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# A SYSTEM DYNAMICS MODEL FOR AGRICULTURE IN DANUBE MOUTHS REGION

Steliana RODINO<sup>1</sup>

## Abstract

*A dual challenge for the sustainable development of the Danube mouths region is the conservation of the natural ecological assets and the improvement of the quality of life for its residents. Aiming to offer support for regional sustainable policies for improvement of land sea synergies in the Coastal area of Romania, we have developed a system dynamics model for the development of agricultural sector in this region. The model scope is strongly linked to Farm to Fork strategy released by European Commission in 2020 as a response to the global challenges of providing access to healthy food, protect biodiversity and adapt to climate changes. The potential of our case study area for conversion to organic farming is closely related to the presence of protected areas on Tulcea territory. The system dynamics model is built so as to highlight that agricultural sector and the work of farmers is part of the solution not the problem, as we move towards transition to bioeconomy.*

**Keywords:** organic agriculture, Romanian coastal area, system dynamics

**JEL classification:** Q15, Q5

## INTRODUCTION

Current European strategies provide for an explicit commitment to aim higher in terms of the environment and climate. An important objective is stimulating the consumption of organic products, increasing organic production and further improving the sustainability of the sector, to ensure a balanced growth of the agriculture sector. In the recommendations to Member States on their CAP strategic plans, published in December 2020, the Commission included the goal of reaching 25% of the EU's organic farming area by 2030. However, the Member States were invited to set national values for this objective in their CAP plans, based on their local conditions and needs.

Transition to a sustainable economy should be one of the key goals of the national strategies in Romania, as well. Of course, objectives and directions to act will be set up based on extensive analysis of regional assets. When speaking of Danube Delta Region, the sustainable development of this region implies both the conservation of key elements of natural heritage and the enhancement of the quality of life for its inhabitants. Agriculture production is an important source of income for the rural community in this region, located mostly in Tulcea County. According to official National Statistical data, agriculture and forestry make up a third of the total workforce in Tulcea County, followed by fishing, industry and services (Rodino et al., 2019). In the last 30 years, the crop cultivation sector in Tulcea region was characterized by extensive production systems, dominated by cereal cultivation. However, the agricultural production must comply with the environmental restrictions imposed by the legislation in force related to of the Danube Delta Nature Reserve (Butu et al., 2016). Farmers will need to produce more with less resource consumption while protecting the environment. The potential for conversion to organic farming is closely related to the presence of protected areas on Tulcea territory.

Taking all these into consideration, while analyzing land sea interactions in terms of possible impact of human activities on water quality in Danube Delta mouths region, we developed a system dynamics model for the socio-economic development of the area. The goal of the model is to explore alternative scenarios to improve the quality of life and sustainability within the Danube Delta Biosphere Reserve and its marine waters (Black Sea) as one of the most impacted areas along the Romanian littoral.

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## MATERIAL AND METHODS

Land-sea interactions in the coastal region were identified through separate sector workshops and a combined multi-sectoral workshop. For practical reasons due to data availability and considering that the activity on the area upstream has effect on this highly biodiverse area the model included data collected for the entire county of Tulcea. Knowledge on the structure of agricultural production was used for predicting the effects of agricultural activities towards the quality of the environment in the case study area.

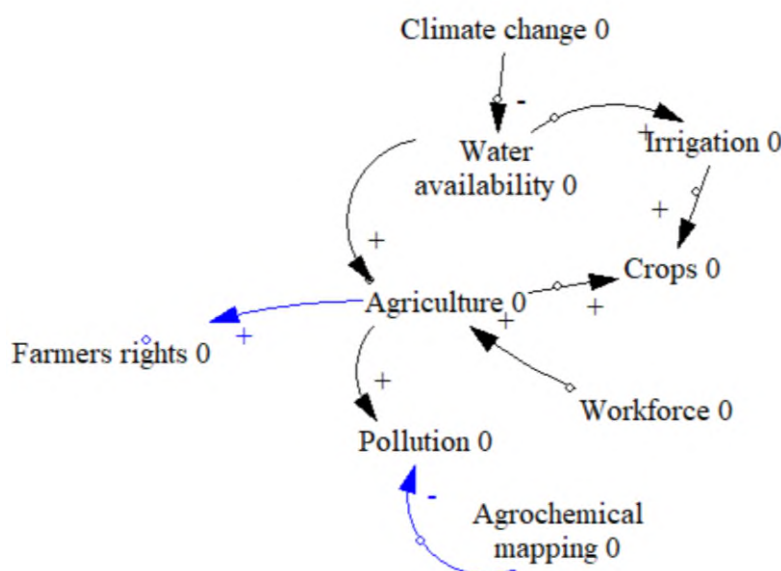
## RESULTS AND DISSCUSION

In order to evaluate potetial impacts and interactions of agriculture sector on sustainable development of Danube Mouth region , was applied an interdisciplinary systems approach assisted by System Dynamics (SD) programming using Vensim programme (Sterman, 2000; Turner et al., 2016).

The interactions between the maritime area and the land considered, were defined based on the goals to improving the overall sustainability of the area and improving the quality of the Black Sea waters which is affected by the quality of the Danube water and possible pollutants (from agriculture and inadequate rural infrastructure)

The initial Causal loop diagram (CLD) from the Agriculture stakeholders meeting (Figure 1.) was translated to a stock and flow model where the main variables were based on the lexical transformation of the initial variables Agriculture to Agriculture production; Traditional farm area and eco-farm area), Farmer rights and Farmers welfare to Farmers income and Pollution to Pollution from Agriculture and further on to Nitrogen load as pollution also is considered in other sub models (More specifically this will be accounted as the impact of agriculture on water quality).

Figure 1. Initial CLD - Agriculture stakeholders meeting -partial view.



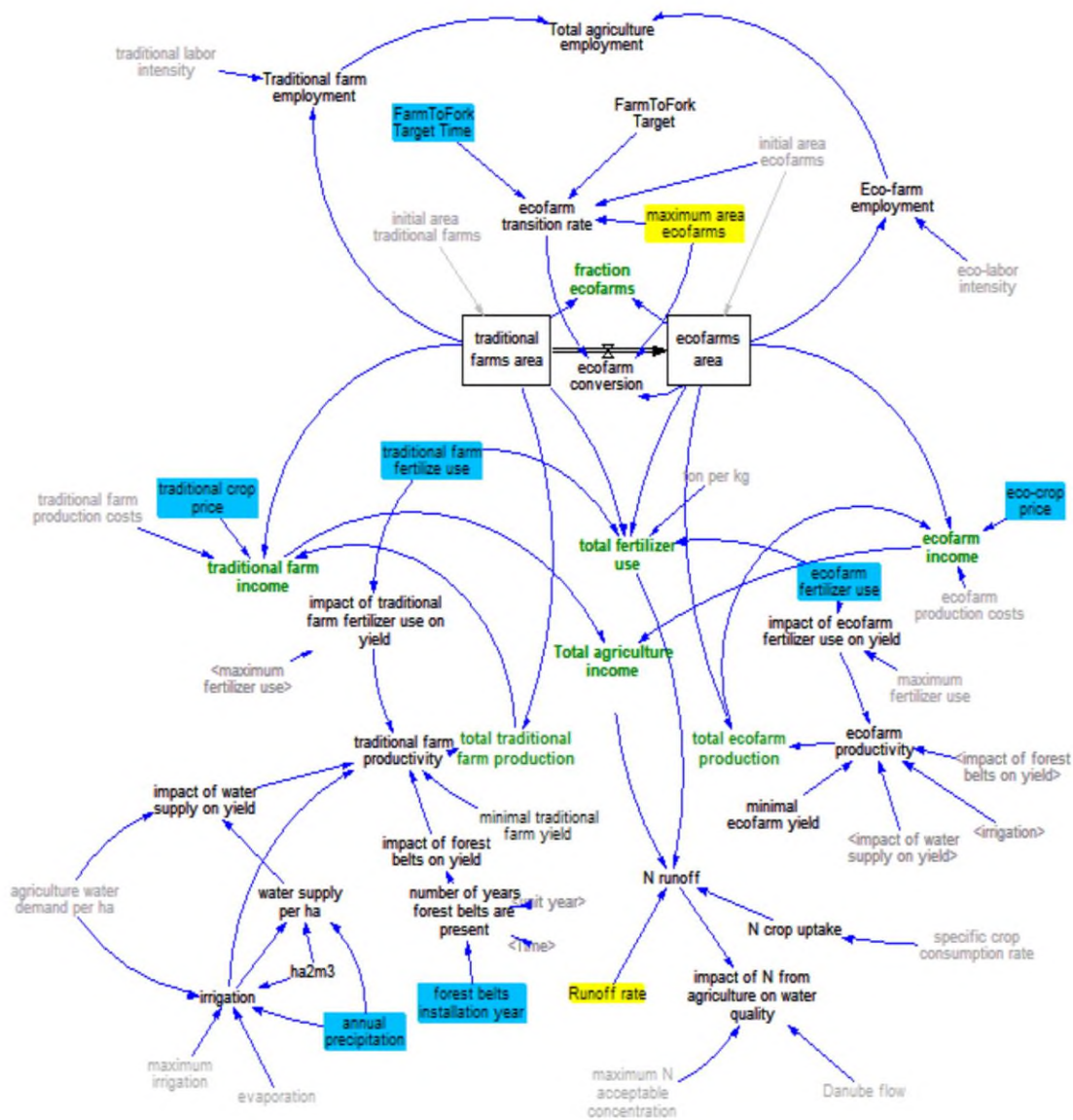
Forest belts as a variable, were also added to the model. The forest belts will improve water availability and this will increase the agricultural productivity. It is to be highlighted that the establishment of protective forest belts and increasing the forested area is part of several policy papers in the development of the Danube Mouths region such as Danube Delta strategy, National Regional Development Program, etc. The forest belts offer multiple beneficial effects including biodiversity increase, reducing soil erosion, mitigating of flood risks, trapping snow, and increasing crop yields.

The potential of our case study area for conversion to organic farming is closely related to the presence of protected areas in the Tulcea territory. Over 500,000 hectares have the status of protected areas, which represents more than half of the county's surface. Only organic agriculture can be practiced within these areas, and the use of chemical fertilizers should be prohibited. Inside the Danube Delta Biosphere Reserve, there are over 40,000 hectares suitable for agriculture.

*Quantification in the agriculture model*

The model is structured as a generic one crop system, namely wheat production. This crop was chosen taking into account that it has the largest share of the cultivated area in the case study region.

**Figure 2. Agriculture stock flow model**



Moreover, organic wheat has the highest share in organic production (across the entire country and in the case study area as well) with an average of 30% and a steady increase over the last ten years.

For accuracy of official statistics data included in the model equations, we took into account, as a case study region, the entire county of Tulcea. The start time of the model data is 2019 and timeframe was set to 2050.

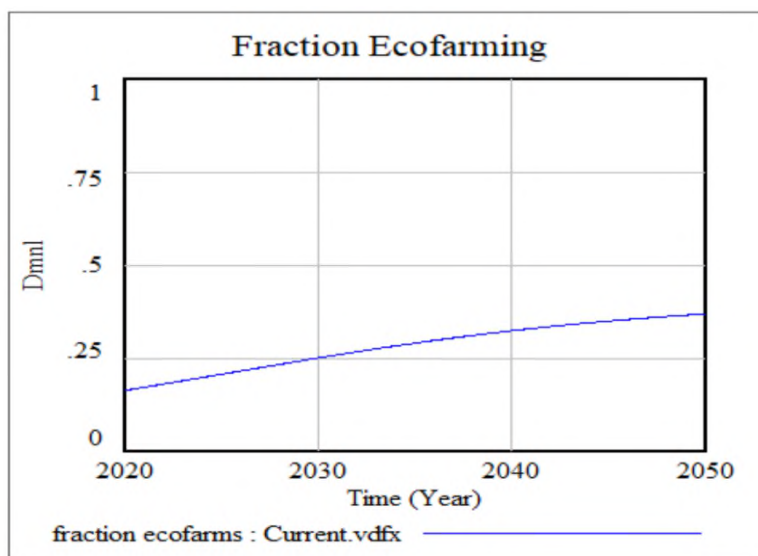
The core objective of this sub-model is to model the transformation from conventional farming vs eco farming by trying to fulfil the EU's recent recommendations, while assuring food security and farmer's competitiveness on the market (Figure 2).

The conversion to eco-farming is expected to have a beneficial effect on the environment by decreasing the negative impact of farming on soil, water and air quality. Given the land-sea interaction envisaged, this sub model is accounting for the impact of farming on water quality.

The model has two stocks: traditional farms area and eco farms area. The entire architecture has a symmetric structure for several variables (farm income, farm production, fertiliser used) respectively for the traditional farming system and the eco farming system.

The eco farms area equation was set taking into account the Farm2Fork strategy of at least 25% of European agricultural area to be cultivated under organic system by 2030.

**Figure 3. Fraction of eco-farms**



At present, the organic production area in Romania accounts for 2,9% of total agricultural land. Tulcea county is ranking the first in the country with a share of 16% area under ecological farming from total agricultural land of the county (366.3 thousand hectares).

The overall traditional farm income is obtained as function of production value (total traditional farms production multiplied by crop price) divided by traditional farm area and subtracting the traditional farm production cost. The same rationale was used for eco-farm income.

Figure 4. Area of eco/traditional farm land

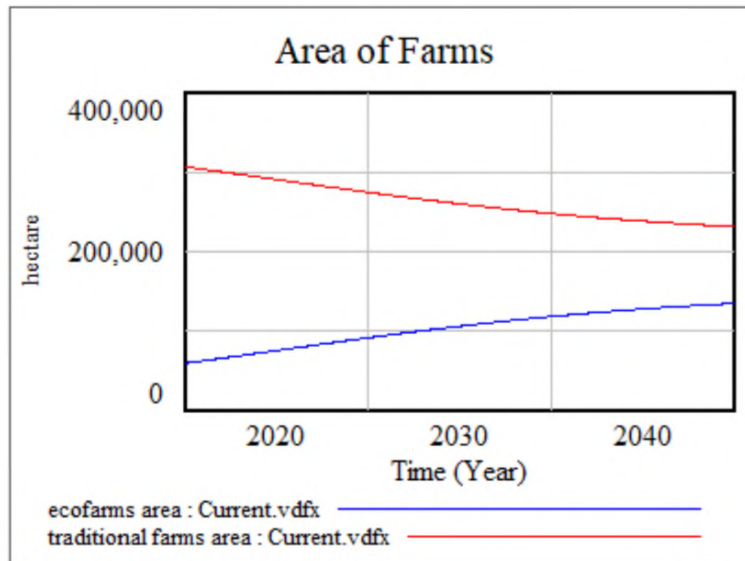
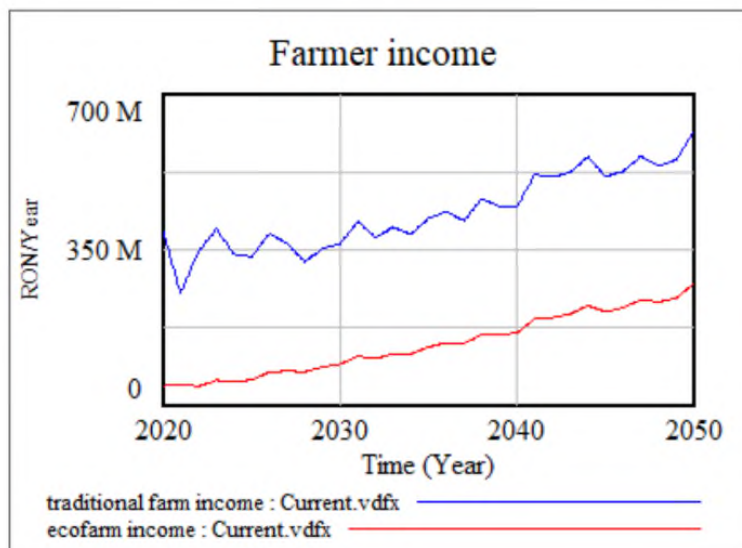


Figure 5. Eco/traditional famer income



The traditional farm yield is expressed as tons crop per year and is obtained by multiplying the average farm production and the total area under traditional farming system. Again, the same rationale applies for eco-farm yield. The higher the yield is the higher the productivity and profitability of a farm and this increases the well-being of farmers.

Generally improved yields are generated with improved practices (innovation, farming infrastructure, irrigation, crop varieties). As our objective is to study land sea synergies, we have chosen for the modelling the water needs (from irrigation and precipitation), fertiliser use and at the stakeholder's suggestion, the installation of forest belts. Regarding the fertilisers, the variables implying this production factor should be read as Nitrogen containing fertilisers. This decision was taken to address the most relevant compound for water quality in the area. Data on fertiliser use were extracted from official statistics and good agricultural practices code for traditional farming and farmers survey and good agricultural practices code for eco-farming.

## CONCLUSIONS

The agriculture sub model scope is strongly linked to the Farm to Fork strategy set out by the EC in 2020. The European Commission's "Farm to Fork" strategy (Farm2Fork) is a response to the global challenges of providing access to healthy food, protecting biodiversity and adapting to climate changes. Farmers working in agriculture will need to produce more with less resource consumption while protecting the environment. The Agriculture sub model is built so as to remember that farmers and their work are part of the solution not the problem as we move towards a transition to a bio-economy. The model can contribute to the Green Deal implementation and Greening the Common Agricultural Policy as follows:

- Support to the objective of at least 25% of the EU's agricultural land under organic farming by 2030 from Farm2Fork strategy by encouraging the expansion of organic area,
- Encouraging the establishment of agro-forestry practices from Farm2Fork strategy by planting forest belts

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