abdulla, I., Arshad, F. M., Bala, B. K., Bach, N. L. and Mohammadi, S. (2016) "Management of beef cattle production in Malaysia: A step forward to sustainability", *American Journal of Applied Sciences*, Vol. 13, No. 9, pp. 976-983. ISSN 15469239.

[2] Alijani, F. and Saboohi, M. (2009) "Measuring market power and cost efficiency of meat and beef in Iran", *Journal of Agricultural Economics Research*, Vol. 1, No. 2, pp. 77-90. ISSN 1043-3309. (In Persian)

[3] Armendàriz, V., Armenia, S., Atzori, A. S. and Romano, A. (2015) "Analyzing food supply and distribution systems using complex systems methodologies", *Proceedings in Food System Dynamics*, pp. 36-58. ISSN 2194-511X. DOI 10.18461/pfsd.2015.1504.

[4] Banson, K., Nguyen, N., Sun, D., Asare, D., Sowah Kodia, S., Afful, I. and Leigh, J. (2018) "Strategic management for systems archetypes in the piggery industry of Ghana: A systems thinking perspective", *Systems*, Vol. 6, No. 4, p. 35. ISSN 2079-8954. DOI 10.3390/systems6040035.

[5] Bergvall-Kåreborn, B., Mirijamdotter, A. and Basden, A. (2004) "Basic principles of SSM modeling: an examination of CATWOE from a soft perspective", *Systemic Practice and Action Research*, Vol. 17, No. 2, pp. 55-73. ISSN 1573-9295. DOI 10.1023/B:SPAA.0000018903.18767.18.

[6] Checkland, P. and Poulter, J. (2006) "*Learning for action: A short definitive account of soft systems methodology and its use, for practitioners, teachers and students*", John Wiley and Sons Ltd. ISBN 0470025549.

[7] Conrad, S. H. (2004) "The dynamics of agricultural commodities and their responses to disruptions of considerable magnitude", *Proceedings of the 22nd International Conference of the System Dynamics Society*, Vol. 22, p. 13. Oxford, England, July 25-29, 2004.

[8] Cox, S. A. (2014) "*Managing information in organizations: A practical guide to implementing an information management strategy*", Macmillan International Higher Education. ISBN 9780230298842.

[9] Ebadi, F. (2015) "*Analysis and comparison of Iran's desirable food basket with agricultural production during the sixth development plan and horizon 2025*", Institute of Planning Research, Agricultural Economics and Rural Development. [Online]. Available: http://www.agri-peri.ac.ir/Dorsapax/userfiles/Sub0/pejoheshmaghale/42.pdf. [Accessed: 20 Sept. 2019].

[10] FAO (2015) "*Livestock Commodities*". FAO. [Online]. Available: http://www.fao.org/docrep/005/y4252e/y4252e05b.htm#TopOfPage. [Accessed: 18 Aug. 2019].

[11] FAO (2016) "*FAO Regional Office for Near East and North Africa*", FAO. [Online]. Available: http://www.fao.org/neareast/news/view/en/c/430391/. [Accessed: 18 Aug. 2019].

[12] Fatemi, S. R. and Mortezaei, A. (2013) "*Food supply Chain strategic plan*", Jihad University Press, Shahid Beheshti University. ISBN 978-964-479-042-3. (In Persian).

[13] Ghasemi, A. (2016) "*Look at the market of livestock and poultry inputs*", Deputy of Economic Affairs. [Online]. Available: http://tolidi.mefa.ir/Portal/Home/default.aspx [Accessed: 15 Sept. 2019]. (In Persian).

[14] Goldstein, M. and Khan, M. S. (1985) "Income and price effects in foreign trade", *Handbook of International Economics*, pp. 1041-1105. ISBN 978-0-444-86793-3.

[15] Groff, J. (2013) "Dynamic systems modeling in educational system design and policy", *Journal of New Approaches in Educational Research*, Vol. 2, No. 2, pp. 72-81. ISSN 2254-7339. DOI 10.7821/near.2.2.72-81.

[16] Grohs, J. R., Kirk, G. R., Soledad, M. M. and Knight, D. B. (2018) "Assessing systems thinking: A tool to measure complex reasoning through ill-structured problems", *Thinking Skills and Creativity*, Vol. 28, pp. 110-130. ISSN 18711871. DOI 10.1016/j.tsc.2018.03.003.

[17] Grunert, K. G. (2006) "Future trends and consumer lifestyles with regard to meat consumption", *Meat Science*, Vol.74, No. 1, pp. 149-160. ISSN 0309-1740. DOI 10.1016/j.meatsci.2006.04.016.

[18] Guimarães, V. P., Tedeschi, L. O. and Rodrigues, M. T. (2009) "Development of a mathematical model to study the impacts of production and management policies on the herd dynamics and profitability of dairy goats", *Agricultural Systems*, Vol. 101, No. 3, pp. 186-196. ISSN 0308-521X. DOI 10.1016/j.agsy.2009.05.007.

[19] Hart, D., and Paucar-Caceres, A. (2014) "Using critical systems heuristics to guide second-order critique of systemic practice: exploring the environmental impact of mining operations in Southern Peru, *Systems Research and Behavioral Science*, Vol. 31, No. 2, pp. 197-214. ISSN 10991743. DOI 10.1002/sres.2195.

[20] Hosseini, S. S. and Shahbazi, H. (2010) "A model of Iran's farm-retail marketing margin for beef", *Journal of Agricultural Science and Technology*, Vol. 12, No. 3, pp. 255-264. ISSN 2345-3737.

[21] Iran Feed Industry Association (2017) [Online]. Available: http://www.irfia.ir/view.aspx?t=10296. [Accessed: 15 Aug. 2019].

[22] Iran Customs Administration (2018) [Online]. Available: https://www.irica.gov.ir/index.php?newlang=eng.[Accessed: 15 Aug. 2019].

[23] Jackson, M. C. (2007) "*Systems approaches to management*", Springer Science and Business Media. ISBN 0306465000.

[24] Li, F. J., Dong, S. C., and Li, F. (2012) "A system dynamics model for analyzing the eco-agriculture system with policy recommendations", *Ecological Modelling*, Vol. 227, pp. 34-45. ISSN 0304-3800. DOI 10.1016/j.ecolmodel.2011.12.005.

[25] Matulova, K., Bubakova, P., Skubna, O. and Taussigova, T. (2010) "Econometric analysis of milk value chain", *Agris on-line Papers in Economics and Informatics*, Vol. 2, No. 4, pp. 51-62. ISSN 1804-1930. DOI 10.22004/ag.econ.99222.

[26] Mehregan, M. R., Hosseinzadeh, M. and Kazemi, A. (2012) "An application of soft system methodology", *Procedia-Social and Behavioral Sciences*, Vol. 41, pp. 426-433. ISSN 1877-0428. DOI 10.1016/j.sbspro.2012.04.051.

[27] Ministry of Agriculture Jihad (2007) "*Deputy of livestock affairs*". [Online]. Available: https://www.maj.ir/ [Accessed: 20 Aug. 2019].

[28] Ministry of Agriculture Jihad (2018) "Agricultural statistics: 2002-2018". [Online]. Available: https://www.maj.ir/Index.aspx?page_=form&lang=1&sub=65&tempname=amar&PageID=11583. [Accessed: 20 Aug. 2019].

[29] Mwanyumba, P. M., Wahome, R. W., MacOpiyo, L. and Kanyari, P. (2015) "Livestock herd structures and dynamics in Garissa County, Kenya", *Pastoralism*, Vol. 5, No. 1, p. 26. ISSN 20417136. DOI 10.1186/s13570-015-0045-6.

[30] Naik, G. and Suresh, D. N. (2018) "Challenges of creating sustainable agri-retail supply chains", *IIMB management review*, Vol. 30, No. 3, pp. 270-282. ISSN 09703896. DOI 10.1016/j.iimb.2018.04.001.

[31] Neven, D. (2014) "*Developing sustainable food value chains*", Guiding Principles, Food and Agriculture Organization of the United Nations. ISBN 9251084815.

[32] Parsons, D., Nicholson, C. F., Blake, R. W., Ketterings, Q. M., Ramírez-Aviles, L., Cherney, J. H. and Fox, D. G. (2011) "Application of a simulation model for assessing integration of smallholder shifting cultivation and sheep production in Yucatán, Mexico", *Agricultural Systems*, Vol. 104, No. 1, pp. 13-19. ISSN 0308-521X. DOI 10.1016/J.AGSY.2010.08.006.

[33] Phillips, I. and Kenley, C. R. (2019) "An SSM-TRIZ methodology for business problem structuring". *In INCOSE International Symposium*, Vol. 29, No. 1, pp. 406-420. John Wiley and Sons, Ltd. ISSN 2334-5837. DOI 10.1002/j.2334-5837.2019.00611.X

[34] Piewthongngam, K., Vijitnopparat, P., Pathumnakul, S., Chumpatong, S. and Duangjinda, M. (2014) "System dynamics modeling of an integrated pig production supply chain", *Journal of Biosystems Engineering*, Vol. 127, pp. 24-40. ISSN 2234-1862. DOI 10.1016/j.biosystemseng.2014.08.007.

[35] Posthumus, H., de Steenhuijsen-Piters, B., Dengerink, J. and Vellema, S. (2018) "Archetypes: common systemic behaviors in food systems", Wageningen Economic Research (Wageningen Economic Research memorandum) - 13, Wageningen University and Research and KIT Royal Tropical Institute. DOI 10.18174/464055.

[36] Rahimi B., S., M. Kohansal., and A. Dourandish. (2014) "Prediction of meat demand in Iran for urban areas using Genetic Algorithm", *Journal of Agricultural Economics*, No. 8, pp. 49-64. E.ISSN 1477-9552. (In Persian).

[37] Senge, P. M. (2006) "*The fifth discipline: The art and practice of the learning organization*", Broadway Business. ISBN 9780385517256.

[38] Setianto, N. A., Cameron, D. C. and Gaughan, J. B. (2014) "Structuring the problematic situation of smallholder beef farming in Central Java, Indonesia: Using systems thinking as an entry point to taming complexity", *International Journal of Agricultural Management*, Vol. 3, No. 3, pp. 164-174. ISSN 2047-3710.

[39] Shamsuddoha, M and Nedelea, A. (2013) "A Vensim based analysis for supply chain model", *Ecoforum Journal*, Vol. 2, No. 2. ISSN 2344-2174.

[40] Sterman, J. D. (2000) "*Business dynamics: Systems thinking and modeling for a complex world*", Boston: Irwin McGraw-Hill. ISBN 9780072389159.

[41] Suryani, E., Hendrawan, R. A., Muhandhis, I. and Dewi, L. P. (2016) "Dynamic simulation model of beef supply chain to fulfill national demand, *Jurnal Teknologi*, Vol. 78, No. 9, pp. 169-177. ISSN 2180-3722. DOI 10.11113/jt.v78.9609.

[42] Tedeschi, L. O., Nicholson, C. F. and Rich, E. (2011) "Using system dynamics modelling approach to develop management tools for animal production with emphasis on small ruminants", *Small Ruminant Research*, Vol. 98, No. 1, pp. 102-110. ISSN 0921-4488. DOI 10.1016/j.smallrumres.2011.03.026

[43] Van Mai, T. (2010) "Systems thinking approach as a unique tool for sustainable tourism development: A case study in the Cat Ba biosphere reserve of Vietnam", *Proceedings of the 54th Annual Meeting of the International Society for the Systems Sciences*, Waterloo, Canada ,Vol. 54, No. 1.

[44] World Bank (2010). [Online]. Available: http://siteresources.worldbank.org/INTIRAN/Resources/Iran_Web_brief.pdf. [Accessed: 20 Aug. 2019].

[45] Zarei, M., Fakhrzad, M. B. and Paghaleh, M. J. (2011) "Food supply chain leanness using

[46] Zarei, M., Fakhrzad, M. B. and Paghaleh, M. J. (2011) "Food supply chain leanness using a developed QFD model", *Journal of Food Engineering*, Vol. 102, No. 1, pp. 25-33. ISSN 0260-8774. DOI 10.1016/j.foodeng.2010.07.026.

[47] Zare Mehrjerdi, Y. (2011) "Quality function deployment and its profitability engagement: A systems thinking perspective", *International Journal of Quality and Reliability Management*, Vol. 28, No. 9, pp. 910-928. ISSN 0265-671X. DOI 10.1108/02656711111172513.