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VULNERABILITY IN AGRICULTURE – DATA ANALYSIS

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Abstract
This paper explores the vulnerability in agriculture in Serbia. Agricultural sector is extremely important for both country and the farmers. The country's exposure to hazards has a direct effect on the economy, since around 20% of the population are farmers. This sector is exposed to all kinds of hazards and climate changes. When a hazard occurs, it is essential to act quickly and determine recovery and risk reduction requirements. This paper shows monetary losses and recorded damaged/destroyed goods in agricultural sector. Data of previously recorded hazards is obtained from United Nations DesInventar Open Source Initiative database. The analysis is based on 1493 agricultural events recorded from 1981. to 2023. Data is analysed using Python programming language. It is processed with Python's DOM parser xml.dom.minidom. inside a Django web application. Visualisation of analysed data is implemented using Chart.js library.

Key words: *agriculture, hazard, python, damage, losses*

1. Introduction

The vulnerability of agricultural systems, defined as their susceptibility and limited capacity to adapt to various stressors, is becoming an increasingly important topic in the context of rapid changes in climate, markets and technologies. The agricultural sector is essential for global food security and economic stability, yet it remains inherently vulnerable to a myriad of challenges, including natural disasters, climate variability, economic fluctuations, and social disparities. Understanding and mitigating these vulnerabilities are crucial steps towards building resilient agricultural systems that can sustainably meet the growing demands of a changing world.

Aligned with the global agenda for sustainable development, particularly the Sustainable Development Goals (SDGs) (United Nations Department of Economic

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and Social Affairs, 2024) addressing vulnerabilities in agriculture is integral to achieving food security (SDG 2), promoting sustainable agriculture (SDG 12), and fostering resilient infrastructure (SDG 9). The SDGs provide a comprehensive framework for understanding the interconnectedness between agricultural vulnerabilities, environmental sustainability, and socio-economic development.

Post-Disaster Needs Assessment (PDNA) (Food and Agriculture Organization of the United Nations, 2024) frameworks provide valuable insights into the immediate and long-term impacts of disasters on agricultural sectors. By systematically evaluating damages and losses, PDNA helps quantify the extent of vulnerability and inform targeted recovery efforts. This assessment is not only pivotal in restoring agricultural productivity but also in enhancing adaptive capacities to future shocks.

In this paper, we will point out the importance of the application of information technologies (IT) in assessing the vulnerability of agricultural systems. Information technologies have the potential to transform the way we understand, measure and manage vulnerability in agriculture.

2. Main cause for application development

Damage in agriculture represents a complex challenge with profound socioeconomic and environmental consequences. The agricultural sector is often exposed to various risks that can threaten its productivity and sustainability.

Natural disasters such as floods, droughts, storms or fires can cause direct physical damage to crops, livestock and infrastructure, leading to losses in food production and farmers' income. In addition, pests, plant and animal diseases, and changes in market conditions present additional challenges with the potential for long-term economic losses.

Damage assessment in agriculture is necessary to quantify losses and enable timely planning and implementation of recovery measures. This assessment not only helps identify urgent support needs for farmers, but also provides a basis for developing resilience strategies that can mitigate future risks and increase the ability of agricultural systems to adapt to unexpected events.

Through a comprehensive analysis of agricultural damages, it is possible to better understand the complexity of the challenges facing farmers around the world, while providing a foundation for improving policies and practices that support the sustainability and resilience of rural communities.

Serbia has been very vulnerable to a wide range of natural hazards, including floods, landslides, droughts, and earthquakes (The World Bank Disaster Risk Management, 2021). From the total territory of the Republic of Serbia (88,848 km2), the structure of surface areas of the main land cover categories is as follows (Ministry of Construction, Transport and Infrastructure of the Republic of Serbia, 2021): agricultural land 43,113 km2, forests and forest land 38,240 km2, wetlands and water surfaces 2,377 km2, and artificial surfaces and barren land 4,757 km2. Having this in mind, it is important to recognize the risks and vulnerabilities of the land.

Serbia is focusing on improving its capacities for prevention, mitigation, and response to disasters, including the agricultural sector. However, data and evidence on damages and losses in the agricultural sector from disasters are not systematically collected and analyzed, which hinders the development of strategic measures to strengthen the sector's resilience.

Hazard specialists are equipped with knowledge on how to prepare the lands and the farmers with proper tools to overcome hazards with minimal damage, but the information available online is not readable to them. The specialists need a tool to analyze the data in order to discover how, where and why the vulnerabilities occur.

3. Framework of choice for analysis

Choosing the programming language for any application development is a fundamental building block. Building software is like building a house. It needs a strong foundation to be built fast, scalable, and maintainable.

The decision was made to use Python. Thanks to its popularity, it is very likely to find a ready-made solution to many experiencing problems. It's community is very strong and is constantly being developed.

One of the biggest advantages of Python are numerous libraries and frameworks. In Python, there is a library for almost anything: data visualization, machine learning, data science, complex data analysis, etc.

When it comes to frameworks, the situation is similar. They are very helpful in speeding up the development time and starting the project. There's a variety of frameworks to choose from, depending on the needs of the project: Django, Flask, Pyramid, Twisted, etc.

Python is very easily maintainable due to its resemblance to actual English. It has a clear syntax and does not require as many lines of code as Java or C to give comparable results.

Given all the advantages listed above, the decision for data analysis and visualization was to use Python's Django framework, which offers built-in database versioning. For data visualization, we chose the Chart.js library, and for XML parsing, we used Python's DOM parser, xml.dom.minidom.

4. Data analysis and processing

Data of previous recorded hazards is obtained from United Nations DesInventar Open Source Initiative (United Nations DesInventar Open Source Initiative) database. The data consists of 2345 records of which 1493 are agricultural events dated from March 20, 1981 to June 16, 2023.

Hazard records are in a xml file. Data is divided into six parts – lev0, regiones, eventos, causas, fichas and extension. Each of these parts has a single record under TR tag.

All municipalities are located under two tags – lev0 and regiones. Lev0 tag contains municipality code, name in native region language and name in English.

Regiones tag has the same data as lev0, but it is extended with coordinates of the municipality. Both lev0 and regiones needed to be parsed and combined since there was a mismatch in data.

Events are located under the eventos tag. Each event contains number, name in native region language and name in English.

Causes are located under the causas tag. Each cause contains name in native region language and name in English.

Recorded events are under the fichas tag. Each event has an agropecuario tag that has the value set to 1 if the event was agricultural. If the value of agropecuario tag was one, the event is parsed, otherwise it is skipped.

Each recorded event has a lot of information bound to it – municipality code, cause, losses in local currency, losses of livestock, hectares, etc. The extension tag contains additional data about each recorded event and each record in this tag is combined with each recorded event under the fichas tag.

4.1 Data Model

Based on the analyzed data, the model is created using 4 entities (Figure 1):

- Municipality – describes the municipality in which the event occurred,
- Cause – describes what caused the event to happen,
- Event – describes the event that can happen,
- Recorded event – describes the event that happened in detail.

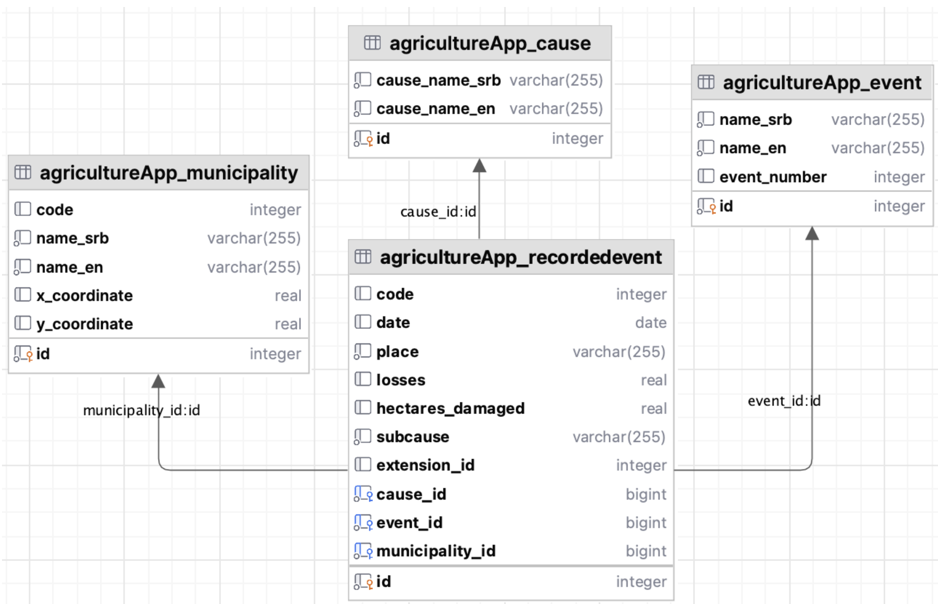

Figure 1: Data model

5. Results

All parsed data is presented in a table format, showcasing comprehensive analysis and visualization of agricultural sectors. The data includes information on both destroyed and damaged items within each sector, as well as monetary losses. Graphical representations include bar charts, pie charts, and doughnut charts. In addition, there are graphs illustrating event frequencies, event costs incurred during hazards, and declarations of emergency situations.

The Table 1 provides a clear overview of the most impactful events and their associated recorded damaged/destroyed goods and monetary losses or lack thereof.

Table 1: Hazard statistics

Category	**Most Impactful event**	**Recorded damaged/destroyed goods**	**Monetary Losses in RSD**
Most expensive event overall	Flood	409	374 820 519 339
Most frequent event overall	Forest Fire	609	51 088 957
Emergency situation declared	Flood	71	374 820 519 339
Crops	Drought	696 608	1 319 769 630
Livestock	Fire	45 792	/
Losses in hectares	Flood	33 301	/
Affected water sources	Flood	199	/
Affected agricultural assets	Fire	3	/
Disabled waterways	Flood	5	/
Agricultural losses in hectares	Flood	1 000	/
Forest losses in hectares	Forest Fire	7 189.47	2 050 000
Affected stock facilities	Fire	101	/

5.1 Visualization

Data visualization was implemented using Chart.js library. Graph used for visualization are pie, doughnut and bar. Below are given examples of the bar (Figure 2) and doughnut graphs (Figure 3).

Figure 2 shows the frequency of hazards in the Republic of Serbia during the observed period. We can conclude that the events with the highest frequency of occurrence are forest fires (609), followed by floods (409) and hailstorms (253).

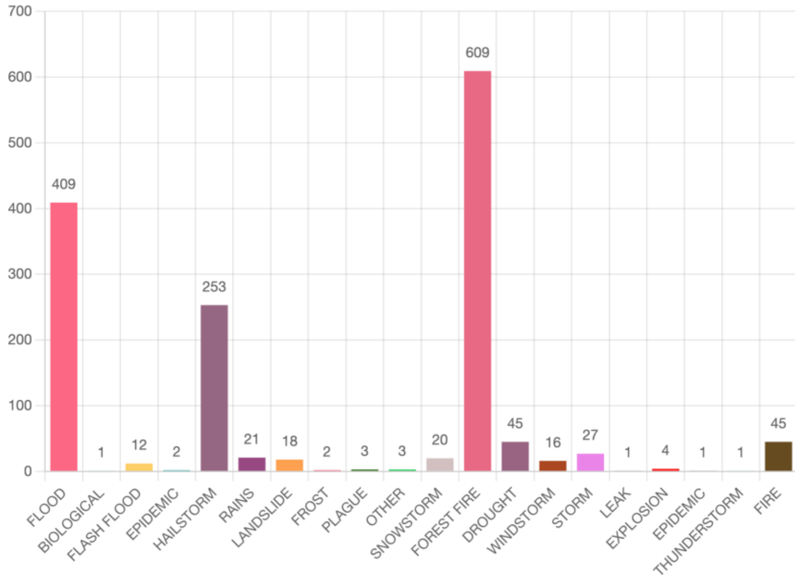

Figure 2: Event frequencies statistics

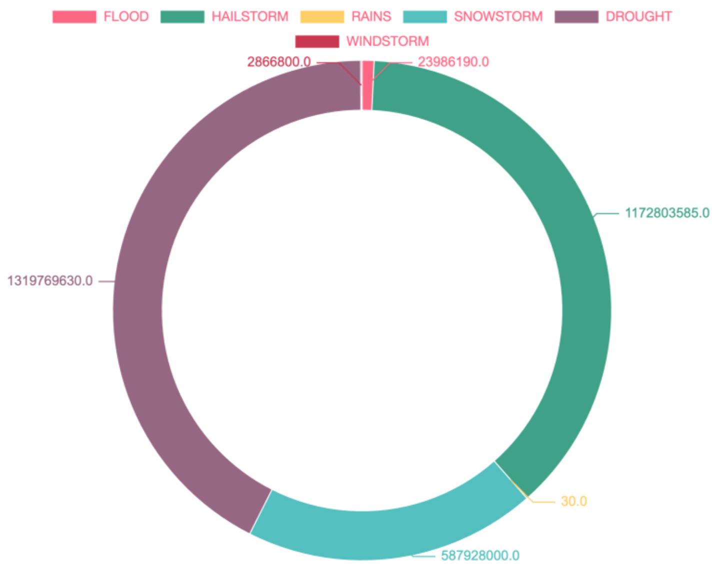

Figure 3: Crop losses statistics

Figure 3 shows the losses recorded in crops during the observed period. Based on the presented results, it was determined that the biggest losses in crops occurred as a result of drought (1 319 769 630 RSD), hailstorm (1 172 803 585 RSD) and snowstorm (587 928 000 RSD).

6. Discussion

Through comprehensive data analysis of agricultural disasters, several key insights have emerged:

- Impact Variation: Different types of disasters, such as floods, droughts, and fires, exhibit varying degrees of impact on agricultural productivity and economic stability.
- Economic Burden: The financial costs associated with agricultural disasters, both direct and indirect, underscore the need for proactive disaster management and preparedness.

Based on our findings, several recommendations can be made to enhance agricultural resilience and disaster preparedness:

- Integrated Approach: Adopting an integrated approach that combines data-driven decision-making with community engagement and local knowledge can improve disaster response effectiveness.
- Insurance and Financial Support: Enhancing access to agricultural insurance and financial support mechanisms can buffer farmers against economic losses during disasters.

7. Conclusion

The application of IT provides the possibility of timely identification of key factors of vulnerability such as climate change, economic fluctuations and social inequalities. Also, IT has the potential to improve communication and cooperation between different actors, enabling better risk management and more effective planning of adaptive strategies.

This study underscores the critical importance of data-driven analysis and visualization in understanding the complex dynamics of agricultural disasters. By leveraging these insights, policymakers, researchers, and agricultural stakeholders can work collaboratively to build resilient agricultural systems capable of withstanding and recovering from disasters effectively.

Acknowledgments

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