

Abstract: Methods for assessing regional food self-sufficiency are poorly developed worldwide, while knowledge of the characteristics of regional food self-sufficiency could help in designing more sustainable and resilient regional food systems. This paper addresses the challenge of defining and assessing food self-sufficiency at different geographical levels and provides a detailed presentation of the method for assessing the regional plant-based food self-sufficiency rate using publicly available data from administrative sources, taking the Slovenian development regions as an example. The results indicate the need to improve the reliability of the data used to identify the characteristics of regional food self-sufficiency and to a more effective coordination between existing agricultural databases.

Keywords: food self-sufficiency, public agricultural databases, crop production, development region, Slovenia

Povzetek: Metode za ocenjevanje regionalne samooskrbe s hrano so v svetu slabo razvite, poznavanje značilnosti regionalne samooskrbe s hrano pa bi lahko pripomoglo k oblikovanju trajnostnih in odpornejših regionalnih prehranskih sistemov. Prispevek odgovarja na izzive pri opredeljevanju in ocenjevanju stopnje samooskrbe s hrano na različnih geografskih ravneh. Podrobneje je predstavljena metoda za ocenjevanje stopnje regionalne samooskrbe s hrano rastlinskega izvora na podlagi javno dostopnih podatkov administrativnih virov na primeru razvojnih regij v Sloveniji. Rezultati nakazujejo na potrebo po izboljšanju zanesljivosti uporabljenih podatkov z namenom prepoznavanja značilnosti regionalne samooskrbe s hrano in učinkovitejši koordinaciji med obstoječimi zbirkami podatkov s področja kmetijstva.

Ključne besede: samooskrba s hrano, javne zbirke podatkov o kmetijstvu, rastlinska pridelava, razvojna regija, Slovenija

Highlights

- Regional self-sufficiency rate can be assessed using publicly available data on agriculture.
 - More data are needed to accurately determine regional food self-sufficiency in Slovenia.
 - The average food self-sufficiency rate in Slovenian development regions is low.
 - Regional food self-sufficiency contributes to a more sustainable and resilient region.
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1. Introduction

The most basic definition of food self-sufficiency is the ratio between food production and consumption in an area (Thomson & Metz 1998). The concept of self-sufficiency is rooted in the natural human desire and need to ensure security, sovereignty, economic and political stability, and improved well-being (Ritson 1980). High-quality, diverse, and stable food self-sufficiency is essential for our survival and of great importance for enhancing our food security – ensuring physical and economic access at all times to sufficient, safe and nutritious food that meets our dietary needs and preferences in order to lead an active and healthy life (Rome Declaration 1996), and also for ensuring our food sovereignty, i.e., "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Nyéléni Declaration 2007). Furthermore, food self-sufficiency has important implications for landscape features and the state of the environment (Plut 2014; Clapp 2017). The majority of agricultural activity, including food production, is concentrated in rural areas, which are thus a key space for shaping the characteristics of local, regional and national food self-sufficiency and ensuring food security at different geographical levels.

Although ensuring an adequate level of food self-sufficiency has traditionally been an important strategic policy in most countries (Ritson 1980), with the advent of the industrial revolution, the expansion of service activities, the strengthening of international food trade, and changing lifestyles, food self-sufficiency rates have been declining in many countries. However, in the current context of uncertain health, economic and political circumstances, which have led to less stable food supply at the global level, there are a growing number of initiatives to ensure stable food security at the local, regional and national levels (Beltran-Peña et al. 2020). The concept of local food supply is being strengthened, there is a push to reduce dependence on international food markets, the importance of rural agricultural landscapes is being emphasised, as is the importance of supplying safe, healthy, high quality and diverse locally produced food. Consequently, the idea of achieving a high level of national, regional and local food self-sufficiency based on local production through the promotion of sustainable agricultural practices is regaining importance (Perpar & Udovč 2010; Plut 2014; Clapp 2017; Joseph et al. 2019).

Numerous studies have focused on food self-sufficiency. Most of them have focused on identifying characteristics and assessing national food self-sufficiency rates. On the other hand, there are significantly fewer studies on regional or local food self-sufficiency. This is mainly due to a lack of adequate publicly available statistical and spatial data on agricultural production and food balance, as well as poorly developed methods for estimating agricultural production and food self-sufficiency at the regional or local level (Ostry & Morrison 2013; Pradhan et al. 2014).

In researching food self-sufficiency, it should be noted that in addition to the lack of publicly available data, the concept of food self-sufficiency itself is not clearly defined and that the food self-sufficiency rate achieved in an area depends on several factors. Key among these are the definition of food self-sufficiency itself, the units of measurement for food production and consumption data, and how food balance data are aggregated, processed and presented (Pradhan et al. 2014; Kim et al. 2015; Porkka et al. 2013; Clapp 2015; Clapp 2017; Schramski et al. 2019).

One of the main objectives of Slovenian regional policy is to promote sustainable and balanced regional development (SRR 2021). The Promotion of Balanced Regional Development Act (2011) divides Slovenia into 12 development or statistical (NUTS 3) regions. These are the basic functional territorial units for regional policy planning and implementation of regional development tasks. General development tasks in the regions are performed by regional development agencies, which prepare, coordinate, monitor and evaluate the regional development programmes of each region. In order to achieve and ensure sustainable and balanced regional development, one of the objectives of the regional development programmes is to accelerate the development of their rural areas. One of the ways they plan to achieve this, is by increasing food self-sufficiency, based on more efficient use of the region's agricultural land and other natural potentials, and by promoting the establishment of short supply chains. By increasing self-sufficiency in locally produced, mainly organic food, and by producing potential marketable surpluses, the regions also hope to increase the external visibility of their food products and thus strengthen food supply links with other development regions, as well as beyond national borders (RRP Gorenjska 2015, RRP JVSI 2015).

The aim of this paper is to develop an appropriate methodology for harmonisation, linking and upgrading of existing official public agricultural databases of plant-based food supply in Slovenia and to test the methodology on 12 Slovenian development (statistical – NUTS 3) regions. An appropriate methodology for a more accurate determination of the regional level of food self-sufficiency, applicable also at other geographical levels both in Slovenia and more widely (especially in EU Member States), could help local and regional decision-makers in designing innovative and sustainable local agricultural policies, i.e., policies that would contribute to strengthening self-sufficiency in locally produced food and ensuring (local) food security.

In our study, we focused on the analysis of the characteristics of self-sufficiency in plant-based food, as we have relevant publicly available data from this segment of food self-sufficiency. Moreover, Slovenia performs significantly worse in plant-based food self-sufficiency compared to animal-based food self-sufficiency (Bilance 2019). Finally, plant-based food self-sufficiency has been identified in a number of foreign studies as key to increasing food self-sufficiency and ensuring long-term food security at local and

regional as well as national and global levels (Warr 2011; Plut 2014; Pradhan et al. 2014; Prosekov & Ivanova 2018; Joseph et al. 2019; Schramski et al. 2019; Beltran-Peña et al. 2020).

2. Scope and area of the study and presentation of the data

Food self-sufficiency is the ratio between the amount of food produced and the amount of food consumed in a given area, such as a region, country, or continent, or within a selected unit, such as a farm. It expresses the extent to which domestic food production meets domestic food demand (Thomson & Metz 1998). According to Statistical Office of the Republic of Slovenia (SORS), the food self-sufficiency rate reflects the extent to which domestic production of the primary product covers domestic consumption for food, feed and industrial uses. If the food self-sufficiency rate is below 100%, a deficit in domestic food supply is indicated, as domestic consumption exceeds domestic food production. Conversely, if domestic production exceeds domestic consumption, there is a surplus in domestic food supply (Gale 2017, 5).

The level of food self-sufficiency or the food self-sufficiency rate of an area depends on the definition of food self-sufficiency itself. In its narrowest definition, food self-sufficiency is understood as a completely closed system of food circulation within an area in which all food produced is also consumed. A somewhat looser definition defines food self-sufficiency as the domestic production of sufficient per capita calories, which does not necessarily mean a given country is assigned to specifically feed their own population (Schramski et al. 2019). Other broader definitions also take into account potential exports of surpluses of a certain food type, and potential imports of foods which are scarce in that area when calculating the food self-sufficiency of an area. In addition to the definition, food self-sufficiency also depends on the units of measurement (kilograms, calories, currencies) used for food production and consumption data and on how food balance data are aggregated, processed, and presented (Kim et al. 2015; Porkka et al. 2013; Clapp 2015; Schramski et al. 2019). For example, food self-sufficiency rates are higher when calculated as the ratio of all food produced to all food consumed than when calculated as the ratio of food produced to food consumed stratified by individual agricultural product groups. This is because low self-sufficiency rates for certain types of agricultural products cannot be compensated by potentially high self-sufficiency rates for other types of agricultural products. In high-income countries, a higher self-sufficiency rate is also seen when expressed in calories, taking into account the per capita daily calorie requirements. Porkka et al. (2013) estimate that sufficient calorie intake in terms of human daily energy needs is 2500 kcal, which is often exceeded in developed countries. Finally, a higher level of food self-sufficiency is achieved by using a looser definition (especially when expressed in calories) that includes potential exports of surpluses and imports of deficits (Pradhan et al. 2014; Clapp 2017).

Most studies on food self-sufficiency examine the characteristics of national food self-sufficiency, while there are far fewer studies on food self-sufficiency at the level of regions, municipalities or individual farms. Existing research has mostly focused on: defining and estimating national food self-sufficiency rates (O'Hagan 1975; Perpar & Udovč 2010; Simelton 2011; Pradhan et al. 2014; Oort et al. 2015; Davis et al. 2016); correlating and distinguishing between food self-sufficiency and food security (Pinstrup-Andersen 2009; Warr 2011; Baer-Nawrocka & Sadowski 2019); identifying factors that influence food self-sufficiency characteristics in an area (Slabe et al. 2011; Vintar Mally 2011; Pradhan et al. 2014; Slabe 2015; Sali et al. 2016; Uhan & Potočnik Slavič 2018); identifying the interrelationship between food self-sufficiency and the food market (O'Hagan 1975; Clapp 2017); investigating and developing interventions to increase self-sufficiency rates, particularly through changes in dietary habits (Pradhan et al. 2013a; Pradhan et al. 2013b); reducing production and consumption losses (Kummu et al. 2012; Pradhan et al. 2014; Joseph et al. 2019); expanding cultivated areas and increasing yields per hectare and on identifying and studying the environmental impacts of increased food self-sufficiency (Tilman et al. 2011; Mueller et al. 2012; Joseph et al. 2019).

Studies on the characteristics of local or regional food self-sufficiency (Bahn & Christensen 1979; Morrison et al. 2011; Morrison et al. 2012; Ostry & Morrison 2013; Kim et al. 2015; Joseph et al. 2019) have shown that it is difficult to rely on adequate publicly accessible data from government institutions, as these are often scarce or non-existent. Therefore, data collection and calculation of food self-sufficiency rates are

mostly supported by processing aerial and satellite imagery, land use analysis, data collection through questionnaires and interviews, and by transposing adapted national food self-sufficiency data.

Our research focuses on the analysis of the characteristics of plant-based food self-sufficiency in development regions (NUTS 3) in Slovenia. Food self-sufficiency is defined as a closed system of food circulation within the territory of the Slovenia. We estimated the food self-sufficiency rate for categories of agricultural products of plant-based origin, i.e., cereals, potatoes, vegetables and fruit.

Statistical and spatial data on the production and consumption of agricultural products, obtained from various administrative sources, were used to assess food self-sufficiency.

Statistical data on crops and cropland as well as food balance data at country level were obtained from the SiStat database. The database is managed by SORS, which is responsible for monitoring and managing agricultural statistical data in Slovenia according to the National Statistics Act (1995). SORS systematically collects and presents data on food self-sufficiency only at the national level. It calculates the national food self-sufficiency rate (%) based on food balances, i.e., balances of annual food production and consumption by type of agricultural products such as fruit, vegetables, cereals, potatoes, eggs, meat, honey and rice, expressed in tonnes (SiStat 2020). It also provides data to Eurostat (Gale 2017), the EU statistical office responsible for publishing data and indicators, allowing for comparisons between countries and regions (Eurostat 2021).

Spatial data on actual land use type, area of agricultural land, area and type of individual agricultural crops grown on agricultural land were obtained from the Ministry of Agriculture, Forestry and Food (MAFF) data portal (RKG 2020). The data portal contains a number of MAFF's agricultural databases that are used primarily for the implementation of agricultural policy measures and financial support monitoring. The primary data sources we relied on were graphical data on land utilised by agricultural holdings (i.e., farms), crop data from single applications, and the Land Use Database. Graphic data on land used by agricultural holdings, are aggregated and maintained in the Registry of Agricultural Holdings (RKG) as Graphical Units of Agricultural Holdings (GERKs) (PRKG 2016). GERKs represent contiguous areas of agricultural land with the same type of land use (ZSDZOK 2014). A GERK can be registered on agricultural land defined by Land Use Database as arable fields and gardens, permanent crops, and grassland, as well as on certain other agricultural land (PEDR 2008). If operators of agricultural holdings in European Union countries wish to obtain Common Agricultural Policy subsidies for the cultivation of agricultural land, they must register their land in a single application (Galluzzo 2020; Kocur-Bera 2020). In Slovenia, such land is included in the register of single applications maintained by the Slovenian Agency for Agricultural Markets and Rural Development (SAAMRD) in the form of GERKs. As part of the single application, data on individual agricultural crops planted on GERKs are also collected. SAAMRD transmits the data on the GERKs (for which a single application has been submitted) to MAFF, which includes them in its databases and publishes them on MAFF's data portal (RKG 2020). For the year 2019, the data are published as "Single application, KMRS graphical data for 2019 for the whole of Slovenia", with the KMRS layer (Layer of agricultural crops from single applications) containing, in addition to the spatial data on GERKs, descriptive data on the agricultural crops planted in 2019 (RKG 2020).

3. Methods

To estimate the food self-sufficiency rate in Slovenian development regions, we drew on existing methods from related domestic and foreign studies (Vrišer 2005; Morrison et al. 2011; Morrison et al. 2012; Ostry & Morrison 2013; Rednak et al. 2016). Vrišer (2005) examined regional differences in agricultural production in Slovenia. Based on publicly available data from SORS, he sought to estimate the value of agricultural production in Slovenia by agricultural estimation districts and geographical regions and subregions. Rednak et al. (2016) attempted to estimate the value of agricultural production or standard output by individual Slovenian agricultural holdings, using data from MAFF's databases on Slovenian agriculture. Morrison et al. (2011), Morrison et al. (2012), and Ostri and Morrison (2013) estimated the level of local food self-sufficiency in the Canadian province of British Columbia using individual Local Health Areas as the example. They calculated local food self-sufficiency rate based on publicly available

official data from the Census of Agriculture and completed a survey designed as part of the study. Data on production (area and type of crops on each agricultural plot) and consumption of agricultural products and land use were obtained from the Census of Agriculture. To calculate crop yields, data on multi-year average yields per hectare (t/ha) of each agricultural product were collected through a questionnaire.

In our study, we analysed publicly accessible statistical and spatial data on agricultural production in Slovenia obtained from SORS and MAFF. We used 2019 as a reference year, for which we were able to obtain all the data we required. We were mainly interested in statistical (SiStat database) and spatial (KMRS layer) data on crop yields, agricultural land area, individual crop areas, type of crop and average annual yield (yield per hectare) of each crop. The data were adapted (interlinked, harmonised and upgraded) for the calculation of regional production and consumption of agricultural products and consequently regional food self-sufficiency.

The analysis of the regional food self-sufficiency rate in 2019 was based on statistical data on average yields per hectare of agricultural crops (SiStat database) and spatial (GIS) data on acreage of agricultural crops on GERKs (KMRS layer). Based on the data used, we calculated the total yields of fruits, vegetables, cereals and potato for each region. For each type of agricultural product, regional production was then compared with regional consumption. Consumption was converted to the regional level using data on per capita consumption in Slovenia and the population of the region in 2019 (Prebivalstvo 2020). Using these data, we calculated estimates of food self-sufficiency by type of agricultural products (fruits, vegetables, cereals and potatoes) for the regions in 2019. The formula for calculating the food self-sufficiency rate by type of agricultural product in each region is shown in equation 1:

$$S = \frac{Pr}{Po} \times 100 = \frac{\sum_{i=1}^a (HA \times Pv \times hk)_i}{SP \times PP} \times 100 = \frac{\sum_{i=1}^a (HA \times Pv \times \left(\frac{haS}{haM}\right)_i)}{SP \times PP} \times 100$$

where:

S is food self-sufficiency in the region (%)

Pr is production in the region (t)

Po is consumption in the region (t)

a is the number of crops and groups of crops taken into account in the calculation

HA is the average yield per hectare for a crop or group of crops (t/ha)

Pv is the total area planted for each crop or group of crops on agricultural land in the region (ha) (KMRS layer)

hk is the ratio of areas for agricultural products in SiStat (haS) to areas for agricultural products in the KMRS layer (haM)

SP is the number of inhabitants in the region

PP is per capita consumption (t)

haS is the agricultural land area, planted with an agricultural product, based on crop production data in SiStat

haM is the agricultural land area, planted with an agricultural product, based on KMRS layer data

The areas of individual types of agricultural land differ in the SiStat database and the KMRS layer. They are generally larger in the SiStat database than in the KMRS layer. The differences in the areas occur mainly because the KMRS layer only contains data on the areas of agricultural land (GERK) in the single application. As a consequence, the KMRS layer covers less than 95% of each crop area in Slovenia, whereas SORS is obliged by Regulation (EC) No. 543/2009 (2009) to provide data for at least 95% of each crop area (wheat, spelt, grain maize, etc.) in Slovenia, which are listed in the Annex to the Regulation. SORS's primary source of data are therefore the single applications for accessing subsidies, however to ensure 95% coverage in the data, a telephone survey of a sample of agricultural holdings that have not submitted a single application is also conducted (Plešivčnik 2018).

To harmonise MAFF's and SORS's data on each type of crop area, e.g., the area of potatoes, cereals, or vegetables, we took the total area of each agricultural product in the KMRS layer and multiplied it by a coefficient (hk) (see equation 1). In doing so, we assumed that on individual types of cropland (e.g., cereal cropland), the ratio between the area of individual crops or groups of crops (e.g., wheat, rye, other cereals-buckwheat) within individual types of agricultural products (e.g., cereals) is constant.

The average yield per hectare (HA) for each crop or group of crops was calculated based on the average annual yield (t/ha) of the main agricultural products by statistical regions of Slovenia. These data are the most accurate publicly available annual crop production statistics (SiStat 2020) and formed the basis for the calculation of HA. The main agricultural products are wheat, spelt, barley, triticale, oats, rye, sorghum, grain maize, potatoes, grapes, apple, peach and nectarine.

For the remaining agricultural crops or groups of crops (buckwheat, pear, chestnut, vegetable crops, etc.), we used their annual production (in tonnes) at the national level (SiStat 2020). Due to the fluctuations in yield between years and the lack of adequate data to calculate a weighted average, the average yield per hectare for these remaining crops or groups of crops was calculated as the arithmetic mean of a reference period of average annual yields (t/ha) covering 10 consecutive years from 2010–2019. The calculation procedure is shown in equation 2:

$$HA = \frac{\sum_{i=1}^n ha_i}{n} = \frac{ha_1 + ha_2 + \dots + ha_n}{n}$$

where:

HA is the average yield per hectare for a crop or group of crops (t/ha)

ha_i is the average annual production for each year in the reference period (2010–2019) (t/ha)

n is the reference period or the number of years of each average annual production

In most cases, we calculated HA using data for individual agricultural crops (e.g., buckwheat, pear and strawberry). Where data for individual agricultural crops were not available (e.g., arugula, raspberry, etc.), we used data for groups of agricultural crops (e.g., certain vegetables, many fruits, and most berries). Due to the different structure of the available data, in the case of fruits, we additionally took into account whether these are areas of intensive or extensive orchards or strawberries in the fields.

We applied a similar method to data on total regional consumption of each agricultural product. In this case, we had population data at the national and regional levels that we used to calculate food consumption data, while we did not have data on feed and industrial use, which is part of the total consumption of agricultural products used in the SORS calculation of the food self-sufficiency rate by individual agricultural product. Therefore, to estimate regional consumption, we calculated total domestic per capita consumption in Slovenia (for food, feed and industry) and multiplied it by the population of each region.

To calculate the volume of crop production by region, we had to match the crop production data listed in the SiStat database with the crop type classification in the KMRS layer (Figure 1). Where appropriate, data from SiStat were merged. In this case, the total average yield per hectare was calculated and assigned to the corresponding crop group in the KMRS code list – for example, data on the production of kale, endives, peppers, etc. were merged into the group vegetables. Where the data in SiStat were less accurate, we assigned to individual crops in the KMRS classification (e.g., goji strawberries, blackcurrant, raspberries) the average yield per hectare calculated for the whole group of crops as recorded in the SiStat database (e.g., berry bushes (without strawberries)).

Due to the specific structure of the available data, the estimate of fruit self-sufficiency is based on combined SORS data on fruit production in orchard plantations and extensive orchards, and on strawberry production on arable fields and in greenhouses. Data on the area of extensive orchards were not available, so the estimated total annual area of extensive orchards according to SORS represents the difference between data on the total orchard area and the area of orchard plantations. Due to the lack of data,

the average yield per hectare, except for berries, is calculated from the total production of all fruit in all extensive orchards.

LIST OF AGRICULTURAL PLANTS

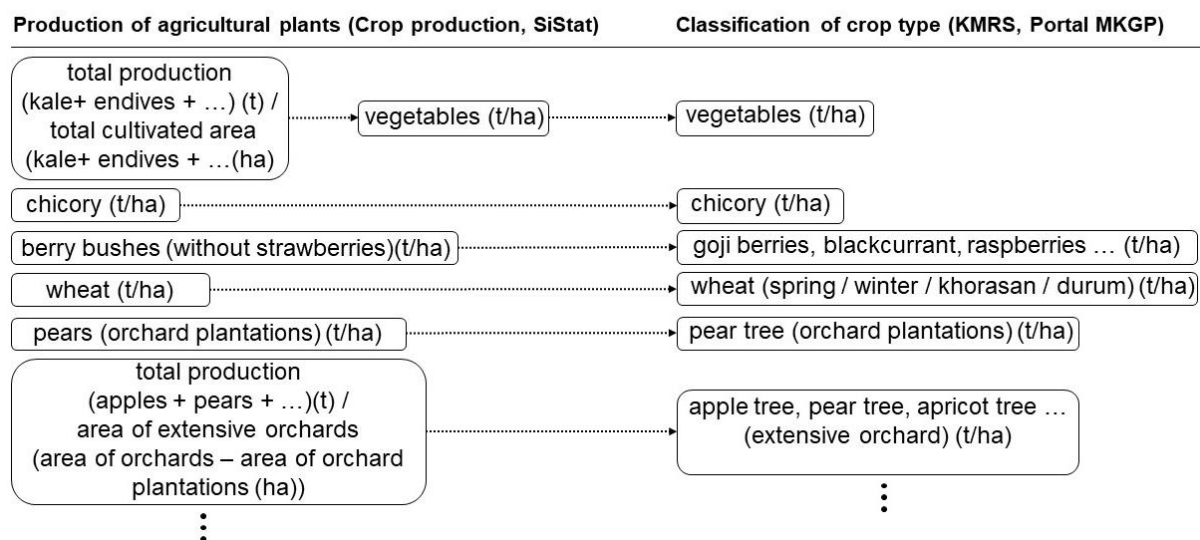


Fig 1. Harmonisation of SORS's and MAFF's data on agricultural crops.

4. Results

The methodology we developed for estimating regional food self-sufficiency rates was also tested at the national level. We found that when adequate data are available (i.e., in the case of potatoes and cereals), the calculations of national food self-sufficiency using the methodology developed in the study are consistent with the official calculations of SORS (Table 1). Due to deficiencies in the data on certain crops in the SiStat database or in the KMRS layer, the method we developed underestimates the national self-sufficiency rate for vegetables and overestimates it in the case of fruits. Despite such limitations in data reliability, the data allow us to draw some basic comparisons between regions.

Most development regions of Slovenia have relatively low self-sufficiency rates for plant-based foods (Table 1 and Figure 2).

Tab 1. Estimated food self-sufficiency rate (%) by type of agricultural product by region in 2019.

Development region	Potatoes	Cereals	Vegetables	Fruit
Gorenjska	148.40	10.64	12.48	51.48
Goriška	23.18	9.77	61.17	30.32
Jugovzhodna Slovenija	45.51	50.87	31.59	19.36
Koroška	42.12	6.14	53.88	2.75
Obalno-kraška	12.06	1.38	22.44	22.75
Osrednjeslovenska	32.26	11.54	7.67	15.40
Podravska	44.76	150.45	58.96	45.47
Pomurska	81.97	639.69	68.96	172.09
Posavska	86.36	150.06	172.18	61.79
Primorsko-notranjska	84.29	6.63	51.90	10.55
Savinjska	13.53	18.83	64.73	19.51
Zasavska	12.51	1.62	28.21	1.07
Slovenia	46.66	74.63	35.01	41.05
Slovenia (SORS)	46.65	74.85	43.20	29.80

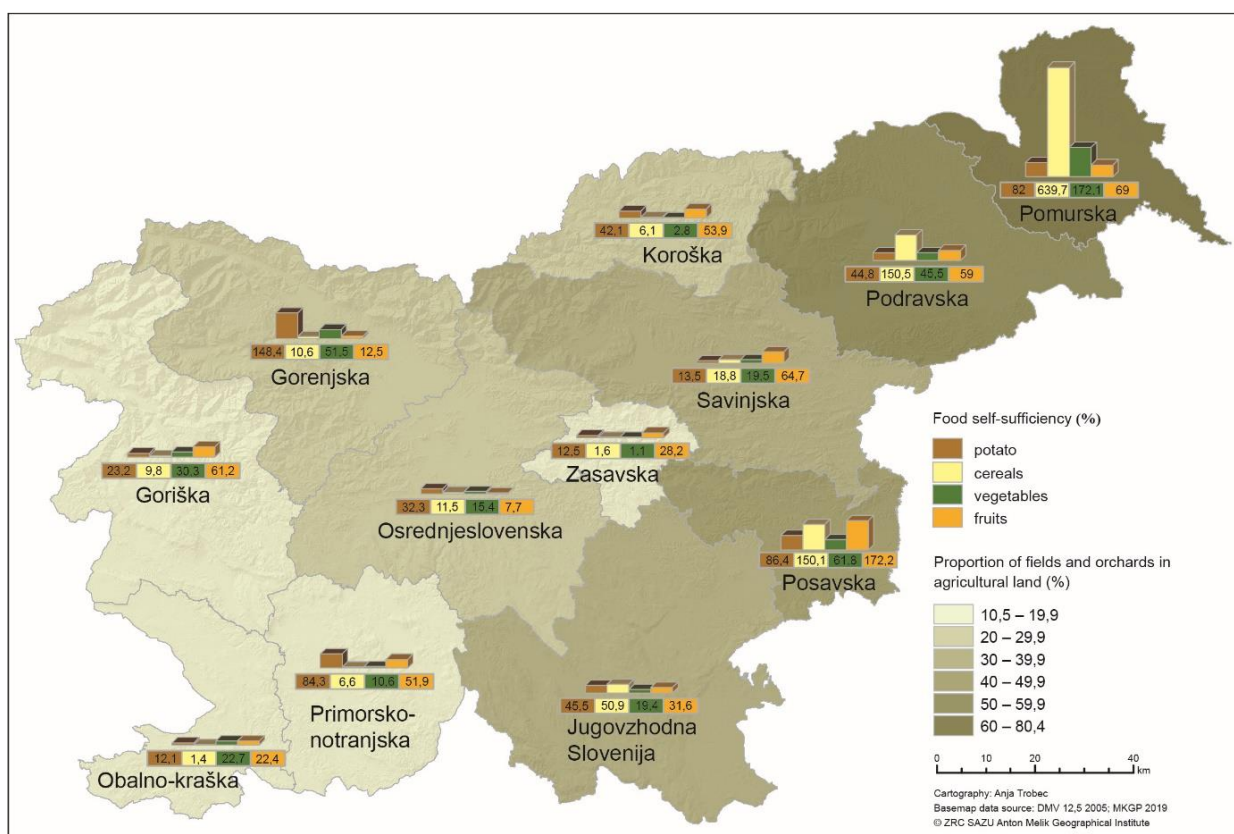


Fig 2. Regional self-sufficiency in plant-based foods and share of arable fields and orchards on agricultural land in 2019.

The most self-sufficient regions in 2019 were the Pomurska, Podravska and Posavska development regions. They were all self-sufficient in cereals due to favourable growing conditions including fertile soils, continental climate, and a relatively high proportion of flat land in their area, as well as traditionally widespread agricultural production of cereals, especially in the Pomurska and Podravska region (Slabe 2015). These regions also had an above-average self-sufficiency rate in most other agricultural products compared to the Slovenian average. Gorenjska was the only region that was self-sufficient in potatoes. The Posavska, Pomurska and Primorsko-Notranjska regions also had a higher than average potatoes self-sufficiency rate compared to the national average (46.65%). The Podravska, Koroška and Jugovzhodna Slovenija had average self-sufficiency rates in potatoes. Compared to other agricultural products, the differences in potatoes self-sufficiency between regions were smaller. The production of this traditional crop is more evenly spread across the country than cereals, fruit and vegetables. Self-sufficiency rate in fruit and vegetables was low in most regions. At national level, fruit production, and consequently fruit self-sufficiency, is highly dependent on weather conditions such as frost and occasional diseases (e.g., pear blight). For example, due to less favourable weather conditions, Slovenian fruit production in 2019 was estimated by SORS to be about half of what it was in 2018 (SORS 2019), which is undoubtedly reflected in production at the regional level. As a result, the estimated fruit self-sufficiency rate by region does not necessarily reflect the potential food self-sufficiency rate that regions could achieve. In 2019, only the Posavska region, traditionally known for its fruit production, was self-sufficient in fruit, while the Pomurska region was self-sufficient in vegetables. The Obalno-kraška region has favourable natural conditions for fruit production in terms of topography and sunshine, but most of the suitable agricultural land is dedicated to vine and olive growing. In the inland (Karst) part of the region, on the other hand, despite the favourable temperatures, particular natural factors such as shallow soils, lack of water and large areas of flat land severely affect vegetable production. The Zasavska region had the lowest level of plant-based food self-sufficiency, with livestock farming being the main agricultural activity. In terms of agricultural land use (Map 1), the region has a high share of permanent grassland and pastures and a low share of arable fields and orchards, while being relatively densely populated. The low

self-sufficiency rate for plant-based foods was also characteristic of the remaining predominantly livestock-oriented regions with a high share of permanent grassland and pastures in agricultural land use, such as the Primorsko-Notranjska, Koroška, Goriška and Savinjska region. In the Osrednjeslovenska region, although crop production is relatively high compared to other regions, the self-sufficiency rate in most plant-based agricultural products was low due to the region's very dense population (Figure 3).

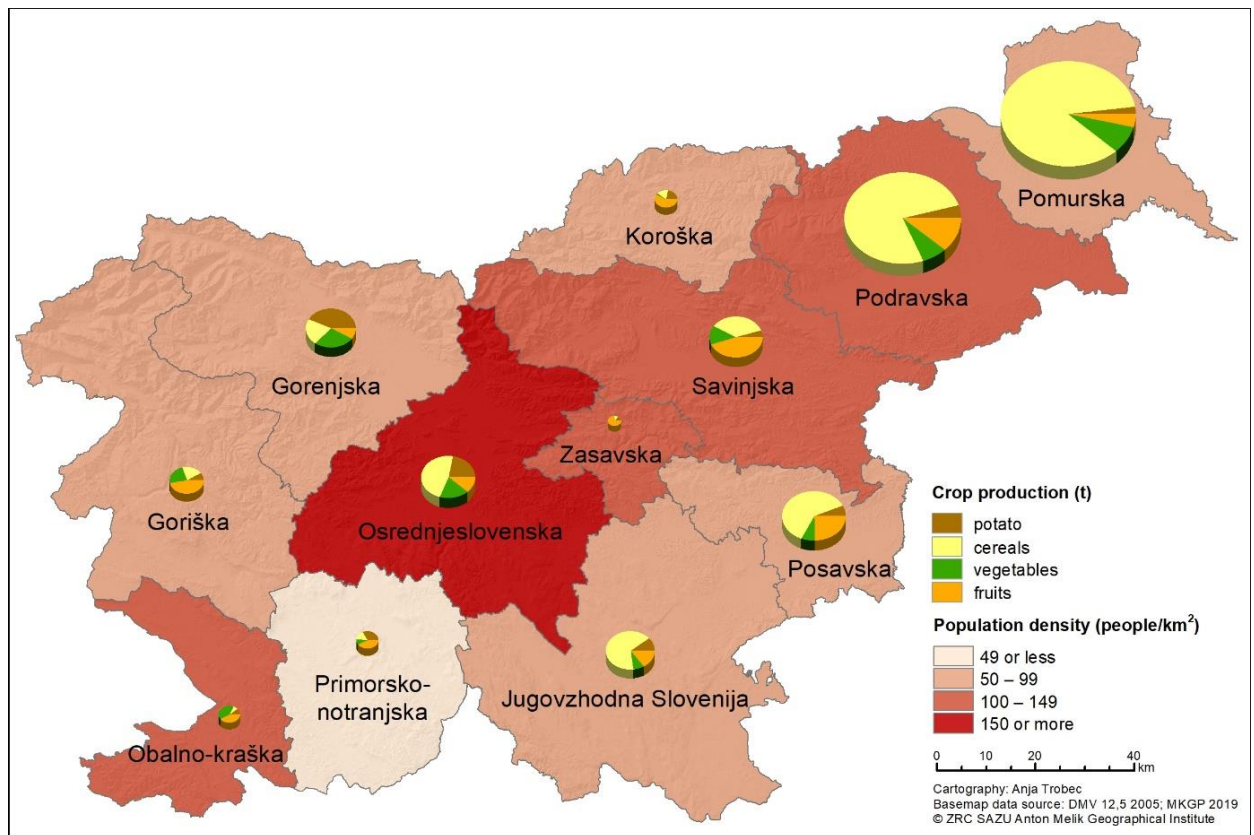


Fig 3. Crop production and population density by region in 2019.

In interpreting the results, it is worth reiterating that the calculated food self-sufficiency rate always depends on the definition of food self-sufficiency itself, on the units of measurement used to express food production and consumption data, and on the way in which food production and consumption data are aggregated, processed, and presented. In the study, food self-sufficiency was understood as a closed system of food circulation within a development region. The food self-sufficiency rate was estimated for each agricultural product group, with production and consumption of each agricultural product group expressed in tonnes. We expect that the estimated food self-sufficiency rate would be higher if food self-sufficiency were defined as a partially open food circulation system with the possibility of cross-regional trade in any food surpluses in the region. We also assume that the estimated food self-sufficiency rate would be higher if it were calculated in other units of measure, i.e., based on all calories produced and consumed within a region.

5. Discussion

In the era of intertwining processes of globalization and glocalization (Potočnik Slavič 2013), food self-sufficiency is a burning concept that raises many questions. On the one hand, sovereignty and self-sufficiency represents a kind of ideal that stems from the natural human desire and need for (food) security, sovereignty, stability, and improved well-being (Ritson 1980; Clapp 2017). Moreover, the idea of food and other forms of self-sufficiency also has a strong emotional charge, as it inspires a sense of pride and helps to strengthen a shared local, regional and (supra)national identity (Clapp 2015; Joseph et al. 2019). On the other hand, excessive pursuit of food self-sufficiency may even have a perverse effect on

our food security and general well-being (for example, low and unstable domestic production may lead to higher prices for domestic products). Therefore, it is important to try to find a stable balance between ensuring an adequate level of food self-sufficiency and integration into international food markets, both at the national as well as at the regional and local levels (Ritson 1980; Clapp 2017).

From the perspective of ensuring an adequate level of food self-sufficiency, the current situation in Slovenia is not ideal. The country has traditionally been a net importer of food (Gale 2014), as domestic production does not meet the demand for agri-food products (Bedrač et al. 2019; Travnikar et al. 2020).

Slovenia has stated in a number of strategic and development documents at various levels that it will strive to increase food self-sufficiency and promote sustainable, cohesive and balanced regional development (Revizija 2013). Consequently, promoting and ensuring sustainable and balanced regional development also through increasing food self-sufficiency based on local production is a key objective in all regional development programmes – the basic strategic and development documents of Slovenian development regions (e.g., Regionalni razvojni ... 2015a, 92; Regionalni razvojni ... 2015b, 149).

The characteristics of food self-sufficiency and food security throughout the world depend mainly on the characteristics of established food supply chains, i.e., the availability and accessibility of food, its quality, nutritional value and dietary habits.

In the case of Slovenian development regions, and more broadly as well, opportunities for establishing sustainable short food supply chains based on local supply of high quality, healthy and environmentally friendly food lie primarily in promoting and fostering the development of organic farming (Štraus et al. 2011) and the formation of ecoregions (Belliggiano et al. 2020). However, when promoting and fostering organic farming practices, it should be noted that organic farming has on average about 20% lower yields per hectare than conventional farming (de Ponti et al. 2012; Seufert et al. 2012), which ultimately also has an impact on lower food self-sufficiency.

Opportunities to increase national, regional or local food self-sufficiency lie primarily in expanding agricultural land, increasing yields per hectare, reducing losses in the food supply chains and changing dietary habits.

In the rural parts of Slovenian development regions, the potential for expansion of agricultural land without affecting forest and other land is represented mainly by abandoned agricultural land (overgrown land, 20–75% of which is covered by young woody or thorny vegetation, trees and shrubs, due to abandonment of farming or poor agricultural use), according to the Land Use Database (PEDR 2008). However, such land accounts for less than 4% of the total agricultural land in Slovenia (RKG 2020), so its conversion would not contribute significantly to increasing food self-sufficiency.

In order to achieve higher yields per hectare and lower production losses, it is also important, when selecting crops, to take into account the specific natural conditions (mainly relief, climate and soil characteristics) that the plants need to thrive, as well as their different adaptability and resistance to natural events such as droughts, frosts and floods. These disasters are also becoming more frequent in Slovenian rural areas and elsewhere due to the effects of climate change, and consequently have an increasing impact on the development of agricultural activity in rural areas (Howden et al. 2007).

According to many experts, the key to increasing food self-sufficiency in high-income countries lies in shifting dietary habits back to a more plant-based diet (Pradhan et al. 2014; Prosekov. Ivanova 2018; Joseph et al. 2019; Schramski et al. 2019; Beltran-Peña et al. 2020). However, these changes are also associated with certain challenges in many of those countries. In the case of Slovenia, the situation regarding fruit self-sufficiency is particularly worrying. Fruit production is declining, while it is becoming increasingly important in our diet. Self-sufficiency in potatoes is also declining, although it plays an increasingly minor role in our diet. Self-sufficiency in cereals and vegetables is increasing. For the latter, both production and dietary intake have been increasing, while the self-sufficiency rate has been slowly increasing since 2010, when it bottomed out at 30%. It should be noted, however, that a certain share of the production of individual agricultural products is not for human consumption but for animal feed, industrial purposes, etc. For example, in the case of cereals, the share of production destined for human

consumption was only 29% in 2019, while as much as 60% of the harvest was destined for animal feed, which has a significant impact on the level of food self-sufficiency (SiStat 2020).

In estimating food self-sufficiency at any geographic level based on publicly available data, we must also be aware that actual food self-sufficiency rates are higher than indicated in the calculations, since official databases on agriculture do not include data on food self-provisioning, also referred to as home gardening and household food production. Indeed, many recent studies (Jehlička et al. 2018; Vávra et al. 2018; Ančić et al. 2019) show that food self-provisioning, although until recently neglected in terms of its contribution to ensuring food self-sufficiency, food security, food sovereignty, and sustainability, is an important form of alternative food networks.

Similar to Vrišer (2005), Morrison et al. (2011), Rednak et al. (2016) and Šumrada et al. (2020), our study concludes that publicly available agricultural databases are of variable quality and reliability. Due to the different ways in which data are collected, managed and publicly disseminated, and the resulting different ways in which data are structured, it is a major challenge to harmonise and link them. Consequently, it is only with a certain degree of generalisation that it is possible to actually assess the state of regional food self-sufficiency and make a basic comparison of the characteristics of food self-sufficiency between regions on the basis of the results obtained. Despite certain shortcomings in the original data, this type of study and the development of methods to identify the characteristics of regional food self-sufficiency are of great value. The methods developed may be useful for researchers to further explore food self-sufficiency at different geographical levels, and for government officials and local authorities to formulate local strategies to promote sustainable regional development. More accurate estimates of regional food self-sufficiency rates will enable regions to identify their food supply opportunities and gaps and provide them with an opportunity to increase interregional integration in the food market, particularly in the area of trading potential local food surpluses. This provides an opportunity for regions to strengthen and make food self-sufficiency more stable, thereby enhancing local food security. Strengthening regional food self-sufficiency based on local production, building short supply chains and reducing dependence on long-distance food transport in turn offers regions the opportunity to build sustainable and more resilient regional and local food systems, which is indeed a common objective of many national and international agricultural policies, such as Farm to fork (2020).

6. Conclusion

In the current circumstances, where we face uncertain health, economic, and political conditions leading to a less stable global food supply, there is a growing desire to create a stable balance between providing locally produced food and integration into international food markets. The importance of providing safe, healthy, high quality and diverse locally produced food is being emphasised, and the idea of strengthening both national as well as regional and local food self-sufficiency is coming back to the fore. This is reflected in many strategic and development documents at different geographical levels, in political and professional debates, and in academic research.

When examining the characteristics of food self-sufficiency in a given area, it is important to bear in mind that the concept of self-sufficiency does not have a universally accepted meaning, and that the characteristics of food self-sufficiency depend primarily on the definition and framing of food self-sufficiency itself in a broader context.

In our study, we aimed to develop an appropriate methodology to estimate plant-based food self-sufficiency at the regional level, using Slovenia as a case study. We relied on publicly available data from various administrative databases managed by SORS, MAFF and SAAMRD. Similar to previous related research, we found that the available publicly accessible data are of variable quality, only partially consistent with each other and difficult to interlink. We consider the methodology for estimating regional food self-sufficiency to be appropriate and transferable to other geographical levels and to other countries, in particular to the Member States of the European Union (EU). Indeed, Member States collect and publish data on production and consumption of agricultural products in a similar way, as part of national administrative databases. Just like Slovenia, they transmit data to Eurostat in order to aggregate

and publish pan-European statistics and indicators that allow comparisons between countries and regions.

Nevertheless, we have to point out that the results of the study should be viewed critically due to the shortcomings of the existing publicly available data and that they are primarily indicative when it comes to identifying the characteristics of regional food self-sufficiency.

We stress that more efficient and higher quality research on food self-sufficiency at different geographical levels would require more effective coordination between the above-mentioned administrative databases. Increasing the amount of publicly available agricultural data through distribution portals such as the MAFF data portal is also needed. Better coordination and increased availability of relevant and harmonised publicly available data could help researchers in the future to conduct high quality and in-depth (scientific) research on food self-sufficiency at different geographical levels and make their findings more widely applicable. Ultimately, these findings could be useful for local decision-makers and policymakers to strengthen self-sufficiency in locally produced, high-quality food and increase the resilience of regional and local food systems. This in turn could support development in rural parts of regions and help achieve more balanced sustainable (inter)regional development.

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