

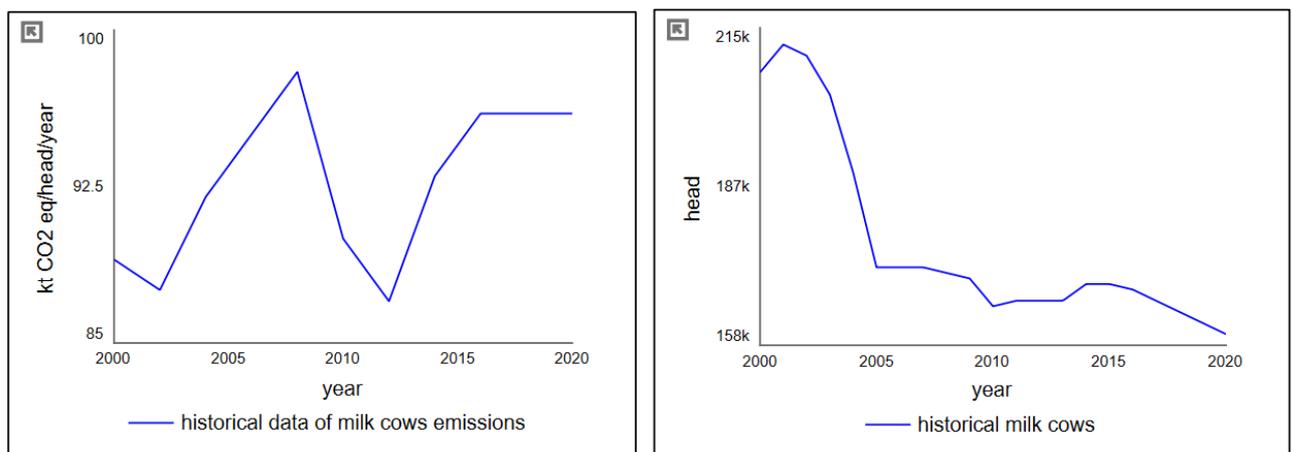
## SYSTEM DYNAMIC MODEL OF GREENHOUSE GAS EMISSIONS REDUCTION

As in every Slavic country, milk culture is very high developed and valuable in Latvia. Farmers pay a lot of attention to the quality of the product. As proof of this it is important to point out that the milk of the dairy brand Mana Saime from the leading Latvian dairy company Food Union was recognized as one of the three most successful new products and the most successful product in the dairy product category in Latvia in 2012, according to the opinion of Nielsen, an international analytical company specializing in marketing research and media measurements (Food Union, 2020). Nielsen assessed the most successful Latvian product innovations in the consumer goods (FMCG) sector. Another example is the fact that there is Milk Museum and Dairy Estate in Berghof (Magnetic Latvia Travel, 2022).

At this point reader could understand that milk production sector occupies a significant part of the production in Latvia. “In this county there are favorable climatic conditions for development of animal breeding” (Berzina, Priekulis, Aboltins, & Frolova, 2019, p. 78). It is important to admit that the number of milk farms declined after Latvia left Soviet Union 1991, although the volume of farms and the number of cows per farm increased rapidly (SIA Gorod.lv, 2022).

The main problem of this work is high level of GHG emissions produced by milk cows in Latvia.

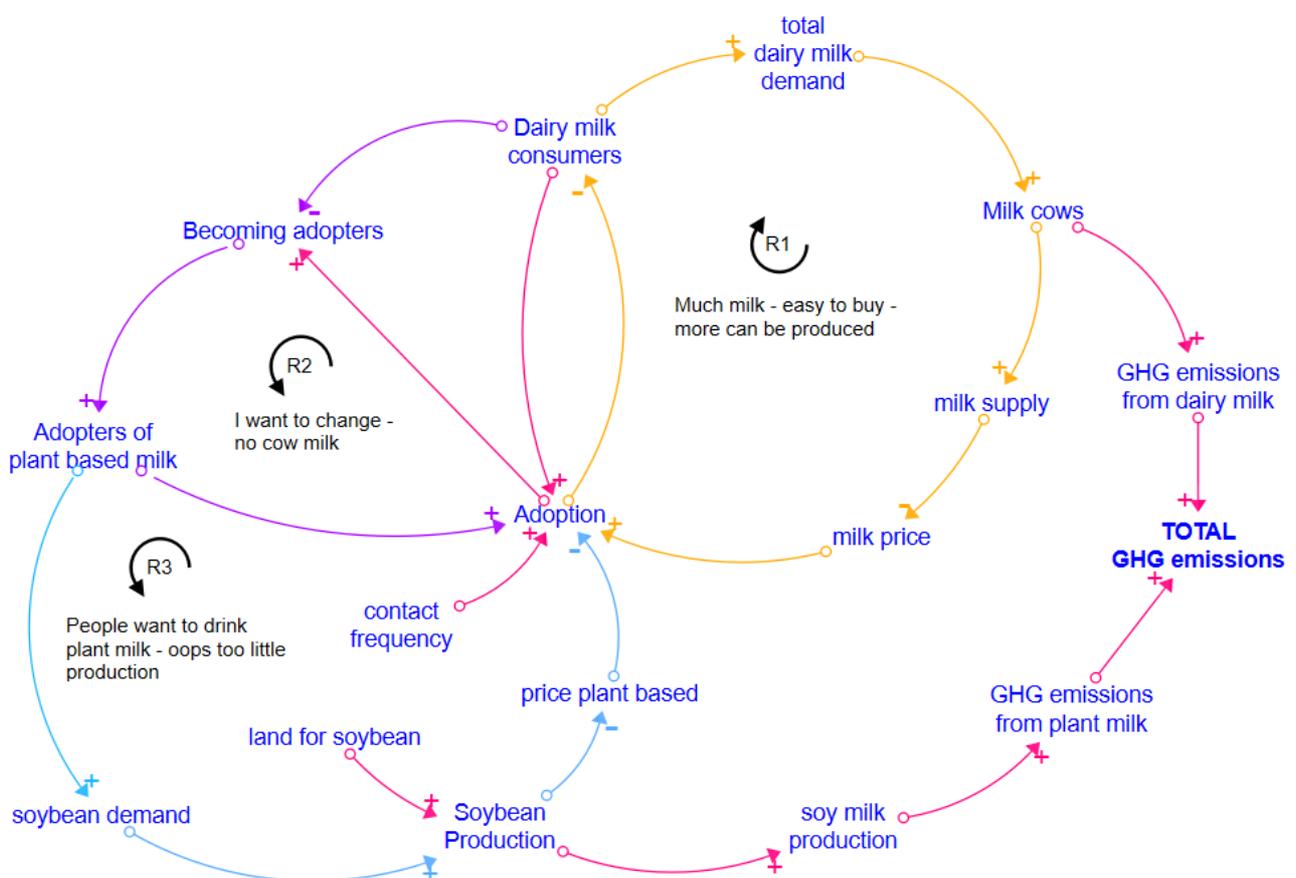
Scientists found out that milk cows produce GHG emissions in atmosphere. However, the increase of GHG (greenhouse gas) emissions cause global warming of the earth (Berzina, Priekulis, Aboltins, & Frolova, 2019, p. 78). Real data of GHG emissions from cow milks from 2000 year until 2020 years can be observed on the figure below (Figure 1).



**Figure 1. Reference mode of behavior**

“Therefore, all EU countries are required to reduce the total amount of these emissions at least by 40% till 2030, but up to 2050 the reduction of GHG emissions should be in the amount of 80-95% compared to 1990. Though, the previous inventory data show that the total amounts of these emissions in the country do not reduce, but they increase with every year. Summarizing the data on GHG emissions caused by farm animal breeding and farm manure management in 2017, it was found that 73% of them are created by movement of farm animal digestive tract” (Berzina, Priekulis, Aboltins, & Frolova, 2019, p. 79).

The purpose of this work is to build a simple model of the problem development and suggest ways to improve the performance in the future. Based on literature and description of reference mode the casual loop diagram was built:



**Figure 2. Casual Loop Diagram**

“GHG emissions in animal breeding are created mainly by carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and univalent nitric oxide (N<sub>2</sub>O)” (Berzina, Priekulis, Aboltins, & Frolova, 2019, p. 78). Also, these authors (2019, p.80) found that “60% of farm manure management GHG emissions are created by breeding milk cows, their calves and young stock”.

Rizojeva-Silava and Zexerte-Rizva (2020, p.1941) in their research state that “despite the fact that the number of dairy cows has decreased, milk production (including milk yield per cow) in the Baltic countries continues to increase”.

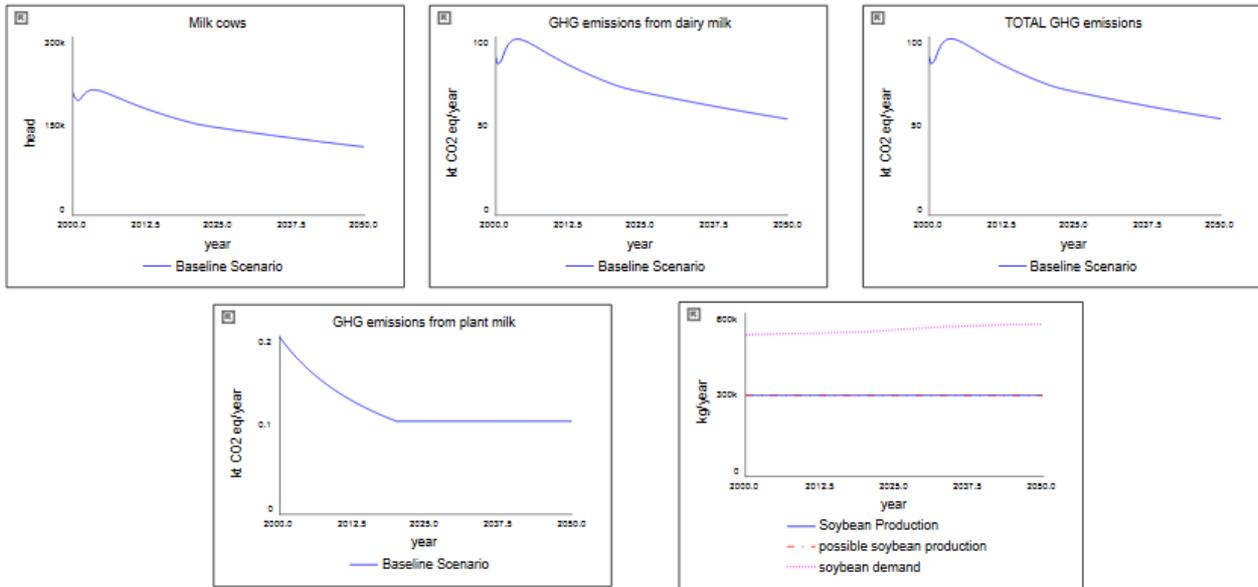
Important factor of consumer buying choice is price as Zhao, Yao, Liu, and Yang (2021) confirmed in their research. The higher the price the more people are reluctant to buy it because of low income. This means that demand for cow milk will not be high, so farmers have to decrease production in order not to produce in vain.

Reinforcing loop R1 (“Much milk – easy to buy – more can be produced”) describes the process of cow milk production, effect of supply on price and thus readiness of consumers to buy it.

Next important reinforcing loop is R2 (“I want to change – no cow milk”). It shows the process of adoption of new eating habits - transition to soy milk. This part was adopted from the diffusion model described by Sterman (2000). The relation between prices of soy milk and cow milk influences the customer’s decision at the shop. Additionally, one more key thing is how those people who have already adopted plant milk try to persuade others to change their habits. In case people really know why choosing soy milk is essential then at least sometimes they can buy more expensive thing. According to the research conducted among young Chinese people “all the items, which includes “more nutrition”, “better flavor”, “safer”, “animal welfare” and “environmentally friendly” are the motivations of their organic food purchase” (Li & Xin, 2015).

R3 (“People want to drink plant milk – oops too little production”): this loop shows how consumer’s decision to make a transition to plant based milk puts pressure on the domestic production. Development of soy production will have economic advantage (ENG.LSM.lv, 2022).

Initially there is a small push upwards through the increase in exports and overproducing, but then the natural decrease in population of Latvia becomes stronger and the total demand for cow milk decreases through loop R1. At the same time there already are some ongoing processes of soy milk adoption, which additionally makes demand for cow milk decline. Increase in adoption pushes expansion of domestic production through loop R3. The total area from soy beans is too little to satisfy the demand. Considering that “just 7% of soy is used directly for human food products” (Ritchie & Roser, 2021) the situation is even worse. At the same time milk yield per cow historically increases (Rizojeva-Silava & Zeverte-Rivza, 2020), this drives the rise in milk supply. Slow adoption of soy milk through loop R2 and natural decrease among Latvians decreases demand so GHG emissions from milk cows decrease too. At Figure 3 below the results can be observed. It is worth noting that as the domestic production of soy is little emissions are not high, thus total emissions from cow and soy milk decline as well.



**Figure 3. Baseline scenario**

Through the model testing and analysis, it has been identified that the main “anchor” in increasing amount of consuming soy milk in Latvia is lack of land. It means even if people are ready to switch into plant-based milk supply does not meet the demand. Obviously, there are imported alternatives in Latvia, however, price of imported milk is quite high in comparison to price of cow milk (3 euro per 1 pack) (ELKOR, n.d.).

With an information above it is possible to formulate the purpose of the first policy: increasing capacity in soy milk production of Latvia via increasing land. It is violent to admit that ecosystem in Latvia is totally adventitious for soy beans growing. This result is consistent with literature that has found. Moreover, “protein content soya in Latvia exactly as high as that of soya farmed in Brazil, for example” (ENG.LSM.lv, 2022).

After implementing this policy by simply increasing land, supply met the demand, what had a positive impact on price, and it went down. This fact influenced positively on decision-making process of potential adopters. Finally, the number of adopters skyrockets. After a few years the velocity of becoming-adopter process decreases, which seems to be logical, because the speed has proportionally the same behavior as density of the number of people who still consume cow milk.

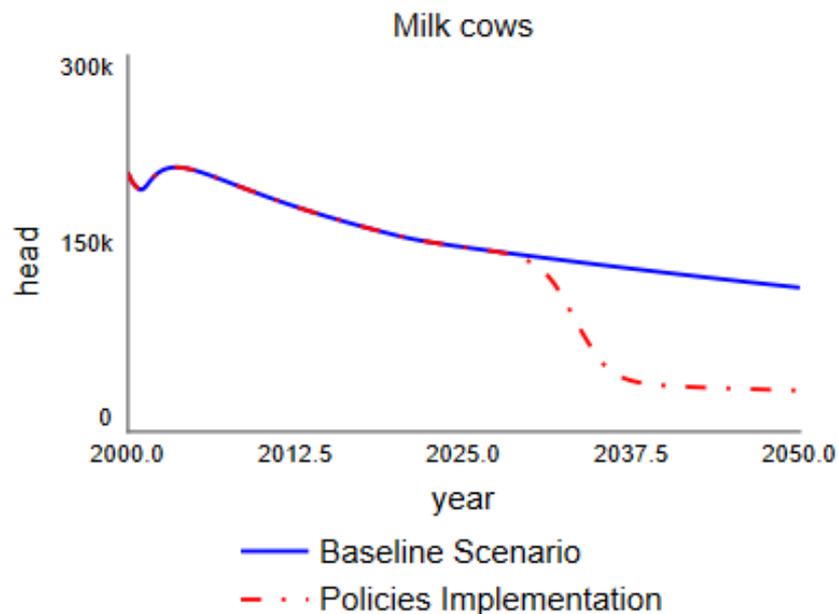
Obviously, it is clear that not all the citizens are ready to switch into plant-based milk. It can be like this, because of the cultural value of cow milk or an allergic reaction of the body to the components of soy milk. It is assumed, that 20% of population are not ready to make this ultimate move, regardless of price or other factors. That is why it is not possible to count on complete reduction of GHG emissions of cow milk production sector.

Because of cultural history of cow milk people are not paying their attention to ecological substitutes. That is why discussions about plant-based food are not very

common among Latvians. Second policy of this work is to build confidence in the need of switching into plant-based milk alternative among citizens.

It is considered education program to be a catalyst of people's making-decision process. This policy was implemented as an increase in contact frequency value. This means, that with educational events (lectures or food-markets, for example) people would meet more and more like-minded colleagues. With volume of conveying knowledge increase, we will get growth in potential adopters. This policy cannot solve the problem; however, it can accelerate and strengthen the result of the first policy.

The following results were obtained according to the available real data, main assumptions, and policy decisions. To better represent the results, it was conducted a comparative analysis, which includes the behavior of variables with and without policy. To begin with, the changes in the total number of Milk cows (Fig. 4).

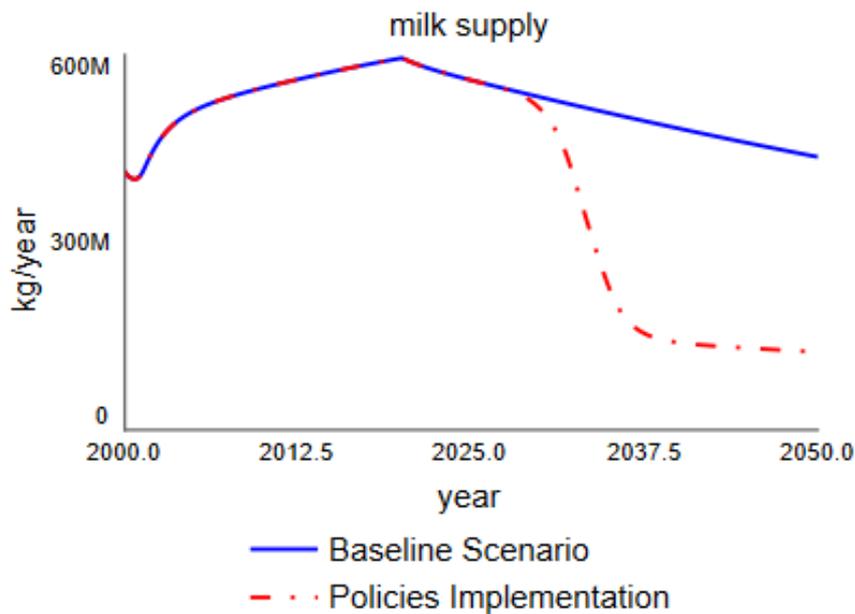


**Figure 4. Changes in Milk Cows**

Due to the increase in soymilk production in a long term as an alternative to ordinary dairy milk, the total number of cows will be reduced. However, these changes would be slow and without sharp declines, because in real life not many consumers are able easily to transit from choosing the traditional products to the new ones (even if these alternatives have more health benefits). The main reason for that is human psychology. According to different scientific researches, the majority of the population is not at risk (risk-aversing person). The risk is that new products would be worse than those, which people are used to buying.

In case of spreading information about health benefits, natural ingredients, and effects on pollution of the new alternatives (soy milk) after some time people will try soy milk, and then there is a high probability to adopt soy milk. This behavior represents the graph with the policy. As it can be seen the changes in the milk cows reduced sharply.

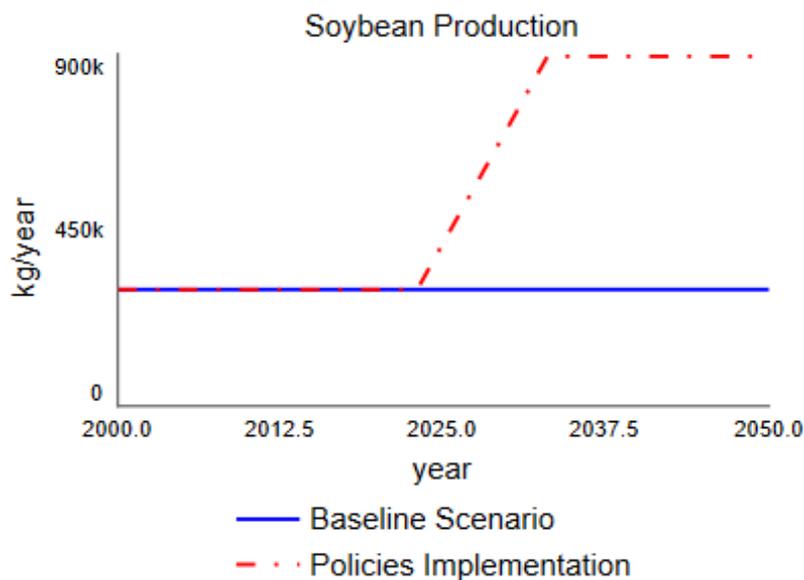
Similar dynamics can be observed in Milk supply (figure 5). If the number of cows reduces the production of dairy milk will decline. That decrease leads to a reduction in milk supply. At the same time, the price of cow milk increased.



**Figure 5. Changes in Milk Supply**

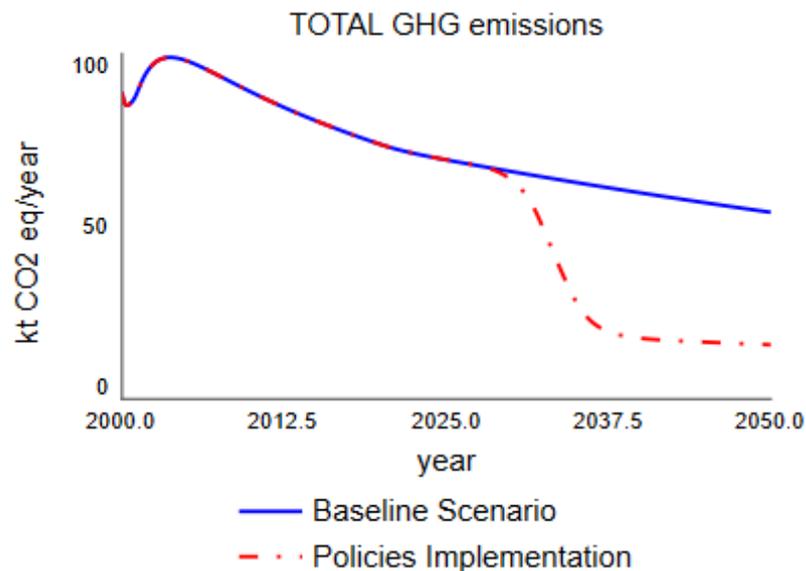
For soybean production, land capacity plays an essential role (figure 6). According to real data, the total hectares, used for soy is only 298 (Zute, S., Damškalne, M., Jansone, I., Morozova, I., & Justs, A., 2020). This creates certain limitations on the potential of soybean production.

So, if there is not enough land for soybean growing there is no potential to meet demand. It is required the extension of the land. That is why the policy considers simultaneously the land policy and education of the people.



**Figure 6. Changes in Soybean Production**

The main result was achieved in the total number of emissions or to be an exact reduction in emissions from production of dairy milk (figure 7). Instead of this, plant-based milk adoption was implemented. The results demonstrate that emissions from soybean manufacturing are much lower than from ordinary milk. At the same time, the emissions from milk production decreased by the end of the time horizon by more than three times.



**Figure 7. Changes in Total GHG Emissions**

To sum up, the main recommendation is to increase the total land area with the simultaneous conduct of education about the benefits of soy milk. The most popular and operational way to implement the second policy is marketing videos and posters. It is also recommended to place food markets with dishes made of soy milk. It is assumed that one of the most efficient ways to grow understanding the importance of transition to plant-based food is to influence teenagers. Classes or lectures devoted to this topic at schools and universities would be useful. At the same time, the second recommendation cannot work without the first one independently. This means that without the land and sufficient capacity education as unproductive as within it. Recapitulating the recommendations given above it might be wise to combine both recommendations proportionally equally.

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