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Trends in the development of crop production in Ukraine in 2010-2021

Abstract: Agricultural production is a key area of economic activity in Ukraine, crucial for ensuring food security in Ukraine and Europe. The article aims to trace the development trends of crop production in Ukraine during 2010-2021, with specific objectives: (1) to identify and analyze the dynamics of crop production, (2) to assess the role and importance of large enterprises, and (3) to evaluate regional variations with a focus on four central regions - Vinnytsia, Poltava, Kherson, and Khmelnytskyi. Statistical methods were used to analyze the volume and observe trends in crop production across all regions from 2011 to 2021, but detailed trends are presented for only the four specified regions. Production trends indicate a shift toward high-yield, export-oriented grains and oilseeds (sunflower) and a decrease in crops requiring high labor and infrastructure (vegetables, fruits, potatoes). Regional differences are caused by natural conditions and processing facilities; however, overall, the regions head toward consolidation, specialization, and expansion of commodity production.

Keywords: agriculture, crop production, Ukraine, development trends

1. Introduction

Ukraine has great economic potential (<https://www.cenyrolnicze.pl/...>), which has been significantly paralyzed by the current political situation (due to the Russian invasion). It applies, among other things, to the agricultural sector, with dominant plant production (cereals, oilseeds, and industrial plants). Natural conditions (climate; vegetation period lasting over 200 days a year in most regions; good fertile soils – chernozems and chestnut) are conducive to agricultural cultivation, mainly in central, eastern, and southern areas. The western and northern parts of the country (with poorer soils

and a less favourable climate) are relatively less agriculturally developed (Matuszak, 2021).

The study aims to show trends in Ukraine's plant production during 2010-2021. The authors intend to draw attention to how the economic situation of the agricultural sector has fared over the more than eleven-year research period adopted. Ukraine has a dual structure of entities in agriculture. Apart from farms, there are primarily large agricultural enterprises, the so-called agroholdings. According to Balcerowicz (2024), they control over 50% of agrarian land and are responsible

for 54% of total farming production. Thanks to their capital and access to modern technologies, they are more effective and are pushing farms out of the market (Balcerowicz, 2024). The paper aims to diagnose the production of agricultural raw materials based on analysis of statistical data on the sown area,

crop structure, efficiency, and concentration of plant production of enterprises. A comparison of changes in this area will allow us to diagnose the main trends and assess their impact on the efficiency of Ukrainian agriculture.

2. Study area

Ukraine is located in Central and Eastern Europe with an area of 603,628 km² (i.e., about 6% of the area of Europe). In 2017, 7.2% of its territory is under Russian occupation (<http://dt.ua/UKRAINE/vid-rosiyskoyi-agresyi>). In 2020, the Ministry of Communities and Territorial Development of Ukraine, in its order of November 26, 2020 No. 290, approved that administrative-territorial system (codifier of administrative-territorial units and territories of territorial communities – KATOTTG) includes: the Autonomous Republic of Crimea; regions; districts; territories of gromadas; settlements: cities, urban settlements, villages, towns; districts in cities ([https://stat.gov.ua/uk/page-](https://stat.gov.ua/uk/page-contents/kodyfikator)

[contents/kodyfikator](https://stat.gov.ua/uk/page-contents/kodyfikator)). Two cities with special status are Kyiv and Sevastopol. Since 2014, as a result of Russian annexation of Crimea, parts of the Donetsk and Luhansk regions and the Autonomous Republic of Crimea and the city of Sevastopol have had the status of temporarily occupied territory of Ukraine (Ukraina. Przewodnik..., 2018). According to data from the State Statistics Service of Ukraine, as of January 1, 2020, it was inhabited by 41.9 million people (UKRSTAT., 2023). Agriculture of Ukraine (2023) indicates that the country's population has been on a downward trend during 2010-2021 (a decrease of 4 million 363 thousand people). In terms of gender structure, women dominate (Fig. 1).

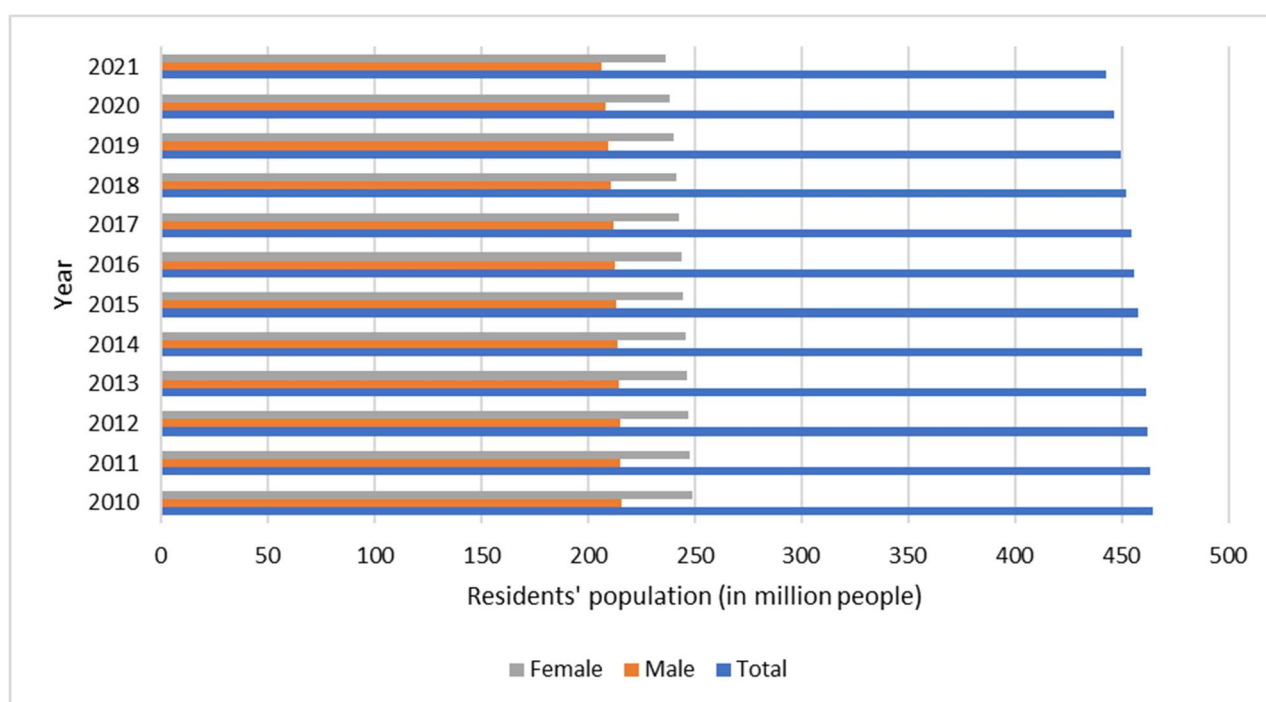


Figure 1. Resident population in Ukraine in 2010-2021. Source: own study based on data from WB Data (<https://data.worldbank.org/indicator/SP.POP.TOTL.MA.ZS?locations=UA>).

Ukraine has a varied terrain. Plains, located at low altitudes, predominate here. A significant part of the country is occupied by the Volyn and Podolia uplands (with an average elevation of 200-300 m above sea level). The Central Russian Upland lies in the north-eastern part of the country, and the Donets Upland lies on the eastern edge. The Ukrainian lowlands consist of the Polesie Lowland, the Dnieper Lowland, and the Black Sea Lowland (covering part of the Crimean Peninsula). The Carpathians (part of the Eastern Carpathians) rise in the south-eastern part of Ukraine.

The climate is moderate continental (influenced by polar maritime and polar continental air masses), with hot summers, cool winters, and mild spring and autumn. The river network of Ukraine belongs mainly to the Black Sea and Azov Sea basins (only 3% of the country's territory has rivers flowing into the Baltic Sea). The soil cover here is closely related to the physical and geographical conditions. The dominant kind of soil is chernozem (occurring in the forest-steppe and steppe zones) with varying humus content. There are also podzolic soils, dark chestnut soils, brown soils, red soils (related to the exposure of the slopes), marsh, and marsh-peat. Because of the climatic and soil diversity,

there are distinguished biogeographic zones: forest, forest-steppe, and steppe with diverse fauna (Europa. Encyklopedia ..., 1996).

Agricultural land in Ukraine covers 71.3% (2021, <https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=UA>) of the country's area. In turn, forests and other forest areas (16.7%, in 2021, <https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=UA>), land under buildings (6%), and land under water and wasteland - 4% each, respectively (Zolotnytska and Kowalczyk, 2022). The arable land is about 56.8% (2021, <https://data.worldbank.org/indicator/AG.LND.ARBL.ZS?locations=UA>) of which almost half is chernozems. Agriculture plays a vital role in the Ukrainian economy, constituting the third largest sector of the economy (11% of GDP, 2021, AgroDigest Ukraine 2025) (for comparison, in 2023 in the EU countries it is on average 1.4% of GDP) (Ukraina ma ogromny potencjał..., 2024). Below are presented various forms of management of the structure of agricultural land in 2020, where one can see their large area owned by agricultural enterprises, as much as 15,434.6 thousand ha (i.e., 37% of all the forms mentioned) (Fig. 2).

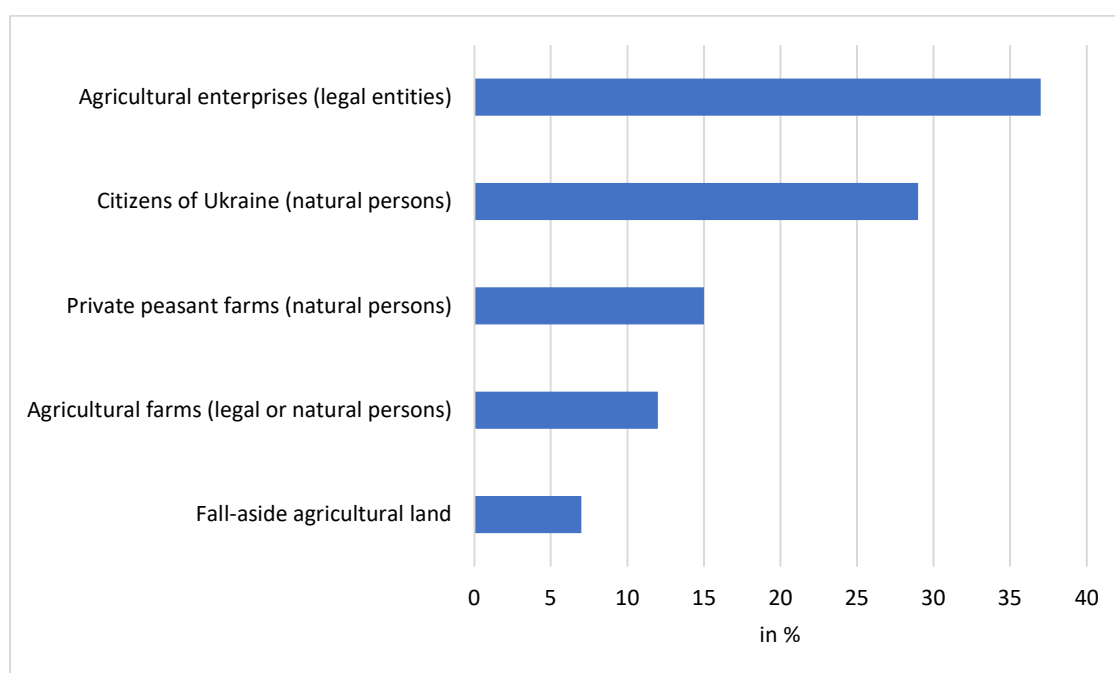


Figure 2. Forms of management of the structure of agricultural land in Ukraine in 2020. Source: own study after Zolotnytska and Kowalczyk (2022).

Ukraine is a large agri-food producer; hence, the importance and share of this sector in the Ukrainian economy is relatively large (Zajac and Bogusz, 2024). It is facilitated by the (previously described) fertile agricultural areas. The basis of the Ukrainian agrarian production is large enterprises developed between 2007 and 2021. It is worth noting that the enterprises, which in 2007 owned 1.7 million ha of land, in 2010, 4 million ha, and in 2015 had 1.6 million ha more. The largest out of them are: Kernel Holding (600 thousand ha), UkrLandFarming (approx. 500 thousand ha), Agroprosperis (approx. 470 thousand ha), Mironowski Chleboprodukt (approx. 370 thousand ha), and Astarta (approx. 250 thousand ha) (Ukraina i jej rolnictwo..., 2024). These are mainly joint-stock companies with their headquarters outside Ukraine.

Ukraine's economy, as Petryshyn (2022) emphasizes, was very volatile during the independence period - it went from crisis to

crisis. The economic recovery in 2010-2012 was slow, with no significant changes until 2013. A severe crisis in the economy was caused by Russian aggression against Ukraine in 2014-2015. Although the level of the recovery was higher in 2016, the pandemic year (2021) brought the recession, and the armed invasion of Russia in 2022 deepened the already challenging state of the country, bringing catastrophic consequences for it. As stated in the CEMA document - European Agricultural Machinery (Dryancour, 2023), "since Ukraine declared its independence from the Soviet Union in 1991, the planted area dropped by about 5 percent, from 32.0 million hectares to 30.4 million, and this for almost every category of crop except for sunflowers. It means that Ukraine still has the potential to re-plant 1.6 million ha of arable land used before the war, despite some limitations of various kinds."

3. Materials and methods

The paper primarily uses the descriptive method and characterization of basic statistical data (including FAOSTAT, UKRSTAT), which allows for the depiction of trends in crop production in Ukraine in 2010-2021. For better visualization, techniques of tabular data presentation were selected to illustrate the data as a panel and distribution series. In addition, bar charts and linear trends, determined using Excel, were used to visualize the data. The statistical measures used included analysis of averages and determined linear trends. Agricultural production indicators are discussed by type of farms, with particular emphasis on enterprises.

The chosen analysis methods allowed for a review of the "empirical base" (including literature and documents), which refers to the subject of the work. Two main parts are distinguished: the first refers to the state of land resources used by enterprises, their surface structure, and crop production. The

second part shows the direction of trends in crop production (over the years 2011-2021) on the example of selected regions of Ukraine (Poltava, Kherson, Khmelnytskyi, Vinnytsia). The year 2010 was omitted due to the imprecise data from that period in the statistics.

We selected four regions of Ukraine for presentation: Kherson, Khmelnytskyi, Poltava, and Vinnytsia. Analyzing these regions allows us to understand how differences in crop structure, agricultural policies, and local conditions influence the development of crop production in Ukraine. Our selection was guided by the following factors: 1. Similar climatic and soil conditions: most of these regions are located in the temperate zone, with fertile chernozem soils favorable for agricultural crops. 2. Dominance of agriculture in the economic structure: all these regions are characterized by a high share of agriculture in the local economy, which means that changes in crop production have a significant impact on

their economic development. 3. Diversity in crop structures: Although these regions share common characteristics, they differ in crop structures, allowing for an analysis of the impact of these differences on the development of crop production. 4. Availability of statistical data: The availability of statistical data (2010-2021) allows for a comparative analysis of changes in crop production in these regions.

The study considers the statistical analysis of the area currently under Russian occupation (the Autonomous Republic of Crimea), because formally it still belongs to Ukraine (according to international law and the position of most states and international organizations, Crimea remains an integral part of Ukraine). In addition, to maintain the continuity of statistical data (data from 2010-2013 cover Crimea in its entirety, and their omission

would lead to a deformation of the image and lack of comparability in long-term analysis; in some years after 2014, data for Crimea were still collected or supplemented by Ukrainian statistical institutions, at least in estimated form). In addition, due to the agrarian importance of the region, Crimea had a significant share in the national crop structure, particularly fruit and vegetables (mainly fruit growing, vineyards), which influenced the national crop production reports. At the same time, the reason was to maintain methodological consistency (excluding one of the regions would disturb the internal consistency of the comparisons and make it difficult to interpret trends and tendencies in a nationwide perspective).

4. Results and discussion

The Ukrainian land has high bioproductive properties. Most cereal crops, sugar beets, sunflowers, perennial fruits, and oil plants are grown on chernozems (Ukraina. Przewodnik..., 2018). Two types of agricultural holdings carry out farming: large enterprises and small farms. Looking at the indicators in 2010-2021, we can see that in the case of large agricultural enterprises, crop production carried out in them showed more pronounced (than in the case of households)

growth trends compared to the previous period (Table 1). We should emphasize here that agricultural enterprises are an economic entity (having legal personality) that voluntarily brings together citizens within an independent enterprise established for the joint production of agrarian products and goods, operating according to the principles of entrepreneurship and self-government (Zolotnytska and Kowalczyk, 2022).

Table 1. Indices of agricultural production by types of agricultural holdings (per cent to the previous year). Source: own study based on Agriculture of Ukraine 2022 (2023).

Specification	2010	2015	2016	2017	2018	2019	2020	2021
All agricultural holdings								
Agricultural production including	98.6	95.2	106.3	97.8	108.2	101.4	89.9	116.4
Crop production	96.4	94.8	109.1	97.1	110.2	101.8	87.9	122.6
Animal production	104.3	96.4	97.3	100.2	101.2	100.2	97.5	95.4
Enterprises								
Agricultural production including:	97.5	128.3	94.8	109.7	112.0	102.7	88.0	122.3
Crop production	94.6	134.9	94.5	112.4	113.6	102.5	85.8	127.8
Animal production	109.8	104.5	96.5	97.5	104.5	103.8	99.3	98.0
Households								
Agricultural production including:	99.9	95.8	100.9	99.3	101.7	99.1	93.6	105.6
Crop production	99.4	95.5	102.8	99.1	103.3	100.2	92.8	111.4
Animal production	100.8	96.3	97.2	99.6	98.1	96.7	95.6	92.4

In 2020, 9,586 large enterprises in Ukraine owned agricultural land (additionally, 6,086 landless farms), of which the largest were those with the size structure of 1,000-4,000 ha (2,986), 100-500 ha (2,520), and 20-100 ha (1,279). There were 184 of those above 10,000 ha. The most considerable areas (in thousand ha) were owned by those with the size from 1,000 to 4,000 (6,007.5) and above 10,000 ha (4,280.1) (Fig. 3). For comparison, we can see that farms have significantly smaller areas of

agricultural land than enterprises (Fig. 3). Although their number in Ukraine (26,691) exceeds the number of enterprises (by 17,105), it is enterprises that farm on thousands and hundreds of thousands of hectares of land, because they can afford, among other things, investments in modern technologies or management. At the same time, their scale of production and access to capital are the main pillars of their advantage over smaller, often traditional (family) farms.

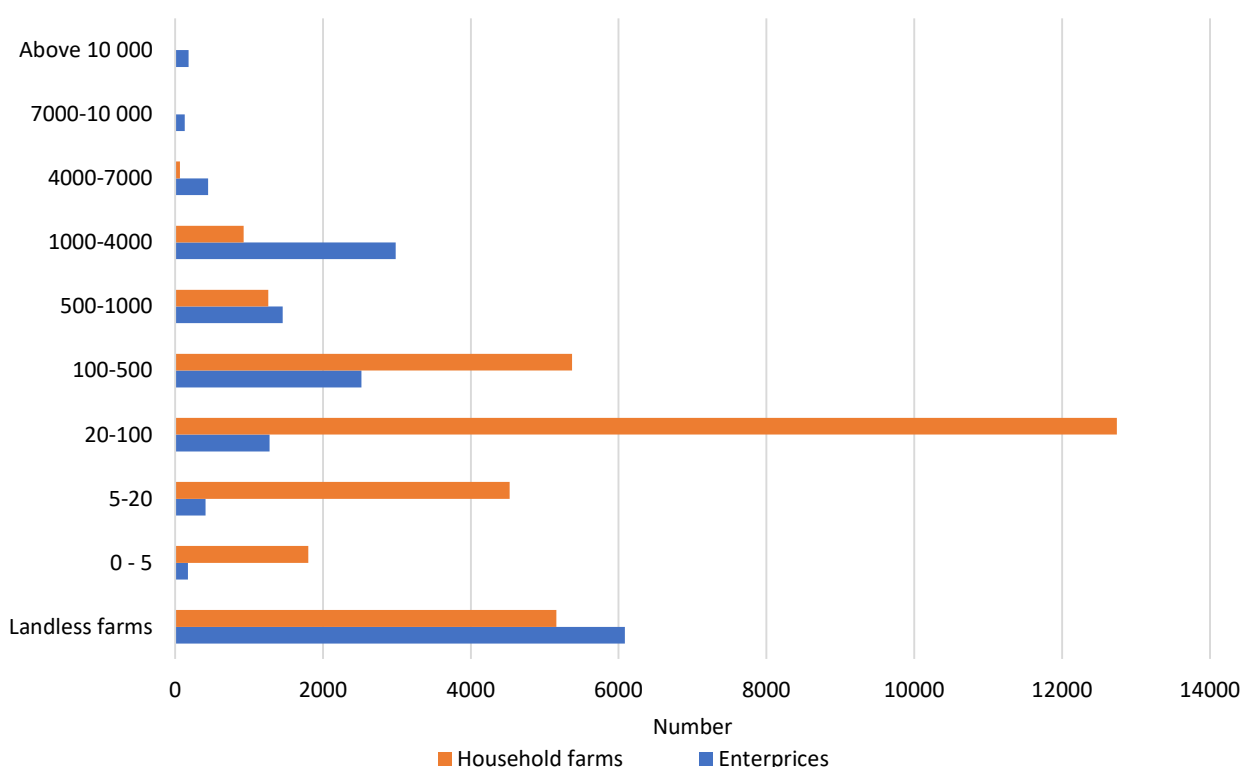


Figure 3. Comparison of the structure of size and area (in ha) of enterprises and farms. Source: own study based on Zolotnytska and Kowalczyk (2022, p. 10).

Large-scale farms in 2021 (compared to 2020) recorded higher crop production than individual farms (Tab. 2) in the regions: Odesa, Cherkasy, Kirovohrad, Mykolaiv, and Chernivtsi. A decrease in crop production was recorded only in 3 regions out of 24 (Zakarpattia, Sumy, Kharkiv).

Wheat cultivation dominates in southern and eastern Ukraine (Zaporizhia, Kharkiv, Odessa, Dnipropetrovsk, and Vinnytsia – 36.7% of the total grain production). Barley predominates in the south of Ukraine (Odessa,

Mykolaiv, Dnipropetrovsk, and Kherson – a total of 37.1%) (Matuszak, 2021).

The fact that crop production plays a key role in Ukraine is confirmed by the revenues recorded from production. Agricultural enterprises recorded an increase of 212,090 million hryvnya (in 2016 prices) over the years 2010-2021 (Tab. 3), and taking into account all agricultural holdings, production was at the level of 250,621.4 million hryvnya (i.e., 56.8% higher in 2021 compared to 2010). We can notice that animal production is much less significant for the country (Tabs 1, 2, 3).

Table 2. Indices of agrarian production in all agricultural enterprises and holdings by regions (per cent of the previous year). Source: own study based on Agriculture of Ukraine 2022 (2023).

No.	Specification	Enterprises				Household farms			
		Agricultural production		including crop production		Agricultural production		including crop production	
		2020	2021	2020	2021	2020	2021	2020	2021
	Ukraine	88.0	122.3	85.8	127.8	93.6	105.6	92.8	111.4
	Regions								
1.	Vinnytsya	82.9	129.1	74.0	147.5	91.6	104.0	90.3	110.4
2.	Volyn	102.9	108.1	103.1	111.6	97.6	96.7	99.5	98.1
3.	Dnipropetrovsk	87.9	121.5	83.1	125.9	80.8	124.1	78.0	135.1
4.	Donetsk	95.7	108.1	94.1	115.3	95.8	107.9	96.7	113.6
5.	Zhytomyr	90.6	123.5	89.4	125.3	101.6	98.4	106.8	100.9
6.	Zakarpattia	116.3	85.4	118.4	86.0	94.5	92.7	97.7	94.8
7.	Zaporizhya	86.9	122.2	86.6	126.6	91.4	108.3	90.6	113.7
8.	Ivano-Frankivsk	111.3	112.8	114.8	126.9	98.6	100.3	99.3	102.4
9.	Kyiv	78.9	125.2	72.3	147.3	98.7	104.4	94.9	109.9
10.	Kirovohrad	65.0	159.3	63.7	163.2	81.8	125.1	77.4	135.8
11.	Luhansk	87.5	108.8	87.5	109.4	91.0	104.3	88.3	105.0
12.	Lviv	107.3	115.1	107.5	113.9	101.6	100.3	104.5	104.3
13.	Mykolaiv	72.2	157.3	72.0	160.0	83.3	130.5	79.4	146.4
14.	Odesa	50.9	255.8	49.6	264.5	76.4	126.8	70.4	140.0
15.	Poltava	86.5	113.5	85.6	114.8	94.2	100.8	93.8	104.3
16.	Rivne	108.0	106.9	110.0	107.4	98.9	97.4	100.5	100.7
17.	Sumy	105.3	90.5	105.7	89.8	98.1	88.8	97.4	94.5
18.	Ternopil	101.9	118.6	101.5	118.4	96.4	103.1	94.2	106.1
19.	Kharkiv	102.3	100.5	102.9	102.1	89.9	93.4	90.4	97.1
20.	Kherson	89.1	117.6	88.8	121.2	103.2	108.9	105.6	114.4
21.	Khmelnyskiy	95.7	119.3	96.2	121.9	101.5	100.2	103.0	98.9
22.	Cherkasy	75.0	140.3	63.3	171.3	94.5	116.5	93.2	125.3
23.	Chernivtsi	101.6	119.1	102.0	132.8	99.1	105.6	100.1	109.7
24.	Chernihiv	104.1	107.9	104.4	108.5	97.7	95.8	103.6	97.4

Table 3. Agricultural production by types of agricultural holdings (in 2016 prices; millions of euro*).

Source: own study based on Agriculture of Ukraine 2022 (2023) and Currency calculator (<https://kalkulatory.gofin.pl/...>).

Specification	2010	2015	2019	2020	2021
All agricultural holdings					
Agricultural production including:	43942.62	22739.33	25604.94	17567.89	23015.89
Crop production	30986.75	17259.94	20255.33	13585.92	18742.65
Animal production	12955.87	5479.39	5349.61	3981.97	4273.24
Enterprises					
Agricultural production including:	24139.76	14010.85	16912.72	11357.10	15636.46
Crop production	18885.97	11405.97	14167.29	9275.79	13340.05
Animal production	5253.79	2604.88	2745.42	2081.31	2296.41
Households					
Agricultural production including:	19802.86	8728.48	8692.22	6210.79	7379.43
Crop production	12100.78	5853.97	6088.04	4310.13	5402.60
Animal production	7702.08	2874.51	2604.18	1900.66	1976.83

*Hryvnia to euro conversion rate based on the National Bank of Poland rates from December 31 of the relevant year for each year specified in the table.

We can state that 118 of the largest agroholdings (companies) own 6.5 million hectares of land, 25% of Ukraine's arable land (Ukraina ma ogromny potencjał..., 2024). In 2023, 20 large enterprises had 3.2 million hectares. These companies also have capital from North American, Saudi, and EU member

states. It proves these enterprises have great power and importance in the market and Ukraine's potential. The country is among the ten biggest suppliers of agricultural product and oats here). The recipients of goods are primarily Germany, Poland, Spain, Italy, and France (Ukraina. Przewodnik..., 2018).

Poltava, Vinnytsia, Cherkasy, and Kharkiv, as well as Odessa (Fig. 4), present high average grain production (in thousand tons) over the years 2010-2021. The most fertile soils (as already mentioned) are found mainly in central and southern Ukraine, e.g., in Poltava, Dnipropetrovsk, and Kirovohrad. They have ideal conditions for growing grains, especially wheat and corn. The northern and western

regions with worse soils, a much colder climate, and a shorter growing season achieve lower yields (e.g., Volyn, Zakarpattia, and Rivne). In turn, the southeastern part of the country (steppes), more exposed to droughts (e.g., Kherson, Mykolaiv, Luhansk), thanks to irrigation and technologies, can be intensively cultivated.

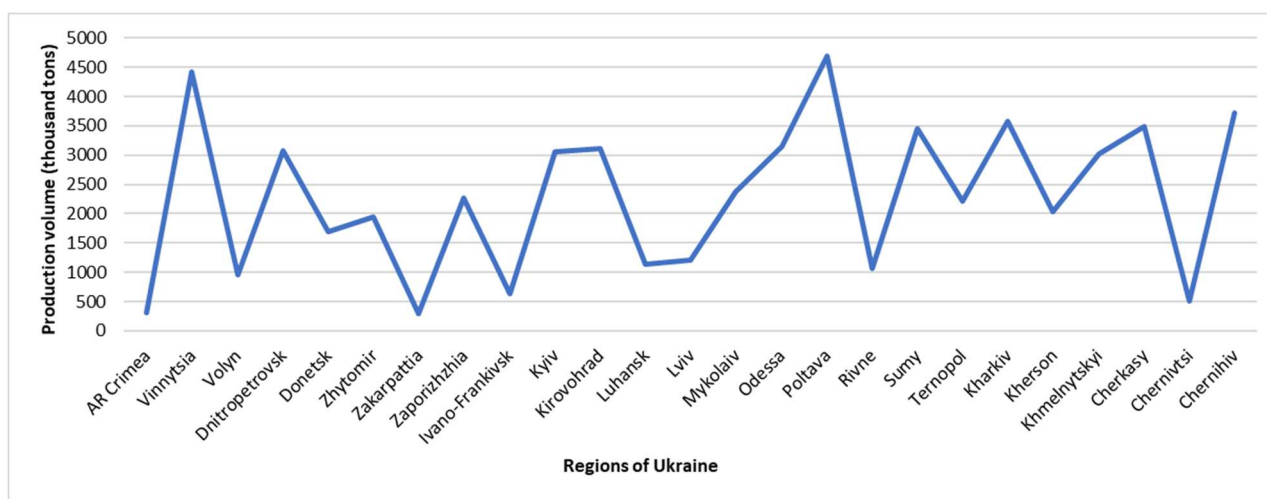


Figure 4. Average grain and leguminous crops production in enterprises in 2010-2021. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

The agricultural products (grains) analyzed above are a key source of convertible currencies in the Ukrainian budget and the basis of the country's food security (Zolotnytska and Kowalczyk, 2022). In 2018-2020, the average share of wheat in world exports (Ukraine and Russia) was around 33%. In 2019, Ukraine was the fifth largest exporter

of wheat and barley, and the fourth largest exporter of corn.

Among the oilseed crops, sunflower is the most important. In 2010-2021, enterprises produced the most sunflower in the following regions: Kharkiv, Kirovohrad, Dnipropetrovsk, Mykolaiv, Poltava and Vinnytsia (Fig. 5).

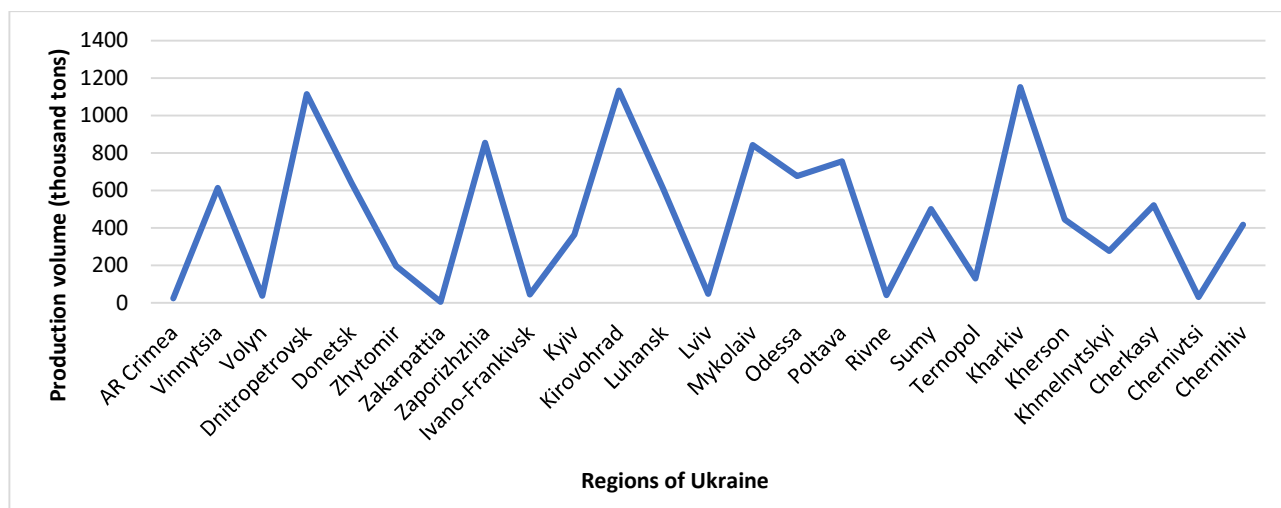


Figure 5. Average sunflower seed production in enterprises in 2010-2021. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

In 2019, Ukraine was the leader in sunflower oil sales and is still among the world's top exporters of sunflower oil (apart from cereals and other oil plants (Matuszak, 2021). Ukraine exported over 90% of its crops, oilseeds, and oils by sea (Ambroziak et al., 2022). Enterprises also grow vegetables. Their production was recorded mainly in two regions: Kherson and Dnipropetrovsk (Fig. 6).

In turn, Vinnytsia, Lviv, Kyiv, Zhytomyr, Chernihiv, Khmelnytskyi, Rivne have a considerable share in potato production (Fig. 7). Potatoes are grown in Ukraine mainly in the western and central regions. In 2015-2019, their cultivation area decreased slightly (by 1.4%), while the harvest increased by 7.3%, and in 2019. amounted to 10.3 million tons (Matuszak, 2021).

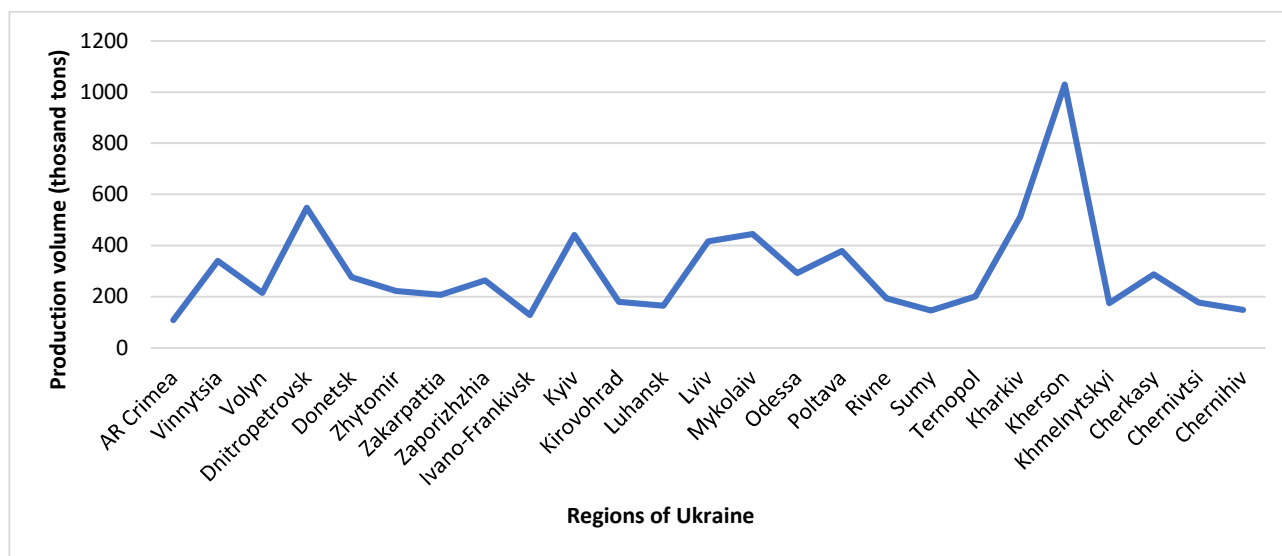


Figure 6. Average vegetable production in enterprises in 2010-2021. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

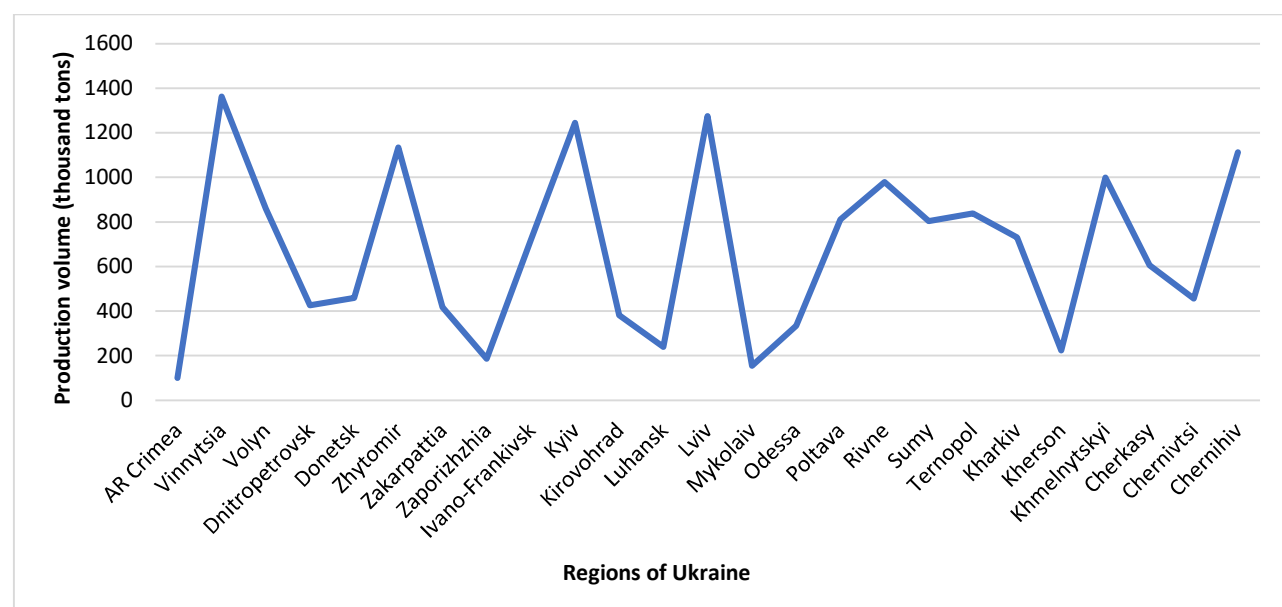


Figure 7. Average potato production in enterprises in 2010-2021. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

The highest average factory sweet beet production (2010-2021) was achieved by large enterprises in the Vinnytsia and Poltava

regions, as well as in Khmelnytskyi and Ternopil (Fig. 8). The latter harvests the most factory sugar beet in Ukraine.

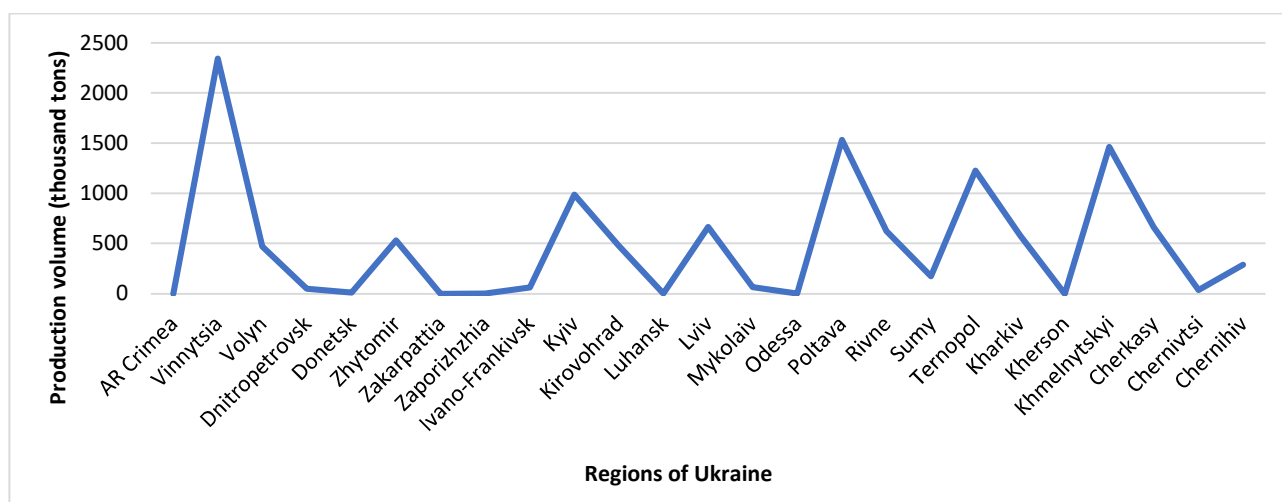


Figure 8. Average factory sugar beet production in enterprises in 2010-2021. Source: <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

Ukraine grows plenty of vegetables in the following regions: Kherson (13.6% of the total harvest), Dnipropetrovsk, Lviv, Kharkiv, and Kyiv (Matuszak, 2021).

Fruit production (average for 2010-2021) exceeded 200 thousand tons by enterprises in

the Vinnytsia region, and from 100-150 thousand tons in the Chernivtsi, Khmelnytskyi, Dnipropetrovsk, and Zakarpattia regions (Fig. 9).

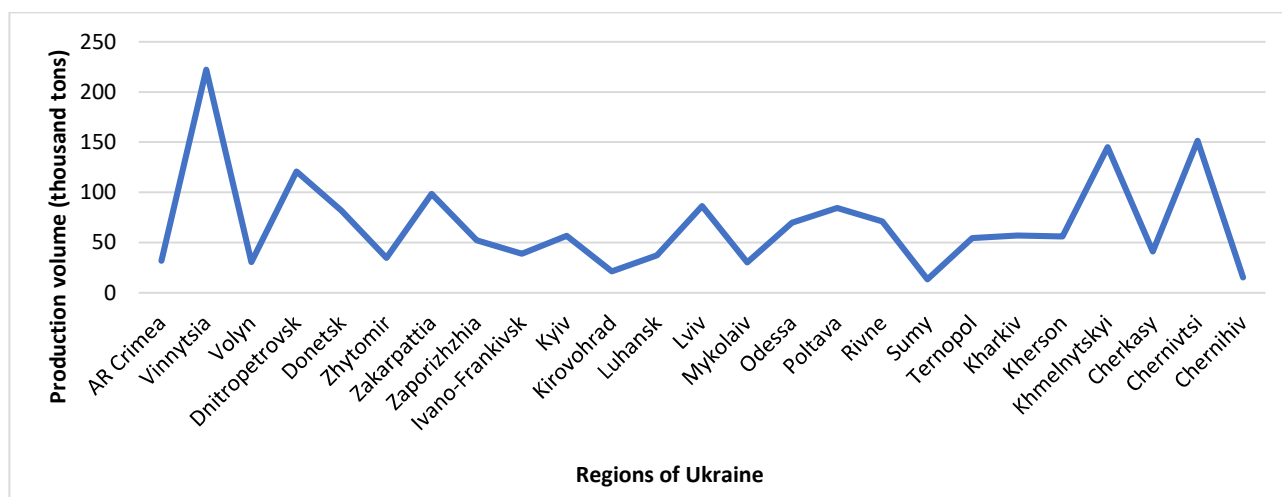


Figure 9. Average fruit and berries production in enterprises in 2010-2021. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

Although in 2015-2019, in Ukraine, fruit production decreased by 8.2%, in 2019 it increased by 2.5% compared to 2015 and amounted to 5 million tons (Matuszak, 2021).

In summary, large enterprises avoided (compared to other crops) the production of fruits and vegetables, which was probably due to the capital and labor intensity of their cultivation (fruits and vegetables are perishable, require storage, cold stores, sorting plants, specialized packaging, or logistics). Therefore, it is demanding to organize the

export of fresh products on a scale comparable to grains or oilseeds (sunflower). South-central Ukraine has an ideal environment for growing sunflowers (Dnipropetrovsk, Zaporizhzhia, Kirovohrad, Kharkiv), and a high yield per hectare is achieved from it in terms of market value (it is more profitable than potatoes or vegetables). In 2019, oilseeds and sugar beets occupied 2.1 million ha (of this area in the case of oilseeds, 99% was sunflower, rapeseed, and soybean). Sunflower was grown on 6 million ha, and 15.3 million tons were harvested. We

note that the volume of crop production varies regionally.

The authors presented trends in crop production over the years 2011-2021 using selected regions of Ukraine: Poltava Region, Kherson Region, Khmelnytskyi Region and Vinnytsia Region as a representative case study. Thus, in the Poltava Region (Fig. 10), we see a clear increasing trend in grain production influenced by exceptionally fertile chernozem soils and favourable climatic conditions. Grains are characterized by high productivity and low reliability, so their production will probably continue to increase. The observed fluctuation in grain cultivation (with a particular decline in crops in 2013, 2017, and 2020) was likely caused by various factors (grain production volume ranged from 3438.5 to 6535.5 million tons, while maintaining an upward trend). A severe drought in central and southern Ukraine significantly reduced grain yields in 2013, and Poltava, as a steppe region, was particularly exposed to these extreme weather conditions. Weather anomalies were also recorded in 2017 (high temperatures accompanied by rains), which could have deteriorated grain quality and limited the harvest (<https://pl.weatherspark.com/h/y/148725/2017/...>).

Climatic instability and COVID-19 were responsible for 2020. Probably, the lack of labor caused by the pandemic could have affected the reduction in the area of cultivation, and thus the efficiency of the harvest. During this period, there were also logistical disruptions, which were felt not only by Ukraine but also by the whole world. Droughts and high temperatures in the summer (<https://pl.weatherspark.com/h/y/148725/2020/...>) could have significantly affected the yield of potatoes, which are sensitive to water shortages (Fig. 10). The pandemic year of 2020 could also discourage potato planting due to the limited functioning of local markets. The decrease in the production of vegetables, fruits and sunflowers in 2016 and 2020 was also caused by the factors described above (weather and disruptions in supply chains, reduced exports, reduced demand on the domestic market) (Fig. 11). In the case of sunflower, which is plant sensitive to long periods of drought, agrohholdings can reduce its cultivation area in favor of more resistant plants. In 2021, the rebound in the production of the presented crops (Figs 10 and 11) could have been caused by more favourable weather conditions, and an increase in the prices of raw materials (e.g., potatoes) or general demand for products.

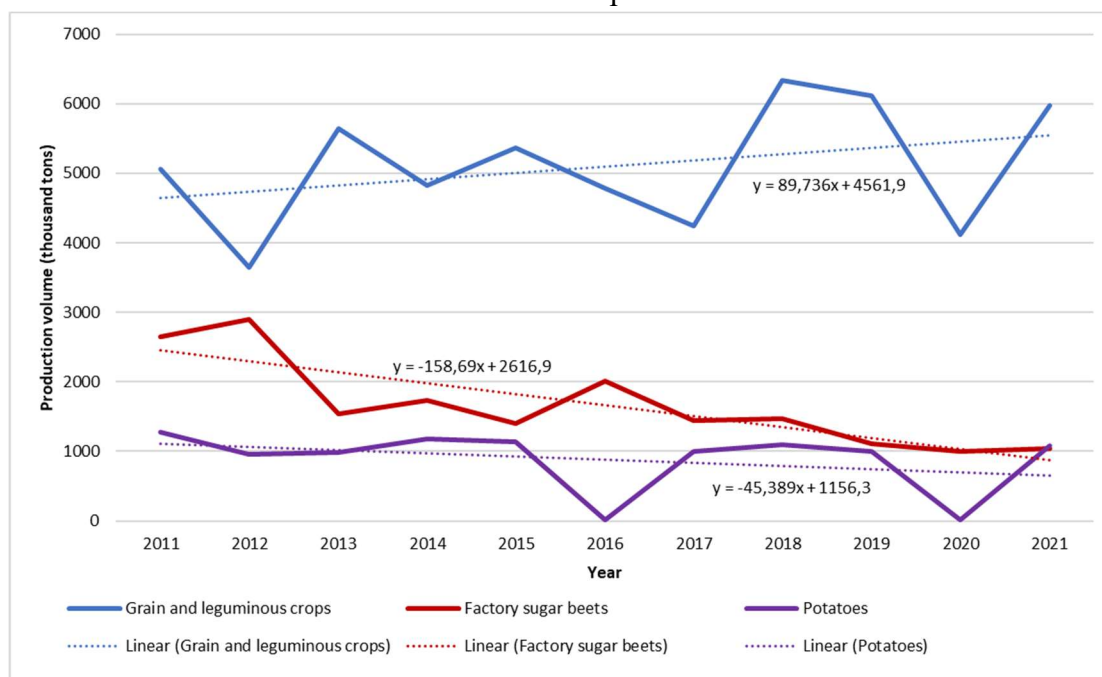


Figure 10. Trends in grain and leguminous crops, factory sugar beet and potato production at enterprises over 2011-2021 in the Poltava Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovizbory>.

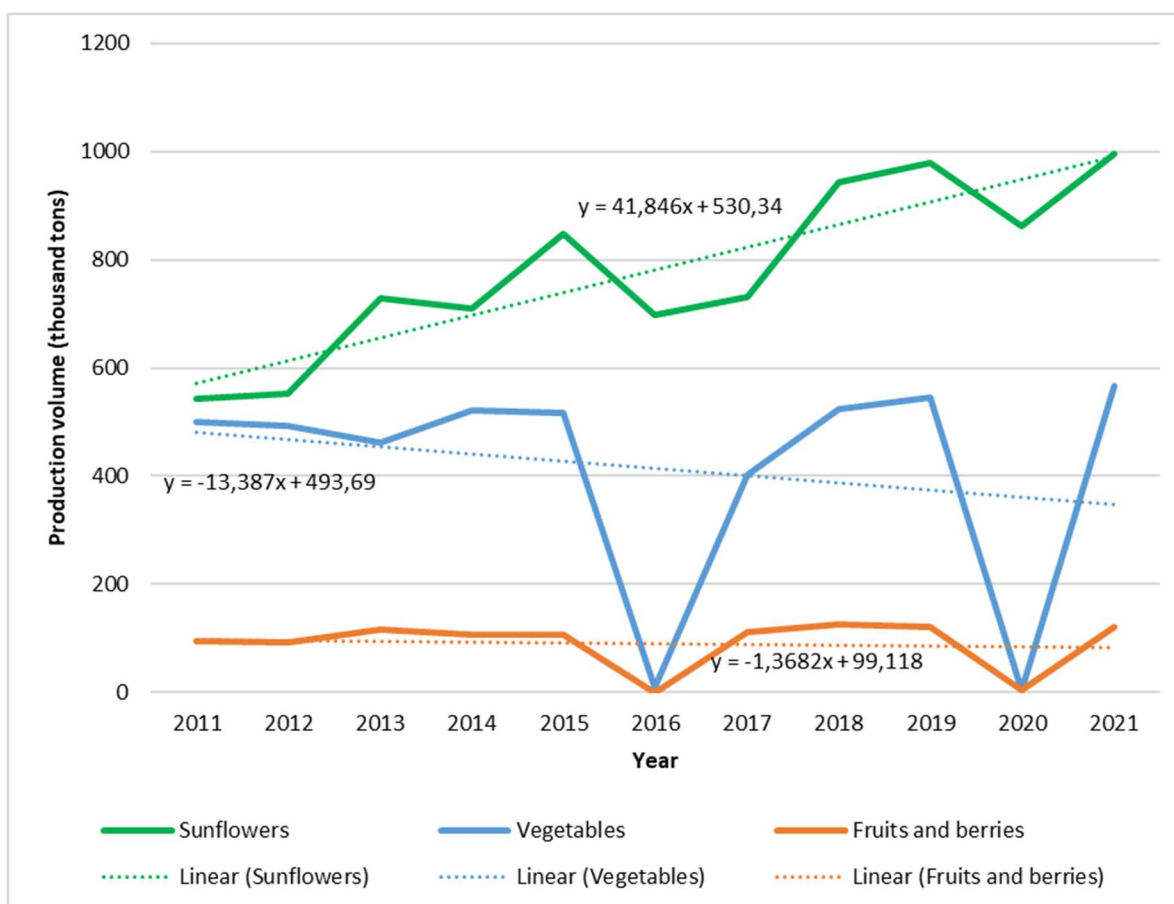


Figure 11. Trends in sunflower, vegetable and fruit and berries production at enterprises over 2011-2021 in the Poltava Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

In the Kherson Region, similarly to the Poltava Region, the same factors described above shaped the fluctuation of crops in 2016 and 2020. The volume of grain production ranged from 3438.5 to 6535.5 million tons, maintaining an upward trend (Fig. 12). In the case of beet and potato production, a downward trend can be observed, and sunflower production maintains a clear upward trend with relatively little fluctuations. On the one hand, the production of vegetables and fruits shows high oscillations and decreasing production volumes (Fig. 13). The Kherson Region is located in the dry steppe zone, which, with limited access to water, favors plants that are less demanding in terms of moisture, such as cereals and sunflowers.

These are the most attractive crops for companies because they are easy to mechanize and store for long periods. On the other hand, the downward trend in fruit and vegetable cultivation may be dictated, on the one hand, by the need for high investments in irrigation or storage. Cutting off the water supply from the Dnieper through the North Crimean Canal in 2014 was unfavourable for enterprises (and therefore for fruit and vegetable farming) (Szeligowski, 2020). Unprofitable logistics (lack of modern processing plants or cold stores) could discourage larger-scale horticultural crops. Potatoes are grown marginally, as a more local crop (due to hot and dry summers).

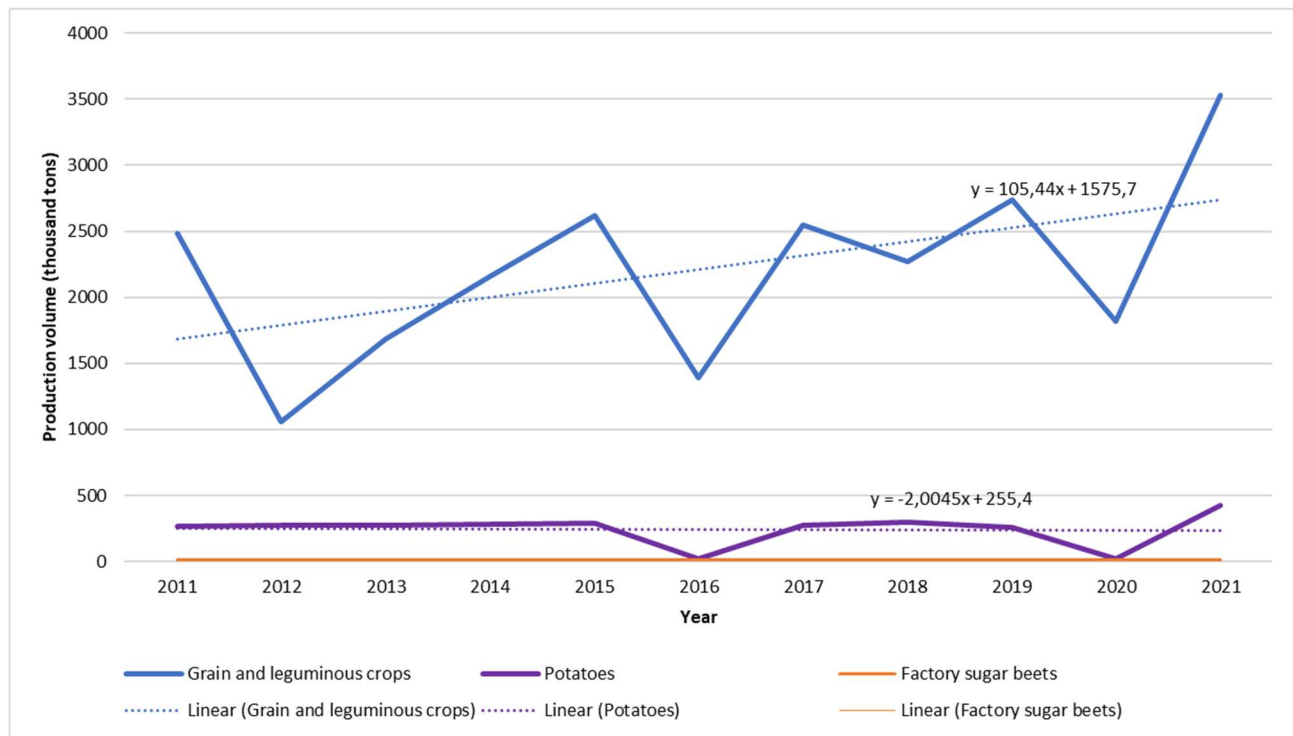


Figure 12. Trends in grain and leguminous crops, factory sugar beet and potato production at enterprises over 2011-2021 in the Kherson Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

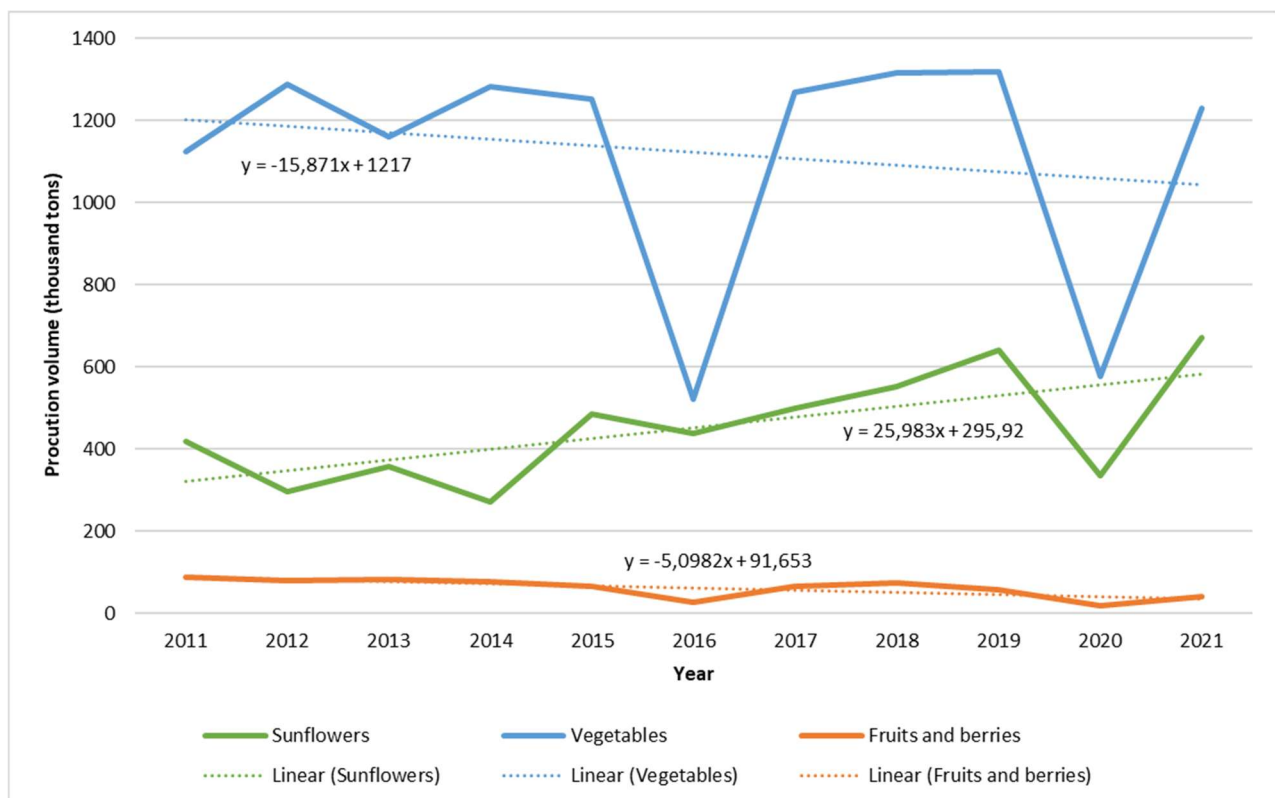


Figure 13. Trends in sunflower, vegetable and fruit and berries production at enterprises over 2011-2021 in the Kherson Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

Interesting observations provided by the analysis of the Khmelnytskyi region, where companies, despite the drought in 2016 (<https://pl.weatherspark.com/h/y/148571/2016/>) and the pandemic in 2020, recorded a considerable increase in sunflower production. The growth trends of this crop show in the demand for sunflower oil (also for export), low harvest costs, and good storage conditions, and undoubtedly the lack of yield losses in the above-mentioned more difficult years, when other crops, such as beets or potatoes, suffered (Figs 14 and 15). The increased growth in grain production in 2014 and 2018 was dictated here, on the one hand, by the consolidation of the agricultural sector and the shift in production (after 2013, the area of grain crops increased at the expense of less profitable crops, such as potatoes or beets), and on the other hand, by favourable weather conditions (the appropriate balance of precipitation and temperatures in 2018 resulted in exceptionally high grain yields) (<https://pl.weatherspark.com/h/y/150053/2018/Historyczne-warunki-pogodowe-w-roku-2018>). At the same time, we should notice the economic crisis that Ukraine experienced after the annexation of Crimea (2014), companies focused on export, because grain was the most stable and predictable

product. The volume of grain production fluctuated in the analyzed years from 3438.5 to 6535.5 million tons, and maintained an upward trend.

The increase in factory sugar beet cultivation in 2012, 2014, and 2017 could have been due to good agrometeorological conditions, growing demand of the sugar industry for this raw material, and government subsidies that encouraged cultivation (Łyżwa, 2019). In turn, the decline in beet production in 2013 and 2015 could have been influenced by economic reasons - low purchase prices of beet related to incurred inputs, and thus unprofitability of cultivation compared to cereals and sunflower. The Ukrainian sugar industry is now primarily oriented towards beet export (Ukraina uprawia więcej buraków..., 2023). The fluctuation of potato cultivation (increase in cultivation in 2012, 2014, 2017) was probably due to good weather conditions, domestic and export demand, low production costs, availability of storage infrastructure, as well as low disease pressure. In Khmelnytskyi, there is no permanent, organized fruit and vegetable base. The production volume in this area shows a constant trend for fruits and a decreasing trend for vegetables (Fig. 14).

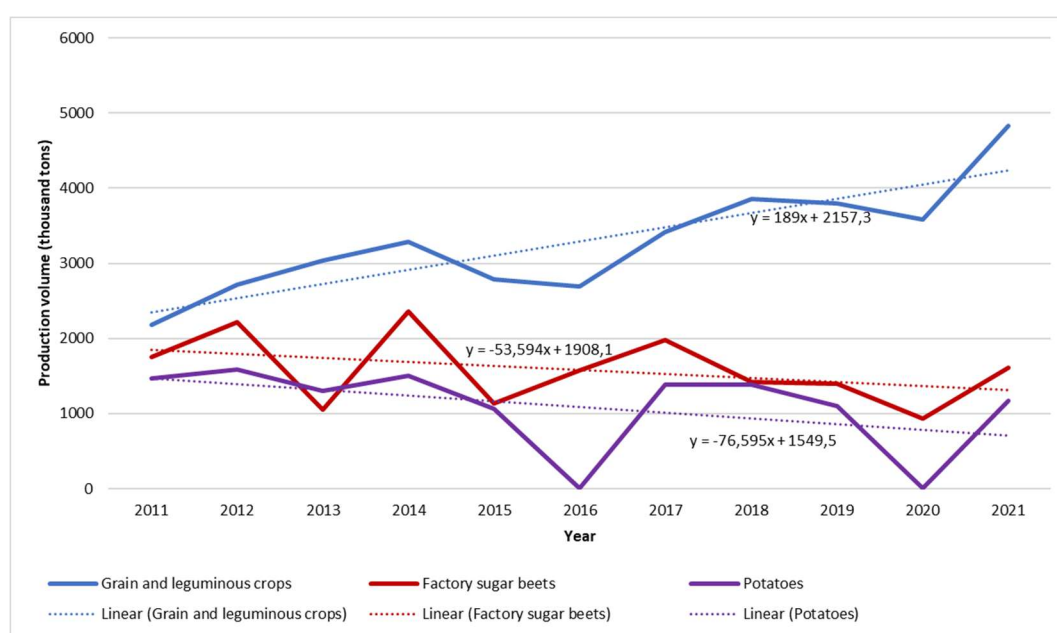


Figure 14. Trends in sunflower, vegetable and fruit and berries production at enterprises over 2011-2021 in the Khmelnytskyi Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

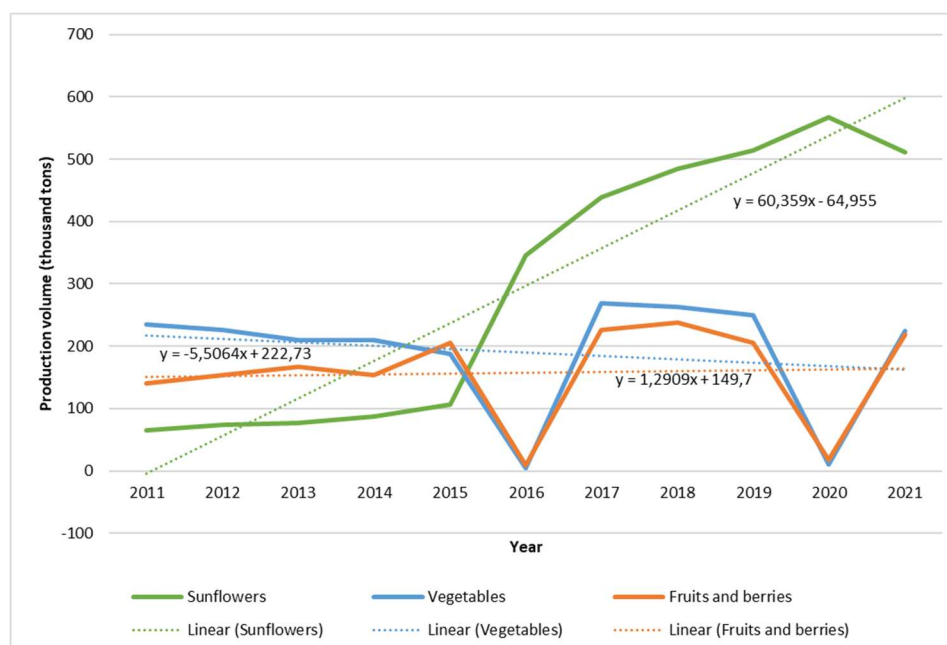


Figure 15. Trends in grain and leguminous crops, factory sugar beet and potato production at enterprises over 2011-2021 in the Khmelnytskyi Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchivalovi-zbory>.

The jumps in crop levels in the Vinnytsia region in 2016 and 2020 were caused by the same factors as in the aforementioned regions (Figs 16 and 17). Vinnytsia is one of the most agriculturally developed Ukrainian regions characterized by a high diversity of crop production. The volume of grain production fluctuated in 2011-2021 from 3438.5 to 6535.5 million tons, but maintained an upward trend (Fig. 16). In the case of beet and potato production, we can observe a downward trend and considerable fluctuations in crop volumes. Sunflower production maintains a clear upward trend with relatively little oscillation, while vegetable and fruit production shows high oscillation and decreasing production volumes (Fig. 17). Enterprises here focus more on commercial crops with high profitability and export potential. They mainly prefer cereals due to their profitability, resistance to price fluctuations, and stable export demand. The area of beet cultivation may have been limited in some years (2015, 2019) due to lower profitability, especially when, for example, sugar prices were falling. Potatoes, as less attractive crops (e.g., more labor-intensive), are more often grown by small farms, as are vegetables and fruits, which are too expensive and unstable on the market. Family farms find it easier to respond to

market (local) changes. After 2015, an increase in sunflower production is noticeable, which may be influenced by its profitability and probably the companies' pressing plants (processing plants).

In summary, we should emphasize that Khmelnytskyi underwent an intensive transformation of the structure of crop production in 2011-2021. First, the region has turned towards commercial and export cereal and oil crops. Cereals and sunflowers gained importance due to profitability, predictability, and favourable soil and climate conditions. Beet and potato production was unstable, dependent on market and weather conditions. Vegetables and fruits remain on the margin of interest of large entities due to high production costs and the lack of infrastructure. The "STRATEHIIA..." (2011) provides interesting observations about the Khmelnytskyi economic and sustainable development. According to Łopatynskyi (2016), the enterprises can provide conditions for sustainable development. They focus on the aspects of economic activity, specializing primarily in grain export, and according to the opinion of the above-mentioned author, can exert economic influence on the situation in the agrarian sector of the national economy, but they do it for their benefit.

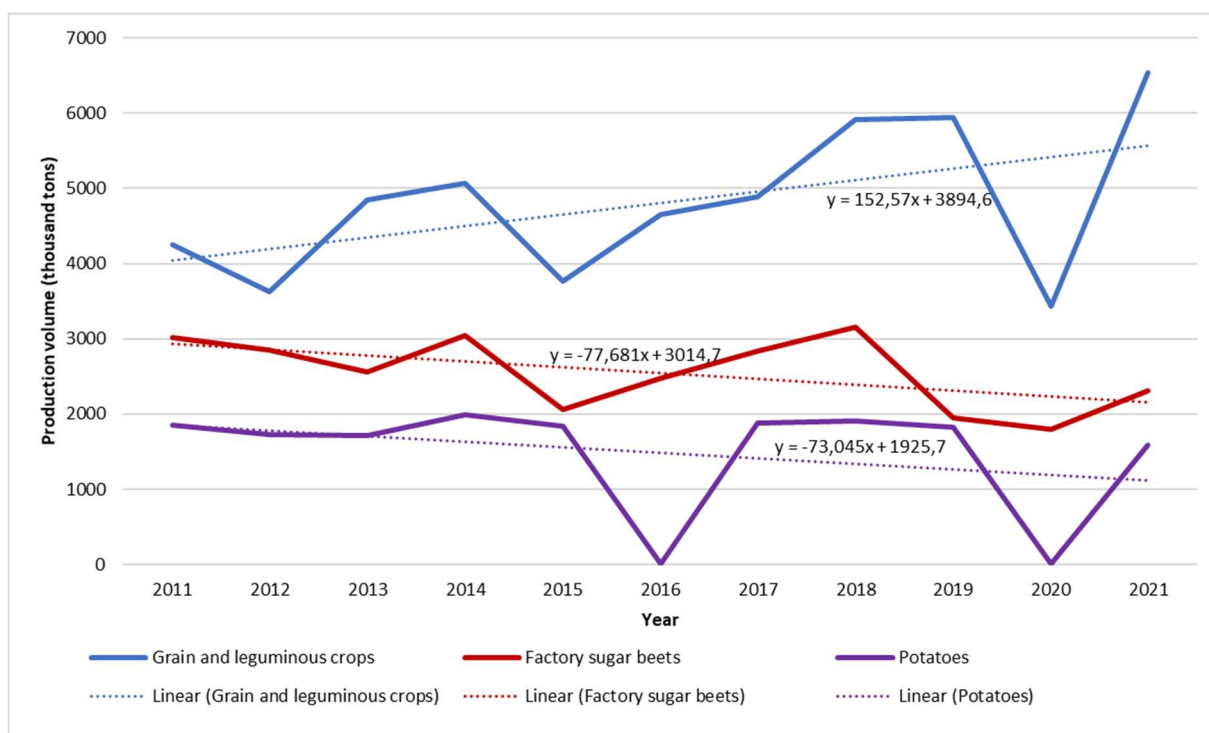


Figure 16. Trends in grain and leguminous crops, factory sugar beet and potato production at enterprises over 2011-2021 in the Vinnytsia Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

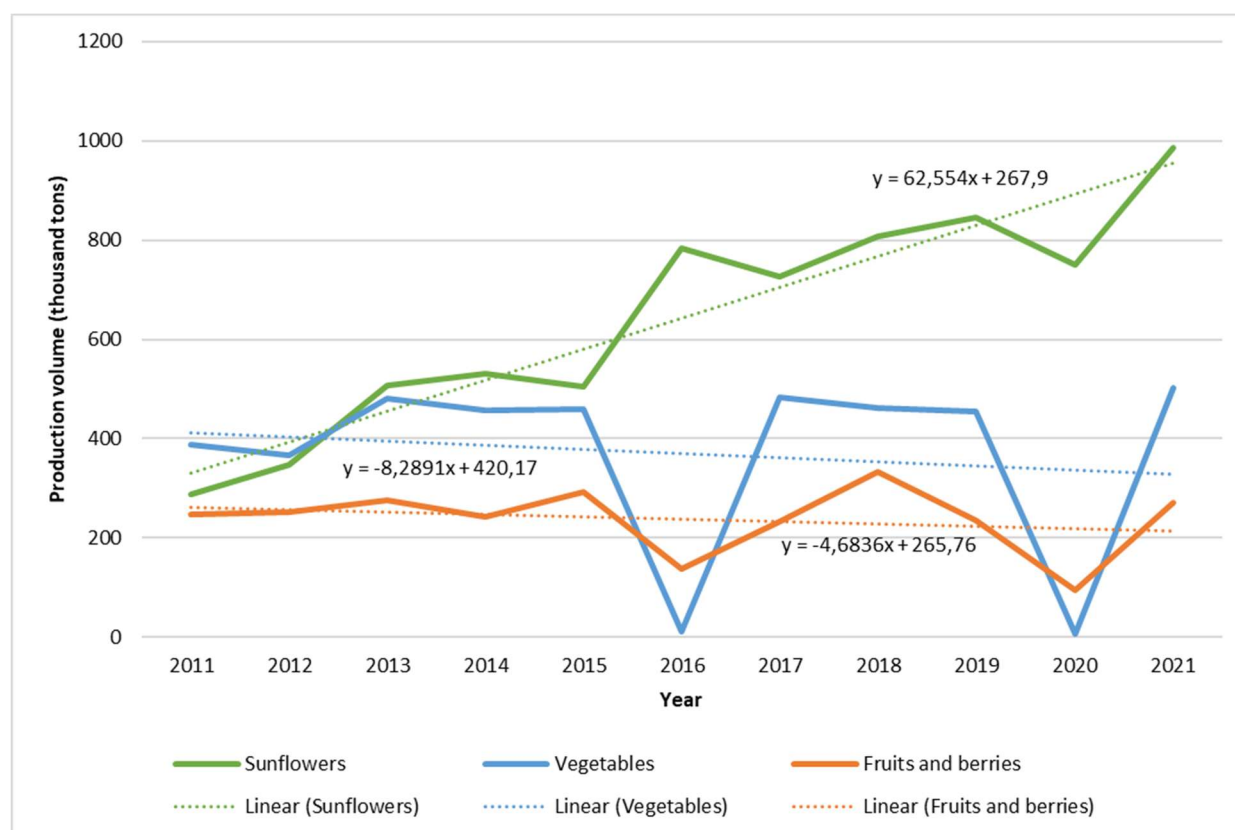


Figure 17. Trends in sunflower, vegetable and fruit and berries production at enterprises over 2011-2021 in the Vinnytsia Region. Source: own study based on <https://stat.gov.ua/uk/datasets/ploshchi-valovi-zbory>.

In the Kherson region, in 2011-2021, there was a vital industrialization of crop production, which favored cereals and sunflowers – plants that tolerate drought well, are easy to mechanize, and transport (even abroad). At the

same time, we can observe a decline in fruit, vegetable, and potato crops, which could have resulted from water shortages, lack of processing infrastructure, and high climatic risk, which discouraged

enterprises from growing them. Trends in crop production in the Poltava region depend mainly on weather conditions (droughts), probably on the strategies of enterprises (cereals and sunflower are priority crops here), the market situation (COVID, price changes), or investments in infrastructure and crop storage possibilities. In Vinnytsia, on the other hand, enterprises focus mainly on the cultivation of cereals and sunflowers, although

this region has a tradition of beet cultivation and a strong processing base (two large sugar factories operate here) (<https://www.cenrolnicze.pl/...>). It can be assumed that beet cultivation will be vital for companies, although variable (as shown by crop trends) and dependent on the market situation (in 2011-2021). Table 4 below summarizes the reasons for changes in plant production and its trends in the years studied.

Table 4. Summary of the main causes of changes in crop production, its share, and tendencies in selected regions of Ukraine in 2011-2020. Source: own based on the analyses performed.

No	Crop grown	Share and tendency	Main cause of change
Poltava Region			
1.	grain and leguminous crops	high share, growth with fluctuations	good soils, export, profitability, and droughts caused declines
2.	factory sweet beet	moderate, unstable share	dependence on sugar mills, price sensitivity, not every company has probably invested in this sector
3.	potatoes	low share, large fluctuations	production mainly on small farms, declines due to droughts
4.	sunflowers	high and stable share	profitability, variety resistance, good climate adaptation
5.	vegetables/fruit, and berries	marginal	companies avoid them (costs, seasonality, local market)
Kherson Region			
1.	grain and leguminous crops	high share, significant increase	vast areas, intensification of technology, drought-resistant varieties
2.	factory sweet beet	none, minimal share	unfavourable climatic conditions and no processing plants; companies abandon this crop
3.	potatoes	very low share	water shortages, high labour intensity, no cold stores or local market
4.	sunflowers	high and growing share	high adaptation to drier climate, export demand, stable profitability
5.	vegetables/fruit, and berries	falling, marginal share	water shortages, no irrigation; degradation of infrastructure in some zones
Khmelnyskyi Region			
1.	grain and leguminous crops	high share, dynamic growth	growth in 2014 and 2018, good conditions, high profitability, modern technologies
2.	factory sweet beet	significant fluctuations	large increases in 2012, 2014, 2017 – contracts with sugar factories; decreases due to price volatility
3.	potatoes	low share, decreasing with local increases	increases in 2012, 2014, 2017 – good humidity, local market needs
4.	sunflowers	steady growth, since 2015, no decreases	exceptionally stable cultivation in enterprises; export, mechanization, and resistance of varieties
5.	vegetables/fruit, and berries	marginal and variable	production mainly by smaller farms; enterprises probably avoided high costs
Vinnytsia Region			
1.	grain and leguminous crops	high and growing	export, technology, stability
2.	factory sweet beet	variable but significant	sugar industry in the region
3.	potatoes	low share	high costs
4.	sunflowers	growing share, no decline	demand, profitability, variety resistance
5.	vegetables/fruit, and berries	marginal	costs, lack of refrigeration infrastructure, logistics

According to Kopiński et al. (2023), the agricultural sector of Ukraine has suffered significantly due to the war, and they stated that, according to the estimates of the US

Department of Agriculture, the area of sown fields of the major Ukrainian crops has decreased by about 30%. Corn production has lessened by 35%, and sunflower production by

30%. The current state of economic processes in Ukraine, according to Gontareva (2022), is characterized by instability and the search for new paradigms for the effective development of agricultural enterprises. Since the beginning

of the political and armed conflict, the prices of agricultural companies have fallen significantly. Most investors avoid investing in companies that do not show a tendency to change the trend to growth (Salek, 2015).

5. Conclusions

The conducted analysis allow formulating the following conclusions:

1. Analyses have shown the established dominance of large agrarian enterprises in the structure of crop production in Ukraine, controlling over half of the agricultural land. They played a key role in shaping the structure of crops and the direction of development of crop production. Thanks to modern technology, access to capital, and a high level of organization, they were characterized by much higher efficiency than individual farms.
2. The observed advantage in the structure of cereal and sunflower crops resulted from the high profitability, durability, and export demand of these plants. They were the backbone of production in the analyzed regions, and their cultivation developed dynamically with periodic fluctuations (especially climatic, in the case of cereals). Sunflower showed a clear upward trend in almost all analyzed regions (e.g., Khmelnytskyi, Kherson, Vinnytsia), which was probably related to its drought resistance and high profitability.

3. The limited role of factory sugar beets and potatoes in the production of enterprises is caused by economic instability (sugar price fluctuations, crop rotation, location of the sugar industry).

4. Crops that are unprofitable in commercial conditions have shown a downward trend in the analyzed regions of Ukraine (potatoes, vegetables, and fruits). Their limited production is caused by high climatic risk (e.g., water shortage) and the lack of developed processing infrastructure. For this reason, it could have discouraged enterprises from investing and taking risks.

5. Regional differences in the analyzed crop production are mainly the result of agroclimatic and infrastructural conditions.

6. In the perspective of the decade 2011-2021, a considerable intensification of production in enterprises can be seen - an increase in yields thanks to technology, fertilization and management; specialization towards grains and oilseeds (simplified sowing structure); export orientation (crop structure subordinated to foreign markets and international prices).

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