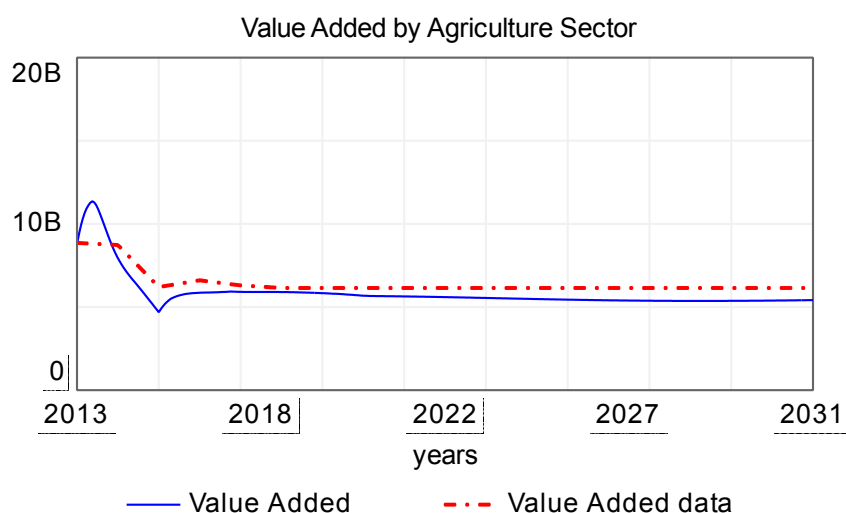


## SYSTEM DYNAMICS MODELING OF AGRICULTURE SECTOR: PRODUCTION AND SALES

After the beginning of the war in 2014, Donbas area, which comprises Donetsk and Luhansk regions, changed from the status of one of the most economically important regions in Ukraine to the most problematic area. Regional GDP decreased rapidly as well as investments and exports.

The beginning of the war in 2014 in Donbas area led to a decrease in the total sown area in the region by 25% compared to 2013. This caused a drop in grain production by 26% in 2019. In turn, in 2019, the volume of livestock decreased by 42% compared to 2013. Because of the rapid decline, livestock production per capita in Donbas area lags behind the national average by more than 90%. Now Donetsk region is in the zone of risky agriculture.

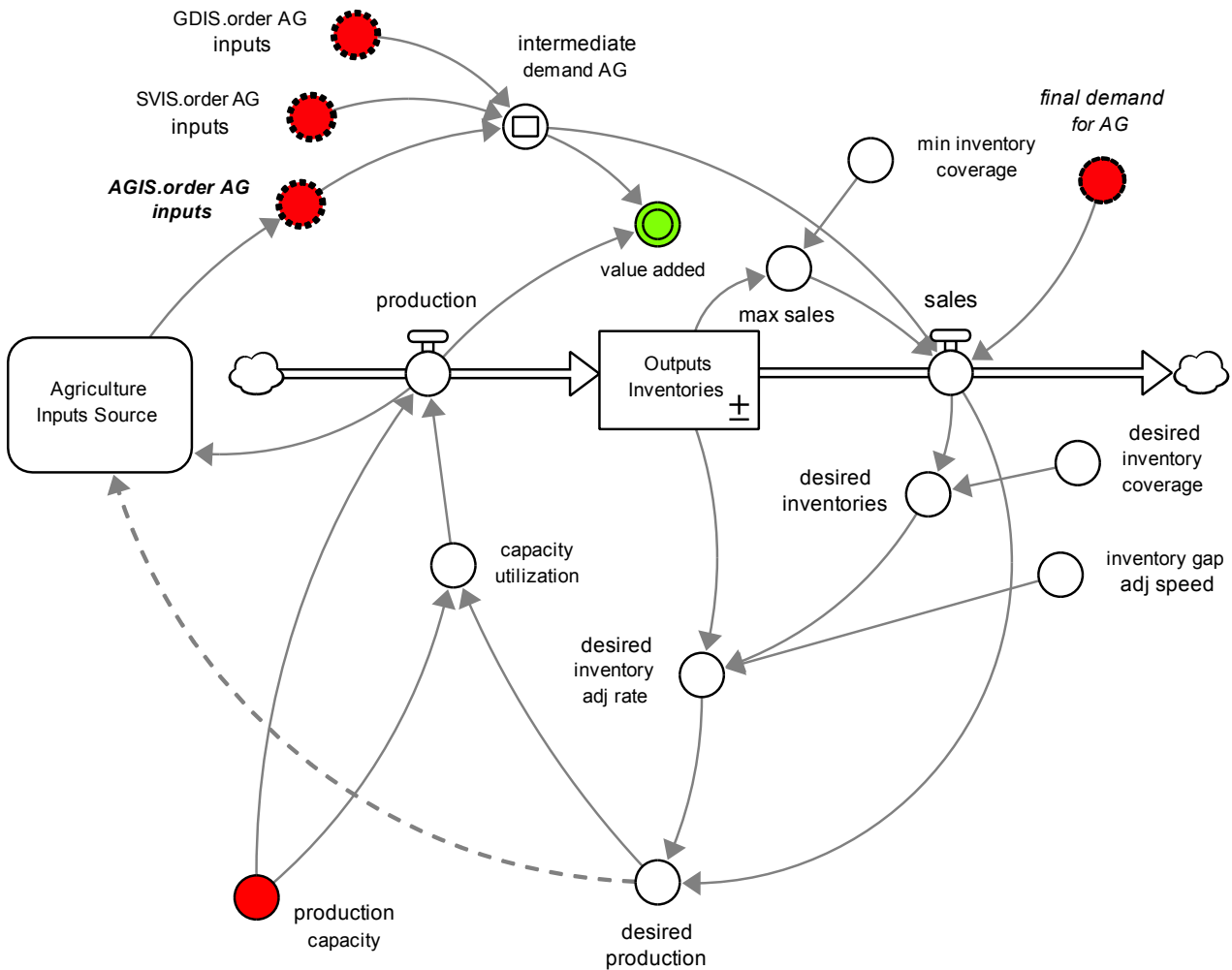
Our work is part of the Dynamic Planning Model for Donetsk and Luhansk Regions developed in collaboration with Professor David Wheat at the University of Bergen and the MAEX Expert Group for the Ministry for Reintegration of the Temporarily Occupied Territories of Ukraine. The temporarily occupied territories in the Donetsk and Luhansk regions are not included in the statistics after 2014.



**Figure 1. Projected Value Added by Agriculture Sector by 2031**

The dynamic problem is the reduction in the value added by the Agriculture Sector. Figure 1 represents value added generated by the model and historical data for the Agriculture Sector. The problem is a sharp decrease in real value added during 2014-2015, from 8,8 billion UAH in 2013 to 6,2 billion UAH in 2015.

In 2015 there was a slight increase and after that there was observed stabilization at a low value with a subsequent slow decline. As can be seen, the simulation matches quite well with the data.



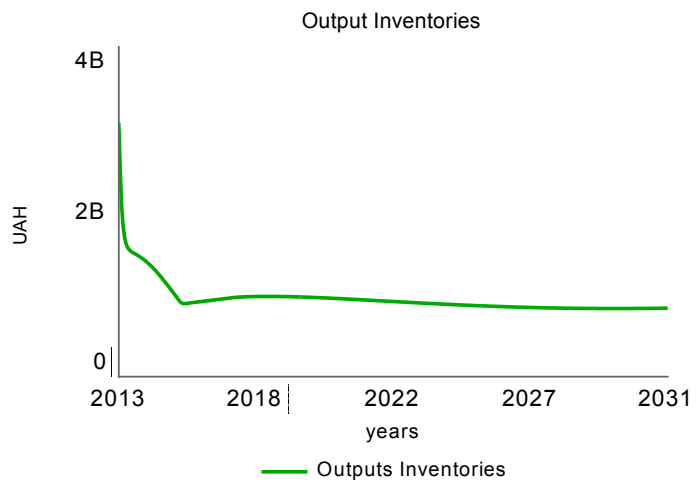
**Figure 2. Structure of Agriculture Production and Sales Model**

Figure 2 shows the structure of the Agriculture Production and Sales Sector. The full Agriculture sector contains several sectors which interact with each other.

The purpose of this sector is to reflect the amount of goods that were produced and sold. It represents one of the key indicators: value added, which is calculated as the differences between the produced amounts of goods and the intermediate demand on them.

The stock ‘Output inventories’ represents reserves of goods. Figure 3 shows that Output inventories rapidly fall in 2014 and continued to decrease in 2015. This is related to the war conflict in Donbas with Russia.

The sales consist of ‘final demand for AG’ and ‘Intermediate demand AG’. The ‘Intermediate demand AG’ is the amount of goods consumed by industries (Agriculture, Goods, and Service) in order to produce their goods.



**Figure 3. Projected Output inventories**

To be able to sell the required amount of goods the sector has to carry sufficient amounts of reserves. Production depends on production capacity and its utilization.

Agriculture Input Source is a sub-model that calculates how much agriculture consumes from other industries and from itself. The link between desired production and Agriculture Inputs Sources marked as ‘wishful thinking’ due to the assumption that all necessary imports and services are fully available. This situation could be partially solved by making reserves of imported goods.

The next equations describe the relationship between production and sales.

$Outputs\_Inventories(t) = Outputs\_Inventories(t - dt) + (production - sales) * dt$	[UAH]
$INIT\ Outputs\_Inventories = (final\_demand\_for\_AG + intermediate\_demand\_AG) * desired\_inventory\_coverage$	[UAH]
$production = production\_capacity * capacity\_utilization$	[UAH/year]
$sales = MIN(max\_sales; final\_demand\_for\_AG + intermediate\_demand\_AG)$	[UAH/year]
$capacity\_utilization = MIN(1,2; desired\_production/production\_capacity)$	[unitless]
$desired\_inventories = SMTH1(sales; 1/12) * desired\_inventory\_coverage$	[UAH]
$desired\_inventory\_adj\_rate = (desired\_inventories - Outputs\_Inventories) * inventory\_gap\_adj\_speed$	[UAH/year]
$desired\_production = (MAX(0; SMTH1(sales; 1/12) + desired\_inventory\_adj\_rate))$	[UAH/year]
$intermediate\_demand\_AG = SMTH1(AGIS.order\_AG\_inputs + SVIS.order\_AG\_inputs + GDIS.order\_AG\_inputs; ,25; 16608206373,6)$	[UAH/year]
$max\_sales = Outputs\_Inventories/min\_inventory\_coverage$	[UAH/year]
$value\_added = production - intermediate\_demand\_AG$	[UAH/year]

Because of the dangers of a further escalation of the conflict, not only private foreign investment isn't coming to the region, but also banks in Ukraine are refusing to give assets as collateral and provide loans in certain areas. It is important to construct a new competitive economy in the country's east, delivering a boost to the Donetsk and Luhansk regions' growth.

The idea of the policy is to return land to agricultural turnover in full and to realize of the potential of the agriculture industry by increasing crop production and livestock.

The implementation of this policy will provide certain obstacles in terms of increasing agricultural output. The proximity to the line of demarcation, in particular, poses a variety of risks and limits. Some of them include:

- Risk to security: insurance firms do not guarantee land and property insurance, and they do not compensate for damages caused by the armed conflict.
- Mine pollution of the environment: according to UN estimates, 700 000 hectares of Ukrainian-controlled territory were mined during the six-year conflict in Donbass. Demining necessitates a 650 million euro investment and a considerable period of time.
- Climate change: agriculture was confronted with a shortage of moisture on the land and reduced precipitation throughout the season, making crop development difficult without the implementation of an irrigation system.
- Lack of qualified workers: as a result of the war, population migration caused a shortage of skilled workers.

- Modern technologies and equipment: lack of modern equipment for agriculture, but the installation of new equipment can cause a new obstacle as a reduction of employment for workers.
- Infrastructure: insufficient development of the railway network, roads, and infrastructure, as well as its partial destruction as a result of military operations, make effective logistics products impossible.

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