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Farmers' perceptions of climate change impacts on agriculture: A regional analysis

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Abstract

This study analyses agricultural producers' perceptions of climate-related hazards and their impacts on agricultural production across regions of the Republic of Srpska, Bosnia and Herzegovina. The main objective is to identify dominant climatic stressors, examine regional differences in perceived impact intensity and damage experienced, and assess the role of selected farm characteristics in shaping these perceptions. Primary data were collected through a cross-sectional survey of agricultural producers operating under diverse agro-climatic and socio-economic conditions. Respondents assessed the intensity of major climate-related hazards and the damage experienced during the previous five years using ordinal scales. The analysis combined descriptive statistics, chi-square tests, and a Weighted Impact Index to enable a comparative regional assessment. The results indicated that drought and high temperatures were perceived as the most severe and damaging climate-related hazards across all regions, with particularly pronounced impacts reported in northern and north-western areas. Other hazards, including floods, hail, storms, frost, and snow, were generally perceived as having weaker and more localized effects, despite statistically significant regional differences. Although the awareness of climate change among agricultural producers was high, the adoption of adaptation and risk management measures remained limited. Perceptions of climate-related risks were primarily influenced by regional climatic conditions and economic exposure, with commercial farms reporting higher perceived impacts and damage. The findings highlighted substantial regional disparities in perceived climate risks and emphasized the importance of region-specific adaptation strategies in agricultural policy and practice.

Key words: Climate change perception; Agriculture; Climate-related hazards; Regional vulnerability; Republic of Srpska.

Introduction

The global agricultural sector is positioned at the intersection of rapidly escalating climate change risks and increasing demands on food production systems, as the current global food system simultaneously contributes to climate change while becoming increasingly vulnerable to its impacts (Mbow et al., 2019; Praveen & Sharma, 2019; Yang et al., 2024). The European continent faces varying regional risks, with Southern Europe (SEU) projected to suffer the most severe consequences (Bednar-Friedl et al., 2022).

The climate change has led to a northward movement of agro-climatic zones in Europe and an earlier onset of the growing season (Ceglar et al., 2019). However, warming has also altered the timing of frost events, and recent evidence from Central and Southeast Europe shows that the lengthening of the frost-free season is mainly driven by earlier spring warming rather than later autumn frosts, increasing the risk of crop damage from late-spring frost events (Chervenkov & Slavov, 2022). Extreme drought and heat stress have had detrimental impacts on agricultural crop production in Southern Europe, where moderate to severe impacts have been observed (Olesen et al., 2011; Fontana et al., 2015; Zampieri et al., 2017). In addition to more frequent and intense heat waves and drought, anomalous wet conditions have also contributed to crop yield reductions (Trnka et al., 2015; Ben-Ari et al., 2018; Ceglar et al., 2018). Anomalous wet conditions and short-term flooding increasingly affect crop development in continental Southeast Europe. In the northern Pannonian region of Croatia, nearly 80% of farmers reported field flooding between 2015 and 2020, mainly during early crop growth stages, resulting in yield losses (Senko et al., 2022). As this region extends into northern Bosnia and Herzegovina, including a large area of the Republic of Srpska, these findings are directly relevant for assessing flood-related risks in the study area. These climatic extremes have caused the largest share of negative economic impacts on European agriculture and are expected to continue in the future (Devot et al., 2023). Additionally, agricultural production has been strongly influenced by socio-economic conditions in the region (Popovici et al., 2013). The fragmentation of agricultural land, a high share of the agricultural population in total active population, ageing of agricultural households, inadequate knowledge, low levels of science implementation, and insufficient investments are among the main constraints reducing the adaptive capacity of the agricultural sector under climate change (Ceglar et al., 2018; Dhillon & Moncur, 2023).

Bosnia and Herzegovina has experienced frequent extreme weather events over the past two decades, causing severe economic losses. During the period 2000-2021, the country experienced floods, droughts, heat waves, cold spells, and stormy winds. In recent years, particularly between 2017 and 2021, intense

late-spring frosts have caused significant damage to fruit production. Climate model projections indicate that the frequency and intensity of these extreme events are likely to increase, posing growing risks to agriculture in Bosnia and Herzegovina. Jalić et al. (2025) identified significant negative impacts of climate shocks on crop yields (wheat, corn, barley, potato, plum, pear, sweet cherry, sour cherry, and apple). Overall, previous studies have documented increasing climate variability across the country, particularly in temperature and precipitation extremes (Trbić et al., 2017a; Popov et al., 2017; Popov et al., 2018; Popov et al., 2019). This trend is further supported by SPEI-based assessments showing a sharp rise in both drought and flood extremes over the past three decades (Čadro et al., 2024). Furthermore, based on the available data and climate projections, exposure to climate-related risks is expected to increase (Council of Ministers of Bosnia and Herzegovina, 2013; Žurovec et al., 2015). In line with broader European trends, sub-national assessments show that rural areas of Bosnia and Herzegovina exhibit significant vulnerability to climate change, particularly in agriculture-dependent regions with limited adaptive capacity. The most vulnerable rural municipalities are predominantly located in the northern and north-eastern parts of the country (Žurovec et al., 2017; Žurovec & Vedeld, 2019). These areas are characterised by high socio-economic sensitivity, a large share of agricultural land, and limited income diversification, increasing the vulnerability of agricultural production systems. The results further indicate that sensitivity and adaptive capacity are more important determinants of vulnerability than exposure alone. At the same time, adaptation remains limited, largely constrained by financial limitations, lack of knowledge, and labour shortages (Žurovec & Vedeld, 2019). Given that a substantial part of the northern and north-eastern regions comprises the Republic of Srpska, these findings are directly relevant for this study.

Public attitudes and farmers' perceptions of climate change across Europe show significant regional differences. According to Ricart et al. (2019), population in Southern Europe express higher levels of concern and perceive climate change as a more immediate threat, largely attributed to human activities. In contrast, respondents from Northern Europe tend to report lower concern and greater uncertainty regarding its drivers and impacts. These findings suggest that direct exposure and regional experience play an important role in shaping climate change awareness and risk perception, particularly among agricultural producers. In this context, Bosnia and Herzegovina represents a particularly relevant case, as increasing exposure to climate extremes may significantly influence farmers' awareness, perceptions, and adaptation responses, especially in agriculturally dependent regions such as the Republic of Srpska.

The aim of this research is to assess (i) the level of awareness and perception of agricultural producers about the impacts of climate change on

agricultural production, (ii) identifying regional differences in perceived impacts and damage, (iii) the association of perceptions of climate change with selected sociodemographic and agricultural household characteristics, and (iv) on local capacities for adaptation and for the development of appropriate new effective policies.

Material and Methods

This study employed a quantitative cross-sectional survey to assess agricultural producers' perceptions of climate change impacts on agricultural production, including the perceived intensity of climate-related hazards and the damage experienced during the previous five years. The analysis focused on identifying regional differences in perceived impacts and examining associations with selected socio-demographic and farm characteristics. The research was conducted in the Republic of Srpska (Bosnia and Herzegovina), covering seven regions: Banja Luka, Bijeljina, Doboj, Gradiška, East Sarajevo, Prijedor, and Trebinje. These regions differ in agro-climatic conditions, production structure, and socio-economic characteristics, providing a suitable basis for comparative analysis.

The analysed regions exhibit substantial agro-climatic variability, shaped by complex topography and the interaction of continental and Mediterranean air masses (Žurovec et al., 2015). Northern and north-western regions, including Bijeljina, Gradiška, and Prijedor, are predominantly lowland areas (below 200 m), characterised by a moderate continental climate and annual precipitation of 700-950 mm (Trbić et al., 2017b). In contrast, eastern and mountainous areas, such as East Sarajevo, are located at higher altitudes (often above 500 m), with lower temperatures and shorter growing seasons. The southern region around Trebinje is characterised by a Mediterranean and sub-Mediterranean climate, with the highest average temperatures; however, despite relatively high annual precipitation, it is marked by pronounced summer water deficits due to the uneven seasonal distribution of rainfall (Čadro et al., 2019). These agro-climatic differences represent an important factor shaping agricultural production and exposure to climate-related risks..

Sampling and data collection

Data collection was carried out in cooperation with the agricultural advisory service of the Ministry of Agriculture, Forestry, and Water Management of the Republic of Srpska. Advisory officers conducted field surveys at the municipal level and facilitated access to agricultural producers during their regular advisory activities. A total of 200 agricultural holdings were surveyed (N = 200), with the following regional distribution: Bijeljina (n = 72), Trebinje (n =

24), Banja Luka (n = 22), Prijedor (n = 22), Gradiška (n = 21), East Sarajevo (n = 20), and Doboj (n = 19).

The regional sample structure reflects both the availability of producers during the survey period and the operational coverage of the advisory service. While percentage-based measures were used to support regional comparisons, the unequal distribution of respondents should be taken into account when interpreting differences across regions. Within municipalities, producers were selected using a field-based, non-probability sampling approach. Advisory officers approached agricultural holdings encountered in situ without prior selection based on production outcomes or reported climate-related impacts. They were instructed to include approximately balanced numbers of commercial and non-commercial farms in order to capture variation in farm orientation and production scale. Participation in the survey was voluntary, and respondents were informed about the purpose of the study prior to participation. No personal identifying information was collected.

Questionnaire design and variables

Data were collected using a structured questionnaire designed by the author specifically for this research. The questionnaire comprised several thematic sections:

1. Socio-demographic and farm characteristics, including gender, age, education level, formal agricultural education, farm size (in hectares), dominant production type, and farm orientation (commercial or non-commercial).
2. Awareness and general perceptions of climate change, including familiarity with climate change concepts, perceptions of exaggeration of climate change impacts, and perceived overall influence of climate change on agricultural production.
3. Perceived intensity of climate-related hazards, where respondents assessed the impact intensity of drought, floods, hail, storms, frost, snow, high temperatures, and soil degradation.
4. Perceived damage caused by climate-related hazards, reflecting self-reported frequency and severity of damage experienced during the previous five years.
5. Adaptation and information-related practices, including monitoring of weather forecasts, use of information sources, insurance of agricultural production, and irrigation use.

Perceived intensity and perceived damage were assessed using a uniform ordinal scale ranging from 0 to 5, where 0 indicated no perceived impact or damage and 5 indicated a very high perceived impact or very severe damage. Items measuring hazard intensity and damage were treated as single-item measures. This approach was considered appropriate given that the hazards

examined represent clearly defined and concrete phenomena familiar to agricultural producers, and the primary objective of the study was to capture regional patterns of perceived impacts rather than to construct latent attitudinal scales. The main dependent variables were perceived intensity of climate-related hazards and perceived damage caused by these hazards. Independent variables included region, gender, education level, formal agricultural education, and farm type (commercial versus non-commercial).

Statistical analysis

Data processing and statistical analyses were performed using the IBM SPSS Statistics software. Descriptive statistics, including frequencies, percentages, means, and coefficients of variation, were used to summarise socio-demographic characteristics and general perception patterns. Regional differences in perceived hazard intensity and perceived damage were initially examined using cross-tabulation analyses. The χ^2 (chi-square) test of independence was applied to assess associations between the region and perceived intensity or damage for each climate-related hazard. Effect sizes were evaluated using Cramer's V in order to assess the strength of associations observed. Given the ordinal nature of the response variables and the presence of contingency table cells with expected frequencies below five in several analyses, χ^2 test results were interpreted with caution. Accordingly, greater emphasis was placed on overall response distributions, effect sizes, and complementary index-based measures.

Weighted Impact Index (WII)

To synthesise regional differences in perceived hazard intensity and associated damage, a Weighted Impact Index (WII) was constructed. Composite indices are commonly used in climate vulnerability and agricultural risk research to aggregate multidimensional information into a single, comparable metric (Pandey & Jha, 2012; Wiréhn et al., 2015). All climate-related hazards were evaluated using the same ordinal scale ranging from 0 to 5. The index was calculated as a weighted average of response categories, with weights corresponding to their numerical values, following a linear aggregation approach.

The WII was computed using percentage distributions of responses within each region, obtained from the SPSS Crosstab analyses using the option "percent within region", according to the following formula:

$$WII = \frac{1 \cdot P_1 + 2 \cdot P_2 + 3 \cdot P_3 + 4 \cdot P_4 + 5 \cdot P_5}{100}$$

where P1-5 represents the percentage of responses in category i within a given region. Category 0 was assigned a weight of 0 and was therefore excluded from the summation. The index was calculated separately for perceived hazard intensity and perceived damage, ensuring comparability across regions and independence from absolute regional sample size differences.

Methodological limitations

The analysis is based on self-reported perceptions of climate-related hazards and damage rather than on climatic or yield data observed. The findings therefore reflect subjective assessments by agricultural producers that may be influenced by individual experience and recall bias. The study employed a field-based, non-probability sampling approach facilitated by agricultural advisory services. In addition, the regional distribution of respondents was uneven, with different sample sizes across regions, which may introduce bias and affect the stability of regional comparisons. Regional differences and associations observed should therefore be interpreted as indicative patterns rather than causal effects. More advanced modelling approaches would require larger and more balanced sub-samples.

Results and Discussion

The age structure of the respondents was characterised by a wide range of different age groups. The average age was 51 years, with a moderate level of variability (CV = 25%). Mode was 55 years. Respondents' age ranged from 21 to 82 years, thus indicating the inclusion of both younger and older individuals in the sample. The age distribution was approximately symmetric, without pronounced deviations.

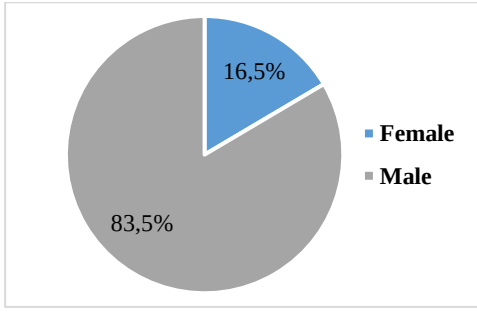


Fig. 1 - Respondents' gender structure

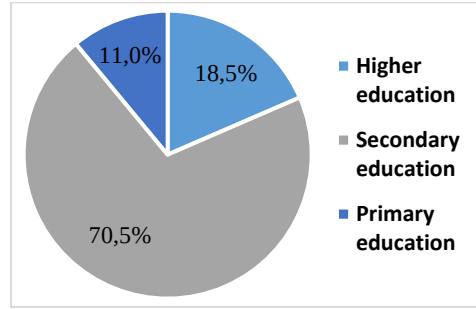


Fig. 2 - Respondents' educational structure

Figure 1 presents a gender structure of the study sample. Male respondents accounted for 83.5% of the total sample, while female respondents represented 16.5%. The gender structure observed confirmed the dominant participation of men in the agricultural production, which reflects broader national trends in Bosnia and Herzegovina, where agriculture is predominantly carried out by male producers (Vaško & Ožegović, 2018; Food and Agriculture Organization of the United Nations [FAO] & UN Women, 2021). Figure 2 illustrates the level of respondents' formal education. The educational structure suggests that agricultural production was mainly performed by individuals with secondary education, which aligns with national-level analyses indicating that farmers in Bosnia and Herzegovina predominantly complete mid-level formal education (FAO & UN Women, 2021).

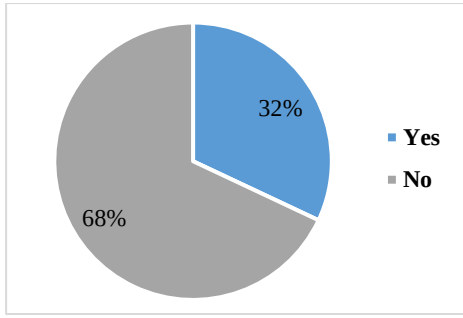


Fig. 3 - Respondents' agricultural education

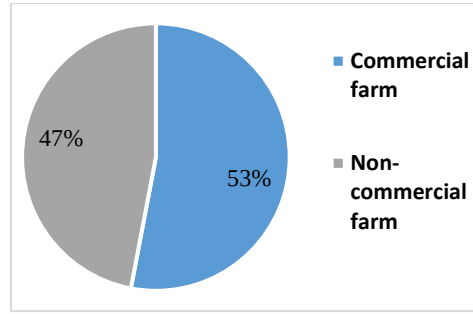


Fig. 4 - Types of agricultural holding

Figure 3 displays the share of respondents with formal agricultural education. A total of 32% of respondents had agricultural education, while 68% did not. This structure may influence production management practices and adaptive capacity to climate change, as formal agricultural education has long been associated with higher farm efficiency and productivity (Lockheed et al., 1980), as well as improved management practices and innovation adoption in more recent studies (Padhy & Kumar, 2015; O'Donoghue & Heanue, 2018). Figure 4 shows the classification of holdings according to their production orientation. Commercial holdings accounted for 47% of the sample, while non-commercial holdings represented 53%, indicating a slight predominance of production primarily oriented toward subsistence. Average holding size was 12.9 ha, mode was 10 ha, with a very high coefficient of variation (CV = 124%), indicating substantial heterogeneity among holdings. Holding sizes ranged from 1 ha to 120 ha, confirming the presence of both small- and large-scale producers in the sample.

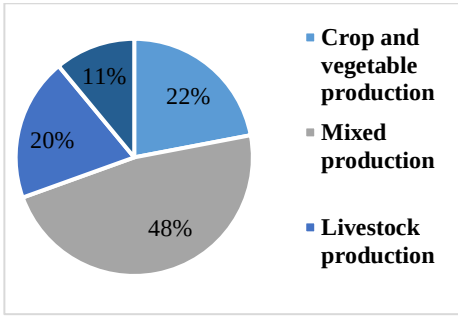


Fig. 5 - Production orientation of holdings

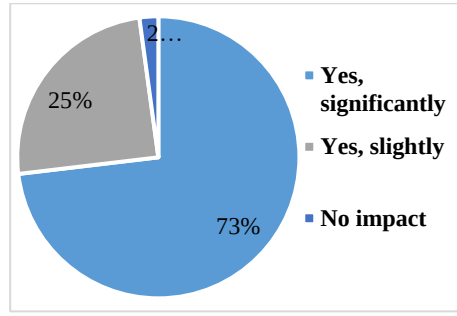


Fig. 6 - Impact of climate change on the agricultural production

Figure 5 illustrates the main production orientations of agricultural holdings. Mixed production was the most prevalent (48%), followed by crop–vegetable (22%), livestock (20%), and fruit production (11%). The structure of agricultural production in the sample reflects the broader characteristics of agriculture in the Western Balkans, which is dominated by small-scale and fragmented farms (Mizik, 2016). Figure 6 presents respondents' perceptions of the overall impact of climate change on the agricultural production. Most respondents (73%) reported a significant impact, 25% indicated a minor impact, and only 2% perceived no impact. Such perceptions are consistent with existing literature showing that farmers widely experience and perceive climate change as having substantial effects on agricultural production (Karki et al., 2020; Shrestha et al., 2022).

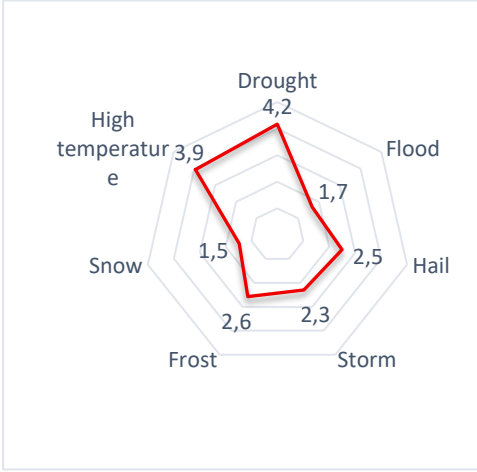


Fig. 7 - Intensity of the impact of climatic events

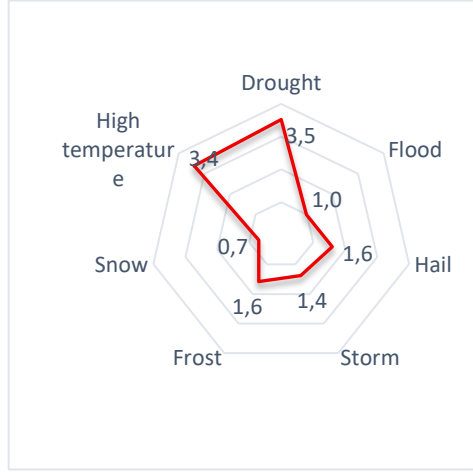


Fig. 8 - Occurrence of damage in the last five years

Figure 7 illustrates respondents' assessments of the intensity of specific climatic events in Republic of Srpska. Drought and high temperatures were perceived as having the highest impact intensity on the agricultural production, whereas snow and floods were assessed as having lower impact intensity. Figure 8 shows the reported occurrence of damage caused by climatic events over the last five years. The results indicate that damage was most frequently associated with drought and high temperatures, while damage related to snow and floods was reported less frequently. The predominance of drought and high temperatures as the most impactful climatic stressors and the most frequent sources of damage is consistent with empirical, review, and regional studies, showing that heat- and drought-related extremes represent the primary climate risks for agricultural production (Vogel et al., 2019; Karki et al., 2020; Stričević, 2020; Shrestha et al., 2022).

Tab. 1 - Climate change awareness, perceptions, and adaptive practices by agricultural respondents

Variable	**Response**	**Share of respondents (%)**
Awareness of climate change	Yes	91.5
	No	8.5
Perception of climate change exaggeration	Yes	15
	No	85
Regular monitoring of weather forecasts	Yes	96
	No	4
Use of social networks for agricultural information	Yes	34.5
	No	65.5
Insurance of agricultural production	Yes	17.5
	No	82.5
Use of irrigation in agricultural production	Yes	32
	No	68

Table 1 summarises the respondents' awareness of climate change, perceptions of its relevance, and the adoption of selected information sources and adaptive measures. A very high proportion of respondents (91.5%) reported being aware of climate change, while only a small share (8.5%) indicated a lack of awareness. Most respondents (85%) did not perceive climate change impacts as exaggerated, suggesting a broad recognition of their severe character. Similar local evidence shows that farm operators perceive climate change as impactful for their agricultural operations (Čop et al., 2021; Gregorić, 2024).

Almost all respondents (96%) reported they followed weather forecasts regularly, hence highlighting the importance of meteorological information in agricultural decision-making. In contrast, the use of social networks as a source

of agricultural information was relatively limited (34.5%), with most respondents relying on other information channels. The adoption of risk management and adaptation measures remained modest. Only 17.5% of respondents reported insuring their agricultural production, while irrigation was used by 32%. These findings indicate a gap between high awareness of climate change and the practical implementation of adaptive measures in agricultural production (Trbić et al., 2017a; Žurovec & Vedeld, 2019). Despite this high level of awareness, the relatively low adoption of adaptation measures suggests the presence of structural constraints beyond individual decision-making.

The survey results indicate that farmers recognise a range of potential adaptation measures, including improved irrigation systems, the use of tolerant crop varieties, diversification of production, and more efficient use of meteorological information. However, many of these measures, particularly those requiring investment, such as irrigation infrastructure, insurance, and access to credit, are closely linked to institutional and policy support. This suggests that the gap between the awareness and implementation reflects not only knowledge limitations but also restricted access to financial resources, advisory services, and risk management instruments.

In this context, public policies and government interventions play a crucial role in enabling adaptation. Strengthening agricultural advisory services, improving access to subsidised insurance schemes, facilitating credit for climate adaptation investments, and promoting targeted training programmes may significantly enhance the resilience of agricultural production systems.

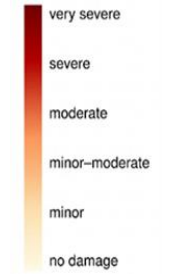
Perceived intensity of climate-related events in the agricultural production

To provide an integrated overview of the perceived intensity of major climate-related hazards affecting the agricultural production, a weighted impact index (WII) was calculated for each hazard and region. The index summarises regional percentage distributions of responses across intensity categories on a 0-5 scale, yielding a single value that represents the average perceived intensity of each climatic factor within a given region.

Table 2 presents the WII values for drought, floods, hail, storms, frost, snow, and high temperatures across the regions observed. Overall, the results indicate that drought and high temperatures exhibited the highest intensity levels across nearly all regions, frequently reaching values corresponding to severe or very severe impact categories. In contrast, floods and snow generally showed lower WII values, suggesting weaker perceived intensity at the regional level. Intermediate patterns were observed for hail, storms, and frost, with notable spatial variability.

Tab. 2 - Weighted Impact Index (WII) of perceived intensity of climate-related hazards across regions

WII	Drought	Floods	Hail	Storms	Frost	Snow	High temp.
Banja Luka	4.05	2.23	2.64	3.00	3.45	2.18	4.05
Bijeljina	4.37	1.59	1.99	1.76	1.72	0.97	3.83
Doboj	3.85	1.60	2.95	3.20	2.60	2.00	4.35
Gradiška	4.36	2.00	3.32	2.82	3.45	1.32	4.59
East Sarajevo	3.90	1.75	2.85	2.45	3.25	2.40	3.70
Prijedor	4.14	2.18	3.77	3.09	3.32	1.55	4.27
Trebinje	4.04	0.67	1.25	1.17	2.21	1.17	3.17



Cell shading reflects increasing WII values, with darker colours indicating higher perceived intensity of climate hazards, based on respondents' answers to the survey question: "Mark with an X the intensity to which climate change affects your production (0 – does not affect at all, 5 – affects to a great extent)."

Marked regional differences were evident. Northern and northwestern regions, such as Gradiška, Bijeljina, Prijedor, and Banja Luka, consistently recorded higher WII values for drought and high temperatures, indicating pronounced exposure to thermal and water-related stress. Conversely, Trebinje displays comparatively low WII values for most hazards, particularly floods, hail, storms, and snow, reflecting its distinct climatic conditions. Elevated WII values for frost and snow in Istočno Sarajevo highlighted the influence of altitude and continental climate features.

The results indicate that agricultural producers across all regions perceived drought as a major factor affecting the agricultural production. In the overall sample, more than half of respondents (51.7%) rated the impact of drought as very strong, and an additional 24.9% reported a strong impact, while a weak or no impact ratings were rare. Although some regional differences were observable, the χ^2 test of independence did not indicate a statistically significant association between the region and perceived drought intensity ($\chi^2 = 37.345$; df = 30; $p = 0.167$), with a weak association (Cramer's V = 0.193).

Regarding floods, producers in most regions perceived them as having weak to moderate effects. In the overall sample, low-intensity ratings predominated: 42.8% reported intensity level 1, while 19.4% reported no impact. A higher perceived impact was more frequent in Bijeljina, Banja Luka, and Prijedor, whereas Trebinje, Doboj, and Istočno Sarajevo were characterised by a predominantly weak or no perceived impact. The χ^2 test confirmed a statistically significant association ($\chi^2 = 70.003$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.264).

For hail, the results indicate regional differences in perceived intensity. Moderate impact ratings were most frequent (21.4%), while weak (14.4%) and very strong impacts (16.4%) were less common. A higher share of strong or very strong impacts was observed in Prijedor (40.9%), while Trebinje was characterised by a predominantly weak or no impact (50.0%). The χ^2 test confirmed a statistically significant association ($\chi^2 = 96.516$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.310).

For storms, regional differences were also evident. Low and moderate intensity ratings were most common (22.9% and 22.4%), while a very strong impact was less frequent (12.4%). Higher shares of a strong or a very strong impact were recorded in Prijedor, while Trebinje again showed a predominantly weak or no impact. The χ^2 test confirmed a statistically significant association ($\chi^2 = 110.533$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.332).

For frost, moderate intensity ratings were most frequent (20.9%), while strong and very strong ratings were also common (31.8% combined). Higher shares of a strong or a very strong impact were observed in Banja Luka, Gradiška, and Prijedor, whereas Bijeljina showed a higher proportion of weak impacts. The χ^2 test confirmed a statistically significant association ($\chi^2 = 86.148$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.293).

Regarding snow, regional differences were evident. Bijeljina, Gradiška, and Doboj were characterised by a dominance of weak impact ratings, while Trebinje had the highest proportion of respondents reporting no impact (41.7%). In contrast, Istočno Sarajevo showed a higher share of moderate to strong impacts, indicating greater sensitivity. The χ^2 test confirmed a statistically significant association ($\chi^2 = 75.483$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.274).

For high temperatures, the results reveal pronounced regional differences, with severe and very severe impacts clearly predominating (74.2% combined). Very strong impacts were especially frequent in Gradiška, Doboj, Bijeljina, and Prijedor, while Banja Luka also showed a high concentration of strong ratings. Istočno Sarajevo exhibited a more balanced distribution, whereas Trebinje showed a more heterogeneous pattern. The χ^2 test confirmed a statistically significant association ($\chi^2 = 66.442$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.257).

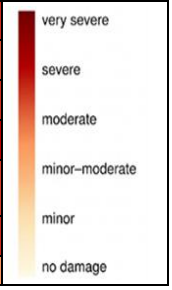
Perceived damage from climate-related events in the agricultural production

To provide a synthetic overview of perceived damage caused by climate-related events, a weighted impact index (WII) was calculated for each hazard and region based on regional percentage distributions of reported damage levels on a

0-5 scale. The index represents the average perceived level of damage associated with each climatic factor and enables direct comparison across regions.

Tab. 3 - Weighted Impact Index (WII) of perceived damage from climate-related hazards across regions

WII	Drought	Floods	Hail	Storms	Frost	Snow	High temp.	
Banja Luka	3.41	1.23	2.23	2.23	2.55	1.27	3.77	
Bijeljina	3.61	0.87	1.04	0.87	0.89	0.38	3.14	
Doboj	3.65	0.60	1.35	2.00	1.35	1.15	3.75	
Gradiška	4.05	1.77	2.59	2.55	2.36	0.95	4.55	
East Sarajevo	3.40	1.10	1.50	1.10	2.5	1.05	3.50	
Prijedor	3.82	1.36	3.00	1.68	1.95	0.41	3.82	
Trebinje	2.63	0.25	0.75	0.42	1.08	0.54	1.96	



Cell shading reflects increasing WII values, with darker colours indicating higher perceived damage levels, based on respondents' answers to the survey question: "How many times in the past five years have you experienced crop damage caused by each of the listed climatic events?" Responses were recorded on an ordinal scale from 0 (no reported damage) to 5 (very frequent damage)."

Table 3 presents regional WII values for damage related to drought, floods, hail, storms, frost, snow, and high temperatures. Overall, the results indicate that drought and high temperatures were associated with the highest levels of perceived damage, with WII values frequently corresponding to moderate to severe damage categories, particularly in northern and northwestern regions. In contrast, floods, snow, and hail generally exhibited low WII values, suggesting limited perceived damage across most regions.

Clear regional patterns were evident. Gradiška, Prijedor, Doboj, and Banja Luka consistently recorded higher WII values for drought- and high-temperature-related damage, indicating pronounced vulnerability to thermal and moisture-related stress. Conversely, Trebinje showed the lowest damage levels for most hazards, particularly floods, storms, hail, and snow. Elevated damage indices for frost and snow in Istočno Sarajevo reflected the influence of altitude and continental climatic conditions.

For drought-related damage, most respondents across all regions reported substantial negative effects. In the overall sample, more than half reported strong or very strong damage (54.2% combined), while the share reporting no or very minor damage was low (7.0%). The most pronounced damage was reported in Bijeljina, Gradiška, and Prijedor, where strong and very strong ratings predominated. In Doboj and Istočno Sarajevo, medium-intensity damage was most frequent, while Trebinje showed a relatively higher share of moderate

damage. The χ^2 test confirmed a statistically significant association ($\chi^2 = 67.758$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.260).

For flood-related damage, the absence of damage or low damage levels predominated. In the overall sample, nearly half reported no damage (47.8%), while an additional 28.4% reported minor damage; severe damage was rare. Bijeljina, Prijedor, and Trebinje had the highest shares of respondents reporting no damage, while Istočno Sarajevo was characterised by predominantly minor damage. Gradiška showed a relatively higher share of moderate damage, whereas in other regions floods generally had a limited effect. The χ^2 test confirmed a statistically significant association ($\chi^2 = 94.107$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.306).

For hail-related damage, results indicate that damage was mostly absent or low to moderate. More than half of respondents reported no or minor damage (55.8%), while strong and very strong damage was uncommon. Bijeljina and Trebinje showed high shares of no damage, while Doboj and Istočno Sarajevo were characterised by minor and moderate damage. Somewhat higher shares of stronger damage were observed in Prijedor and Gradiška, but without a clear pattern of consistently high losses. The χ^2 test confirmed a statistically significant association ($\chi^2 = 134.934$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.366).

For storm-related damage, the absence of damage or low damage levels also predominated. In the overall sample, most respondents reported no or minor damage (62.7%), while strong and very strong damage was rare. Bijeljina and Trebinje had high shares of no damage, while Istočno Sarajevo showed predominantly minor damage. Gradiška recorded a higher share of moderate damage, whereas Banja Luka, Doboj, and Prijedor showed a more heterogeneous distribution. The χ^2 test confirmed a statistically significant association ($\chi^2 = 142.945$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.377).

For frost-related damage, low to moderate damage predominated. More than half of respondents reported no or minor damage (56.2%), while strong and very strong damage were less frequent (13.0%). Bijeljina and Trebinje had high shares of no or minor damage, while Istočno Sarajevo and Gradiška more often reported moderate damage. Banja Luka and Prijedor showed somewhat higher shares of stronger damage, but without dominance of extreme values. The χ^2 test confirmed a statistically significant association ($\chi^2 = 94.849$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.307).

For snow-related damage, it was generally absent or low. In the overall sample, 53.7% reported no and 30.3% minor damage, while higher damage levels were rare. Bijeljina, Prijedor, and Trebinje had very high shares of no damage, while Gradiška and Istočno Sarajevo showed somewhat higher shares

of minor damage. The χ^2 test confirmed a statistically significant association ($\chi^2 = 80.230$; df = 24; $p < 0.001$), with a moderate effect size (Cramer's V = 0.316).

Considering high temperature-related damage, this climatic factor represents the most important cause of loss. In the overall sample, more than half of respondents reported strong or very strong damage (57.7% combined), with very strong damage being the most frequent category (39.3%). Gradiška stood out, with 81.8% reporting very strong damage. High shares were also observed in Prijedor, Banja Luka, Bijeljina, and Doboj, while Istočno Sarajevo showed a more balanced distribution. Trebinje exhibited a less severe pattern, with a higher share of weak and moderate damage. The χ^2 test confirmed a statistically significant association ($\chi^2 = 80.626$; df = 30; $p < 0.001$), with a moderate effect size (Cramer's V = 0.283).

Synthesis of regional patterns

Across all regions, drought and high temperatures clearly stood out as the most severe and widespread stressors, a pattern consistent with previous findings (Žurovec et al., 2015; Vogel et al., 2019; Karki et al., 2020). These hazards were associated with high shares of strong and very strong ratings for both perceived intensity and reported damage, as well as statistically significant regional differentiation.

Northern and northwestern regions, particularly Gradiška, Bijeljina, and Prijedor, consistently exhibited higher perceived exposure and reported damage (Žurovec et al., 2017; Žurovec & Vedeld, 2019), suggesting alignment between perceived hazard intensity and reported losses. In contrast, Trebinje recorded low proportions of strong impact and damage ratings across multiple climatic factors, indicating a comparatively lower perceived impact within the study sample.

Tab. 4 - Regions most and least affected by major climate-related factors

Climate factor:	Most affected regions	Least affected regions
Drought	Bijeljina, Gradiška, Prijedor	East Sarajevo
Floods	Gradiška	Trebinje, Bijeljina
Hail	Prijedor, Gradiška	Trebinje, Bijeljina
Storms	Prijedor	Trebinje
Frost	Banja Luka, Gradiška, Prijedor	Bijeljina
Snow	Gradiška, East Sarajevo	Bijeljina, Trebinje
High temperatures	Gradiška, Bijeljina	Trebinje

Other climatic events, including floods, hail, storms, frost, and snow, displayed more localized and moderate patterns. Although regional differences for these hazards were statistically significant, response distributions were largely dominated by a low to a moderate impact and damage levels, suggesting

that their effects were more episodic and spatially constrained. Higher-altitude conditions were associated with greater sensitivity to frost and snow in East Sarajevo, while lowland regions reported negligible effects more frequently.

The synthesized overview presented in Table 4 summarises these patterns by identifying regions that were most and least affected by individual climatic factors, integrating evidence from weighted indices, response distributions, and χ^2 analyses. Overall, the results indicate that climate-related risks and perceived damage in the agricultural production were unevenly distributed across regions, with a clear north–south gradient in perceived intensity and reported impacts. Northern and northwestern regions consistently exhibited higher levels of perceived exposure and damage, particularly for drought and high temperatures, whereas southern regions, especially Trebinje, were characterised by a substantially lower perceived impact. These findings highlight the importance of region-specific adaptation and risk management strategies rather than uniform policy approaches.

The analysis also examined associations between perceived climate-related risks and selected farm and socio-demographic characteristics, including gender, agricultural education, and farm type. Overall, these factors showed limited and mostly non-significant associations, indicating broadly similar perceptions among respondents. Statistically significant differences emerged only for selected climatic events, particularly in relation to sudden or economically disruptive hazards, where the farm type played a more pronounced role. Commercial farms more frequently reported higher perceived intensity and greater damage from events such as drought, hail, storms, frost, and high temperatures, likely reflecting stronger economic dependence on agricultural output, higher levels of input use, and greater financial exposure to yield losses. In contrast, non-commercial farms tended to report a lower perceived impact, likely due to smaller production scales and more diversified livelihood strategies. These differences are consistent with previous findings suggesting that higher levels of investment and market integration are associated with increased exposure and sensitivity to climate-related production risks (Below et al., 2012). Overall, the results suggest that perceptions of climate risks and damage are shaped primarily by regional exposure and economic dependence on agriculture, while socio-demographic and educational factors play a more limited and hazard-specific role.

Conclusion

This study has provided a regionally differentiated assessment of agricultural producers' perceptions of climate-related hazards and their impacts

on the agricultural production in the Republic of Srpska. Drought and high temperatures were perceived as the most severe and widespread climatic stressors, both in terms of perceived impact intensity and the damage reported. Although these stressors affect all analysed regions, their perceived severity and consequences varied considerably, revealing pronounced spatial heterogeneity.

Northern and north-western regions, particularly Gradiška, Bijeljina, Prijedor, and Banja Luka, exhibited higher perceived exposure and greater damage reported, while the southern region, especially Trebinje, was characterised by a substantially lower perceived impact and damage, indicating a clear north–south gradient in climate-related risks to agriculture. Other climate-related hazards, including floods, hail, storms, frost, and snow, were generally perceived as more localised and episodic threats, with a predominantly weak to moderate impact across regions.

The application of the Weighted Impact Index proved useful for synthesising perception-based data and facilitating a comparative regional assessment. Despite a very high level of awareness of climate change and its impacts on agricultural producers, the adoption of concrete adaptation and risk management measures remains limited. The results further suggest that perceptions of climate-related risks have been primarily shaped by climatic conditions experienced and the degree of economic exposure, with commercial farms more frequently reporting higher perceived risks and damage.

Overall, this research can contribute to an improved empirical understanding of region-specific climate risk perceptions in agriculture and it highlights the importance of targeted, regionally adapted policies and measures aimed at strengthening resilience to drought and heat stress in vulnerable agricultural areas.

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Перцепције пољопривредника о утицајима климатских промјена на пољопривреду: регионална анализа

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Сажетак

Ово истраживање анализира перцепције пољопривредних произвођача о климатским ризицима и њиховом утицају на пољопривредну производњу у различитим регионима Републике Српске, Босна и Херцеговина. Главни циљ је идентификација доминантних климатских стресора, испитивање регионалних разлика у перципираном интензитету утицаја и пријављеним штетама, као и анализа улоге одабраних карактеристика газдинстава у обликовању ових перцепција. Примарни подаци прикупљени су путем анкетног истраживања пресјечног типа на узорку пољопривредних произвођача који послују у различитим агроклиматским и социо-економским условима. Испитаници су оцијенили интензитет главних климатских ризика и штете настале у претходних пет година коришћењем ординалних скала. Анализа је обухватила дескриптивну статистику, χ^2 тестове и Индекс пондерисаног утицаја (WII) ради омогућавања компаративне регионалне процјене. Резултати показују да се суша и високе температуре перципирају као најинтензивнији и најштетнији климатски фактори у свим регионима, са посебно израженим утицајима у сјеверним и сјеверозападним подручјима. Остали фактори, укључујући поплаве, град, олује, мраз и снијег, углавном се перципирају као слабијег и локализованог утицаја, упркос статистички значајним регионалним разликама. Иако је ниво свијести о климатским промјенама међу пољопривредним произвођачима висок, примјена мјера адаптације и управљања ризиком остаје ограничена. Перцепције климатских ризика превасходно су условљене регионалним климатским карактеристикама и економском изложеношћу, при чему комерцијална газдинства чешће пријављују већи интензитет утицаја и веће штете. Резултати указују на значајне регионалне разлике у перципираним климатским ризицима и наглашавају потребу за развојем регионално прилагођених стратегија адаптације у оквиру аграрне политике и праксе.

Кључне ријечи: климатске промјене; перцепција; пољопривреда; климатски ризици; регионална рањивост; Република Српска

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