Adapting to the Future Climate Risks and Resilience in Rural Bulgaria

Institute of Agricultural Economics, Sofia

ADAPTING TO THE FUTURE CLIMATE RISKS AND RESILIENCE IN RURAL BULGARIA

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Sino-Bulgarian Joint Lab on Climate Change Adaptive Governance for Rural Ecosystem

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Foreword

The accelerating pace of climate change has rendered rural regions-often marginalized in global discourse-among the most vulnerable yet critical frontiers for adaptation. *Adapting to the Future: Climate Risks and Resilience in Rural Bulgaria - Insights from CMIP6 Projections* emerges as an examination of these challenges, offering a blueprint for resilience that transcends national borders while grounding its analysis in the socioecological fabric of Bulgaria's countryside. This book synthesizes climate science, socioeconomic vulnerability assessments, and policy critiques to bridge the gap between global climate models and localized adaptation strategies. Its significance lies not only in its empirical contributions but also in its methodological innovations, which redefine how scholars and practitioners approach rural resilience.

Scientific and Policy Relevance

By integrating CMIP6 projections with granular field data, this work addresses a critical gap in climate adaptation literature: the scarcity of region-specific studies that contextualize global trends within local realities. The authors' interdisciplinary approach—spanning agronomy, hydrology, economics, and governance—provides a holistic framework for understanding cascading risks, from crop failure triggered by erratic precipitation to the erosion of traditional livelihoods under rising temperatures. Particularly groundbreaking is the application of microclimate modeling (Chapter 7) to village-scale planning, demonstrating how technical precision can empower communities to reengineer-built environments against heat stress.

For policymakers, the book's value resides in its actionable insights. By dissecting the failures of fragmented governance (Chapter 5) and proposing mechanisms like climate-smart financing (Chapter 8), it challenges inertia in institutional frameworks. The case studies in Samokov and Thrace lowlands (Chapter 7-9) exemplify how adaptive measures-from green infrastructure to participatory governance-can yield co-benefits for biodiversity and economic stability. Such findings align with the EU's Climate Adaptation Strategy, yet the authors' critique of top-down policy implementation offers a cautionary counterpoint.

Limitations and Future Directions

While this volume excels in rigor, certain constraints merit acknowledgment. First, the reliance on CMIP6 models, though state-of-the-art, inherits uncertainties inherent to regional downscaling, particularly in simulating localized precipitation extremes. Second, the socioeconomic data-primarily drawn from national statistics-may underrepresent informal economies prevalent in rural Bulgaria, such as small-scale subsistence farming. Third, the focus on technical and institutional solutions, while vital, could be enriched by deeper engagement with cultural narratives shaping community responses to climate risks.

These limitations, however, delineate fertile ground for future research. Expanding longitudinal studies to track adaptation efficacy, integrating Indigenous knowledge systems, and coupling quantitative models with ethnographic methods could further refine the resilience paradigm advanced here.

A Call to Action

By centering rural voices and demonstrating the feasibility of context-specific solutions, we urge stakeholders to reimagine adaptation as a collaborative, iterative process rather than a static checklist. As the global community grapples with the uneven burdens of climate change, adapting to the Future stands as both a warning and a roadmap, a testament to the urgency of science-informed, empathy-driven policymaking.

Executive Summary

Key Findings

This book presents a comprehensive analysis of climate risks and adaptive pathways for rural Bulgaria, synthesizing CMIP6 projections, socioeconomic vulnerability assessments, and case-based resilience strategies. Key findings include:

Climate Projections and Regional Specificity

Under high-emission scenarios (SSP5-8.5), Bulgaria's rural regions face accelerated warming (up to 4.9°C by 2100), intensifying droughts in the Thrace Lowlands and erratic precipitation in mountainous zones. CMIP6 models, calibrated via Delta downscaling, reveal spatially heterogeneous impacts, with agricultural productivity declines (e.g., maize yields reduced by 12–18% under 2°C warming) and heightened heat stress in lowland villages.

Sectoral Vulnerabilities

Agriculture: Smallholder farms, constituting 91% of holdings, are disproportionately affected by soil degradation and water scarcity. Temperature-driven pest proliferation exacerbates crop losses.

Forestry: Drought-induced Forest dieback threatens 25% of ecosystem services, while fire-prone conifer monocultures in low elevations lack adaptive management.

Water-Energy Nexus: Declining snowpack reduces hydropower potential, compounding energy insecurity in fossil fuel-dependent rural grids.

Institutional and Financial Gaps

Policy fragmentation persists, with climate adaptation sidelined in core legislation. Overreliance on EU funds (e.g., CAP) fails to address systemic barriers, including weak local governance, limited access to climate finance, and low adoption of adaptive technologies.

Resilience Co-Benefits

Case studies in Samokov demonstrate that integrating nature-based solutions with participatory planning can reduce heat island effects by 2–3°C while enhancing biodiversity and community cohesion.

Recommendations for Policy and Practice

To operationalize climate resilience in rural Bulgaria, the following actions are critical:

Policy Integration and Governance

Legislative Reform: Embed climate adaptation into national laws, mandating cross-sectoral coordination (e.g., joint agriculture-water-energy task forces).

Local Capacity Building: Decentralize decision-making by empowering municipalities to design context-specific adaptation plans, supported by EU technical assistance funds.

Climate-Smart Financing

Risk-Sharing Mechanisms: Establish government-backed loan guarantees to incentivize private investment.

Blended Finance: Redirect CAP subsidies toward agroecological transitions and pilot green bonds for forestry carbon offsets.

Technological and Ecological Innovation

Precision Agriculture: Scale IoT-based irrigation systems and early warning platforms for pest outbreaks, leveraging Horizon Europe funding.

Ecosystem Restoration: Prioritize mixed-species reforestation in fire-prone areas and integrate traditional knowledge (e.g., rainwater harvesting) into modern water management.

Community-Centric Adaptation

Participatory Design: Institutionalize community-led resilience audits, as piloted in Rayovo, to align infrastructure upgrades (e.g., wind corridors) with local needs.

Education and Outreach: Launch farmer field schools to disseminate adaptive practices (e.g., crop diversification) and build trust in climate science.

Conclusion

Rural Bulgaria’s climate resilience hinges on bridging the gap between global-scale projections and hyperlocal vulnerabilities. By adopting an integrated, equity-centered approach—one that harmonizes policy coherence, financial innovation, and grassroots agency—this work provides a replicable model for vulnerable regions worldwide. The urgency of action cannot be overstated; delayed adaptation risks irreversible losses to ecosystems, livelihoods, and cultural heritage. As climate change increasingly manifests through systemic ecological disruptions, the imperative for anticipatory, systemically integrated, and equity-centered adaptation frameworks has reached critical prominence. The pursuit of resilience constitutes not merely a localized or sectoral priority, but a multidimensional imperative requiring transnational coordination, reflecting both the transboundary nature of climate risks and humanity's codependent obligation to forge socioecological sustainability.

Acknowledgments

This book is the culmination of collaborative efforts spanning international borders, disciplinary domains, and institutional frameworks. We extend our deepest gratitude to the *Science and Technology Commission of Shanghai Municipality* and the *Guilin Municipal Bureau of Science and Technology* for their funding and unwavering support. Specifically, this research was made possible through the Shanghai Municipality's Action Plan for Science and Technology Innovation International Science and Technology Cooperation Project (Grant №22230750500) and the Guilin City Scientific Research and Technological Development Program (Grant №20230127-3).

As an important output of the *Sino-Bulgarian Joint Laboratory on Climate Change Adaptive Governance for Rural Ecosystem*, this book embodies the laboratory's mission to bridge scientific inquiry with actionable policy solutions. The laboratory has served as a dynamic platform for integrating Bulgarian expertise in agricultural resilience with China's innovations in climate modeling and rural governance. We acknowledge the pivotal role of partner institutions, including the Institute of Agricultural Economics, Sofia, Agricultural University Plovdiv, University of National and World Economy and Shanghai Jiao Tong University, in facilitating knowledge exchange and fieldwork coordination between Bulgaria and China.

The synthesis of data on rural climate adaptation and disaster risk reduction presented herein draws from multi-year collaborations with farmers, local policymakers, and international organizations. Special recognition is due to the Bulgarian Ministry of Agriculture, Food and Forestry and the Shanghai Municipal Science and Technology Commission for their institutional backing, which enabled the integration of CMIP6 climate projections with hyperlocal vulnerability assessments.

We also thank the contributions of early-career researchers from both nations—particularly in microclimate modeling and participatory resilience audits—were indispensable to the case studies featured in Chapters 7–9.

Finally, this book stands as a testament to the power of South-South cooperation in climate governance. By aligning Bulgaria's EU-aligned adaptation frameworks with

China’s rural revitalization strategies, we aspire to catalyze a new paradigm for sustainable development in Global South contexts.

This effort is managed and led by Prof. Shengquan Che (Shanghai Jiao Tong University, Chinese Director of the Joint Lab) and Prof. Hrabrin Bachev (Institute of Agricultural Economics, Sofia, Bulgarian Director of the Joint Lab).

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Chapter 1: Introduction

After more than 10,000 years of relative stability—the full span of human civilization—the Earth's climate is changing. As average temperatures rise, acute hazards such as heat waves and floods grow in frequency and severity, and chronic hazards, such as drought and rising sea levels, intensify. Climate change is already having substantial physical impacts at a local level in regions across the world; the affected regions will continue to grow in number and size. Since the 1880s, the average global temperature has risen by about 1.1 degrees Celsius with significant regional variations （IPCC, 2022）. This brings higher probabilities of extreme temperatures and an intensification of hazards. A changing climate in the next decade, and probably beyond, means the number and size of regions affected by substantial physical impacts will continue to grow.

Projected risks and impacts of climate change on natural and human systems at different global warming levels (GWLs) relative to 1850-1900 levels. In the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), Work Group II (WGII) provides assessment of the impacts on human and natural systems using these projections and additional lines of evidence (IPCC, 2022). (a) Risks of species losses as indicated by the percentage of assessed species exposed to potentially dangerous temperature conditions, as defined by conditions beyond the estimated historical (1850-2005) maximum mean annual temperature experienced by each species, at GWLs of 1.5oC, 2oC,3oC and 4oC. Underpinning projections of temperature are from 21 Earth system models and do not consider extreme events impacting ecosystems such as the Arctic. (b) Risks to human health as indicated by the days per year of population exposure to hyperthermic conditions that pose a risk of mortality from surface air temperature and humidity conditions for historical period (1991-2005) and at GWLs of 1.7°C–2.3°C (mean = 1.9°C; 13 climate models), 2.4°C–3.1°C (2.7°C; 16 climate models) and 4.2°C–5.4°C (4.7°C; 15 climate models). Interquartile ranges of GWLs by 2081–2100 under RCP2.6, RCP4.5 and RCP8.5. The presented index is consistent with common features found in many indices included within WGI and WGII assessments (c) Impacts on food production: (c1) Changes in maize yield by 2080–2099 relative to 1986–2005 at projected GWLs of 1.6°C–2.4oC (2.0°C), 3.3°C–4.8oC (4.1°C) and 3.9°C–6.0oC (4.9°C). Median yield changes from an ensemble of 12 crop models, each driven by bias-adjusted outputs from 5 Earth system models, from the Agricultural Model Intercomparison and Improvement Project (AgMIP) and the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). Maps depict 2080–2099 compared to 1986–2005 for current growing regions (>10 ha), with the corresponding range of future global warming levels shown under SSP1-2.6, SSP3-7.0 and SSP5-8.5, respectively. Hatching indicates areas where {`<`}70% of the climate-crop model combinations agree on the sign of impact. (c2) Change in maximum fisheries catch potential by 2081–2099 relative to 1986–2005 at projected GWLs of 0.9°C–2.0°C (1.5°C) and 3.4°C–5.2°C (4.3°C). GWLs by 2081–2100 under RCP2.6 and RCP8.5. Hatching indicates where the two climate-fisheries models disagree in the direction of change. Large relative changes in low yielding regions may correspond to small absolute changes. Biodiversity and fisheries in Antarctica were not analyzed due to data limitations. Food security is also affected by crop and fishery failures not presented here.

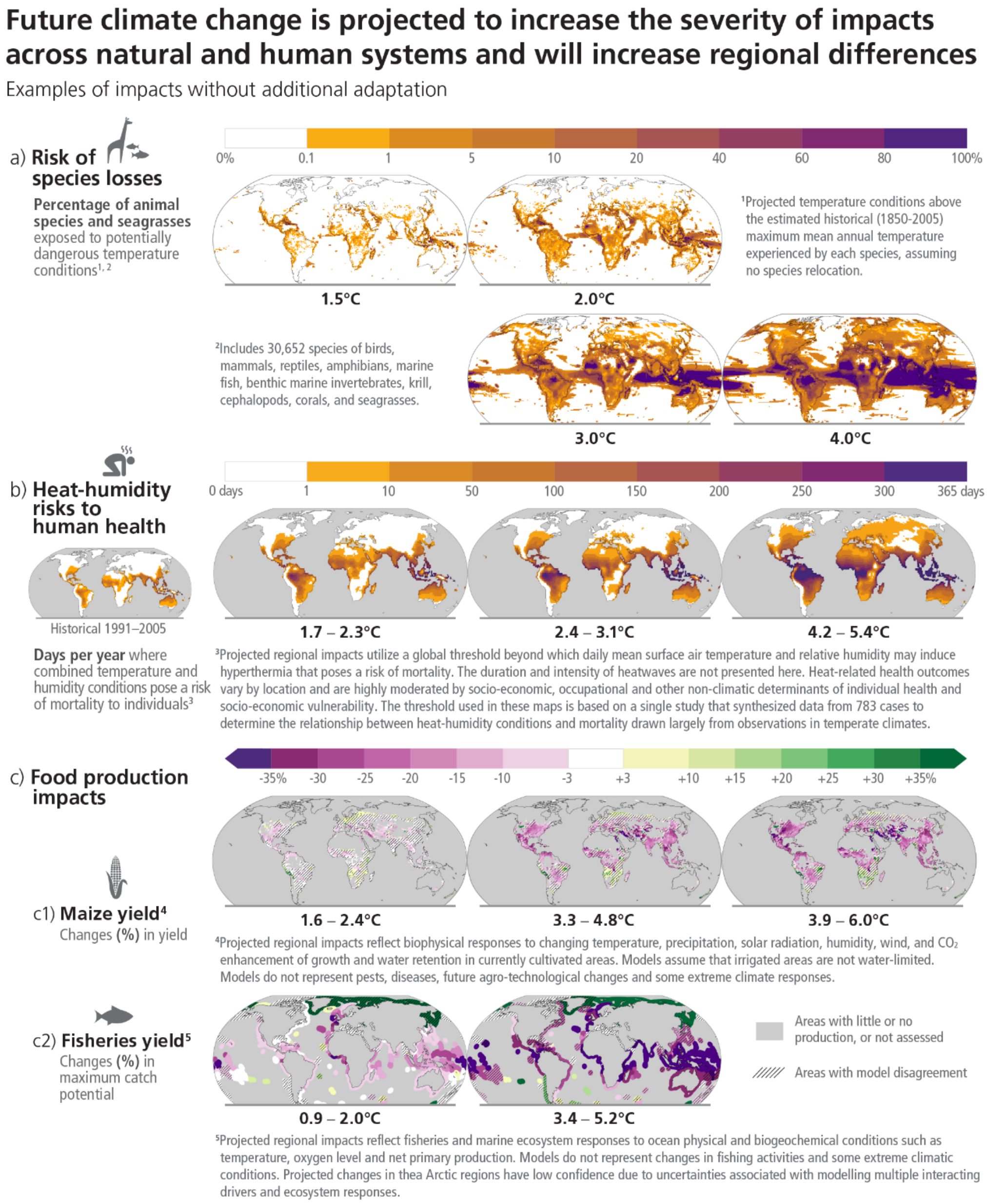


Figure 1-1 Example of climate change impacts without additional adaption

Source: IPCC, 2022

1.1 Understanding climate risk

A changing climate is introducing new risks that are significant today and will grow. These risks can be grouped into three types: physical risk (risks arising from the physical effects of climate change); transition risk (risks arising from transition to a low-carbon economy); and liability risk (risks arising from those affected by climate change seeking compensation for losses). This book mainly focuses on the physical risks associated with climate change, particularly their impacts on rural areas, including people, communities, economic activities, and agricultural industries. The implications for governments and individuals are also examined, while transition risks and liability risks are beyond the scope of this book.

The Reality of a Warming World

The global temperature has risen by 1.1° C above pre-industrial levels, and this seemingly small increase has already triggered significant and unprecedented changes in the climate system. These changes are evident across all regions of the world, manifesting in various forms such as sea-level rise, more frequent extreme weather events, and the rapid melting of sea ice. Further increases in temperature are expected to exacerbate these changes, leading to more severe and frequent impacts.

For instance, research indicates that for every 0.5 ° C increase in global temperature, extreme high temperatures, heavy rainfall, and regional droughts become more frequent and severe. To put this into perspective, in the absence of human-induced climate change, heatwaves would occur approximately once every 10 years. However, as the average global temperature rises by 1.5° C, 2° C, and 4° C, the frequency of high-temperature heatwaves could increase by 4.1 times, 5.6 times, and 9.4 times, respectively. Moreover, the intensity of these heatwaves could also rise by 1.9° C, 2.6° C, and 5.1° C, respectively. This escalation in temperature and heatwave frequency and intensity poses significant threats to human health, infrastructure, and natural ecosystems.

Tipping Points and Irreversible Changes

The rise in global temperatures also increases the risk of the climate system reaching critical tipping points. These tipping points are thresholds beyond which the climate system undergoes abrupt and potentially irreversible changes. For example, if the global average temperature rises by 2° C to 3° C, it could trigger the irreversible melting of almost all ice sheets in western Antarctica and Greenland over thousands of years. This melting would result in a significant rise in sea levels, potentially by several meters, leading to widespread coastal flooding and the displacement of millions of people.

Human and Ecosystem Impacts

The impacts of climate change on human societies and ecosystems are far more extensive than initially anticipated, and these risks are expected to escalate rapidly as global warming intensifies. Currently, approximately half of the global population experiences severe water shortages for at least one month each year. Rising temperatures have also facilitated the spread of vector-borne diseases such as malaria, West Nile virus, and Lyme disease, posing significant public health challenges.

Agriculture, a sector that is vital for food security and economic stability, is particularly vulnerable to climate change. In mid to low latitude regions, agricultural productivity has already been hindered by changing climatic conditions. For example, since 1961, the growth rate of crop productivity in Africa has decreased by one-third. Extreme weather events, such as floods and storms, have also had devastating impacts on human settlements. Since 2008, over 20 million people have been forced to leave their homes annually due to such events.

The Urgency of Temperature Control

Every incremental increase in global temperature, even by a few tenths of a degree Celsius, exacerbates these crises. Even if the global temperature rise is limited to 1.5°C, it cannot guarantee that everyone's life safety will remain unaffected. For example, under the current trajectory of temperature rise, 950 million people living in arid regions worldwide will face a range of problems, including water stress, heatstroke, and desertification. Additionally, the proportion of people affected by floods globally could increase by 24%.

Moreover, even a temporary exceedance of the 1.5°C temperature rise threshold can lead to serious and irreversible consequences, such as local species extinction, the complete inundation of salt marshes, and even human fatalities due to extreme heat. Therefore, controlling the amplitude and duration of temperature rise above 1.5°C and striving to keep it as close to 1.5°C or lower is crucial for ensuring a safe and livable future.

Examples of Climate Change Impacts

(1) Extreme Weather Events: Extreme weather events, such as hurricanes, typhoons, and cyclones, have increased in both frequency and intensity due to

climate change. Warmer ocean temperatures provide more energy for these storms, leading to more powerful and destructive events. For example, Hurricane Harvey in 2017 and Hurricane Maria in 2018 caused unprecedented damage in the United States and Puerto Rico, respectively. These events highlight the vulnerability of coastal communities and the need for robust adaptation measures.

(2) Sea-Level Rise: Sea-level rise is another critical consequence of climate change, driven primarily by the thermal expansion of seawater and the melting of glaciers and ice sheets. The Intergovernmental Panel on Climate Change (IPCC) projects that global mean sea levels could rise by 0.26 to 0.77 meters by 2100, depending on future greenhouse gas emissions. This rise poses significant threats to low-lying coastal areas, including increased coastal flooding, erosion, and saltwater intrusion into freshwater resources.

(3) Changes in Precipitation Patterns: Climate change is also altering precipitation patterns, leading to more intense and frequent heavy rainfall events in some regions, while others experience prolonged droughts. This variability can exacerbate water management challenges, affecting both water supply and quality. For example, regions that rely on seasonal rainfall for agriculture may face significant declines in crop yields due to irregular precipitation patterns.

The impact of climate on humans and ecosystems far exceeds expectations, and risks will rapidly escalate as climate warming intensifies. Currently, about half of the global population faces severe water shortages for at least one month each year, and rising temperatures have exacerbated the spread of vector borne diseases such as malaria, West Nile virus, and Lyme disease. Climate change has also hindered the growth of agricultural productivity in mid to low latitude regions. Since 1961, the growth rate of crop productivity in Africa has decreased by one-third. Since 2008, extreme floods and storms have forced over 20 million people to leave their homes every year.

Every few tenths of a degree Celsius increase in temperature exacerbates these crises. Even if the global temperature rise is controlled within 1.5 ° C, it cannot guarantee that everyone's life safety will not be affected. For example, under the current trend of temperature rise, 950 million people living in arid regions around the world will face a series of problems such as water pressure, heatstroke, and desertification, while the proportion of people affected by floods worldwide will increase by 24%.

Similarly, even if the temperature rise temporarily exceeds 1.5 ° C, it can lead to serious and irreversible effects, including local species extinction, complete inundation of salt marshes, and even human death due to increasing extreme high temperatures. Therefore, controlling the amplitude and duration of temperature rise exceeding 1.5 ° C, and controlling it as much as possible at a level of 1.5 ° C or lower, is crucial to ensure a safe and livable future.

Understanding the multifaceted risks associated with climate change is crucial for developing effective adaptation strategies. The impacts of climate change are already evident and are projected to worsen, making it imperative to address these challenges proactively. By focusing on physical risks and their implications for rural areas, this book aims to provide a comprehensive analysis of the challenges and opportunities for climate adaptation in Bulgaria and beyond.

1.2 Changing climate and its impact to rural area

Bulgaria, a country with a diverse rural landscape, is particularly susceptible to the impacts of climate change. Covering an area of 110,900 km^2 , Bulgaria's rural regions account for 81% of the total land area. Of this, 46.1% is designated as agricultural land, while forests cover 37.4%. The total population of Bulgaria is approximately 6.5 million, with 39% residing in rural areas. These rural areas are not only vital for providing natural resources, food, energy, water, and forests but also serve as important recreational spaces. The agricultural sector contributes significantly to the country's economy, accounting for 6% of the Gross Value Added (GVA) and 18.3% of employment opportunities. Additionally, the food industry holds a 3.8% share in the GVA and 3.4% in employment. The structure of agricultural holdings in Bulgaria is characterized by a significant number of small-scale farms, with 91% of the country's 370,500 agricultural holdings utilizing less than 5 hectares of land. The average economic size of an agricultural holding is €6,847, with 23% of farms falling within the €2,000 – €7,999 range, contributing to 24% of agricultural employment. Traditional agricultural sectors such as fruit and vegetables and livestock are currently underperforming and facing structural difficulties.

Rural Economic and Community Dynamics

The economic foundations and community cohesion in rural areas are intricately linked to natural systems, which are inherently vulnerable to climate change. This vulnerability extends beyond rural communities themselves, as urban areas that rely on goods and services from rural regions are also affected by climate change-driven impacts. The interconnectedness of rural and urban economies means that disruptions in rural areas can have cascading effects on urban populations.

Climate Change and Rural Economies

Warming trends, climate volatility, extreme weather events, and environmental changes all have significant implications for the economies and cultures of rural areas. Rural communities face considerable risks to their infrastructure, livelihoods, and overall quality of life due to observed and projected climate shifts. These changes are expected to increase volatility in food commodity markets, alter the geographical ranges of plant and animal species, and exacerbate existing environmental challenges such as water scarcity, flooding, coastal erosion, and the intensity and frequency of wildfires.

For example, changes in seasonal timing, temperature, and precipitation patterns will shift the locations where specific economic activities can thrive. In Bulgaria, the agricultural sector is particularly vulnerable to these changes. While some regions may benefit from longer growing seasons and altered temperature and precipitation patterns, others may face significant challenges. For instance, increased temperatures and changes in rainfall patterns could lead to water scarcity in some areas, making it difficult to sustain agricultural productivity. Additionally, air pollution, exacerbated by climate change, can damage crops, plants, and forests, further complicating agricultural production.

Community Stability and Economic Diversity

The impacts of climate change on rural communities are not uniform, and some regions may even experience short-term benefits. However, the long-term consequences are likely to be more severe and widespread. Many rural communities in Bulgaria have less diverse economic activities compared to urban areas, meaning that disruptions in one traditional economic sector can place disproportionate stress on community stability. For example, if agricultural productivity declines due to climate change, it could lead to job losses and economic hardship in rural areas that are heavily reliant on agriculture.

Agricultural Resilience and Adaptation

Despite these challenges, the Bulgarian agricultural system is expected to exhibit a degree of resilience to climate change in the short term. This resilience is due to the system's flexibility to engage in adaptive behaviors such as expanding irrigated acreage, shifting crop production to different regions, implementing crop rotations, adjusting management decisions (such as input choices and cultivation practices), and altering trade patterns to compensate for yield changes. However, in the long term, more transformative changes may be necessary to keep pace with the projected impacts of climate change.

Environmental and Ecological Impacts

Climate change will also have significant environmental and ecological consequences for rural areas in Bulgaria. In lakes and riparian zones, warming temperatures are projected to increase the growth of algae and invasive species, particularly in areas already facing water quality issues. This can further degrade water quality and impact aquatic ecosystems. Additionally, changes in temperature, rainfall, and frost-free days can affect crop growth conditions. While longer growing seasons may offer some benefits, such as the potential for longer-maturing crops or additional crop cycles, they may also require increased irrigation and other inputs to manage the extended growing period.

The impacts of climate change on rural areas in Bulgaria are multifaceted and far-reaching. From economic challenges to environmental degradation, rural communities face significant risks that require proactive adaptation strategies. Understanding these impacts and developing targeted solutions is crucial for ensuring the continued vitality and resilience of rural areas in the face of a changing climate.

1.3 The Importance of Rural Climate Adaptation

Given the profound and multifaceted impacts of climate change on rural areas, the importance of rural climate adaptation cannot be overstated. Rural regions, such as those in Bulgaria, are characterized by their close interdependence with natural systems, which are inherently susceptible to climatic variability and extremes. Given that rural areas provide essential resources and services, including food, water, and energy, the impacts of climate change on these regions have far-reaching implications not only for local communities but also for urban areas that rely on rural inputs.

Economic Implications

Rural economies, particularly those heavily reliant on agriculture, forestry, and tourism, are at significant risk from climate change. In Bulgaria, where agriculture contributes to 6% of the country's Gross Value Added (GVA) and employs 18.3% of the workforce, the potential disruptions to agricultural productivity due to changing climate conditions can have profound economic consequences. Climate change can lead to shifts in crop suitability, increased frequency of extreme weather events, and greater water scarcity, all of which can undermine agricultural productivity and rural livelihoods. Effective adaptation strategies are essential to maintain economic stability and ensure the continued contribution of rural areas to national economic growth.

Community Resilience

Rural communities are often more tightly knit and less diverse in their economic activities compared to urban areas. This lack of economic diversity means that rural communities may face disproportionate stresses when traditional economic sectors are disrupted by climate change. For example, a decline in agricultural productivity due to prolonged droughts or increased flooding can have cascading effects on local employment, income levels, and overall community well-being. Rural climate adaptation is therefore crucial for building community resilience, enabling rural populations to better withstand and recover from climate-related shocks.

Environmental Sustainability

Rural areas are the primary stewards of natural resources and ecosystems, which are essential for maintaining environmental sustainability. Climate change poses significant threats to these ecosystems, including increased risks of wildfires, shifts in species ranges, and degradation of water quality. By implementing adaptive measures, rural communities can help protect and enhance the resilience of natural systems, ensuring that they continue to provide essential ecosystem services such as water filtration, carbon sequestration, and biodiversity conservation. This is particularly important in Bulgaria, where forests cover 37.4% of the land area and play a vital role in maintaining ecological balance.

Food Security

Agriculture is a cornerstone of rural economies and a critical component of national food security. Climate change threatens to disrupt agricultural production through changes in temperature, precipitation patterns, and the frequency of extreme weather events. Rural climate adaptation is essential to safeguard food production and ensure that rural areas can continue to meet the food demands of both local and national populations. This involves developing and implementing strategies to enhance agricultural resilience, such as improving irrigation systems, adopting climate-resilient crop varieties, and optimizing land management practices.

Policy and Governance

Effective rural climate adaptation requires coordinated efforts across multiple levels of governance. Policymakers must recognize the unique vulnerabilities and needs of rural areas and develop targeted policies and programs to support adaptation initiatives. This includes providing financial and technical assistance to rural communities, promoting research and innovation in climate-resilient technologies, and fostering collaboration between different stakeholders, including local governments, farmers, and civil society organizations. By prioritizing rural climate adaptation, policymakers can help ensure that rural areas are better equipped to cope with the challenges posed by climate change.

Rural climate adaptation is of paramount importance for safeguarding the economic, social, and environmental well-being of rural areas. It is essential for

maintaining economic stability, building community resilience, protecting natural resources, ensuring food security, and promoting effective governance. By investing in rural climate adaptation, Bulgaria can enhance the resilience of its rural regions and contribute to a more sustainable and secure future for all. Successful adaptation strategies, such as those implemented in the Plovdiv and Varna regions, demonstrate the potential for rural communities to thrive in the face of climate change through innovation and collaboration.

Chapter 2: Bulgaria's Climate: Past, Present, and Future

2.1 Climate overview

Bulgaria has two climate zones: the northern region has a continental climate, and the southern region has a Mediterranean climate. The Mediterranean climate of the country is hot and dry in summer and cool in winter. The distinction between the mountains in the northern and southern regions has a significant impact on the temperature of the country (Alexandrov et al., 2004). Compared to coastal areas, the temperature and precipitation changes in the northern part of the mainland are often greater (National Institute of Meteorology and Hydrology, 2018). Approximately 50% (5.2 million hectares) of the territory is agricultural land. It is estimated that 29.5% of the area is used for irrigation. Forests cover 34% of the total area of the country (FAO, 2017).

The mean monthly temperature in Bulgaria ranges from −1°C to 22 °C. Coldest temperatures are experienced in the northern winter months of December and January and warmest temperatures during northern hemisphere summer months of July and August (WBG, 2020). Over the past century, the region has experienced gradual warming, while the intensity and length of heat waves in the Mediterranean region have increased (Lelieveld et al., 2012). The average monthly precipitation ranges from 40 to 71 millimeters and varies seasonally; May and June have the highest precipitation, while the two periods (February and March, as well as August and September) have the lowest precipitation. Over the past century, precipitation has varied greatly, and recent short-term increases in precipitation have led to floods.

2.2 Current trends in Bulgaria climate

2.2.1 Temperature

The temperature in Bulgaria ranges from 15 ° C to 25 ° C, steadily increasing from March to June. Summer usually starts in early June, with temperatures typically reaching over 30 ° C. July and August are the hottest months, with the highest temperature in summer reaching 35 ° C to 38 ° C or above. Summer usually ends in mid-September, when the temperature drops and the days become shorter. September and October are usually warm, with temperatures ranging from 10 ° C to 25 ° C. However, Bulgaria has experienced a warming trend over the past century, with the difference between the highest and lowest temperatures decreasing (Figure 4). The annual average temperature continues to exceed the historical record of average temperature and continues to reach a new historical high. From 1988 to 2016, the average annual temperature in lower areas of the country (below 800 meters above sea level) increased by 0.8 ° C. Since the 1970s, a warming trend has been observed. In 2014, it reached the highest temperature since 1901, with an annual average temperature of 12 ° C, 1.45 ° C higher than the average temperature. The annual average temperature observed in 2015 was 1.12 ° C higher than the average temperature. Overall, the winter in Bulgaria was relatively mild in the second half of the 20th century, with more and more periods of high temperatures and drought (Republic of Bulgaria, 2018).

2.2.2 Precipitation

Dobrudzha in the northeast, the Black Sea coastal area, and parts of the Thracian Lowland usually receive less than 500 mm precipitation per year. The Thrace lowlands often suffer from summer drought. High altitude areas have the highest precipitation in the country, averaging over 1000 to 1100 millimeters per year. The precipitation varies greatly across the country. For example, the annual average precipitation in Bulgaria in 2013 was 49.7 millimeters, 1.7 millimeters lower than the average level, while the rainfall in 2014 was 80.9 millimeters, 29.4 millimeters higher than the normal level. The average annual precipitation in 2015 was 60.4 millimeters, 8.9 millimeters higher than the average level. We also observed an increase in the frequency of extreme rainfall and precipitation events, especially on days with high precipitation (volume exceeding 100 millimeters). The snow moon has decreased, the snow cover has significantly decreased, and the upper limit and sound of the deciduous forest have also changed. (Republic of Bulgaria, 2018)

2.3 Future climate simulation in Bulgaria

2.3.1 Data sources

The study of relevant papers under the background of climate change in CMIP6 focuses on three criteria for model selection: accuracy, applicability, and data availability of the models as applied in Bulgaria. Ultimately, 13 CMIP6 global models were selected, as detailed in the following table.

Table2-1 Global model information sheet

Serial number	Model name	Organization	Spatial resolution
1	ACCESS-ESM1-5	CSIRO	1.875°×1.25°
2	BCC-	Beijing Climate Center	1.120°×1.120°
3	CanESM5	the Canadian Centre for Climate Modelling and Analysis	2.810°×2.770°
4	CMCC-ESM2	CMCC	1.120°×1.120°
5	CNRM-CM6-1	CNRM	1.406°×1.389°
6	CNRM-ESM2-1	CNRM	1.406°×1.389°
7	INM-CM4-8	Russian Institute for Numerical Mathematics Climate Model	2.000°×1.500°
8	INM-CM5-0	Russian Institute for Numerical Mathematics Climate Model	2.000°×1.500°
9	IPSL-CM6A-LR	IPSL	2.5°×1.27°
10	MIROC6	MRI (Meteorological Research Institute)	1.400°×1.400°
11	MRI-ESM2-0	MRI	1.4°×1.4°
12	NorESM2-LM	NCC	
13	NorESM2-MM	NCC	

2.3.2 Downscaling of Statistics

Due to the high spatial resolution of global climate model data, it is necessary to perform down-scaling processing before these data can be applied to community climate prediction. Statistical downscaling mainly includes methods like bias correction of probability, quantile correction, and the Delta method. Compared to other statistical down-scaling methods, the Delta downscaling can effectively reduce the systematic bias between global climate models and regional climate, while retaining the fluctuation characteristics of the global model based on land surface processes and global circulation physical parameterization processes. Therefore, the Delta method is chosen for downscaling. This method corrects the prediction data of the global model by comparing the differences between the historical data of the global model and observational data. The calculation methods are shown in formulas (1), (2), (3), and (4).

Temperature：

$$delta_{ymoni\_tmax} = gcm_{ymoni\_tmax} - obs_{ymoni\_tmax} \qquad (1)$$

$$gcm(downscaled)_{dailyi\_tmax} = gcm_{dailyi\_tmax} - delta_{ymoni\_tmax} \qquad (2)$$

Precipitation：

$$delta_{ymoni\_p} = obs_{ymoni\_p} / gcm_{ymoni\_p} \qquad (3)$$

$$gcm(downscaled)_{dailyi\_p} = gcm_{dailyi\_p} \times delta_{ymoni\_p}. \qquad (4)$$

Where, gcm_{ymoni_tmax} is the long-term monthly average of daily maximum temperature from historical global model data. obs_{ymoni_tmax} is the long-term monthly average of daily maximum temperature from meteorological station observational data, and gcm_{dailyi_tmax} is the daily maximum temperature from global model temperature prediction data. gcm_{ymoni_p} is the long-term monthly average of precipitation from historical global model data. obs_{ymoni_p} is the long-term monthly average of precipitation from meteorological station observational data, and gcm_{dailyi_p} is the daily precipitation after downscaling of global model data.

2.3.3 Analysis of Spatio-temporal Variation Predictions for Future Climate and Precipitation in Bulgaria Using a Multi-Model Ensemble Approach

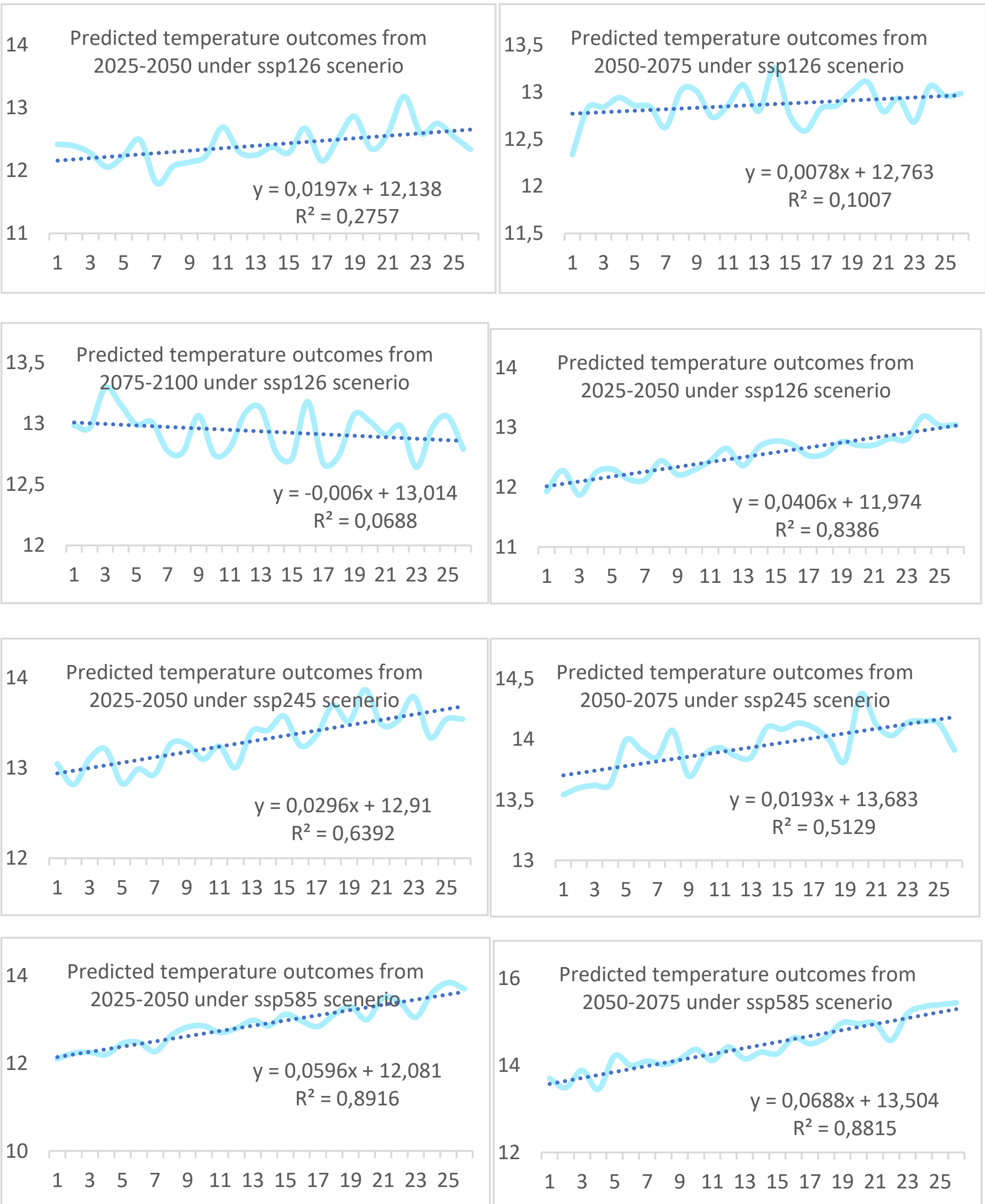
(1) Temporal Trends of Temperature and Precipitation Variability

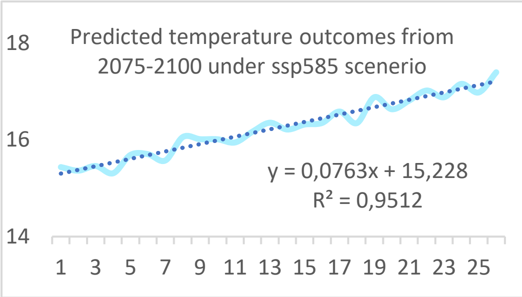
The selected 13 models were subjected to downscaling under three scenarios: SSP126, SSP245, and SSP585, and multi-model ensemble averages were performed. This process aims to analyze the overall changes in temperature and precipitation in Bulgaria over a 75-year period, divided into three phases: 2025-2050 (early period), 2050-2075 (mid-term), and 2075-2100 (long-term).

Temperature Forecast Results

Analysis from the following chart indicates that Bulgaria is projected to experience a fluctuating upward trend in temperature from 2025 to 2100. Specifically, the fastest rate of temperature increase is observed during 2025-2050, with an average acceleration of 0.0399. In contrast, the slowest rate of temperature increase is anticipated between 2075 and 2100, with an average acceleration of 0.0299. The temperature rise rate in the early phase ranges from 0.0197 to 0.0596, while the mid-term increase ranges from 0.0078 to 0.0688, and the long-term increase ranges from -0.006 to 0.0763. It is evident that Bulgaria will experience more intense fluctuations in temperature over the long term, with a relatively stable increase in temperature in the early phase.

Figure 2-1 Temperature Changes in Bulgaria from 2025 to 2100 Under Different Scenarios





Source: authors

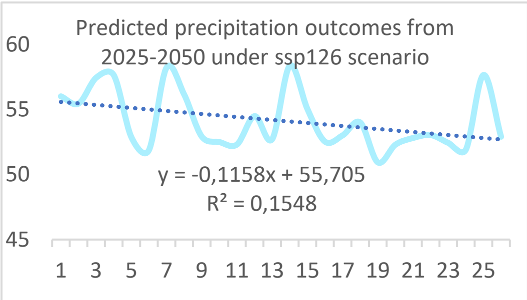
Table 2-2 Summary of temperature predictions

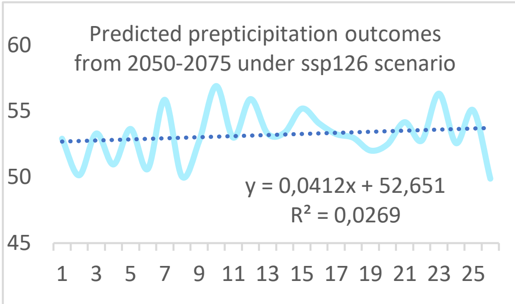
Period	Near term	Middle term	Long term
Range 0f annual temperature growth rates	[0.0197,0.0596]	[0.0078,0.0688]	[-0.006,0.0763]
Average annual temperature growth rates	0.0399	0.0354	0.0299

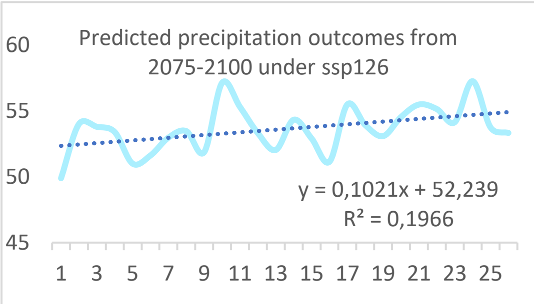
Precipitation Forecast Results

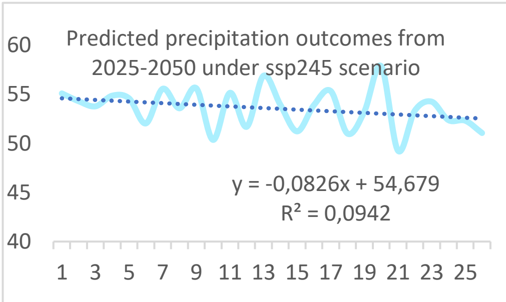
Analysis of the data presented in the following chart reveals that Bulgaria is expected to experience a fluctuating downward trend in precipitation from 2025 to 2100. Specifically, the period from 2025 to 2050 will see the fastest rate of decline with minimal fluctuation, having an average rate of decrease at -0.1007. Conversely, the period from 2075 to 2100 is characterized by the slowest decline in precipitation, with an average rate of -0.0047 and the highest fluctuation. The rate of precipitation decreases ranges from [-0.1158, -0.0826] in the early phase, [-0.1594, 0.0412] in the mid-term, and [-0.0596, 0.1021] in the long term. This downward trend in precipitation could potentially impact agricultural development in Bulgaria.

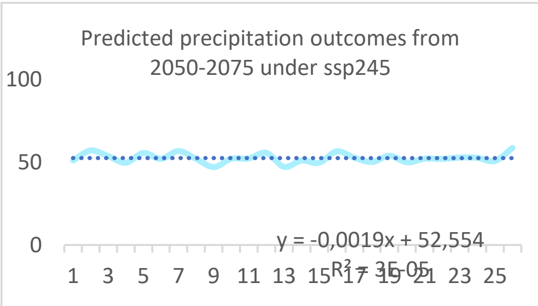
Figure 2-2 Precipitation Changes in Bulgaria from 2025 to 2100 Under Different Scenarios

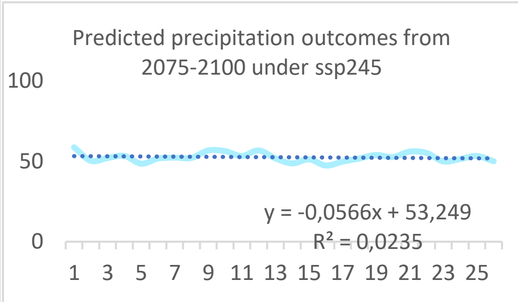


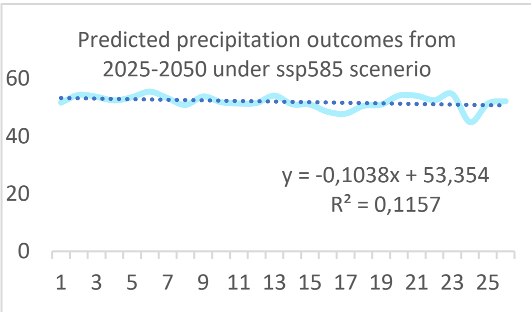


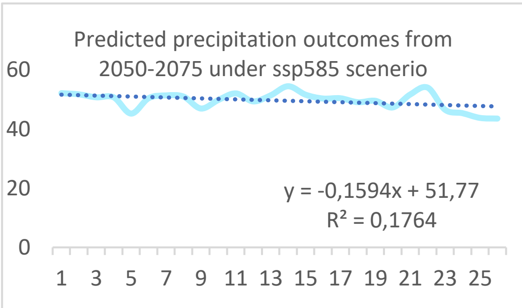


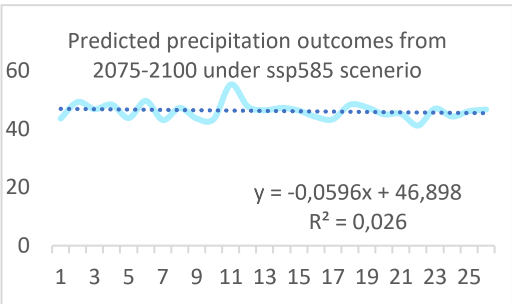












Source: authors

Table 2-3 Summary of precipitation predictions

Period	Near term	Middle term	Long term

Range 0f annual precipitation growth rates	[-0.1158,-0.0826]	[-0.1594,0.0412]	[-0.0596,0.1021]
Average annual precipitation growth rates	-0.1007	-0.04	-0.0047

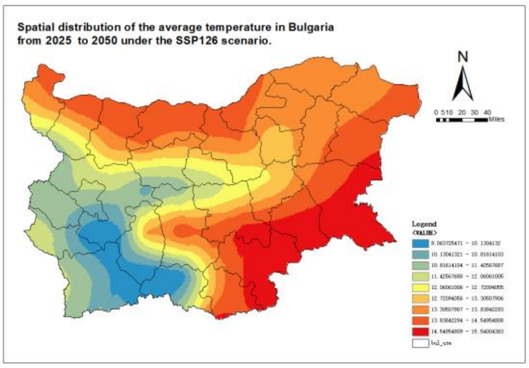
(2) Spatial Variation Trends of Temperature and Precipitation

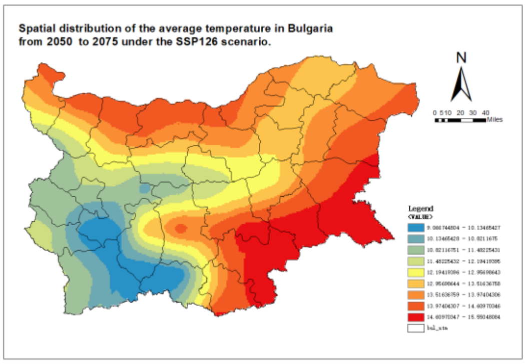
The grid temperature and precipitation data obtained from the above models are averaged across multiple models, and the annual average temperature and precipitation distributions for the years 2025-2050, 2050-2075, and 2075-2100 are calculated separately under the SSP126, SSP245, and SSP585 scenarios. This analysis examines the spatial changes in temperature in Bulgaria in the short-term, mid-term, and long-term periods.

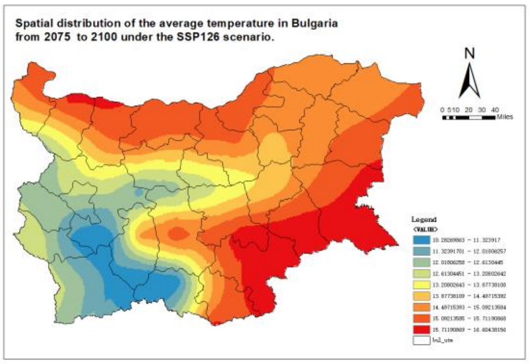
Spatial Distribution Results of Temperature Prediction

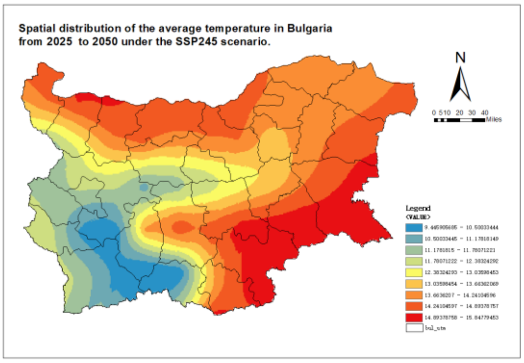
Analysis of the below figure reveals that the temperature distribution in Bulgaria presents a "layered structure with gradually increasing temperatures from the southwest direction outward," with the highest temperatures in the southeast region. Examining the changes in spatial distribution of temperature over three time periods, it can be observed that in the future, the areas of red (hot) and blue (cold) temperatures are gradually diminishing, while the regions of intermediate colors are increasing. This indicates a trend of decreasing high and low temperatures, but an overall rise in average temperature. Additionally, there is an increasing trend of temperature increments moving from the periphery towards the center.

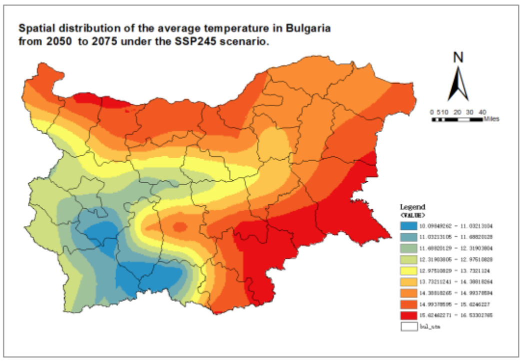
Figure 2-3 The Spatial Distribution of Temperature in Near, Mid, and Long-Term Phases under Three Scenarios

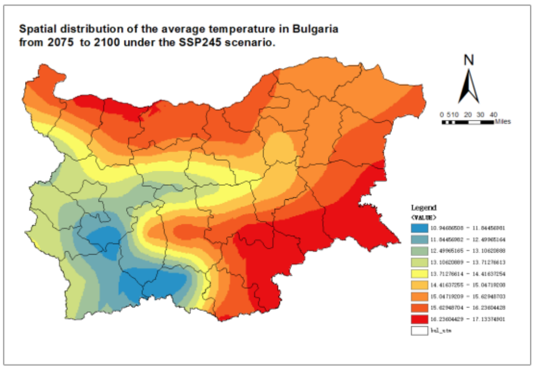


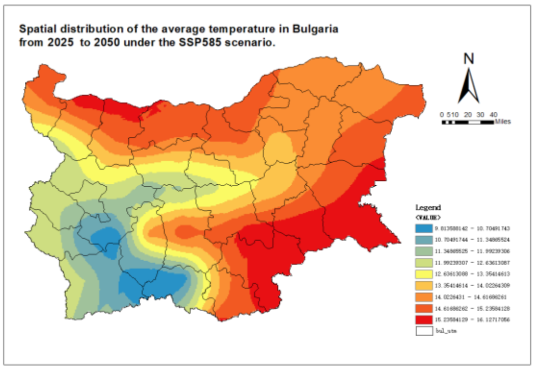


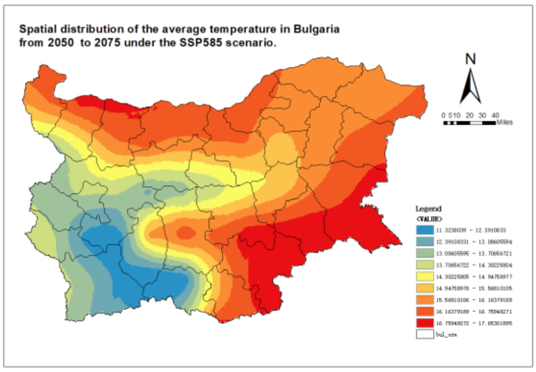

Spatial distribution of the average temperature in Bulgaria
from 2075 to 2100 under the SSP126 scenario.
N
0 5 10 20 30 40
Miles
Legend

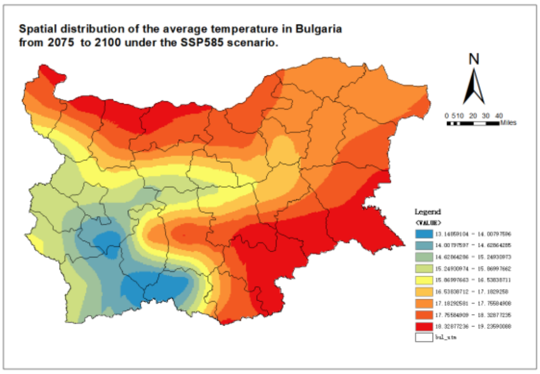

Spatial distribution of the average temperature in Bulgaria
from 2025 to 2050 under the SSP245 scenario.
N
0 5 10 20 30 40
Miles
Legend


Spatial distribution of the average temperature in Bulgaria
from 2050 to 2075 under the SSP245 scenario.
N
0 5 10 20 30 40
Miles
Legend


Spatial distribution of the average temperature in Bulgaria
from 2075 to 2100 under the SSP245 scenario.
N
0 5 10 20 30 40
Miles
Legend


Spatial distribution of the average temperature in Bulgaria
from 2025 to 2050 under the SSP585 scenario.
N
0 5 10 20 30 40
Miles
Legend


Spatial distribution of the average temperature in Bulgaria
from 2050 to 2075 under the SSP585 scenario.
N
0 5 10 20 30 40
Miles
Legend

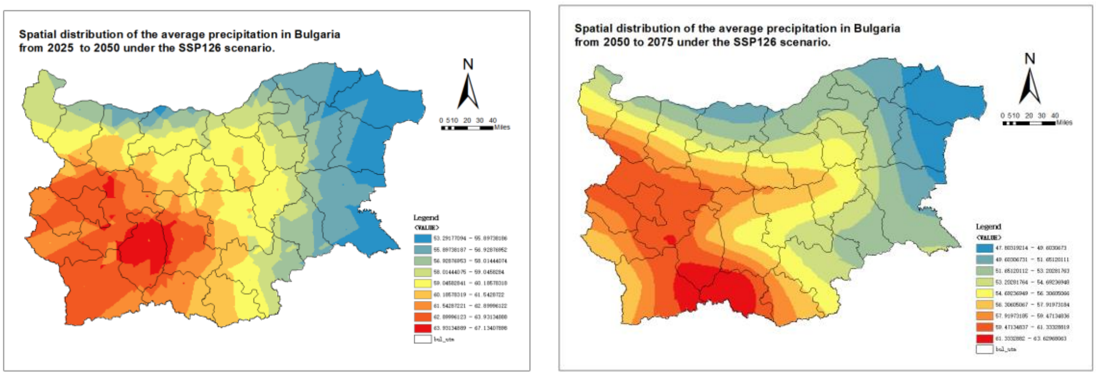


Source: authors

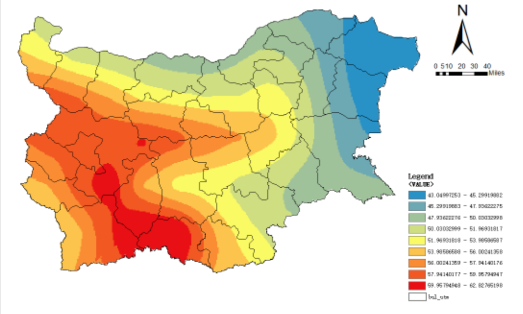
Spatial Distribution Results of Precipitation Prediction

The analysis of the figure below indicates a spatial distribution trend of precipitation decreasing gradually from southwest to northeast. Over time, from the initial to the later period, there is a trend of decreasing precipitation, with the red areas (indicating reduction) expanding and the blue areas (indicating increase) growing. This demonstrates a trend of precipitation decreasing gradually inward from both the southwest and northeast.

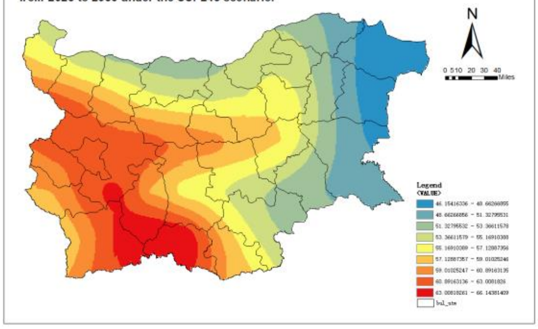
Figure 2-4 The Spatial Distribution of Precipitation in Near Mid, and Long-Term Phases under Three Scenarios



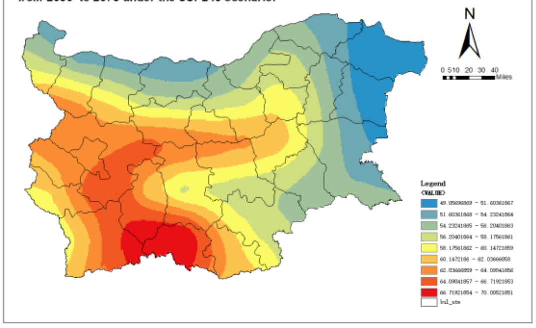
Spatial distribution of the average precipitation in Bulgaria
from 2075 to 2100 under the SSP126 scenario.



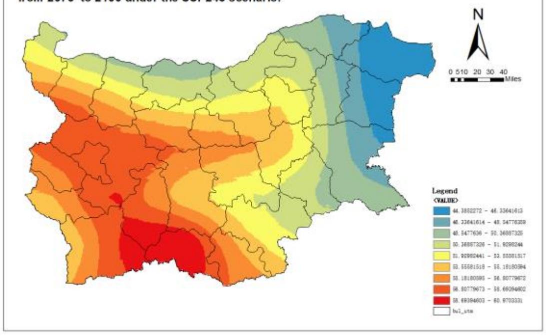
Spatial distribution of the average precipitation in Bulgaria
from 2025 to 2050 under the SSP245 scenario.



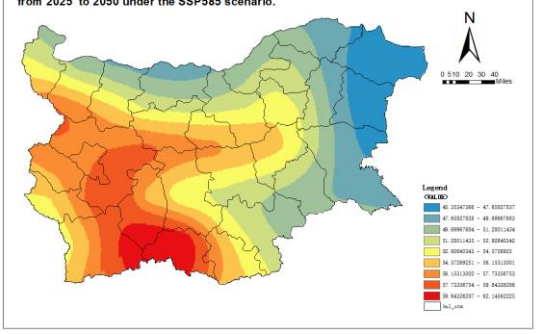
Spatial distribution of the average precipitation in Bulgaria
from 2050 to 2075 under the SSP245 scenario.



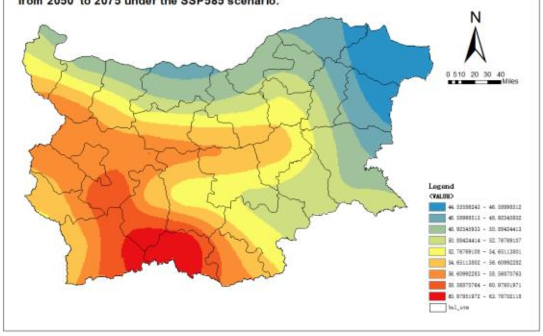
Spatial distribution of the average precipitation in Bulgaria
from 2075 to 2100 under the SSP245 scenario.

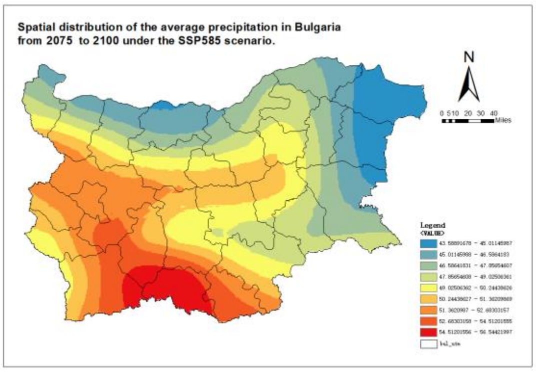


Spatial distribution of the average precipitation in Bulgaria
from 2025 to 2050 under the SSP585 scenario.



Spatial distribution of the average precipitation in Bulgaria
from 2050 to 2075 under the SSP585 scenario.





Source: authors

2.3.4 Summary of Future Climate Conditions in Bulgaria

In Bulgaria, the temperature from 2025 to 2100 is projected to show a fluctuating upward trend, while precipitation is expected to demonstrate a fluctuating downward trend. During 2025-2050, the temperature is anticipated to increase at the fastest rate, with an average increase of 0.0399, and precipitation is expected to decrease at the fastest rate, with an average decrease of -0.1007, potentially leading to extreme high temperatures and drought hazards in the near term. The temperature in Bulgaria is expected to exhibit a trend of expansion outward from the southwest, while precipitation is projected to gradually decrease from the southwest outward. Between 2025 and 2100, both precipitation and temperature are expected to gradually expand towards the center, with an overall decrease in precipitation and an increase in temperature.

Chapter 3: Climate Hazards and Disasters in Rural Bulgaria

3.1 An Overview of Climate Hazards

In the past decade, scientists have reached a clear consensus that the world is experiencing rapid global climate change, most of which can be attributed to human activities (IPCC, 2021). The extent of the impact of climate change is difficult to determine precisely, for example, changes in crop yields due to future temperature increases. This uncertainty arises because there are many unknowns regarding how the climate will change and the socio-economic factors that will affect the magnitude of this change. However, the evidence of climate change impacts is already visible and is expected to worsen in the coming decades (IPCC, 2021).

Currently, Bulgaria is classified as a high-risk area for several types of climate hazards, including river floods, urban floods, and wildfires (Ministry of Environment and Water of Bulgaria, 2025). It has a moderate risk of experiencing earthquakes, water shortages, and extreme heat, with a low to extremely low risk of landslides, coastal floods, and storms (Ministry of Environment and Water of Bulgaria, 2025). Among these hazards, floods are the most common natural disaster in Bulgaria, with an annual impact on approximately 80,000 people and an average GDP loss of $400 million (Ministry of Environment and Water of Bulgaria, 2025). Areas along major rivers are most exposed to flooding risk, although the provinces of Jambol, Pazardzhik, and Plovdiv have the highest flood risks. Recent modeling work estimates that floods that occur once every 50 years (with a probability of 2% occurring every 50 years) may affect a GDP of $2 billion (Ministry of Environment and Water of Bulgaria, 2025).. Based on different climate change and socio-economic predictions, GDP losses may double or quadruple by the 2080s (Republic of Bulgaria, 2018).

Bulgaria's vulnerability to climate hazards is not uniform across the country. The Black Sea coastal areas face significant risks from geophysical dynamics and seismic activity, as well as earthquakes (Ministry of Environment and Water of Bulgaria, 2025). Landslide activity is frequent in most areas of the northern coast, exacerbated by rainfall, earthquakes, and declining groundwater levels. These regional differences in vulnerability highlight the need for localized climate adaptation strategies that address specific hazards and risks.

Historically, Bulgaria has experienced a range of climate hazards that have had significant socio-economic impacts. For example, in the past decade, the country has faced multiple severe flood events, causing extensive damage to infrastructure, agriculture, and human settlements. These events have highlighted the need for improved disaster preparedness and response mechanisms. Additionally, the increasing frequency of extreme weather events, such as heatwaves and droughts, has put additional strain on the country's resources and infrastructure.

Future projections indicate that climate hazards in Bulgaria are likely to increase in both frequency and intensity. Rising temperatures and changes in precipitation patterns are expected to exacerbate existing risks, particularly for agriculture, water resources, and human health (IPCC, 2021). For instance, the increased frequency of heatwaves and droughts could lead to reduced agricultural productivity and increased water scarcity Additionally, the risk of wildfires is expected to rise due to higher temperatures and prolonged dry periods. These changes will have significant implications for the country's economic stability and the well-being of its population.

The socio-economic impacts of climate hazards in Bulgaria are multifaceted. Floods, for example, not only cause immediate damage to infrastructure and property but also have long-term economic consequences, such as increased insurance premiums and reduced investment in affected area. Similarly, droughts can lead to reduced agricultural yields, affecting food security and rural livelihoods. The health impacts of climate hazards, such as increased heat-related illnesses and vector-borne diseases, also place additional strain on the country's healthcare system.

In response to the growing threat of climate hazards, the Bulgarian government has developed a National Climate Change Adaptation Strategy and Action Plan. This plan includes measures to enhance governance for adaptation, build knowledge and awareness, and adapt the external environment to reduce health impacts. However, the implementation of these measures requires significant investment in infrastructure, training, and public education. Additionally, the European Union recommends that

Bulgaria prioritize climate resilience in the use of support from EU funding programs, such as the common agricultural policy and cohesion policy funding (European Union, 2024). This can help ensure that future infrastructure investments contribute to long-term resilience rather than increasing vulnerability.

Climate hazards pose significant challenges to Bulgaria's socio-economic stability and environmental sustainability. Addressing these challenges requires a comprehensive approach that includes enhancing agricultural resilience, protecting public health, investing in climate-resilient infrastructure, and promoting social equity. By taking proactive measures to adapt to climate change, Bulgaria can mitigate the adverse effects of climate hazards and build a more sustainable and resilient future for its rural communities.

3.2 Key climate hazards and disasters in Bulgarian rural area

3.2.1 Spatial distribution of meteorological events and climate events in Bulgaria

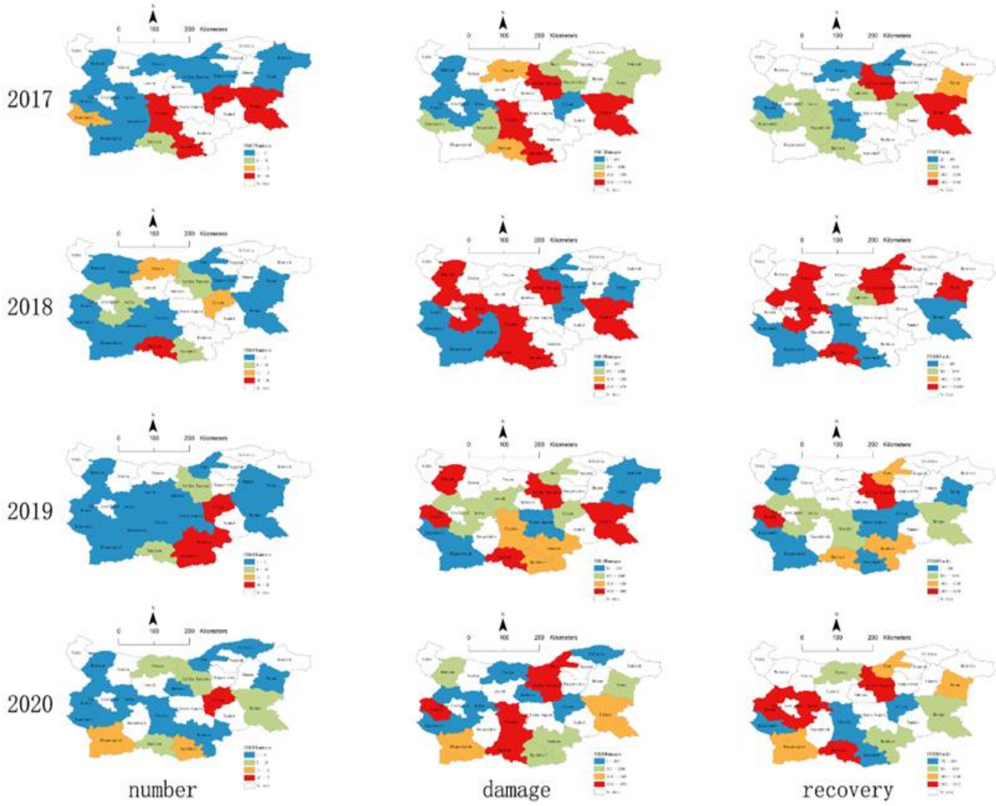


Figure 3-1 Floods for the period 2017 - 2020

Source: authors

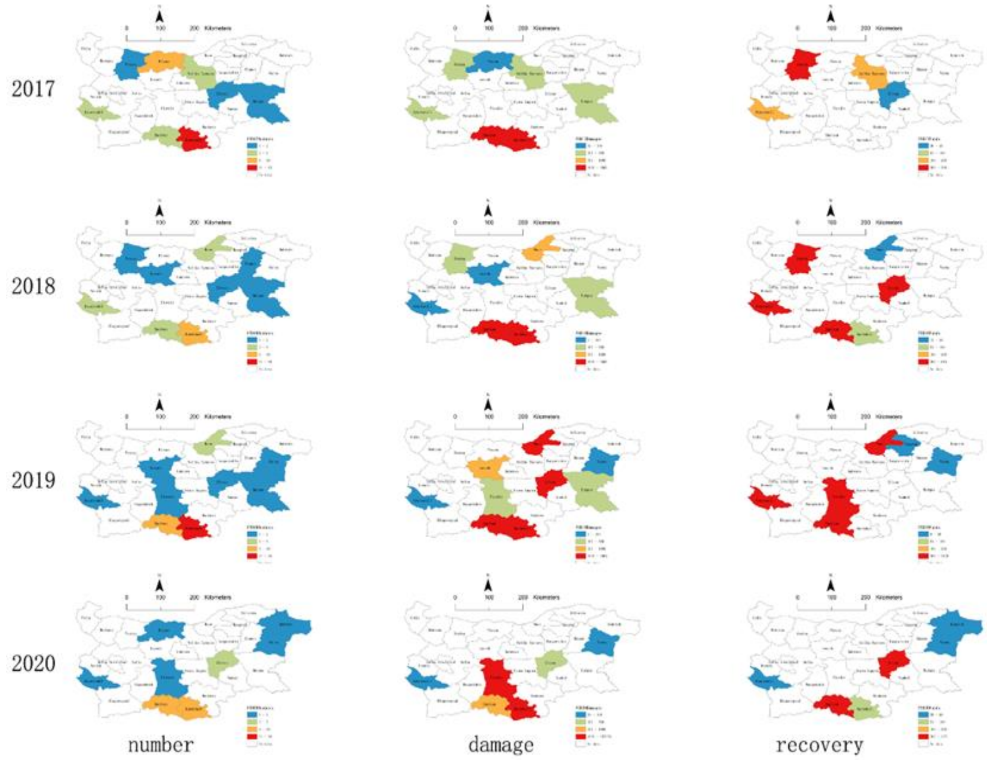


Figure 3-2 Landslide for the period 2017 - 2020

Source: authors

The number of floods, compensation for losses and post disaster reconstruction funds, the losses from disasters have shown a decrease from 2017 to 2020. The main economic losses caused by flood disasters being in Plovdiv and its surrounding areas.

Floods are the most frequent natural disaster in Bulgaria, causing substantial economic losses and affecting a large number of people. Between 2017 and 2020, the number of flood events and associated losses showed a slight decrease, but the impact remains significant. The main economic losses from flood disasters were concentrated in the Plovdiv region and its surrounding areas, which are particularly vulnerable due to their location along major rivers.

Landslides also pose a significant risk, particularly in mountainous regions. Similar to floods, the frequency and economic impact of landslides decreased slightly from 2017 to 2020. However, regions such as Plovdiv, Smolyan, and Kardzhali continue to experience substantial losses due to these events.

3.2.2 Spatial distribution of meteorological events and climate events in Bulgaria

We conducted a statistical analysis of the number of meteorological disasters in Bulgaria in 2021. Meteorological disasters include storm, extreme winter conditions, fog. In 2021, a statistical analysis revealed that the Stara Zagora district experienced the highest number of meteorological disasters, including storms, extreme winter conditions, and fog. These events not only disrupt daily life but also impact local economies by damaging infrastructure and affecting agricultural productivity.

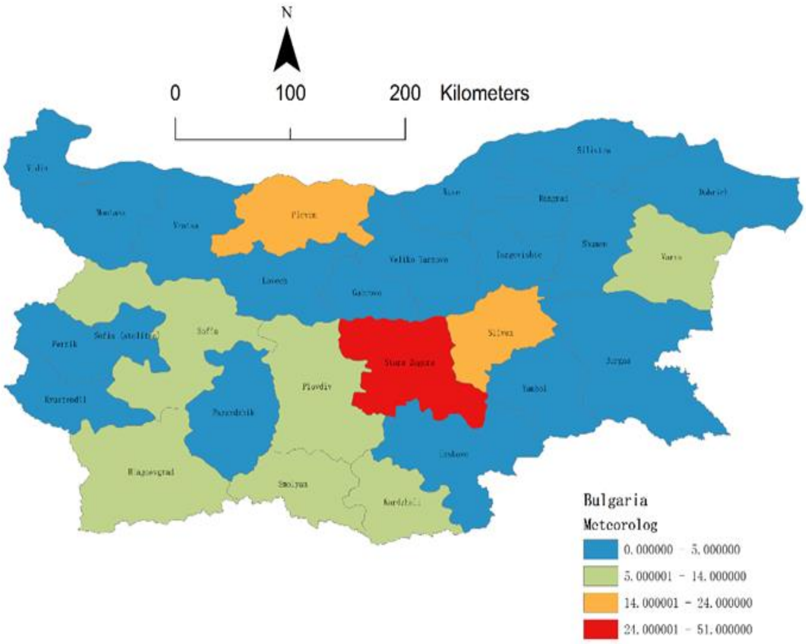
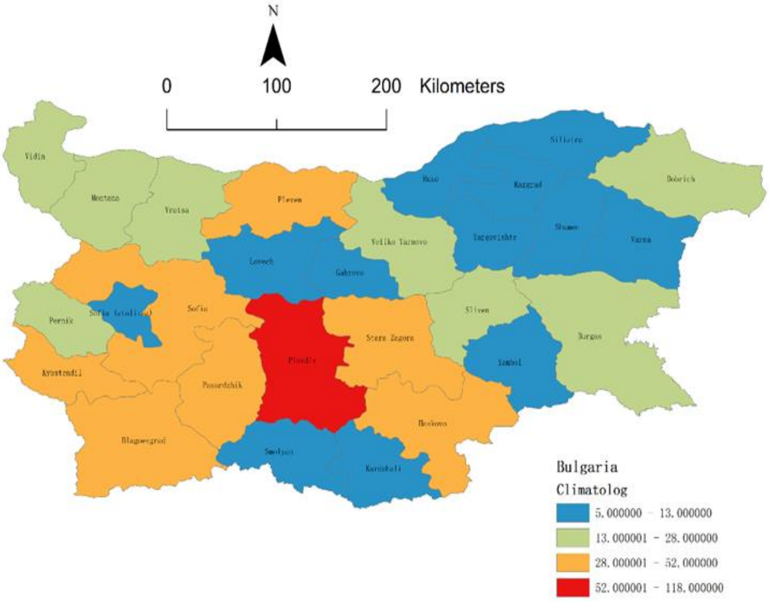


Figure3-3 Number of meteorological events occurred by districts in 2021

Source: authors

Figure3-4 Number of climatological events occurred by districts in 2021



Source: authors

We conducted a quantitative analysis of climate events in 2021. Climatological events Include： drought, forest fire, field fire. Climatological events such as droughts, forest fires, and field fires were most prevalent in the Plovdiv region. These events have long-term impacts on soil fertility, water resources, and overall ecosystem health, further complicating efforts to maintain agricultural productivity and rural livelihoods.

3.2.3 Characteristics and Trends of Key Climate Hazards

Forest Fires: Bulgaria faces a relatively high threat from forest fires, with significant impacts on both the environment and human health. Between 2000 and 2021, a total of 12,036 wildfires were recorded, averaging 573 fires per year. The highest average number of forest fires was observed in southwestern Bulgaria, particularly in the districts of Sofia-oblast and Blagoevgrad. The risk of wildfires is expected to increase due to rising temperatures and changing precipitation patterns, which create more favorable conditions for fire ignition and spread.

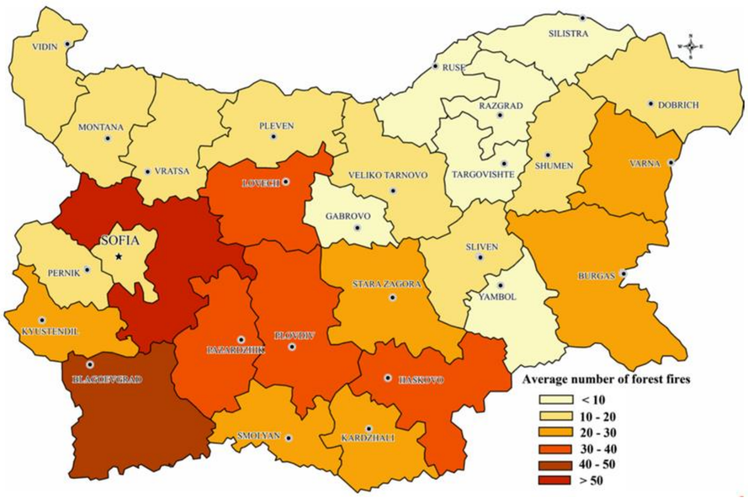
Heatwaves and Droughts: Heatwaves and droughts are becoming more frequent and severe, posing significant risks to human health and agricultural productivity. The number of extreme weather events in Bulgaria increased by 30% between 1991 and 2007, compared to the period from 1961 to 1990. By 2050, the number of extreme weather events could triple, with significant implications for heat-related illnesses and water scarcity. The health impacts of these events are particularly pronounced in rural areas, where access to healthcare and cooling facilities may be limited.

Water-Related Hazards: Changes in precipitation patterns have led to increased risks of both floods and droughts. Bulgaria's complex topography, with significant areas of hills and mountains, exacerbates the risk of landslides and flash floods. The Danube River, which forms part of Bulgaria's northern border, is particularly vulnerable to changes in river flow patterns, with potential impacts on water availability and quality.

3.3 Impacts of climate hazards and disasters in Bulgarian rural area

The threat of forest fires in Bulgaria is relatively high. The analysis of the conditions for the occurrence of forest fires was carried out on the basis of data on forest fires from 2000 to 2021. During this period, a total of 12,036 wildfires occurred, or 573 fires on average per year. The highest average number of forest fires was observed in southwestern Bulgaria, including the districts of Sofia-oblast (54) and Blagoevgrad (44). But the smallest average number of fires was observed in northeastern Bulgaria, in the districts of Targovishte (3), Razgrad (5), Ruse (6), and Silistra (8) (Nojarov and Nikolova, 2022).

Figure 3-5. Average number of forest fires in Bulgaria by administrative districts (2000–2021)



Source: Nojarov and Nikolova, 2022

There was no significant trend in the average maximum temperature of heat waves between 1979 and 2021 (except for southwestern Bulgaria). This is due to changes in the atmospheric circulation over Bulgaria in the 21st century, resulting in an increase in summer air mass transport from the northeast. The heatwave has had a significant impact on Bulgaria's summer forest fires. More, longer, and hotter heat waves provide more favorable conditions for the occurrence and development of forest fires.

Climate change is expected to increase the frequency and scale of extreme weather events in the region, including extreme precipitation and temperature, storms, floods, wildfires, landslides, and droughts. The main dangers facing Bulgaria include floods, droughts, extreme heat, wildfires, storms, earthquakes, and landslides. The expected increase in temperature may exacerbate the existing risks of temperature related hazards such as heatwaves, droughts, and fires. The prediction estimates that due to rising temperatures and changes in rainfall, the risk of wildfires increases and the fire season extends. Changes in temperature and precipitation may also affect soil fertility, further affecting the food system. Although the mortality rate caused by low temperatures is expected to decrease, high temperatures, increased heat wave risks, and drought may have an impact on temperature related mortality rates.

Climate change is expected to affect the reduction of water volume in the country's major rivers, thereby affecting the availability of water resources. In addition to changes in precipitation, changes in regional hydrology may also be related to the risk of extreme events such as drought and floods. The changes in regional precipitation are expected to affect the existing river flow patterns by increasing peak flow in major catchment areas such as the Danube River on the northern border of Bulgaria. Bulgaria is known for its diverse and fertile soil, which is susceptible to erosion caused by changes in precipitation patterns, which has raised concerns among governments that prioritize agricultural production. The tourism industry is an important contributor to GDP and is also sensitive to changes in climate and tourism infrastructure in coastal areas.

3.4 The Socio-Economic Impact of Climate Hazards

Climate hazards in rural Bulgaria have profound socio-economic impacts, affecting not only the economic stability of rural communities but also the overall well-being of the population. These impacts are multifaceted, encompassing agriculture, health, infrastructure, social equity, and economic development. Understanding these impacts is crucial for developing effective adaptation strategies that can mitigate the adverse effects of climate change and build resilience in rural areas.

3.4.1 Impact on Agriculture

Agriculture is a cornerstone of the rural economy in Bulgaria, contributing significantly to both employment and economic output. The agricultural sector employs 18.3% of the workforce and contributes 6% to the country's Gross Value Added (GVA). Climate hazards such as floods, droughts, and extreme temperatures pose substantial risks to agricultural productivity. For example, floods can destroy crops and damage agricultural infrastructure, while droughts can lead to reduced yields and increased irrigation costs. The increased frequency and intensity of these events due to climate change are expected to exacerbate existing vulnerabilities in the agricultural sector.

Changes in temperature and precipitation patterns can affect soil fertility and the suitability of certain crops. This may necessitate shifts in agricultural practices, such as adopting new crop varieties or changing planting schedules. The economic impact of these changes can be significant, particularly for small-scale farmers who may lack the resources to adapt quickly. For instance, a study by the Bulgarian Academy of Sciences found that climate change could reduce crop yields by up to 30% in some regions, leading to significant economic losses (Dimova et al., 2024).

3.4.2 Impact on Health

Climate hazards also have direct and indirect impacts on human health in rural Bulgaria. Extreme weather events can lead to physical injuries, while prolonged exposure to high temperatures can exacerbate cardiovascular and respiratory diseases. Additionally, changes in climate conditions can increase the prevalence of vector-borne diseases such as malaria and Lyme disease. For example, a study by the Bulgarian National Institute of Public Health found that the incidence of Lyme disease has increased by 25% over the past decade, largely due to warmer temperatures and changing precipitation patterns (Dimova et al., 2024).

The Bulgarian government has recognized these health risks and has developed a National Climate Change Adaptation Strategy and Action Plan to address them. This plan includes measures to enhance governance for adaptation, build knowledge and awareness, and adapt the external environment to reduce health impacts (World Health Organization, 2024). However, the implementation of these measures requires significant investment in infrastructure, training, and public education.

3.4.3 Impact on Infrastructure

Rural infrastructure in Bulgaria is particularly vulnerable to climate hazards. Floods and extreme weather events can damage roads, bridges, and other critical infrastructure, disrupting transportation and communication networks (Ministry of Environment and Water of Bulgaria, 2025). The cost of repairing and maintaining infrastructure in the face of increasing climate hazards is substantial, placing additional strain on local and national budgets.

The need to build climate-resilient infrastructure presents an opportunity for investment and innovation. For example, the European Union recommends that Bulgaria prioritize climate resilience in the use of support from EU funding programs, such as the common agricultural policy and cohesion policy funding. This can help ensure that future infrastructure investments contribute to long-term resilience rather than increasing vulnerability (Ansah et al., 2024).

3.4.4 Impact on Social Equity

The socio-economic impacts of climate hazards are not evenly distributed across rural Bulgaria. Vulnerable communities, including those with lower incomes and limited access to resources, are disproportionately affected by climate hazards. This can exacerbate existing inequalities and create new challenges for social cohesion and economic development.

To address these issues, the Bulgarian government is encouraged to engage vulnerable groups in the design and implementation of adaptation policies. This includes documenting the process and outcomes of consultations with these groups to ensure that their needs are adequately addressed. Additionally, efforts to build socio-economic capacity, such as developing programs for prophylactic control of human health status and providing medical treatment, can help reduce the unequal burden of climate risk (Ministry of Environment and Water of Bulgaria, 2025).

The socio-economic impacts of climate hazards in rural Bulgaria are multifaceted and far-reaching. Addressing these impacts requires a comprehensive approach that includes enhancing agricultural resilience, protecting public health, investing in climate-resilient infrastructure, and promoting social equity. By taking proactive measures to adapt to climate change, Bulgaria can mitigate the adverse effects of climate hazards and build a more sustainable and resilient future for its rural communities.

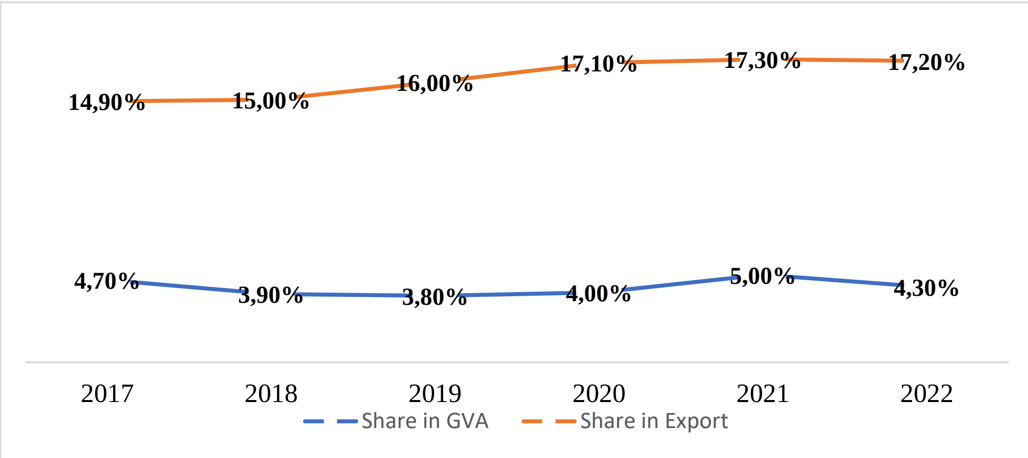
Chapter 4: Impacts of climate change to key sectors

4.1 Agriculture

4.1.1 Overview

Bulgarian agriculture plays an essential role in the national economy. Although the sector's share in the generated gross value added (GVA) is declining, agriculture is considered a main source of income and employment in rural areas, especially in North Bulgaria.

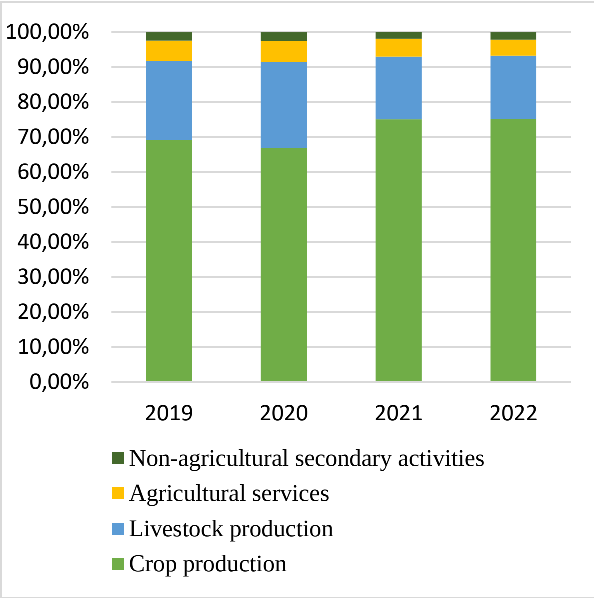
Figure 4-1 Role of agriculture in Bulgarian economy

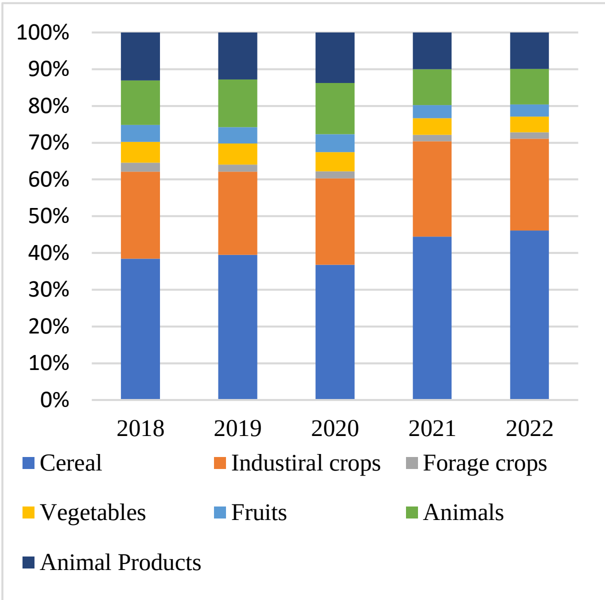


Source: National Statistical Institute, Ministry of Agriculture and Food

The decreased share of agriculture in the national economy, a trend in EU-27 and developed countries is a positive phenomenon only when an increase in the volume and quality of agricultural production accompanies it. In the country, however, there is a decrease in production and challenges related to competitiveness. Therefore, the downward rate of change in GVA is a sign of structural and production issues.

Figure 4-2: Structure of agricultural gross production (%)





Source: National Statistical Institute, Ministry of Agriculture and Food

Bulgaria's agricultural output is dominated by crop production. Since the accession to the EU, livestock production in Bulgaria has shown a significant decrease. Cereals, especially wheat, maize and sunflower, accounted for a significant share of agricultural output. The data shows that the role of cereals and industrial crops is increasing.

Bulgaria has undergone a structural transformation in agricultural holdings. The total number of farms in Bulgaria declined by more than 80% for 2003-2020. On the other hand, the average size of the farms increased more than eight times.

Table 4-1: Trends in the number of agricultural holdings (Source: Ministry of

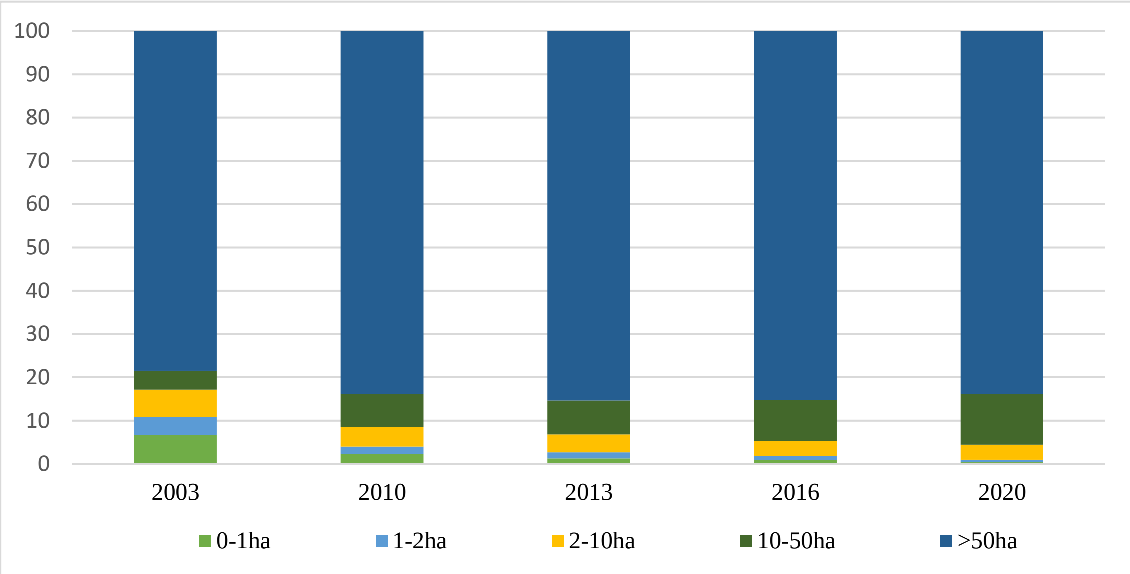
Agriculture and Food, Farm Structure Survey)

Indicators	**2003**	**2005**	**2007**	**2010**	**2013**	**2016**	**2020**
Number of holdings	665548	534613	493133	370222	254142	201014	132742
Average size (ha)	4.4	5.2	6.3	10.1	15.5	20.6	33.2

The structural changes are linked to farm concentration, innovations, and the introducing of new technologies and precision farming in cereal production.

A polarized farm structure characterizes the Bulgarian agriculture sector.

Figure 4-3 Structure of agricultural holdings by farm size (UAA, %)



Source: Ministry of Agriculture and Food, Farm Structure survey

The share of small agricultural holdings is much higher than the EU-27 average. Small farms are important in terms of employment in rural areas- 47% of all farms are under 2 hectares. On the other hand, these agricultural holdings account for 1% of the utilized agricultural area. By contrast, the accumulated UAA in the large holdings above 50 ha is 80% of the UAA in the country. The analysis of the number of holdings shows that the ongoing transformations after Bulgaria accession to the EU led to an unbalanced agricultural structure.

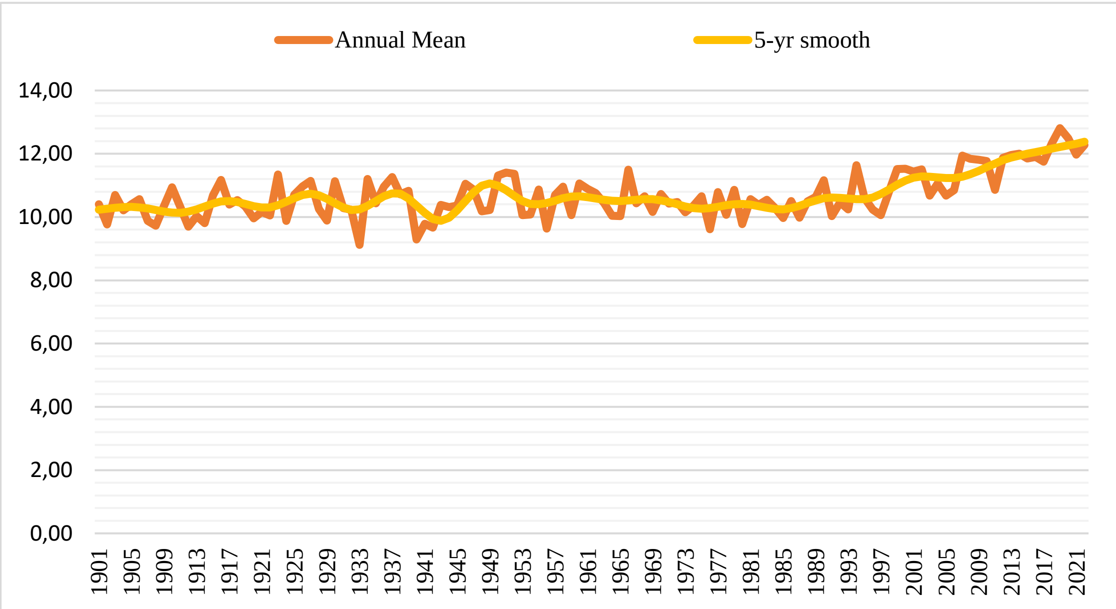
4.1.2 Climate Change Impacts

According to Word Bank (2021), Bulgaria is located in a region significantly influenced by climate change, such as increased temperatures and precipitation, extreme weather, floods, and droughts. These events have a serious impact on agriculture and the national economy.

Bulgaria is a relatively small country in terms of area. However, it has a complex climate profile with five zones: moderate continental, intermediate, continental Mediterranean, maritime, and mountainous (UNFCCC, 2014).

Bulgaria has been undergoing a consistent warming trend since the late 1970s. Approximately 20 out of 23 years spanning from 1989 to 2011 displayed notably higher average temperatures compared to the baseline period of 1961 to 1990, tendencies similarly observed between 2000 and 2014. From 1988 to 2014, the average annual air temperature (within areas up to 800 meters in altitude) increased by 0.8°C in contrast to the reference average for the climatic period of 1961 to 1990, fluctuating from 10.6°C to 13.0°C. Notably, temperature anomalies for all years post-2007 (excluding 2011) recorded deviations surpassing +1°C.

Figure 4-4 Average Mean Surface Air Temperature (1901-2022)

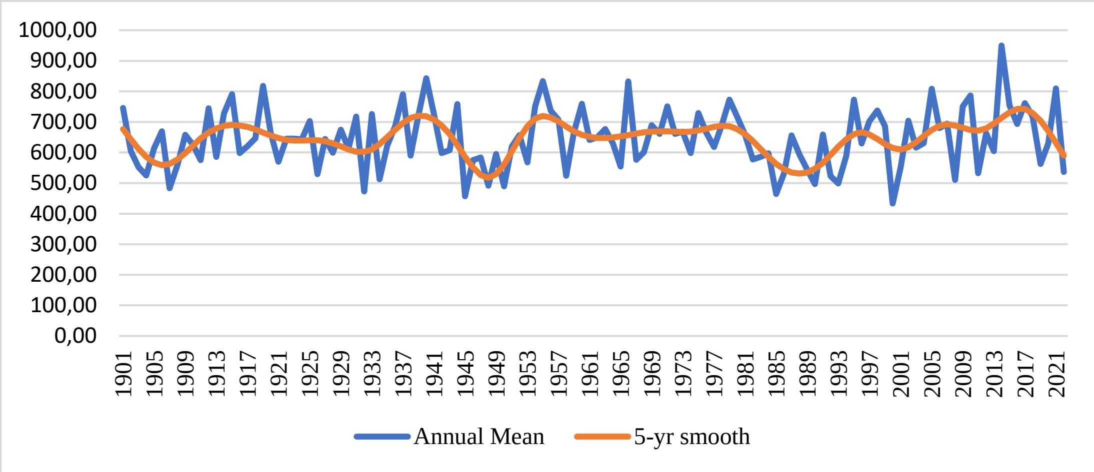


Source: Word Bank Climate Change Knowledge Portal

Over the past decade, Bulgaria's weather patterns have been characterized by substantial fluctuations in seasonal temperatures. Two prolonged heatwaves were documented in 2007 and 2011, affecting southwestern and northern Bulgaria, where temperatures soared to absolute maximum values ranging between 38°C and 40°C. Notably, January 2017 marked Sofia's coldest month in the past 53 years, accompanied by temperatures dropping below minus 20°C in various regions throughout the country.

(ICPDR, 2015). Deviation for 2022-2023 by months compared to 1961-1990 is 1.7 °C.

Figure 4-5 Observed annual precipitation (1901-2022)



Source: Word Bank Climate Change Knowledge Portal

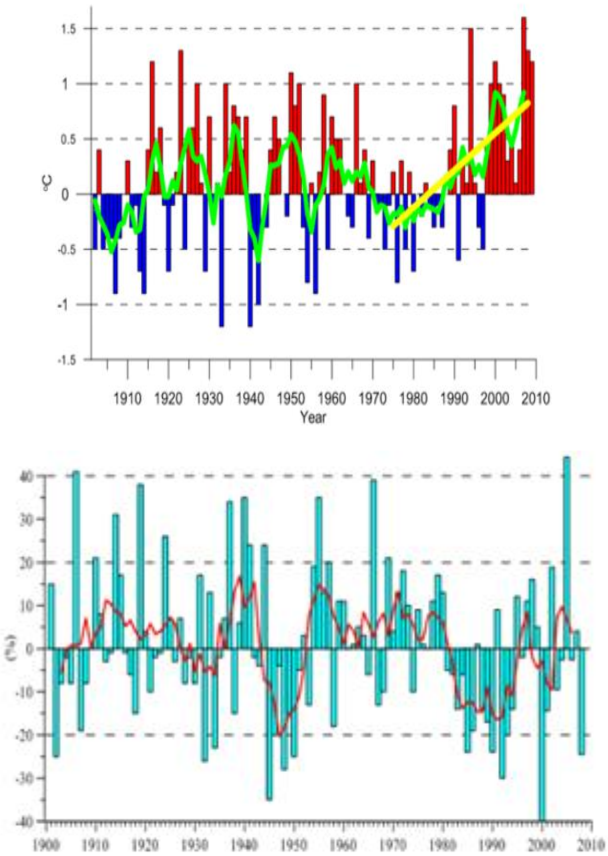
According to the data, there has been a serious increase in average precipitation levels in the past two decades. Between 1988 and 2014, Bulgaria experienced an average annual precipitation ranging from 377 mm to 1,013 mm. Notably, the average number of days with overnight precipitation exceeding 100 mm showed a significant rise, approximately 30 %, from 1991 to 2007 when contrasted with the baseline from 1961 to 1990. Moreover, the meteorological network recorded a higher frequency of heavy rainfall occurrences. Uncommonly associated with winter months such as January and February, cloudiness, thunderstorms, and hailstorms became more frequent.

Between 1988 and 2014, the average annual rainfall stood at 166 % of the baseline norm recorded from 1961 to 1990.

Throughout the past century, Bulgaria experienced three distinct periods of drought: 1902–1913, 1942–1953, and 1982–1994. The drought persisted through 1990, resulting in dwindling river discharge rates and substantial drops in water levels within multiyear reservoirs. Remarkably, 1993, 1994, and 2000 were recorded as the driest in Bulgaria's history.

The droughts in 2000, 2007, and 2012 significantly reduced Bulgaria's average maize grain yield to less than 1.8 tons per hectare (Popova et al., 2014).

Figure 4-6 Anomalies of Annual Temperature (left) and Historic Mean Annual Precipitation in Bulgaria (right), relative to 1961–1990



Note: Bars measure monthly precipitation anomalies compared with period 1961–1990; red line measures moving average.

Source: UNFCCC, 2014

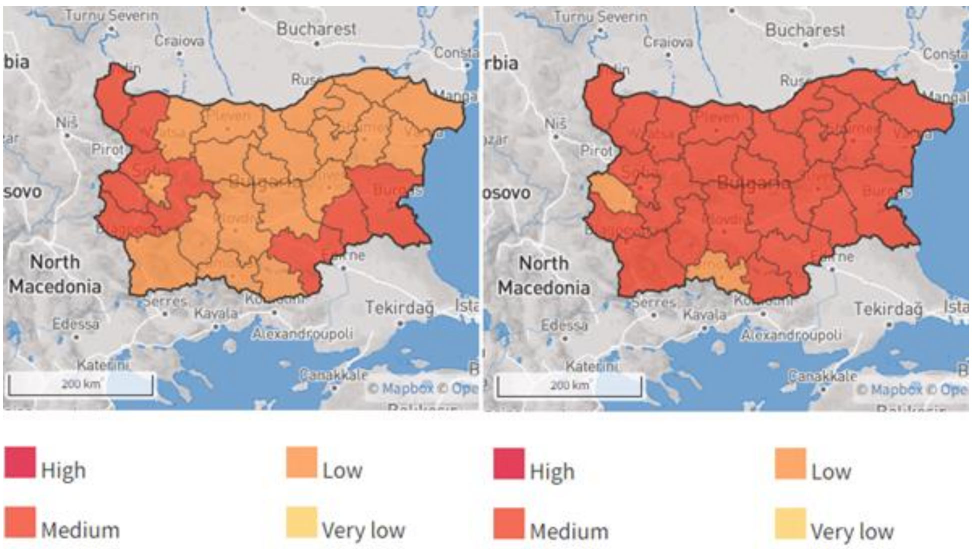
A defining characteristic of Bulgaria's agro-climatic conditions is water scarcity. While meteorological drought pertains to the duration and severity of dry periods, agricultural drought links various aspects of meteorological or hydrological drought to agricultural impacts. It specifically addresses issues such as soil water deficits, insufficient precipitation, disparities between actual and potential evapotranspiration, as well as diminished groundwater or reservoir levels.

Bulgaria is facing an escalated frequency of flood occurrences. Between 1991 and 2007, there was a 30 % rise in the average number of days featuring precipitation exceeding 100 mm compared to the baseline of 1961 to 1990. According to the UNFCCC statistics, specific regions experienced precipitation within a few hours, equaling the typical amount expected over three months. The increased incidence of intense, short-duration heavy rainstorms contributes to amplified short-term surface runoff and heightens the risk of soil erosion, particularly in areas with more vulnerable soil types and sloping terrains.

According to GFDRR, in Bulgaria river flood, urban flood, landslide, and wildfire hazards are classified as high. In addition, water scarcity and extreme heat hazards are characterized as medium.

Higher temperatures affect crop yield, water shortages, stress on animals, new pests, viruses, diseases, loss of crops.

Figure 4-7 Water scarcity (left) and extreme heat (right) hazards



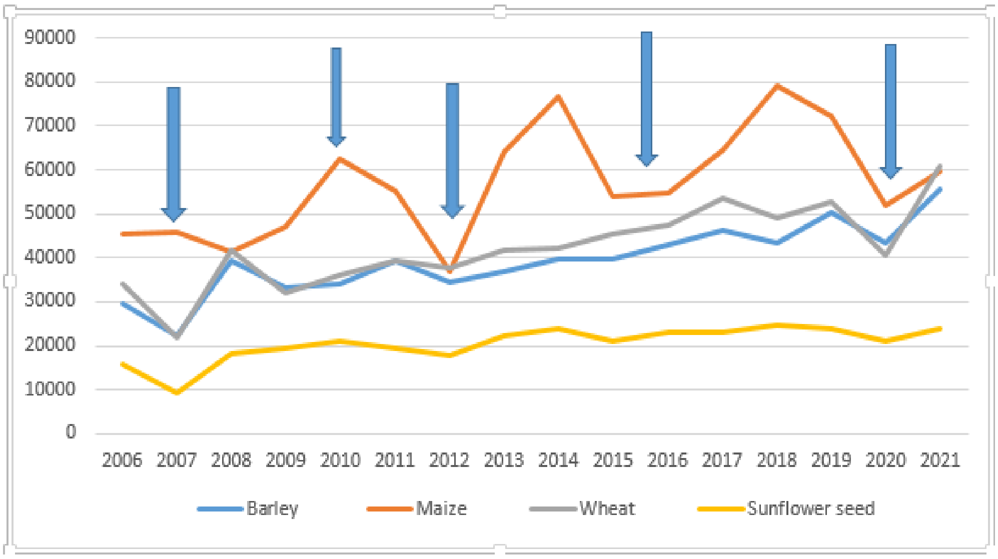
Source: GFDRR

Based on the National Climate Change Adaptation Strategy and Action Plan, the main effect of the abovementioned climate change trends on Bulgarian agriculture can be divided into (***1) Climate change impact on crop productivity, (2) Climate change impact on livestock; (3) Pests, diseases and weeds (4) Impact on natural resources.***

(1) Climate change impact on crop productivity

Weather conditions play an important role in determining agricultural crop productivity. Extreme weather events and climate variations significantly impact yields and can potentially negatively affect agricultural output and food security.

Figure 4-8 Main crop yields (100 g/ha)

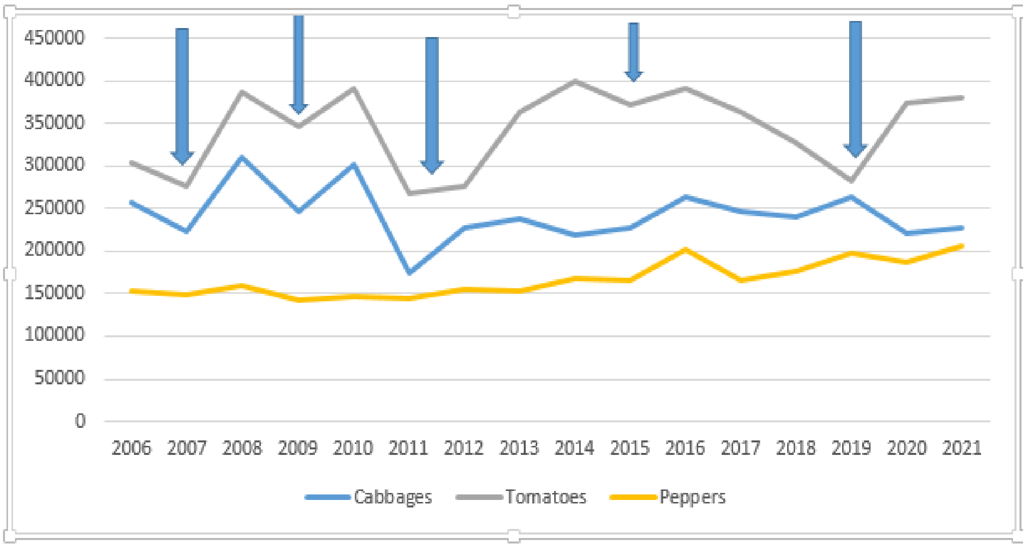


Source: FAOSTAT

The anticipated rise in CO^2 concentration might provide conditions that will increase the yields of main crops. On the other hand, this potential growth could face obstacles due to drought risks and a shorter reproductive period caused by rising air temperatures. Consequently, there may be a shift in crop maturity dates, growing period alterations, and crop yield fluctuations.

The data for 2007-2022 shows the negative impact of droughts on average yields for crucial Bulgaria crops such as wheat, maize, barley and sunflower. Based on the results, it can be concluded that the temperature increase may hinder vernalization in winter cereals.

Figure 4-9 Vegetable yields (100 g/ha)



Source: FAOSTAT

Vegetables are also affected by droughts because they limit the availability of water resources. These main crops decreased average yields due to water shortages during the 2009, 2011, and 2012,2015,2020 droughts. Another important factor that is a major challenge for the sector is the old irrigation infrastructure and the decline in the irrigation area.

Climate change can also affect the length of the growing season. In this regard, the longer growing season can positively impact thermophilic species and ensure better irrigation opportunities and conditions for crop growth, development, and productivity. In addition, climate change can lead to the potential expansion of new varieties in North Bulgaria and mountainous areas. On the other hand, a longer growing season can cause the spread of weeds, diseases, and pests.

Changes in the occurrence dates of phenological phases, specifically earlier fruit plants flowering or ripening, are monitored in European countries (IPCC, 2013). In Bulgaria, these processes can lead to changes in natural crop cycles. In the fruit sector, these changes can positively impact productivity; however, regarding cereals, the shorter reproductive period can negatively affect yields.

2) Climate change impact on livestock

Increased temperatures have adverse effects on livestock. It most directly affects the health and welfare of animals. The expected temperature increase would impact the mountainous regions more than the rest of the country, especially the lowlands, where the animals are better adapted to the temperature variations.

In general, higher temperatures can also decline the reproductive capacity of animals, with reduced fertility in dairy cattle and sows.

In addition, climate change may lead to the development of pathogens and parasites, as a result of which we may have an increase in mortality or additional costs for medicines and a decrease in economic results.

Fodder crops are also affected by global warming. A decline in their yields and quality will affect animal husbandry and the profitability of the farms.

Longer dry periods may reduce groundwater and affect water supply. Scarcity of water resources can affect the livestock. In addition, drought would affect pasture areas and, hence, animal nutrition. Therefore, due to climate change, less pasture at certain times of the year could lead to overgrazing and erosion risks in these regions.

Based on that, it can be concluded that climate change can affect the food security and nutrition of the population.

(2) Pests, diseases and weeds

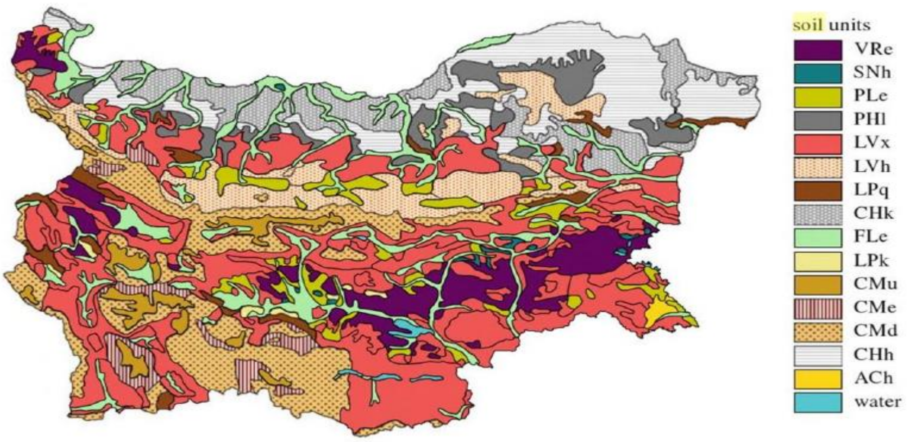
Climate change could increase the spread of many weeds, diseases and pests in agriculture. Temperature and moisture changes can lead to different interactions between pests and their natural enemies and hosts. There are 347 alien terrestrial arthropods in Bulgaria, of which 52 species are crop pests with a negative impact on agriculture (UNECE, 2017). The increased temperatures can shorten the reproductive cycle of many pests, increasing the risk to crops. Based on that, there will be a need for increased use of pesticides and herbicides that would affect crops and human health. Climate change can stimulate the development of toxigenic micro-fungi and easily contaminate crops like wheat and maize. In addition, a longer growing season would create favorable conditions for increasing the number of generations of pests. Climate change can lead to the spread of new for the region pests, diseases and weeds.

(3) Impact on natural resources

Soil types, soil erosion, desertification, and salinization

Bulgaria has different types of soils, and fertile Chernozems occupy 21% of the country's territory. In addition, other soil types have an important role in developing vegetable production.

Figure 4-10 Spatial Distribution of Soil Formations in Bulgaria



FAO Classification	*Code*	*FAO Classification*	*Code*
Eutric Vertisoils	Vre	Eutric Fluvisols	Fle
Haplic Solonetzs	SNh	Rendzic Leptosols	PLk
Eutric Planosols	Ple	Humic Cambisols	Cmu
Kuvic Phaeozems	PHl	Eutric Cambisols	Cme
Chomic Luvisols	LVx	Dystric Cambisols	CMd
Haplic Luvisols	LVh	Haplic Chernozems	CHh
Lithic Leptosols	LPq	Haplic Acrisols	Ach
Calcic Chernozems	CHk		

Source: Shishkov T. and Kolev N. 2014.

Most soil types do not have a high natural resistance to deteriorating physical conditions such as high temperatures or intense rainfall. Particularly vulnerable are regions in South-Eastern Bulgaria, which have lower amounts of precipitation during the warm half-year event. (Shishkov, Kolev,2014). As a result of the above-mentioned, it can be concluded that climate change will lead to lower soil fertility.

Droughts and winds will increase erosion and soil degradation. This may result in desertification and an increase in the share of abandoned land. Such processes will have a negative impact on agricultural production and yields.

About 65 % of arable land is threatened by varying water erosion. In addition, 24 % is threatened by wind erosion. The average annual intensity of soil erosion varies by land use, but soil losses for agricultural land are estimated at 12,256 tonnes/ha (Ministry of Environment and Water, 2015) per year. About 35,500 ha of arable land (Ministry of

Environment and Water, 2014) have been identified as affected by salinization processes. Overall, climate change will significantly affect future land use.

Water scarcity and shortages

Climate change can lead to water scarcity, which has a direct impact on irrigation. This process will influence the production capability of a number of crops. Trends predicting continued droughts and extreme heat will lead to competition for irrigation and water use in agricultural production, affecting crop production stability.

4.2 Forestry

4.2.1 Overview

The Bulgarian government recognizes forestry as a priority sector in addressing climate change, not only because forests cover more than one-third of the country, but also because forests contribute to economic growth, provide ecosystem services, and support disaster risk management. Bulgaria's total forest area is 4.2 million hectares, contributing approximately 500 million euros to the economy annually, including 43000 jobs in the forest sector. In areas with high forest coverage, the forestry sector is the most important economic activity. In the past 50 years, the forest area has increased by 500000 hectares and the forest stand area has doubled, mainly due to afforestation and land use shifting from farmland to forests (Republic of Bulgaria, 2017, 2018).

The average age of forests in Bulgaria is 57 years old. In the context of erosion control, forest health is also important because forests support land protection and soil health, with approximately 39.8% of forests considered to have a protective or restorative effect. The state manages 74.5% of the forest, while municipal governments, private individuals, and religious groups manage the remaining 25.5% of the forest. The majority of forests are deciduous forests (69.5%) and coniferous forests (30.5%), with a total volume of approximately 680 million cubic meters, of which the majority are deciduous forests, accounting for 55.4%. The average annual timber harvest is 14 million cubic meters. The government's forest strategy focuses on ensuring the sustainable use of forest resources, strengthening the role of forests in supporting economic growth and socio-economic development, and increasing their contribution to the green economy.

4.2.2 Climate Change Impacts

Changes in precipitation and the occurrence of more extreme weather events may have long-lasting impacts on forest health. Attempts to calculate degradation estimated that Bulgaria lost 25.2% of its ecosystem value due to degradation in 2015 (Sutton et al., 2016). Forests help maintain soil health and prevent erosion, but they are also affected by degradation. The trend of rising temperatures has changed the phenolic composition of forests, with the development stage of forests advanced by 7-15 days, leading to an increase in the length of the growing season. However, there is also a high risk of damage caused by late frost or long-term exposure to high temperatures.

The increase in drought risk may also increase stress and lead to high mortality rates in forests. Death outbreaks in forest health are often associated with deteriorating health, making certain forests more susceptible to insect outbreaks and other diseases. The availability of water resources or changes in precipitation distribution increase the likelihood of forest fires. In the past few decades, forest fires have significantly increased, which is closely related to the dry summer years. Most forest fires occur in lowlands, but in dry years, there are also forests in mountainous coniferous forests. Most forests in Bulgaria have an altitude below 800 meters and therefore face a higher risk of heat stress. The decline in forest health also increases the risk of natural disasters such as forest fires, thereby affecting other sectors such as agriculture, health, and energy.

4.3 Water & Energy

4.3.1 Overview

Compared to other European countries, Bulgaria has abundant freshwater resources and more favorable soil and climate conditions. These areas are concentrated in major waterways, river basins, and snow, although only 2% of the areas are covered by fresh water and vary according to season. Water provides important services to the economy as an input for agriculture, a habitat for aquaculture, and participates in domestic consumption and energy production. In 2015, the main economic sectors used 473.5 million cubic meters, of which 86% were used for industry, 8% for agriculture, 5% for private household consumption, and 1% for the service industry. The country has up to 21.3 km^3 of long-term annual renewable water resources, most of which come from surface water compared to groundwater resources. Despite abundant water resources, in 2016, 10.7% of the population had no basic sanitation facilities, compared to 1.9% in Europe. The quality of wastewater management has significantly improved; However, the biochemical oxygen demand in rivers continues to be higher than the European average (2.86 milligrams of oxygen per liter in Bulgaria and 2.19 milligrams of oxygen per liter in Europe). It is estimated that 86% of the population has improved sanitation facilities, although 14% of the population shares sanitation facilities (Eurostat, 2018; UNICEF, 2018).

Bulgaria has a total primary energy supply of 18.6 Mtoe, of which 12.1 Mtoe are produced locally and 6.9 Mtoe are imported (Republic of Bulgaria, 2019). The country consumes approximately 34.87 megawatt hours per year, with a per capita consumption of 4.86 megawatt hours per person. Compared to Europe, Bulgaria has a lower energy dependence, with 37.2% of its energy imports, while the average level in Europe is 53.6% (International Energy Agency Statistics, 2015). Although the vast majority of the population has access to electricity, it is estimated that 36.5% of the population cannot maintain sufficient warmth in their homes during winter. Fossil fuels provide most of Bulgaria's energy, particularly coal (33.8%), oil (21.7%), and natural gas (13.3%). However, energy also comes from nuclear energy (2.5%), biofuels/waste (6.3%), hydrology (2.5%), and other renewable energy sources (1.7%). Most renewable energy comes from hydroelectric power resources and is susceptible to the impact of climate change (Eurostat, 2018).

4.3.2 Climate Change Impacts

For water, climate change not only affects precipitation, but also affects river hydrology and soil moisture levels. Seasonal and flow changes may lead to hydrological and meteorological disasters such as floods and droughts; In some river basins, the emission rate is expected to decrease by 10% over the next 30 years compared to the levels from 1976 to 2005. In recent years, evidence of natural disasters has shown that there is a significant risk of river floods and droughts occurring. As shown in the future climate simulation section, areas that heavily rely on surface water are more susceptible to drought compared to areas that use groundwater. Some predictions predict that the southeastern and northwestern regions of the country have the highest risk of long-term water scarcity. In high emission scenarios, it is expected that by the 1990s, the likelihood of severe annual drought will change from less than 21% to 40% -90%. In the short term, areas near rivers may experience vulnerability, and flow fluctuations in these areas may increase. Natural systems may also face challenges due to the lack of wastewater management, which can exacerbate this situation in extreme events and increase the demand for agricultural inputs (fertilizers and pesticides), which may lead to runoff pollution. Freshwater extraction used for energy production accounts for 65.3% of the extracted water demand (5.629 billion m3 in 2015), which is the main reason for increasing water demand. If water becomes scarce or highly variable, critical infrastructure such as hydroelectric power plants, nuclear power plants, and sanitation facilities that currently require a large amount of water may also be affected, which rely on reliable water flow.

For energy, climate change is expected to increase the pressure on existing energy infrastructure. Most power generation methods require a large amount of water for cooling, which has a particularly strong impact on nuclear power generation. Hydrological changes may lead to water scarcity and changes, thereby affecting energy production. Energy production may also face the risk of pressure from floods and rising temperatures, depending on their location in the country. Rising temperatures will increase energy demand and also put pressure on energy production infrastructure. Climate prediction predicts that due to adaptation to temperature rise behavior (i.e. the use of air conditioning and fans), the number of days requiring cooling will mainly increase during the summer months of June to September. As the temperature rises, the demand for winter heating fuel may also decrease with the decrease of heating days. The future of obtaining renewable energy through hydroelectric power generation is uncertain, considering the expected changes and the height changes of river flow across years.

Chapter 5: Climate adaption policy

"Institutional frameworks, policies and instruments that set clear adaptation goals and define responsibilities and commitments and that are coordinated amongst actors and governance levels, strengthen and sustain adaptation actions (very high confidence)."

(IPCC, Summary for policy makers, 2022)

5.1 Policy framework for climate adaptation in rural area

The adaptation is the only available and appropriate response to the changing climate even if all new CO2 emissions are halted today (IPCC, 2022; EU Climate Adaptation Strategy, 2021). The IPCC report pointed out that the key enabling conditions for adaptation were "political commitment, institutional frameworks, policies and instruments with clear goals and priorities, enhanced knowledge on impacts and solutions, mobilization of and access to adequate financial resources, monitoring and evaluation, and inclusive governance processes" (IPCC, 2022).

The 2022 IPCC Summary for policy makers also warned against maladaptation practices. They included actions that focused on sectors and risks in isolation and on short-term gains. The implementation of maladaptive actions can result in infrastructure and institutions that are inflexible and/or expensive to change. The examples given included hard defences against flooding; which reduce space for natural processes and represent a severe form of maladaptation for the ecosystems they degrade, replace or fragment, thereby reducing their resilience to climate change and the ability to provide ecosystem services for adaptation.

5.1.1. The global policy framework for adaptation

The UN Framework Convention on Climate Change (UNFCCC, 1992) treated mitigation and adaptation as being equally important. Article 3 positioned adaptation as one of the policies and measures to mitigate the adverse effects of climate change (Art. 3(3)). However, for over two decades the global efforts were focused on mitigation with significantly less attention on adaptation. Verschuuren underlined that the unbalanced focus was valid not only "for the policy and legal measures taken on the basis of the UNFCCC, but also for academic research" (Verschuuren, 2022).

The 2015 Paris Agreement stressed that adaptation is equally important as mitigation, and in fact referred to the necessary balance between mitigation and adaptation in several articles. It set a global goal for adaptation for the first time (Box 1), recognizing that the current need for adaptation is significant, and that greater levels of mitigation can reduce the need for additional adaptation efforts (Art. 7(4)). The need for integrating adaptation into relevant socioeconomic an environmental policies and actions was also stressed (Art.7(5)).

Box 1. Global goal on adaptation, Paris Agreement, Article 7

1. Parties hereby establish the **global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change**, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2 [keeping global average temperature rise limited to between 1.5 and 2 degrees Celsius].

The commitments of the countries parties to the Paris Agreement comprised (Art.7(9)):

- The implementation of adaptation actions, undertakings and/or efforts;
- The process to formulate and implement national adaptation plans;
- The assessment of climate change impacts and vulnerability, with a view to formulating nationally determined prioritized actions, taking into account vulnerable people, places and ecosystems;
- Monitoring and evaluating and learning from adaptation plans, policies, programs and actions; and
- Building the resilience of socioeconomic and ecological systems, including through economic diversification and sustainable management of natural resources.

Six years after the Paris Agreement, at the 26^{th} meeting of the signatories of the UNFCCC (CoP 26) agreed a bi-annual work programme (2022-2023) to support the global goal on adaptation – known as the Glasgow-Sharm el-Sheikh work programme. It had eight main objectives:

(1) Enhancing overall adaptation action and support;

(2) Understanding of the methodologies, indicators, data and metrics, needs and support needed for assessing progress towards it;

(3) Reviewing the overall progress made in achieving the global goal on adaptation;

(4) Enhancing national planning and implementation of adaptation actions;

(5) Better communicating national adaptation priorities, implementation and support needs, plans and actions;

(6) Facilitating the establishment of robust, nationally appropriate systems for monitoring and evaluating adaptation actions;

(7) Strengthening implementation of adaptation actions in vulnerable developing countries;

(8) Improving complementarity and reducing overlapping communication and reporting efforts.

In 2022, the implementation of the Glasgow-Sharm el-Sheikh work programme agreed on a joint implementation work programme focused on food and agriculture for the 2023-2026 period. It emphasized the need to scale up the adaptation action regarding capacity building, access to finance and technology development and transfer for reducing the farmers' vulnerability to climate change. It also highlighted that each food production system had its own challenges and that solutions and policies must be context-specific and take into account national circumstances. The need for stronger collaboration, cooperation and partnerships between public institutions and agencies, the research community, the private sector, civil society and farmers' organizations was also encouraged.

The objectives of the Glasgow-Sharm el-Sheikh 2023-2026 joint work program on food and agriculture (2022) comprised:

a) Promoting a holistic approach to addressing issues related to agriculture and food security, taking into consideration regional, national and local circumstances, in order to deliver a range of multiple benefits, such as adaptation, adaptation co-benefits and mitigation, especially for vulnerable groups, including women, indigenous peoples and small-scale farmers;

(b) Enhancing coherence, synergies, coordination, communication and interaction to facilitate the implementation of actions related to agriculture and food security;

(c) Promoting synergies and strengthening engagement, collaboration and partnerships among national, regional and international organizations and other relevant stakeholders, processes and initiatives, in order to enhance the implementation of climate action related to agriculture and food security;

(d) Providing support and technical advice to partners on climate action in agriculture and food security;

(e) Enhancing research and development on issues related to agriculture and food security and consolidating and sharing related scientific, technological and other information, knowledge (including local and indigenous knowledge), experience, innovations and best practices;

(f) Evaluating progress in implementing and cooperating on climate in agriculture and food security;

(g) Sharing information and knowledge on developing and implementing national climate change policies, plans and strategies, while recognizing country-specific needs and contexts.

The EU welcomed the development of the Joint work program on agriculture and food (Swedish Presidency of the Council of the European Union, March 2023) and proposed that the next four years were used to "enhance the exchange between Parties and stakeholders for more ambitious climate action in agriculture, food systems, food security and nutrition by establishing common ground and knowledge on the state of implementation of those actions in all countries. This should be done by identifying challenges and barriers for enhanced implementation, highlighting best practices and lessons learned as well as identifying potential sources of financial and technical support and exploring how to ensure that financial flows in the sector are consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." The EU also proposed to organize dedicated workshops on the objectives with specific thematic topic for each workshop. The proposed non-exhaustive list of themes included among others the following themes:

i) Synergies between mitigation, adaptation and biodiversity:

- Improving and restoring ecosystem health and biodiversity, sustainable land management and resilient agroecosystems.
- The role of enhanced carbon removals and their links to increased food security and nutrition in the context of climate change and climate action.
- The role of agroecology including agroforestry in this context.
- The synergistic role of rural women as promoters of sustainability
- How to facilitate the implementation of those mitigation and adaptation measures.

ii) Food systems and climate:

- Options for low emission food systems, incl. agroecology and nature-based solutions.
- Deforestation free production and value chains.
- Meaning of the Global Goal on Adaptation for agriculture, food security and nutrition.
- The contribution of rural women to food systems as food security drivers.

5.1.2. The European policy framework for adaptation

The European Green Deal, published on 11 December 2019, set out a new growth strategy that aimed to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there were no net emissions of greenhouse gases in 2050 and where economic growth was decoupled from resource use. The European Green Deal also aimed to protect, conserve and enhance the Union's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive, leaving no one behind.

The European climate policy framework contributing to the Paris Agreement commitments and implementing the EU Green Deal strategy included the first EU

Climate Law (Regulation 2021/1119) and the second[1] EU Climate Adaptation Strategy (COM (2021)82) both adopted in 2021.

The first EU Strategy on Adaptation to Climate Change (2013) provided a framework and mechanisms to improve the preparedness of member states for current and future impacts of climate change. The strategy aimed to enhance the capacity to respond to the impacts of climate change at the local, regional, national, and European level and supports the development of a coherent approach and improved coordination at the EU level. Both agriculture and fisheries were defined as key vulnerable sectors, dependent on the impact of climate change.

The European Climate Law, 2021

The European Climate Law recognizes that adaptation is a key component of the long-term response to climate change and that the adverse effects of climate change can potentially exceed the adaptive capacities of the EU member states (Art.5, European Climate Law). Thus, member states should enhance their adaptive capacity, strengthen resilience and reduce vulnerability (Art.7 of the Paris Agreement) as well as maximize the co-benefits with other policies and legislation.

The European Climate Law underlines that improving climate resilience and adaptive capacities to climate change requires shared efforts by all sectors of the economy and society, as well as policy coherence and consistency in all relevant legislation and policies; and that nature-based solutions can benefit climate change mitigation, adaptation and biodiversity protection.

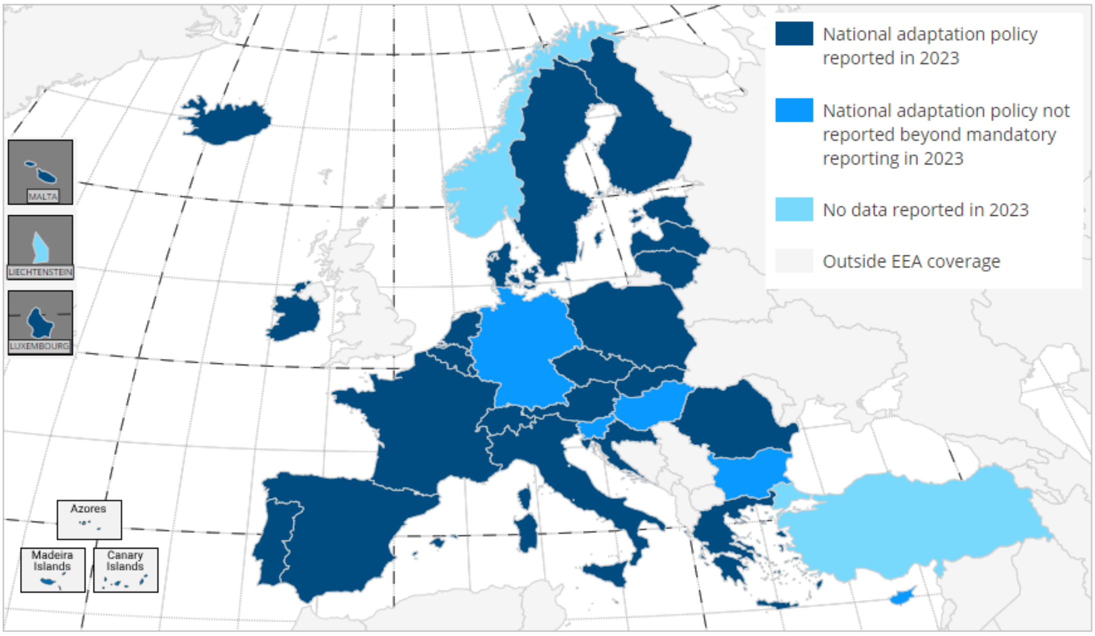
Both the EU institutions and member states have to ensure that their policies on adaption are coherent, mutually supportive, provide co-benefits for sectoral policies, and work towards better integration of adaptation to climate change in a consistent manner in all policy areas, including relevant socioeconomic and environmental policies and actions, as well as EU external actions (Art.5(3)). They have to focus on the most vulnerable and impacted populations and sectors, and identify shortcomings in consultation with civil society.

[1] The first EU Strategy on adaptation to climate change is COM(2013)216 final.

Member states have to adopt comprehensive national adaptation strategies and plans based on robust climate change and vulnerability analyses, progress assessments and indicators, and guided by the best available and most recent scientific evidence (Art.5(4)). In their national adaptation strategies, member states have to address the vulnerability of the relevant sectors - agriculture, and of water and food systems, as well as food security, and promote nature-based solutions and ecosystem-based adaptation.

By 30 September 2023, and in every five years, the EU Commission will assess the relevant national measures, and issue recommendations where it finds that a member state's measures are inconsistent with the climate-neutrality objective or inadequate to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change (Art.7). As per this report in 2023, Bulgaria is among the four EU member states that provided only the mandatory information without a long-term adaptation policy (Figure 5-1).

Figure 5-1 Reporting on national adaptation policies in the EU and EEA countries, 2023



Source: https://climate-adapt.eea.europa.eu/en/countries-regions/countries

The EU Climate Adaptation Strategy, 2021

The new EU Climate Adaptation Strategy accompanies the European Climate Law to step up action across the economy and society towards the 2050 vision for climate resilience, while increasing synergies with other policy areas such as biodiversity. It aims to provide solutions to enable the progress towards the 2050 vision through the following focus areas and actions:

(1) Smarter adaptation: improving knowledge and managing uncertainty

- *Pushing the frontiers of knowledge on adaptation* – Actions: Understand better the interdependencies between climate change, ecosystems, and the services they deliver.

- *More and better climate-related risk and losses data* – To avoid "climate-blind" decisions, data from both the private and public sector should be recorded, collected and shared in a comprehensive and harmonised way. The Commission will facilitate access to climate-related risk and losses data for stakeholders.

- *Making Climate-ADAPT the authoritative European platform for adaptation* – Climate knowledge platforms play an increasing role in decision-making for adaptation action.

(2) More systemic adaptation: Support policy development at all levels and sectors

- *Improving adaptation strategies and plans* – Adaptation strategies at all levels must be effective and based on the latest science. Monitoring, reporting and evaluation are essential to setting a robust baseline against which to measure progress on adaptation. Policy coherence must systematically take into account adaptation to avoid inadvertently undermining it.

- *Fostering local, individual, and just resilience* – The local level is the basis of adaptation, so EU support must help increase local resilience. The EU and Global Covenant of Mayors will be strengthened to assist local and regional authorities. Achieving resilience in a just and fair way is essential so that the benefits of climate adaptation are widely and equitably shared.

- *Integrating climate resilience in national fiscal frameworks* – National fiscal frameworks in the EU include climate change and natural disaster fiscal risks only to a limited extent. Macro-fiscal resilience requires factoring the range of plausible climate scenarios into economic policies and an understanding of disaster risk management.

- *Promoting nature-based solutions for adaptation* – Implementing nature-based solutions on a larger scale would increase climate resilience and contribute to multiple Green Deal objectives. Europe needs to leverage more investments in nature-based solutions to generate gains for adaptation, mitigation, disaster risk reduction, biodiversity, and health.

(3) Faster adaptation: Speeding up adaptation across the board

To accelerate adaptation action, implementation requires resources that are commensurate with the challenge.

- *Accelerating the rollout of adaptation solutions* – The lack of access to actionable solutions is one of the main barriers to adaptation. **Solutions are urgently needed to help farmers and land managers tackle climate risks.** Climate resilience decision support systems and technical advice must become more accessible and rapid to foster their take-up.
- *Reducing climate-related risk* – Investing in resilient, climate-proof infrastructure pays off. Climate adaptation action must better leverage synergies with broader work on disaster risk prevention and reduction.
- *Closing the climate protection gap* – The climate protection gap is the share of non-insured economic losses caused by climate-related disasters. Using insurance as a risk-transfer mechanism to absorb financial losses related to climate risks can be a first step from crisis reaction towards risk management and anticipation. Dialogue and innovation can greatly increase the climate resilience potential of insurance regimes.
- *Ensuring the availability and sustainability of freshwater* – Ensuring that freshwater is available in a sustainable manner is fundamental for climate resilience. EU needs to sharply reduce water use. Climate change also threatens water quality.

5.1.3. The Bulgarian policy framework for adaptation

The Bulgarian policy framework on climate change adaptation is comprised of the Climate Change Mitigation Law (adopted in 2014), the Climate Change Adaptation Strategy and Action Plan (adopted in 2019) and the Long-term Strategy for Climate

Change Mitigation towards 2050 (adopted in October 2022). The 2050 Long-term Strategy refers to Bulgaria's international commitments under the 2015 Paris Agreement, the 2021 European Climate Law and 2021 European Climate Adaptation Strategy. However, as the names of the strategic documents indicate they are primarily focused on climate change mitigation.

Bulgarian Climate Change Mitigation Law, 2014

The Climate Change Mitigation Law was adopted in 2014 and amended several times since then, with the latest amendments in October 2023. Its main focus is on mitigation actions and emissions trading and reporting. There only a few references to climate change adaptation, but still important ones. The law aims to ensure the long-term planning of the climate adaptation measures (Art.2) and delegates the responsibilities for sector specific adaptation measures to the respective sectoral ministers (Art.4(1.5)) with the support of the minister of environment (Art.6(2)). The overall responsibility for the development of a national climate adaptation strategy remains with the minister of environment with the support of the sectoral ministers (Art.9(1)). Furthermore, the income from the emissions trading can be used for the development and implementation of climate adaptation measures (Art.23(2)).

It has to be noted that despite the very recent amendment of the Law it does not transpose the European Climate Law in the Bulgarian legislation. This is considered a major weakness and risk of non-implementation of the European climate legislation. Other weaknesses of the law include the lack of science-based and participatory climate governance approaches (Peev, 2022).

Bulgarian Climate Change Adaptation Strategy and Action Plan, 2019

The Bulgarian climate adaptation strategy was adopted in 2019 and thus was based on the first EU climate adaptation strategy from 2013. Although, it is not yet updated to reflect the 2021 European Climate Law or the 2021 European Climate Adaptation Strategy, it provided a thorough risks and vulnerability analysis per sector and between sectors – agriculture, biodiversity and ecosystem services, energy, forestry, human health, tourism, transport, urban environment, and water and disaster risk management.

There were four general strategic objectives, which were also refered to in the 2022 Long-term Strategy for Climate Change Mitigation towards 2050:

- **Mainstream and integrate climate change adaptation** by strengthening the policy and legal framework for adaptation and the integration of adaptation considerations into existing national and sectoral plans and programs.
- **Build institutional capacity for climate change adaptation** by building expertise, training, the knowledge base, monitoring and research to enable and support adaptation actions.
- **Raise awareness on climate change adaptation** by enhancing education and public awareness about climate change adaptation issues and the need for adaptation actions to be implemented in Bulgaria to build public acceptance and participation of adaptation-related policies and actions.
- **Build climate change resilience** by strengthening infrastructure and asset management and the protection of natural capital and covers water system infrastructure, energy supply infrastructure, and protecting and enhancing ecosystem services including those provided by forest resources.

The specific objectives for the agricultural sector comprised:

- Sustainable management of the agricultural practices for adaptation to climate change.
- Promote the adaptive capacity and awareness in agricultural sector.
- Promote research and innovation for climate change adaptation,
- Strengthen the policy and legal framework for adaptation in the agricultural sector.

The Strategy also proposed specific adaptation options for each sector by grouping them into vertical that address specific subsectors and horizontal covering the whole sector. It was further noted that the horizontal options could support the vertical options by enabling specific subsector actions.

The Strategy highlighted that the climate adaptation actions in the agriculture sector were needed both at the national and at the farm levels, with the engagement of the regional/local administrations and communities. The vertical options for the agriculture sector related to the first specific objectives, while the horizontal options related to specific objectives 2 to 4 (Table 5-1).

Table 5-1 Summary of the agriculture adaptation options (Source: Bulgarian Climate Change Adaptation Strategy and Action Plan, 2019)

Strategic objective	Type of option	Examples
Vertical options		
Sustainable management of the agricultural practices for adaptation to climate change	Agricultural productivity (Crops)	Adjust timing of farm operations; grow thermophilic crops; and develop suitable irrigation systems.
	Livestock production	Develop systems and mechanisms for storing water on farms; diversify livestock farming; and save existing pastures for grazing.
	Natural resource management (soil, water, fisheries)	Increase the use of perennial crops; improve water management practices; and maintain and improve existing aquaculture habitats.
Horizontal options		
Promote the adaptive capacity and awareness in agricultural sector	Building adaptive capacity	Develop climate change training; and develop knowledge dissemination actions.
	Improving awareness	Engage in wider dissemination of CCA knowledge to reach local farmers; and establish a formal platform for aquaculture.

Promote research and innovation for climate change adaptation	Research, technology development, and innovation	Develop research on new crop varieties; and develop farm-level resource management innovations.
Strengthen the policy and legal framework for adaptation in the agricultural sector	Risk management	Develop insurance and risk management programs
	Legal framework	Update and amend the legislation affecting fisheries and aquaculture

The Climate Change Adaptation Action Plan, 2019, prioritised the following options in the agriculture sector:

1. ***Horizontal adaptation options***

- Develop climate change training
- Develop knowledge dissemination actions
- Develop insurance and risk management programs
- Develop water management innovations
- Improve the climate change adaptation legal framework.

2. ***Vertical adaptation options***

- Improve water management practices
- Adjust the timing of farm operations
- Improve the soil structure maintenance, increase the soil organic matter reserves and improve the soil cultivation technologies
- Eliminate secondary salinization conditions and the anthropogenic soil acidification
- Maintain and improve existing aquaculture habitats.

5.2 Current institutions and mandates for climate change adaptation in Bulgarian rural areas

In Bulgaria, the ultimate responsibility for climate policy is with the Parliament, as stipulated in the Climate Change Mitigation Law. The Council of Ministers has the overall responsibility of any policy implementation. The climate policy is within the competences of the Ministry of Environment and Water (MoEW). The Bulgarian Climate Coalition[2] advocated for over a decade the need for recognising the high priority of climate policy and action. The first indication of the high level of political importance of climate change was given at the end of 2021, when a deputy prime minister on climate was appointed. However, the government was short-lived (13 December 2021 – 22 June 2022) and the next government did not renew either the priority or the position. Thus, climate remained one among equal policy topics in MoEW; the ministry not even (re)named as ministry of environment (water) and climate.

MoEW established a Climate Policy Directorate with a broad climate mitigation and adaptation policy mandate. The responsibilities comprised developing legal acts, coordinating the development and implementation of the national climate policy as well as coordinating the work of other ministries and institutions in relation to the national climate policy (Art.38, RCM 208/2023). However, it is the smallest specialised unit in the MoEW with only 11 staff members. In comparison, the Air Quality Directorate has 13 staff, the Water Management and Waste Management Directorates have respectively 24 and 23 staff, and the Nature Conservation Directorate – 32. At the same time, none of the subordinate MoEW institutions – the Regional Inspectorates, the River-Basin Management Directorates or the Executive Environmental Agency received an official climate adaptation mandate (Table 5-2).

[2] https://climatebg.org/en/documents/stanovishta/

Table 5-2 Climate mandates as regulated in the legal acts on the institutions' functioning (Source: Kazakova-Mateva, 2023. Institutions and mandates for climate change adaptation in Bulgarian rural areas. UNWE Conference report.)

Institution	Climate	Mitigation	Adaptation	Directorate	Legal act
Environment institutions					
Ministry of Environment and Water	x	x	x	Climate Change Policy	RCM 208/2017, 2023*
Executive Environmental Agency	x	x	.	Environment Monitoring, Permits	RCM 331/17.10.2022
Regional Inspectorates Environment and Water	.	.	.	.	MoEW, SG 54/2020
River-basin Directorates	.	.	.	.	MoEW, SG 54/2020
Agriculture Institutions					
Ministry of Agriculture and Food	x	.	.	Rural Development	RCM 260/2019
State Fund Agriculture	.	.	.	.	RCM 151/2012, 2020*
District Directorates on Agriculture	x	.	.	Agriculture Development	MoA, SG 41/2022
National Agriculture Advisory Service	.	.	.	.	MoA, SG 25/2022
Exec Agency Fisheries & Aquaculture	.	.	.	.	RCM 95/2010, 2020*
Food Risk Assessment Center	.	.	.	.	RCM 231/2016, 2020*
Bulgarian Agency on Food Safety	.	.	.	.	RCM 35/2011, 2020*
Executive Agency for Combating Hail	.	.	.	.	RCM 85/2000, 2021*
Agriculture Academy	.	.	.	.	RCM 151/2018, 2022*
Executive Forestry Agency	x	x	.	Forest Management	RCM 173/2011, 2022*

Notes: Resolution of the Council of Ministers (RCM)/ Order of respective minister in State Gazette (SG); * year of latest change

The Climate Change Mitigation Law and the Third National Plan on Climate Change Mitigation 2013-2020 (3rdNPCCM) planned for the setting up of dedicated climate units in the related ministries, including in the Ministry of Agriculture (MoA). In 2022, the final implementation report of the 3rd NPCCM disclosed that the MoA declined the setting up of such unit. The justification provided was the "*cross cutting character of climate change affecting the work of multiple units in the MoA system*" (p.32). The MoA stated that the "*existing structure was sufficient to ensure a good coordination of issues requiring a complex approach and complementarity*". The functional structure regulations of the agriculture institutions revealed that there was only one unit in the MoA with official climate related functions. This was the Rural Development Directorate, which was responsible for the programming of the Common Agriculture Policy (CAP) support. One of its over 15 other functions was to "*program appropriate measures and schemes <u>to combat climate change</u>, to protect soils, biodiversity and water resources, through which to ensure the fulfilment of commitments related to the environment and climate, arising from the applicable European legislation for the European Structural and Investment Funds*" (Art.38(1) p.11), RCM 260/2019). Again, climate change was one of four environmental issues to be addressed.

The other MoA institution with climate related responsibilities was the Executive Forestry Agency. Its Forest Management Directorate had two functions related to climate change mitigation – to participate in intra-institutional meetings and working groups and to develop and implement projects on climate change mitigation in forests. None of the functions mentioned explicitly climate adaptation responsibilities.

The 2019 Climate Change and Adaptation Strategy assessed the institutional capacity on climate change adaption as needing improvement "*at all levels and in all sectors*". The proposed focus was on "*building expertise, training of the administration and stakeholders, the knowledge base, monitoring and research to enable and support adaptation actions*" (CCAS, 2019).

The public bodies' decision-making on climate issues was regulated in the Climate Change Mitigation Law. It stipulated that a National Expert Council on Climate Change supported the Minister of Environment and Water. Thus, the Council was established as a consultative body. Its members comprised representatives of nine other ministries, the Executive Environmental Agency, the Bulgarian Academy of Science, the Association of Municipalities as well as other non-governmental bodies. The Ministry of Agriculture and Food was one of the members. The operation of the Consultative Council was regulated by an Order of the Minister of Environment and Water. The order stipulated that its operating principles were transparency, publicity and equality among its members.

5.3 Recommendation

5.3.1 Adaptation options for agriculture sector

Based on the Climate Adaptation Strategy and Action plan, the adaptation options can be divided into: Vertical; Horizontal; Cross-cutting.

(a) Vertical adaptation options

Based on the impact of climate change on the agricultural sector, adaptation options can be grouped into the following:

1) Adaptation options for agricultural productivity

Irrigation infrastructure and irrigation system implementation can help achieve higher yields and productivity. Another option is better management of woodland, hedgerows, and trees on agricultural land that will benefit the livestock and crop sector. Better management of farm operations and better pest and disease control are also adaptation options. In addition, developing new varieties better adapted to new conditions and climate change effects can be pointed out as an option.

2) Adaptation options for livestock

The adaptation options in this field include developing systems and storage for water and efficient and optimal water use. In addition, new alternative energy sources can be used on the farm level. Improving cooling and heating systems is an important part that could help maintain animal health and welfare. In this direction, a significant aspect is the development of new livestock breeds, changes in diet patterns of animals and better management of grassland.

3) Adaptation options for natural resources

Regarding the soil, a critical adaption option can be using perennial crops that are more resistant to climate change as extreme weather conditions. Another option is maintaining soil structure and increasing soil infiltration capacity and organic matter reserves. Soil management should be improved by increasing water retention to conserve soil moisture. Better use of crop residues as raw material is an important part of these options and is at the centre of the emerging bioeconomy.

Regarding water resources, better irrigation management and practices are essential. The secondary salinization conditions have to be eliminated.

(b) Horizontal adaptation options

1) Building adaptive capacity

In this direction, important options are staff training in different institutions and organizations among the main stakeholders. In addition, dissemination actions such as conferences and seminars can be organized. Financial support such as grants, subsidies or other instruments could boost the implementation of the new practices.

Crucial for adapting to climate change is developing and improving a monitoring and evaluation system.

2) Better awareness

Options in this field include different online portals or platforms with specific information that will engage society. In addition, dissemination among farmers is also important. Opportunities for local community engagement are newsletters, workshops, and brochures. Introduction climate change challenges in education in schools and universities curricula can be outlined as an option. Developing enhanced ecosystem observation systems is also a step-in adaptation to climate change.

3) Strengthening research, technology development, and innovation

In this field, a wide range of options includes different stakeholders. The research of new crop varieties and livestock breeds is an important step. Further and broader studies on the impact of climate change on different sectors and interaction between sectors are the options for a better understanding of the processes.

On the farm level, better management of resources and implementation of new technologies and innovations is essential. These innovations include irrigation systems, water use and new renewable energy resources.

Better climate information systems are recommended and can help combat climate change.

4) Risk management and legal framework

In this direction, important steps are developing insurance and risk management programs. In addition, harmonization and adapted legal framework concerning the Green Pact and other EU actions is vital part of the adaptation.

(c) Cross-cutting

Coordination and interaction between different institutions, organizations and other stakeholders is crucial. Climate change is linked to the quality of natural resources, urban and rural development, food security and human health. Therefore, the adaptation strategies include rural and urban development and should be considered together. Adapting to climate change requires the adoption of an integrated approach which includes social, economic and environmental aspects.

Promoting synergies between adaptation and mitigation in agriculture can help develop and implement adaptation strategies. Risk assessment and monitoring frameworks that include different actors are also essential. Research, knowledge transfer and dissemination of the best practices are important for adaptation to climate change.

5.3.2 Adaptation options for forestry sector

In Bulgaria, forests provide important inputs to the economy through timber and non-timber forest products, including ecosystem services. The Bulgarian government recognizes the importance of the forest sector in its national communication and national forest sector development strategy. Facing the pressure brought by temperature and hydrological changes, adaptation work can be carried out, which can improve forest health and protect biodiversity in the short term. Increasing research and promotion to promote sustainable forest utilization is crucial for effective forest management. In areas where forests are under pressure or prone to flooding, investing in reforestation can not only improve forest health but also alleviate flooding. Supporting biodiversity and genetic diversity in forests through accommodation, conservation, and restoration practices is also an important approach that can be taken. The current forest management methods must be changed to ensure the long-term availability of resources.

5.3.2 Adaptation options for water & energy sector

For water sector, the sustainable utilization of surface water, groundwater, and river systems is an effective effort to limit the impact of human behavior such as runoff and wastewater management pollution, and is also a requirement for the long-term availability of water resources. Bulgaria's water sector can adopt adaptive options by strengthening adaptive water management technologies, including scenario planning, learning based methods, and flexible and low regret solutions in the face of expected climate risk trends, to support more adaptive governance. Considering poverty alleviation and equity, financial tools can be developed to achieve more sustainable water resource management. It can support engineering plans to develop and integrate ecologically efficient climate adaptation and risk mitigation water infrastructure. Water can be transferred to water scarce areas in the country. Bulgaria's vertical adaptation strategy needs to include national level policies to support adaptive governance of water resources through legislation and cooperation in shared resources such as river basins.

For energy sector, the adaptation choices of the energy sector need to include the transition from fossil fuels to renewable energy in highly uncertain situations, especially in terms of hydrological changes. Adaptation options should focus on energy security and energy investment strategies, including components of climate change, including preparing for future energy needs and reducing risks for critical infrastructure in vulnerable areas. The adaptation measures for the Bulgarian energy sector include:

- Convert monitoring, forecasting, and weather data for the energy sector
- Mainstream climate change considerations into energy sector policies and plans
- Integrating climate adaptability into the design and engineering of new power plants, as well as the operation and emergency plans of existing power plants and coal mines
- Integrating climate adaptability into the design and engineering of new T&D infrastructure, as well as the operation and emergency planning of existing T&D infrastructure

- Diversified supply, including regional energy trade, regional heating/cooling, household gasification, and small-scale renewable energy, to enhance the overall resilience of the energy system
- Improve the energy efficiency of public and private sector buildings to ensure the maintenance of existing supply-demand balance
- Establish institutional capabilities and knowledge networks
- Developing financial mechanisms to establish resilience

Developing knowledge tools to provide information for integrated energy strategies incorporating climate change will require knowledge products such as maps and regional forecasting estimates. It is worth noting that financial mechanisms need to be established for large-scale investments required for energy production and distribution. It is necessary to incorporate resilience planning into the current energy plan to ensure long-term energy resilience.

Chapter 6: Designing Resilient Rural Communities

6.1. Planning for Climate Resilience

Resilience as a term has been part of scientific and political discussion since the late 1990s. (Vogt, 2015). The EU aims to address the issue in the latest two programming periods. In addition, climate resilience became a vital objective of the 2015 Paris Agreement of the United Nations Framework Convention on Climate Change to overcome global climate hazard issues (UNFCCC 2015).

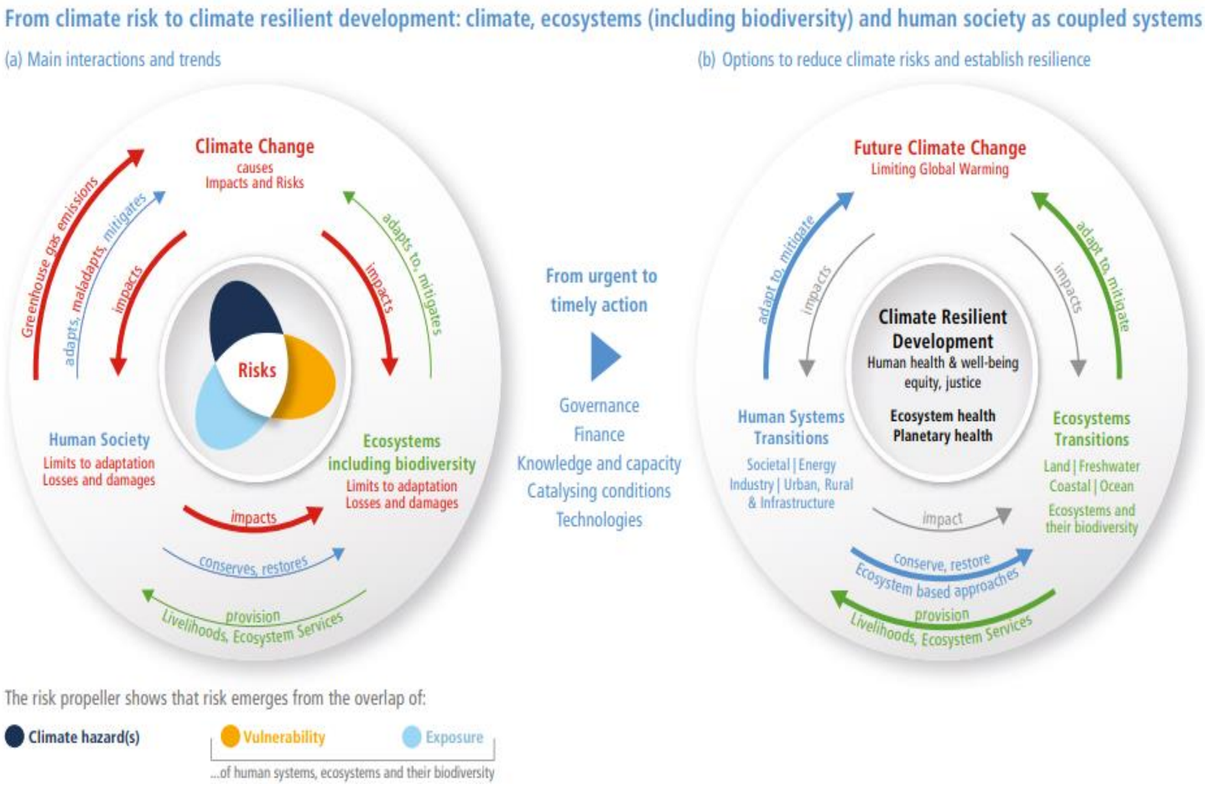
The Special Report of the Intergovernmental Panel on Climate Change (IPCC,2018) defines climate resilience as “the capacity of social, economic and environmental systems to cope with a hazardous event or trend, while also maintaining the capacity for adaptation, learning and transformation” (IPCC, 2018). The document highlighted the evolution of the climate resilience concept through ‘climate-resilient development pathways’, which are defined as “trajectories that strengthen sustainable development at multiple scales while reducing the threat of climate change through ambitious mitigation, adaptation and climate resilience”.

Although serious economic growth and social development have occurred in the past thirty years, the process has been uneven, and many countries are also exposed to climate change hazards differently (Byers et al., 2018; Schleussner et al., 2018). However, the impacts of climate change on economics contribute to wider inequality in wealth distribution between countries (Diffenbaugh & Burke, 2019). Rural areas are especially vulnerable to this situation. Based on the definition proposed by ecology (Holling, 1973), rural resilience is identified as “rural communities' ways of handling shocks or disturbances, from which it is then possible to bounce either back (equilibrium resilience) or forward (evolutionary resilience)” (Scott, 2013).

Resilience in the literature has various interpretations. Adaptation is often linked to resilience and related not just to the ability to maintain but also to the capacity for transition and transformation.

IPCC's (2022) report highlights the adaptation process to support sustainable development as climate-resilient development. The figure 6-1 explains the links between different systems. The development of human society has led to climate change, on the one hand. On the other hand, climate hazards and vulnerability affect society and create risks that can hinder adaptation and lead to negative consequences. Human society can adapt and mitigate climate change; ecosystems also can, but within certain limits. Achieving climate-resilient development goals, thereby supporting the health of people, ecosystems and the planet, as well as human well-being, requires society and ecosystems to transform to a more sustainable and resilient level.

Figure 6-1: Interactions among the coupled systems climate, ecosystems (including their biodiversity) and human society



Source: IPCC, 2022

Recognizing climate risks can strengthen adaptation and mitigation actions and transitions that reduce risks. Taking action is possible through governance, knowledge, and technology.

According to the United Nations Framework Convention on Climate Change, the vision of climate resilience is to be achieved through three directions: Resilient people and livelihoods, Resilient Businesses and Economies, and Resilient Environmental Systems.

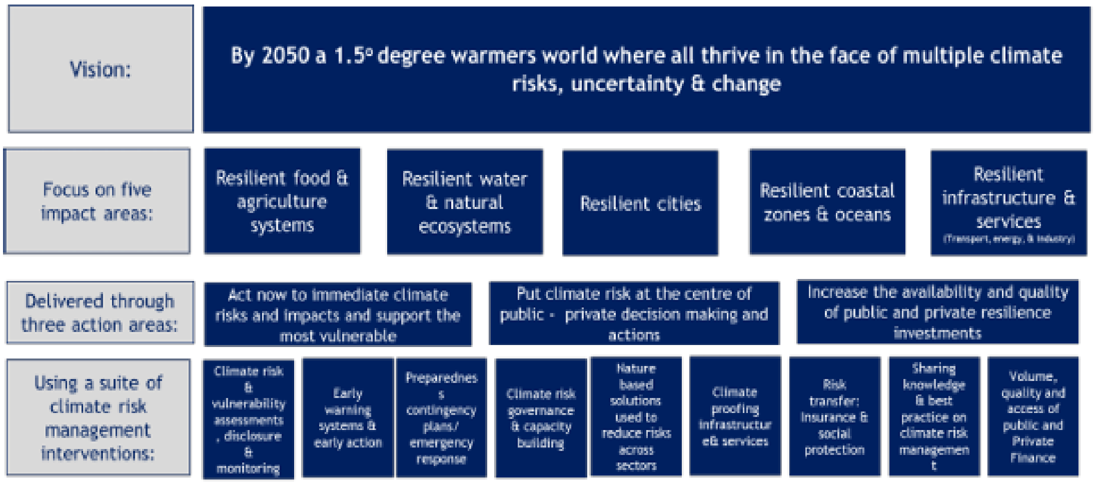
The Marrakech Partnership for Global Climate Action's Climate Resilience Network report highlights the main element of climate resilience that includes all stakeholders.

The UNFCC (2021) presents six steps in designing and developing climate resilience:

1. Awareness-raising and advocacy
2. Climate risk assessments at national, local (city/region), sectorial or organizational levels and use a systems approach.
3. Develop and implement appropriate actions and interventions.
4. Mobilize resources
5. Monitor and track progress.
6. Share knowledge, experiences and solutions.

United Nations for Climate Change developed an action table with focus areas, actions and interventions.

Figure 6-2: Structure of climate resilience pathway action table



Source: UNFCC, 2021

Another important organization, Word Bank, published an Action Plan on Climate Change Adaptation and Resilience in 2019.

According to the document, the Action's objectives are part of the 2025 Climate Change Targets of the Word Bank Group. The Action Plan is structured around three objectives (World Bank, 2019): (1) Boost adaptation financing. (2) Drive a mainstreamed, whole-of-government programmatic approach. (3) Develop a new rating system: better observing the global progress on adaptation and resilience.

Another serious step towards climate resilience is the National Climate Resilience Framework of the USA (White house, 2023), which outlines climate resilience efforts at all levels:

• Embed climate resilience into planning and management.

• Increase resilience of the built environment to both acute climate shocks and chronic stressors.

• Mobilize capital, investment, and innovation to advance climate resilience at scale.

• Equip communities with the information and resources needed to assess their climate risks and develop the climate resilience solutions most appropriate for them.

• Protect and sustainably manage lands and waters to enhance resilience while providing numerous other benefits.

• Help communities become not only more resilient but also more safe, healthy, equitable, and economically strong.（White house, 2023)

The climate resilience activities in the Action Plan are developed to be proactive, equitable, just, people-centered, collaborative, inclusive, multi-benefiting, and implement a whole-system approach (White House, 2023).

The actions related to designing and planning climate resilience in the USA Action plan include measures associated with: Advance and simplifying community climate planning; Strengthen interagency coordination bodies to support community resilience; Tailor and vetting future climate risk information and tools; Setting targets and indicators to measure climate adaptation and resilience progress.

In 2022, China developed and presented a National Climate Change Adaptation Strategy (2022–2035), which aimed to strengthen China's societal and economic resilience to climate change (Chinese Ministry of Ecology and Environment, 2022)

Climate resilience efforts are also part of the EU's narratives. The staff working document Closing the Climate Protection Gap states that the EU's resilience to climate-related economic losses is not a given. The term ‘climate protection gap’ is a “reference to the share of non-insured economic losses in total losses after a climate-related catastrophe" (EC, 2021a). It also describes the gap between climate-related effects and existing resilience measures. The Climate Resilience Dialogue (EC, 2024a) is a temporary group developed by the European Commission to study, discuss, and present action that narrows the climate protection gap and increases climate resilience.

In 2021, the new EU strategy on adaptation to climate change was adopted (EC, 2021b). The Strategy includes four objectives: to make adaptation smarter, swifter and more systemic, and to step up international Action on adaptation to climate change. The main targets of the Strategy are closely linked to the EU Green Pact, which aims to transform Europe into a climate-resilient society.

The European Climate Law provides the framework for increased ambition and policy coherence on adaptation. It is linked to the efforts for continuous progress to boost adaptive and resilience capacity, strengthen resilience and reduce vulnerability. European Green Deal boost important strategies such as the Biodiversity Strategy, Renovation Wave, Farm to Fork Strategy, the Circular Economy and Zero Pollution Action Plans, Forest Strategy, Soil Strategy and others.

The Member-States should strengthen their involvement and be proactive in resilience measures. In addition, the countries should share knowledge and good practices because challenges can be local and specific, but solutions are often applicable on a regional, national or transnational scale. Climate change resilience issues are multi- and cross-dimensional. Regional and local-level resilience and adaptation are crucial, and the citizens will play a key role in the success of the strategies and plans.

For years, the importance of a systematic and comprehensive resilience and adaptation process has been acknowledged, leading to the development of various tools and guidance. Most of these resources highlight that resilience adaptation planning can be divided into key phases that form an effective framework for Action. While these frameworks may vary slightly in structure, they are designed to offer flexible approaches to decision-making in the face of climate change. The core principles often draw from past experiences in disaster risk reduction, sustainable development, and previous programs, describing a continuous and evolving process with clear stages.

Crucially, all planning frameworks are iterative, recognizing that resilience and adaptation must evolve in response to new knowledge and changing circumstances.

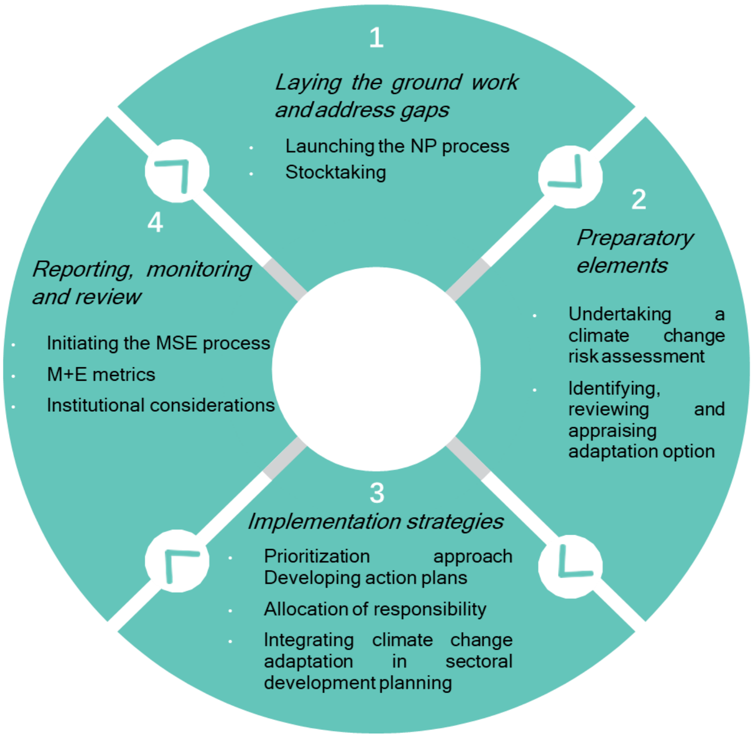
The UNFCCC outlines several key objectives for adaptation and resilience planning in guidelines (UNFCCC, 2012): (1) Reduce vulnerability to climate change impacts by enhancing adaptive capacity and resilience. ; (2) Facilitate the integration of climate change adaptation into relevant new and existing policies, programs, and activities. ; (3) Identify and address capacity gaps in adaptation and resilience efforts on an ongoing basis.

One of the early frameworks that established the idea of a planning cycle is the UKCIP Risk, Uncertainty, and Decision-Making framework (Willows & Connell, 2003). The European Environmental Agency's Adaptation Support Tool, developed as part of the European Climate Adaptation Platform (Climate-ADAPT, 2022), promotes a cyclical approach to planning and adaptation, breaking down the process into six phases, each serving a different purpose.

Street et al. (2016) stress that decisions may need to be reconsidered in light of new evidence to ensure that measures remain effective and robust. Moreover, experience shows that successful planning must include engaging stakeholders at critical points throughout the process. The planning presented by the UNFCCC framework has been focused on the national level. However, as the Adaptation Wizard demonstrates, significant progress and innovation in approaches have emerged from sub-national and organizational levels. The interaction between planning at different scales is crucial. The way adaptation and resilience planning are harmonized across various scales often depends on the specific governance framework. For instance, in Europe, the EU Adaptation Strategy provides a broad framework for adaptation but allows flexibility in how individual countries develop their national plans. The relationship between national and sub-national adaptation planning processes varies, but generally, the national level tends to coordinate actions with local, particularly when addressing national priorities. At the same time, national strategies are designed to offer enough flexibility for local decision-making.

Figure 6-3 presents a summarized review of the existing resilience and adaptation framework outlined by GIZ, 2023. The authors' survey (GIZ, 2023) reviewed the implemented adaptation and resilience planning framework. Based on their survey, the main elements of the planning cycle are outlined.

Figure 6-3: Planning Cycle



Source: GIZ, 2023

The initial planning phase aims to lay a solid foundation for a successful approach, structuring the process and allowing for influence over subsequent stages. The Adaptation Wizard (UKCIP, 2013) emphasizes the necessity of establishing essential building blocks, such as understanding how the planning process functions to maximize its effectiveness and assembling a collaborative team.

The UNFCCC technical guidelines (UNFCCC/LEG, 2012) recommend developing a roadmap that outlines the necessary steps to initiate the planning process. This roadmap could be a strategic document, such as a national strategy, resulting from the scoping phase. UKCIP (2013) stated that securing political support for planning is essential. This support may arise from governance-issued recommendations or be part of specific legal frameworks and obligations. In the European context, the EEA emphasizes that “credible political commitment increases the political relevance of adaptation, i.e., its priority relative to other policy issues, at all levels” (EEA, 2022a).

This stage offers an opportunity to educate stakeholders about the significance of adaptation and to craft suitable messages tailored to various target audiences (EEA, 2022b). The Adaptation Support Tool (AST) enhances awareness and understanding of adaptation and resilience measures through diverse formats. Engaging stakeholders is crucial throughout all phases of the planning cycle. This includes assessing vulnerability, understanding preferences for adaptation options, and conducting Monitoring and Evaluation. Therefore, it is essential to map stakeholders early in the process.

The European Environment Agency suggests forming a core team with a clear mandate to oversee the adaptation process. This team, comprised of personnel at national or subnational levels with extensive experience in weather and climate-related issues, plays a key role in shaping and guiding the process. Another critical consideration in the initial phase is the open discussion of potential conflicts. Stage one is also an important opportunity to assess the financial resources required for planning and identify potential funding sources. This is often connected with securing political commitment and clarifying objectives.

Moreover, the concept of mainstreaming—integrating climate adaptation into existing processes, instruments, and structures—is highlighted in Step 1.3 of the Adaptation Support Tool (AST). Mainstreaming can enhance efficiency, avoid unnecessary expenses, and promote the adoption of adaptation measures. Thus, aligning adaptation opportunities with the current policy landscape may be beneficial.

Timing plays a crucial role in this context; for instance, when a sectorial policy is scheduled for revision, it can be an ideal moment to incorporate planning. Such timing can influence which sectors or locations are prioritized for efforts.

The European Environment Agency (EEA) has developed various indicators to illustrate observed and projected climate change impacts. It also publishes periodic assessments that provide insight into climate change, its effects, and vulnerabilities, which includes an overview of relevant indicators and the existing policy framework. Additionally, several databases cover topics such as climate services, past weather, climate-related events, and insurance data.

Another essential component of the planning process is taking stock of ongoing initiatives. This approach helps build a network of practitioners and enables a better understanding of existing efforts, gaps, and priorities. Collecting information on past and current adaptation measures, related projects, programs, policies, and capacity-building efforts is a valuable learning resource for stakeholders in future initiatives.

The Climate-ADAPT portal provides an interactive overview of country-specific activities related to adaptation across the EU. Under the Regulation on the Governance of the Energy Union and Climate Action, countries report on the status of their strategies, action plans, assessments, and best practices. The portal also showcases successful adaptation measures as potential models for good practice. However, it is important to recognize that the effectiveness of these measures is contingent on specific regional contexts and may not be universally applicable.

To comprehensively understand existing gaps and potential weaknesses in planning and address related challenges, the UNFCCC recommends conducting a gap analysis as part of its framework.

The second phase of the planning cycle is dedicated to identifying climate risks and vulnerabilities, followed by identifying, assessing, and prioritizing measures. The Adaptation Wizard (UKCIP, 2013) treats current and future vulnerabilities as distinct steps. This separation highlights an understanding that many organizations struggle to adapt to existing climate-related risks.

Various institutions, including the European Environment Agency (EEA) and UNFCCC, advocate for a multi-step climate risk assessment methodology. The AST outlines five essential steps in the general sequence for evaluating climate impacts, vulnerabilities, and risks. Additionally, the UNFCCC's Technical Guidelines on National Adaptation Plans (NAPs) outline three indicative activities for assessing vulnerability to climate change across various levels—sectorial, subnational, national, or others—by utilizing applicable frameworks (UNFCCC/LEG 2012: 64).

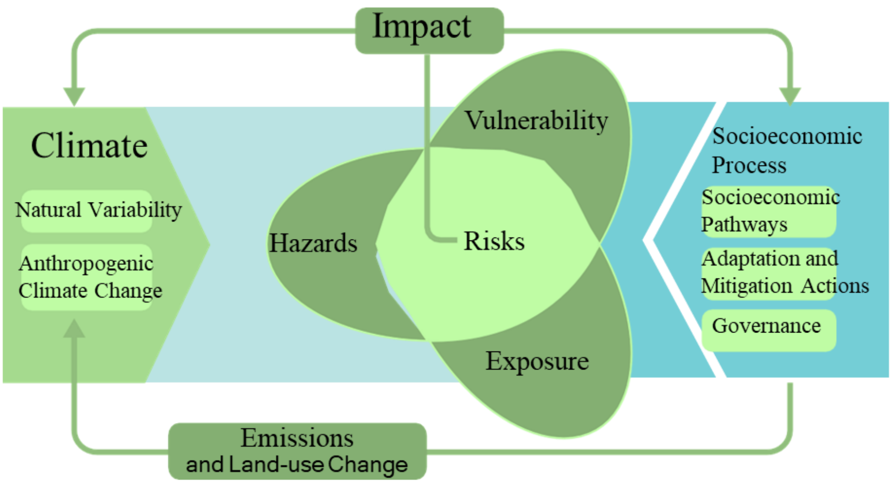
To effectively classify the concept of "climate change risk assessment," it is essential first to define the term "risk." Traditionally, many assessments were grounded in the climate vulnerability concept presented in the IPCC's Fourth Assessment Report

(AR4), which predominantly focused on vulnerability analysis. The IPCC defines climate risks as "potential adverse consequences for human or ecological systems caused by climate extremes and climate change." For example, a climate risk such as drought damage in agriculture arises from the interplay of climate-related hazards and the vulnerability of natural and human systems.

At its core, a climate change risk assessment seeks to gather data and information on hazards, impacts, vulnerabilities, and exposures to evaluate and classify current and future risks. This process involves a formal analysis of the potential consequences and likelihood of climate impacts, alongside societal responses to these challenges, while considering existing constraints (Adger & Brown, 2018).

Vulnerability assessments are frequently conducted alongside, and sometimes in place of, risk assessments. Vulnerability, which can be seen as a subset of risk, refers to the susceptibility of individuals, communities, or sectors to the adverse effects of climate hazards. The primary goal of vulnerability assessments is to identify who or what is at risk from the impacts of climate change, whether it be a specific community, geographical area, or sector.

Figure 6-4: Core concept of risk as result from the interaction of climate-related hazards, with vulnerability and exposure of human and natural systems



Source: IPCC, 2014

There is a widespread consensus on the importance of identifying specific measures derived from climate change risk assessments as a key aspect of planning.

Effectively translating the outcomes from the assessment phase into a comprehensive and actionable plan is vital. This phase involves determining which adaptation actions should be undertaken and specifying how, when, and by whom they will be implemented. It allows national and sub-national authorities to select suitable measures and prioritize them based on their urgency.

All the reviewed frameworks and tools recognize the critical role of identifying specific measures based on climate change risk assessments as a vital component of the planning cycle. This process involves selecting appropriate adaptation and resilience options, the foundation for creating a comprehensive action plan or strategy. Such a plan outlines how, when, and by whom the chosen adaptation measures will be executed. It enables national and sub-national authorities to identify additional specific actions and prioritize them according to their urgency, stakeholder needs, and values.

In preparation for prioritizing potential adaptation measures, the Adaptation Support Tool (AST) emphasizes the importance of detailing these options as clearly as possible. It offers a checklist of considerations to create a solid foundation for comparing and prioritizing different options, which will aid in their implementation later.

Table 6-1: Adaptation and resilience measures

Structural and physical measures (“hard”, “grey”, or “green” options)	**Social measures (“soft” options)**	**Institutional measures (also considered “soft” “options”)**
Engineered and built environment options	Educational options	Economic options
Coastal protection, building codes, infrastructure	Awareness-raising, sharing knowledge	Taxes and subsidies, off-setting losses (via insurance), financial transfers
Technological options	Informational options	Laws and regulations

Efficient irrigation, hazard mapping, new crop varieties	Systematic monitoring and remote sensing, improved climate forecasts	Land zoning laws, building standards, disaster planning and preparedness
Ecosystem-based options	Behavioral options	Land zoning laws, building standards, disaster planning and preparedness
Ecosystem-based options	/	Government policies and programs
Wetland-restoration, afforestation, natural resource management	Evacuation planning, managed re-treat, economic diversification	Regional and sectorial action plans, city-level plans, adaptive management approaches

Source: IPCC, 2014

The Climate-ADAPT portal features a comprehensive catalogue of adaptation measures categorized by impact and sector, along with recent case studies intended to guide stakeholders in the Member States by showcasing successful adaptation practices.

When prioritizing measures, it is essential to recognize where climate change impacts are most likely to occur and which systems are most vulnerable. The selection process should consider the urgency of the measures, mainly focusing on those that are time-sensitive or may incur higher costs or risks if postponed. The UNFCCC has developed a framework that outlines various methods and tools for appraising and prioritizing options. These include techniques like threshold analysis, social preference ranking, scenario-building, multi-criteria evaluation, cost assessment, and environmental impact analysis (UNFCCC 2012: 76). The choice of appropriate methods will depend on the information gathered from climate change risk assessments and the previously identified adaptation measures.

The Adaptation Support Tool (AST) outlined that it is crucial to use multi-criteria analysis to evaluate and rank various options. This decision-making approach involves establishing criteria designed to assist stakeholders, including experts and representatives from relevant sectors, in assessing and prioritizing adaptation measures.

In addition to multi-criteria analysis, cost-benefit analyses are frequently employed to prioritize actions. These analyses aim to quantify the costs and benefits of measures in monetary terms, allowing for straightforward prioritization based on potential economic returns. However, this focus on economic metrics is also a significant limitation when addressing climate change adaptation. While calculating the costs associated with adaptation measures can be relatively straightforward, assessing their benefits is far more complex. This complexity raises critical questions about whether and how potential benefits can be quantified. As a result, cost-benefit analysis may predominantly emphasize immediate economic gains, potentially overlooking long-term impacts on human health, environmental sustainability, and cultural values (Ackerman & Heinzerling, 2002).

The third phase of the planning process focuses on executing the measures identified and prioritized in previous stages. The UNFCCC guidelines and the AST highlight the importance of providing clear guidance for creating and implementing action plans. They also stress the need for integrating strategies into existing policies and ensuring effective coordination and collaboration across different levels of governance.

An action plan is a comprehensive overview of the chosen measures and outlines their implementation process. These plans can either be integrated into a broader national strategy or function as standalone, iterative documents that further define the national strategy's overall objectives and strategic directions.

The action plans organize the selected measures systematically within a strategic framework and may be categorized into sector-specific activities or cross-sectorial initiatives. To address regional needs effectively, subnational governance levels should create policy documents or action plans. Engaging stakeholders throughout this stage is crucial; action plans should be developed in consultation with representatives from relevant sectors and governance levels, ensuring that public input is included.

Effective implementation of measures necessitates robust coordination and collaboration across both horizontal and vertical governance levels. Given that climate change impacts all sectors of administration and socio-economic activities, implementing measures and establishing action plans must consider the existing policies, instruments, and management structures across all sectors.

This approach is commonly known as "mainstreaming." Mainstreaming seeks to incorporate considerations into policy agendas, legislation, budgets, and existing programs and plans, ensuring that sectorial policies are aligned with adaptation objectives. Embedding adaptation into the fabric of policy-making at all levels fosters a more cohesive and comprehensive response to the challenges posed by climate change.

The AST framework differentiates between two approaches to governance: formal “hard” approaches and informal “soft” approaches. Hard approaches typically involve legally binding obligations imposed top-down, which can create pressure to comply. In contrast, soft approaches emphasize voluntary agreements and knowledge-sharing, facilitating quicker decision-making and potentially reducing conflicts. The AST framework states that a successful strategy combines both hard and soft governance mechanisms, leveraging the strengths of each to optimize adaptation efforts.

In the EU context, several examples of mainstreaming can be seen in policies such as the Water Framework Directive, which addresses water management.

Monitoring and evaluation are crucial in planning and fundamental to any iterative process. Understanding what strategies are effective, in which contexts they work, and the reasons behind their success or failure is essential for continually improving adaptation efforts (Pringle, 2011).

Typically, monitoring and evaluation is positioned after planning frameworks, allowing lessons learned and insights gained to inform future planning cycles. While this sequential approach is logical, it is important to integrate monitoring and evaluation considerations early in establishing the adaptation plan's goals, objectives, and desired outcomes. This proactive approach identifies suitable indicators and assessment methods right from the start. Moreover, ongoing monitoring should occur continuously, supplemented by strategic mid-term evaluations. This evidence-based reflection allows for timely adjustments in response to new information rather than waiting for a final evaluation report late in the planning cycle.

According to the Adaptation Support Tool (AST), monitoring and evaluation at the national level should establish connections both vertically and horizontally. This means that national decisions should be informed by the experiences and insights gained at sub-national levels while also facilitating the sharing of adaptation progress and lessons learned with the broader international community.

Creating an effective monitoring and evaluation system can be complex, making it essential to clearly define its purpose before developing indicators requiring extensive data collection. While monitoring and evaluation of policies and plans have been established for a long time, applying these practices specifically to planning presents several unique challenges, as highlighted by Bours et al. (2015):

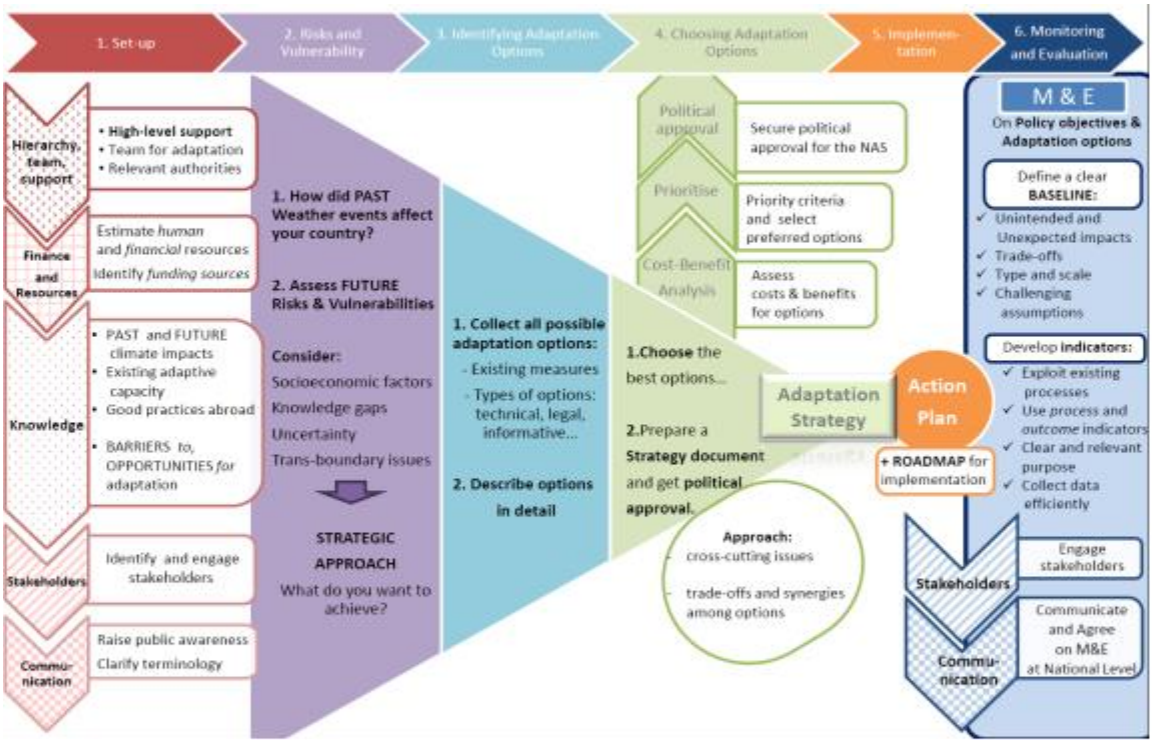
- ✓ Long Time Horizons
- ✓ Uncertainty
- ✓ Attribution
- ✓ Diverse Values and Perceptions
- ✓ Complexity

Effective planning must navigate processes across different contexts and scales, from local communities to the global arena. As such, it needs to be flexible, inclusive, and interactive. Adaptation action plans should establish clear objectives, delineate roles and responsibilities, facilitate inclusive learning processes, and secure adequate funding. Additionally, these plans must be grounded in realistic theories of change, which inform the implementation strategies necessary for translating theory into practice, ultimately ensuring that adaptation measures are effective.

European Commission provided guidelines for strategies and plans for development directed at climate change adaptation and resilience issues. The guidelines are linked to the need for common understanding in adaptation and resilience. The EC presented a common basis for adaptation activities between different stakeholders. The guidelines related to planning and successful adaptation and resilience measures are also associated with knowledge transfer and sharing lessons and good practices.

The recommendations and guidance provided by the European Commission under the CLIMATE-ADAPT tool could benefit member states in planning, developing and implementing climate adaptation and resilience measures and activities. Figure 6-5 presents the planning and development of climate adaptation and resilience strategies and plans at the EU level.

Figure 6-5: Steps in adaptation and resilience strategies and plans



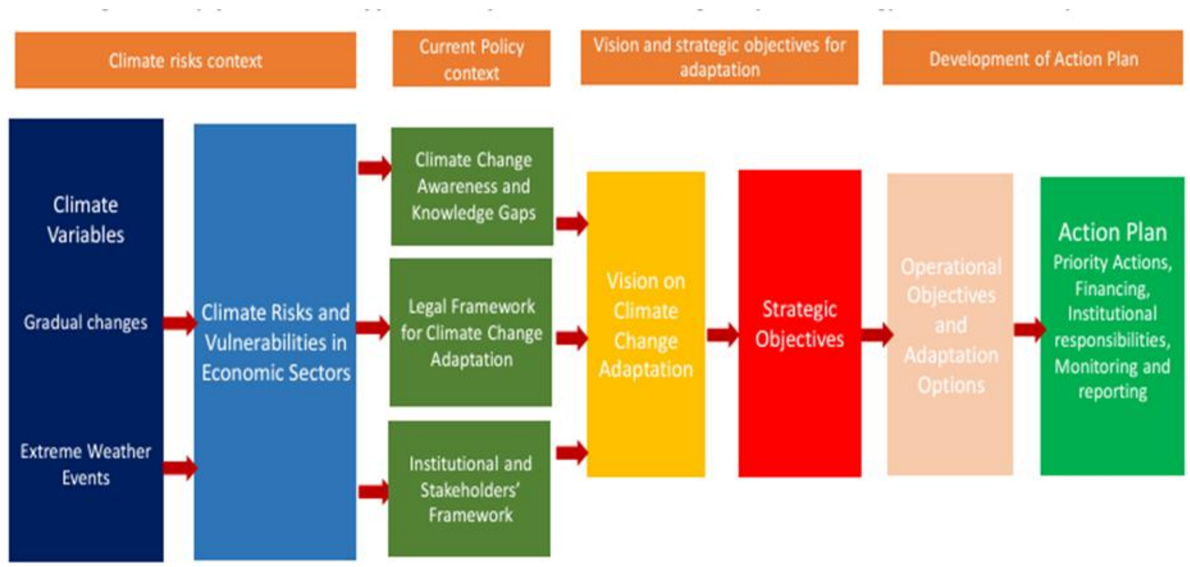
Source: EC, 2013

In 2023, the EU published a new edition of the guidelines, including the new areas of adaptation policy. They include (1) Just resilience related to the vulnerable groups most affected by climate change. To achieve just resilience, it is vital to prevent uneven burdens and to leave no one behind. The programs linked to just resilience are, for example, gender mainstreaming and combating discrimination. (2) Maladaptation - The IPCC defines maladaptation as "actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future". The success of climate change combat efforts may differ from transformation to climate-resilient pathways. (3) Climate stress testing; (4) Nature-based solutions- The UN (2022) defines them as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits". According to the EEA (2021), nature-based solutions reduce the vulnerability to climate hazards and improve resilience capacity for addressing such hazards. There are three main directions:

- ✓ Conservation and restoration of natural ecosystems.
- ✓ Sustainable management and climate-proofing of managed ecosystems to provide multiple ecosystem services
- ✓ Creating new, engineered ecosystems for particular adaptation needs

Based on the guidelines provided by the European Commission, Bulgaria planned and developed a National Climate Change Adaptation Strategy and Action Plan for the Republic of Bulgaria until 2030. Figure 6-6 presents a framework for climate change resilience and adaptation vision, strategy, and action plan.

Figure 6-6: Bulgarian framework for climate change adaptation and resilience



Source: Bulgarian Ministry of Environment and Water, 2019

Bulgaria is vulnerable to climate change and the increased frequency of climate change-related extreme events, such as droughts and floods. According to National Strategy's economic analysis, the cumulative loss in the real gross domestic product in 2050 is between 1 percent and 3.5 percent, compared with the baseline scenario.

Similarly, the climate change-related institutional framework in Bulgaria has, over recent years, focused mainly on mitigation. Based on SWOT and PEST analysis that address issues in the Bulgarian context, the planning is directed towards (1) Mainstream and integration of climate change adaptation and resilience; (2) Building institutional capacity (3) Raising awareness; (4) Building climate change resilience - strengthening infrastructure and asset management and the protection of natural capital and covers water system infrastructure, energy supply infrastructure, and protecting and enhancing ecosystems service.

The Strategy presents medium- and longer-term activities and actions for building climate change resilience, including managing infrastructure and assets and protecting and enhancing natural capital.

6.2 Infrastructure and Service Delivery

The rural areas are the backbone of the European Union. In rural regions, 137 million people live (30% of the total population), covering over 80% of the territory. Rural areas are considered vital for food production, biodiversity restoration, as well as climate resilience measures. The EU rural areas are connected to maintaining cultural inheritance and traditions.

However, rural areas face several challenges and issues. Depopulation and ageing are a reality in these territories. Nowadays, quality of life and well-being depend on services and infrastructure. According to the EC (2024b), digital connectivity, infrastructure and employment are the most critical issues that have to be overcome. Water, energy, and transport infrastructures are essential in this direction. In addition, childcare, long-term and social services, education, and employment are also considered important.

Delivering services in rural areas is critical for maintaining equality and inclusiveness. In addition, rural areas are key elements in fighting climate change and establishing resilient communities. Towns and smaller cities in rural areas can drive rural development and provide access to services. Therefore, the national priorities should be directed to organising public services and new pathways related to digitalisation.

New business models, private-public partnerships, social enterprises, and cooperatives could be key drivers for rural development. However, important factors in the process are digital skills and digital infrastructure.

Rural areas are linked to climate change and environmental degradation issues. According to the EC (2024b), rural areas face higher costs for transformation to a climate-resilient society. The main activities in rural areas, such as farming and forestry, are more vulnerable to climate events like storms, floods, and droughts. These sectors are more sensitive to climate change, need adaptation measures and feel the consequences of biodiversity loss.

Nowadays, especially after the COVID-19 pandemic, rural areas attract attention again, and new opportunities such as circular and green economy and digitalisation present new pathways.

In this regard, natural resources are key to developing a sustainable society. The management of rural landscapes could be an essential element in regulating water, carbon and air pollutants, preventing soil erosion and providing ecosystem services. Sustainable agriculture and forestry could also ensure climate and risk resilience. Improving the quality of rural infrastructure, farming management and revitalising rural entrepreneurship could boost a greener transition.

The key focus on climate change adaptation and resilience is a step for rural areas to combat energy poverty and provide better living conditions.

The bioeconomy, as an emerging concept that includes agriculture, forestry, fisheries, aquaculture, bio-energy, and bio-based products, is considered a factor that boosts the circular and low-carbon economy. The bioeconomy could help develop new business solutions in rural areas, supported by initiatives such as Startup Villages.

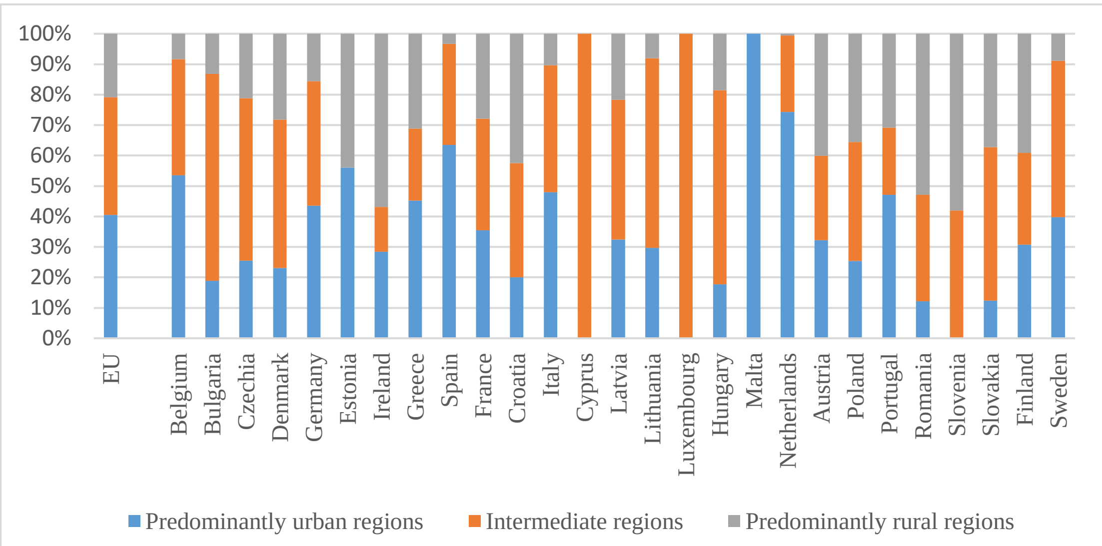
Rural areas are considered crucial to the EU Green Deal and its targets for climate neutrality by 2050. However, green transition and goals related to combating climate change require the cooperation and coordination of all stakeholders: businesses, local authorities, universities and research institutes.

The changes in consumer behaviour and the new lifestyle related to more healthy food and organic products are a possibility for the rural economy. The transition towards organic production related to the Farm to Fork Strategy and the Organic Action Plan can help farmers increase growth and contribute to sustainable development.

Rural communities are important in the process of service and infrastructure delivery. European Commission's recognition of the potential of rural areas can be found in the new Long-term vision for rural areas and the Rural Action Plan (EC, 2021c). The Commission define four main drivers for shaping rural areas to 2040 and different actions and activities.

The priority of the EU's long-term vision for rural areas is related to ***stronger rural areas.*** Alongside the advantages of rural areas, such as better quality of life, lower living costs, and less pollution, there are disadvantages linked to the weaker infrastructure and lower access to public services, fewer job opportunities and a lower level of digitalization. Therefore, the population in rural areas is decreasing (figure 6-7).

Figure 6-7: Distribution of population according to the urban–rural typology, (% share of total population, 2021)



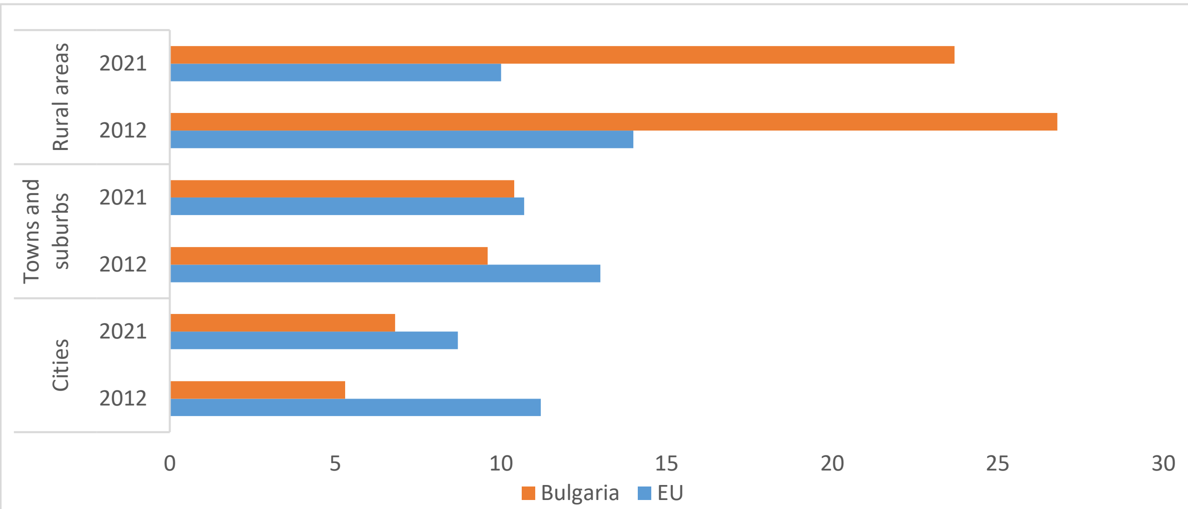
Source: Eurostat, 2022

In 2021, in the EU, more than 40% of the population live in predominantly urban regions, around 39% in intermediate regions, and the fifth in predominantly rural regions. In five Member States, half of the population is located in predominantly urban regions: aside from Malta (100 %), the highest share is registered in the Netherlands (74%), followed by Spain (56%). On the other hand, in Romania, Ireland and Slovenia, more than 50% of the population lives in rural areas. In Bulgaria, the share of the rural population is low (13%), and more than 65% of the people are located in intermediate regions.

Another important feature of the rural region is its education status. People who leave school early may face difficulties in the labour market. In addition, the low educational level negatively affects the economy in the long run.

In 2021, 9.7 % of all young people in the EU were early leavers from education and training. The gap of early leavers in cities and rural regions is the highest in Romania (18%) and Bulgaria (16%). The pattern of early leavers not being employed is more common in rural regions, and the differences between Bulgaria (18%) and the EU (5.5%) are noticeable.

Figure 6-8: Early leavers from education and training (18–24 years) by degree of urbanisation, 2012 and 2021 (%)



Source: Eurostat, 2022

These trends are leading to a number of questions related to the quality of education and motivation and show the need for measures directed towards inclusiveness.

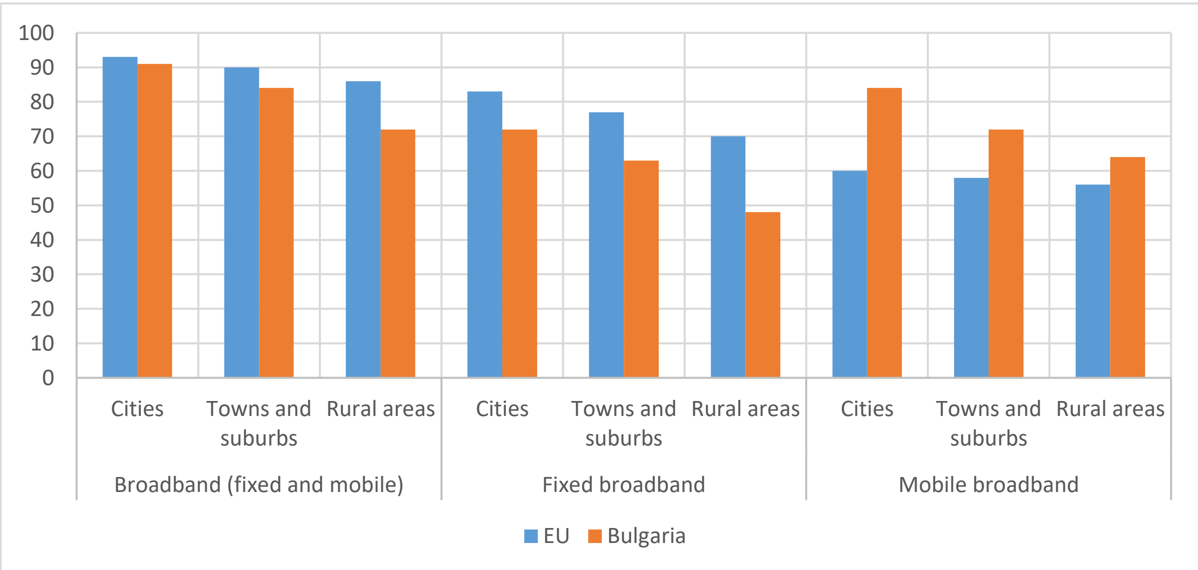
The second priority of long-term vision for rural areas is linked to ***the connected rural areas.***

The number of households connected to broadband internet has increased in the past ten years. In 2021, 93% of households in cities, 90% in towns and suburbs and 86 % in rural areas are connected to broadband Internet. The gap between cities and rural areas in Bulgaria is higher compared to the EU-27. However, the share is still close to the EU average. The introduction of 4G and 5G technologies led to broader mobile broadband applications. In Bulgaria, the share of mobile broadband applications is higher than the EU average.

Compared with cities, broadband connectivity rates (fixed and/or mobile) are usually lower in rural areas.

The share of households with a fixed broadband internet connection is higher than those using a mobile connection in the EU. However, in Bulgaria, the trend is the opposite.

Figure 6-9: Households with broadband internet by type of connection and degree of urbanisation, 2021

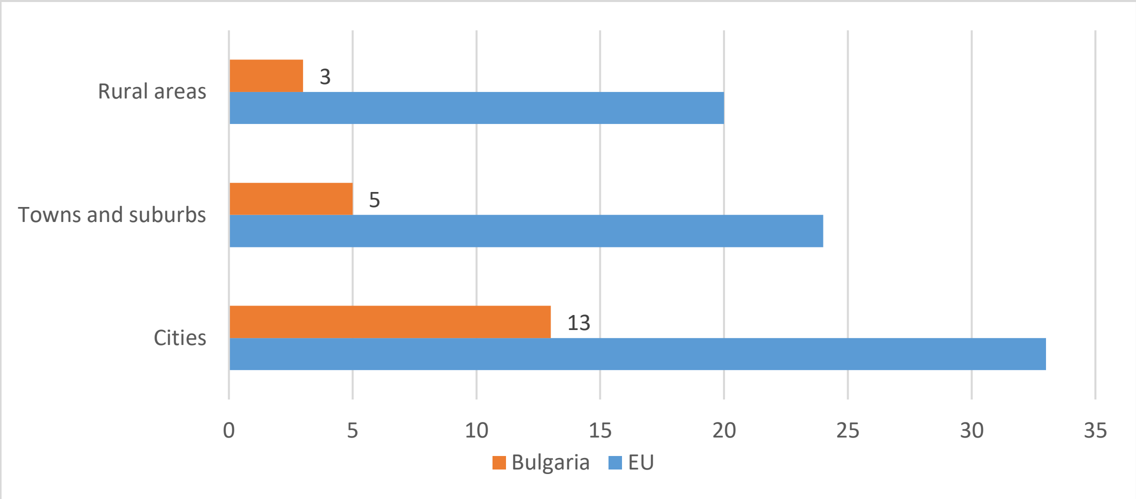


Source: Eurostat, 2022

Digital skills are essential for the labour market, career opportunities and everyday life. The EU's main goals are linked to an inclusive digital society and capacity building.

Based on EU methodology, there are five specific areas related to digital skills: information and data literacy skills, communication skills, digital content creation skills, and safety skills. According to the EU targets, 80 % of people between 16 and 74 years old should have basic digital skills by 2030.

Figure 6-10: Individuals with above basic overall digital skills, 2021



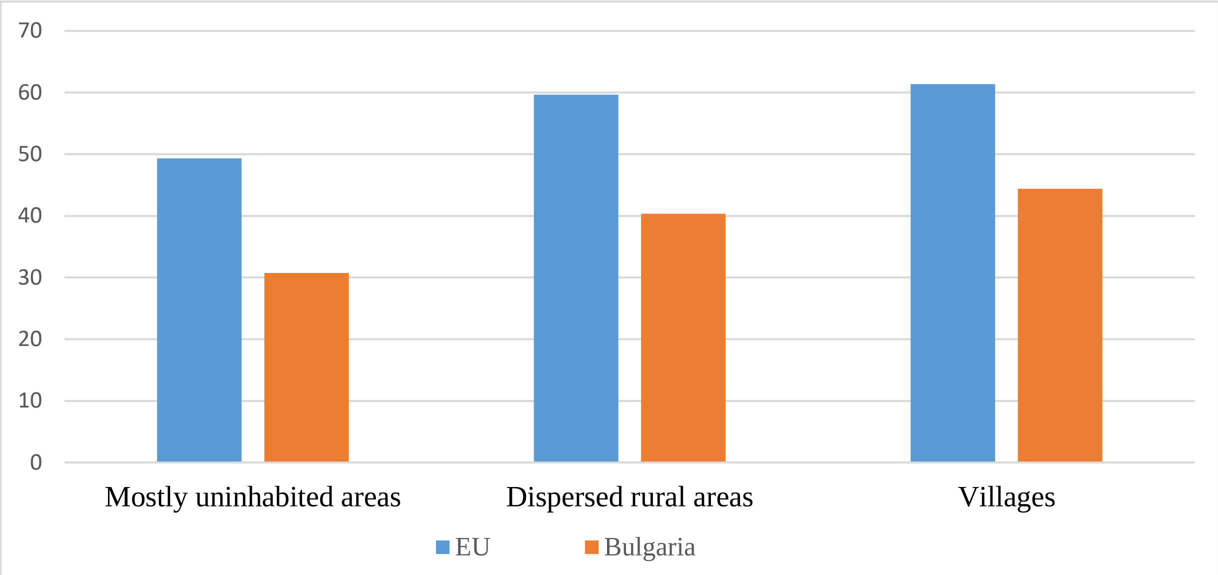
Source: Eurostat, 2022

In 2021, around 26 % of the EU population aged 16–74 years have above basic overall digital skills. This share was considerably higher for people living in cities (33 %). In comparison, fewer people living in towns and suburbs (24 %) and rural areas (20 %) had above basic overall digital skills.

The data shows a big difference in the level of digital skills between rural areas and cities in Bulgaria. In addition, in the country, the share of individuals with above-basic digital skills is significantly lower than the EU average. The results indicate serious obstacles in rural areas because new business models and innovative solutions will likely be linked to digital technology. The broadband connection is relatively close to the EU-27 in Bulgarian rural areas. However, the country is significantly lagging in capacity and capabilities.

An important indicator related to the infrastructure is accessibility.

Figure 6-11: Population living in rural areas within 15 minutes driving time of a main healthcare service by degree of urbanisation level 2, 2018



Source: Eurostat, 2022

Access to healthcare services is considered essential for quality of life and human well-being. The highest levels of access to primary healthcare services among rural populations were generally registered for people living in villages, and the lowest levels were recorded for people living in mostly uninhabited areas. The population share in Bulgarian rural regions is lower than the EU average.

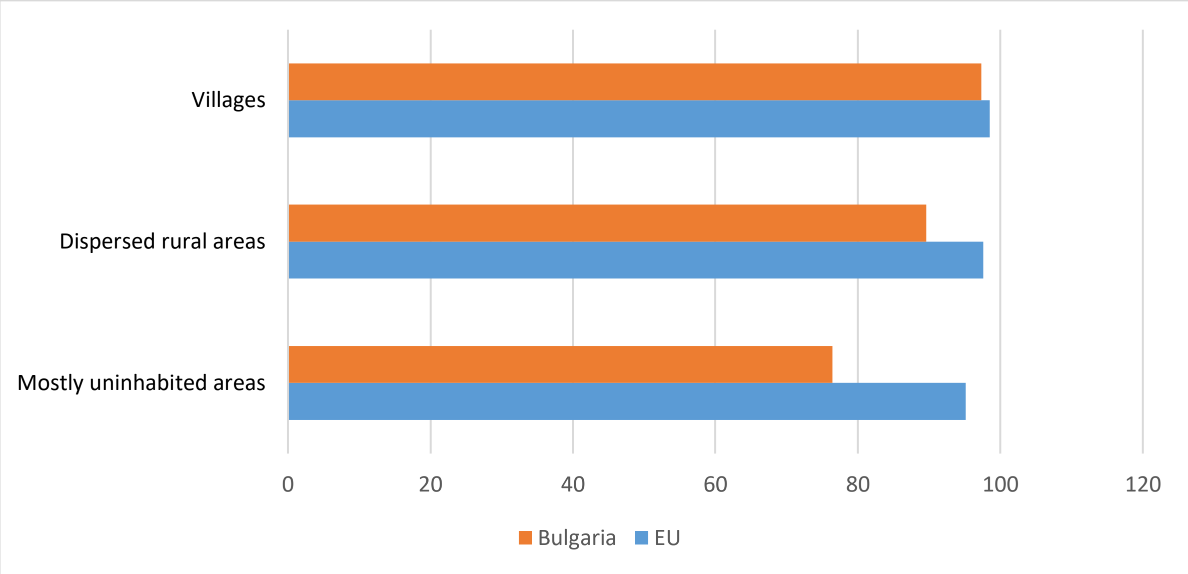
People living in predominantly rural regions closer to cities have better access to services, while people living in more remote areas often rely on local services.

Remoteness is a crucial factor when assessing accessibility issues. Accessibility is higher for people living in villages than for those living in mostly uninhabited areas. For example, 98.5 % of the EU population living in villages could drive to a primary school within 15 minutes, while the indicator is lower in mostly uninhabited areas.

In most EU Member States, the extensive majority of the rural population was living within 15 minutes of a primary school driving time; this was also the case for the subpopulation of people living in mostly uninhabited areas.

Among rural populations, the highest levels of accessibility for primary schools were generally recorded for people living in villages and the lowest for those living in mostly uninhabited areas. Based on the data, it can be concluded that Bulgarian rural territories are close to the EU average, except for the indicator for mostly uninhabited areas, where the share is almost 20 pp lower than the EU-27.

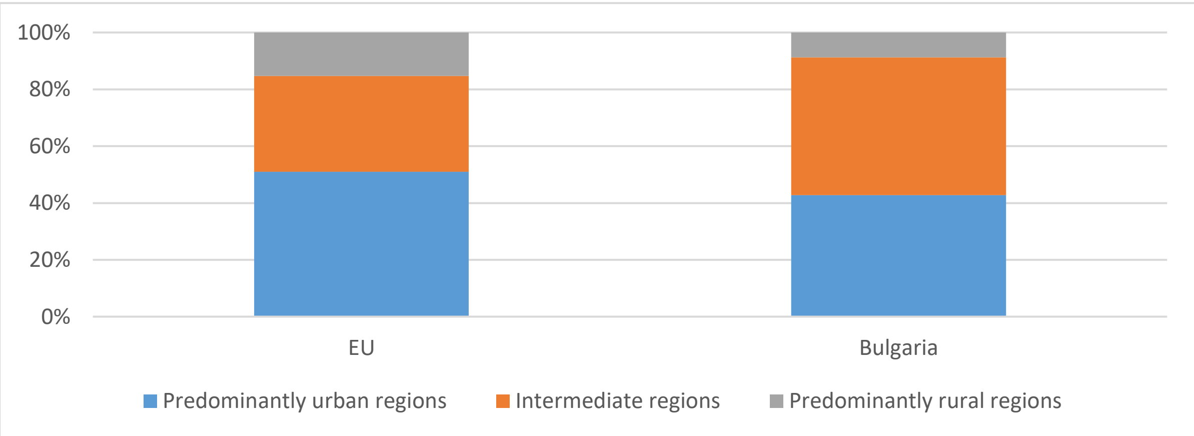
Figure 6-12: Population living in rural areas within 15 minutes driving time of a primary school by degree of urbanisation level 2, 2018



Source: Eurostat, 2022

Resilient rural areas are the third area of action under the Long-term vision for rural regions in the EU.

Figure 6-13: GDP by urban–rural typology, 2019 (Share of total GDP %)

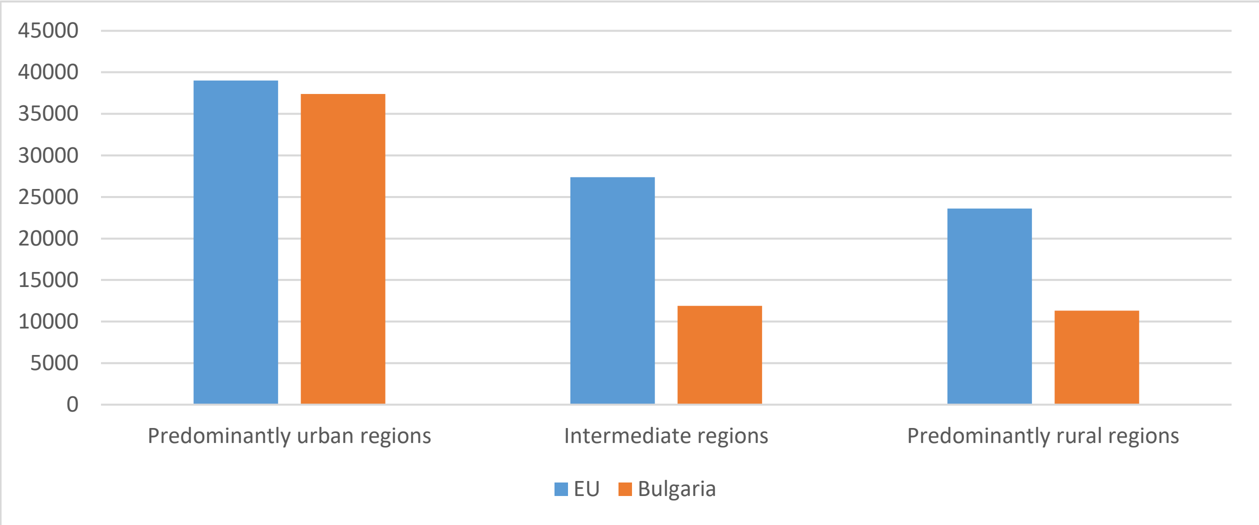


Source: Eurostat, 2022

The gross domestic product (GDP) is an important indicator of economic resilience. Based on the Eurostat data, more than half of the GDP in the EU is generated in predominantly urban regions; intermediate regions concentrate 34 %, while predominantly rural regions account for 15%. In Bulgaria, most of the GDP is generated in intermediate regions, while only 8% is recorded in rural areas.

Urban regions are drivers for the EU economy, providing opportunities for wealth creation and attracting large numbers of people due to the wide range of opportunities they offer in economic, educational, social and cultural spheres.

Figure 6-14: GDP per inhabitant by urban–rural typology, 2019 (PPS)



Source: Eurostat, 2022

The GDP per capita in Bulgaria is lower than the EU average. The difference between EU and Bulgarian rural areas is even higher. In 2019, GDP per inhabitant in the predominantly urban regions is 1.7 times as high as in predominantly rural regions. In Bulgaria, Romania, and Hungary, the GDP per inhabitant for predominantly urban regions was more than three times higher than that of predominantly rural regions. The data show polarization and serious regional imbalances in Bulgaria. The economic resilience of rural regions in the country continues to be the main challenge. Therefore, the government should prioritize and support these territories.

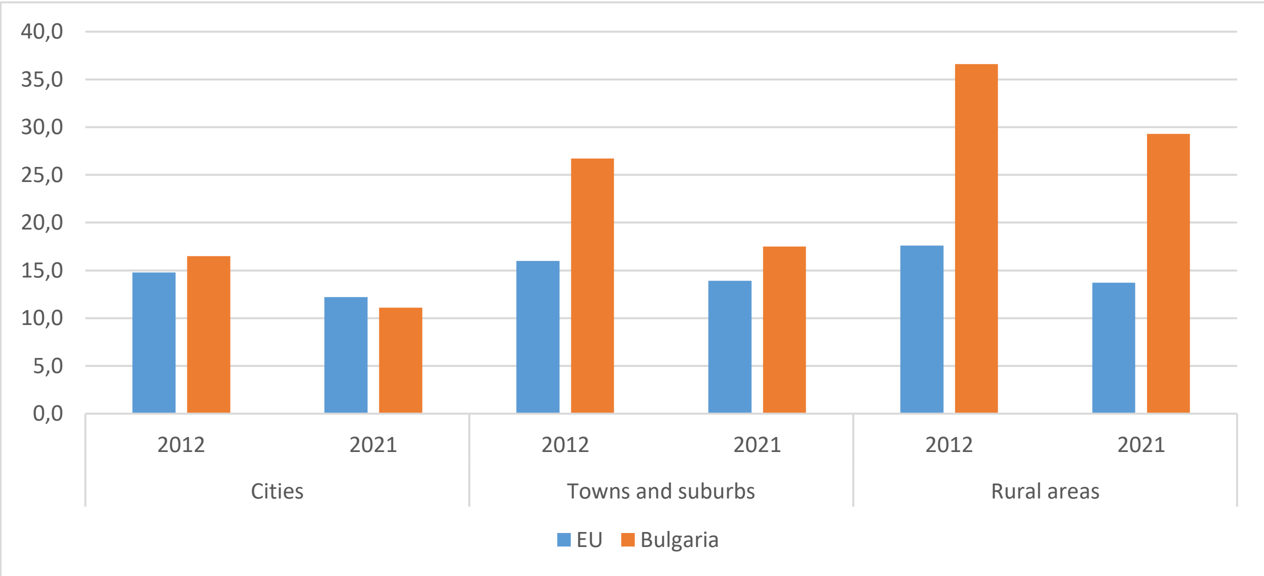
Other serious issues that rural communities face are the young people who are not employed or educated. Many young people in the EU are not part of the labour force. The indicator is a key element for equal opportunities within the European pillar of social rights.

In 2021, 13% of all young people in the EU are neither employed nor educated or trained. The rate is higher in towns, suburbs, and rural areas, while it is lower for young people living in cities. The indicator level in Bulgarian rural regions is more than two times higher compared to the EU-27.

In 2021, the highest rates were recorded in Italy, Romania, Bulgaria and Greece. The share of people who are not employed, not in education and training, was mainly concentrated among young people living in rural areas in Bulgaria.

In the EU, the share of young people neither in employment nor in education and training decreased by 2.9 pp between 2012 and 2021. The most significant decline is recorded in rural areas, followed by cities (2.6 points). In Bulgaria, the reduction is more visible.

Figure 6-15: Young people neither in employment nor in education and training (15–29 years) by degree of urbanisation, 2021



Source: Eurostat, 2022

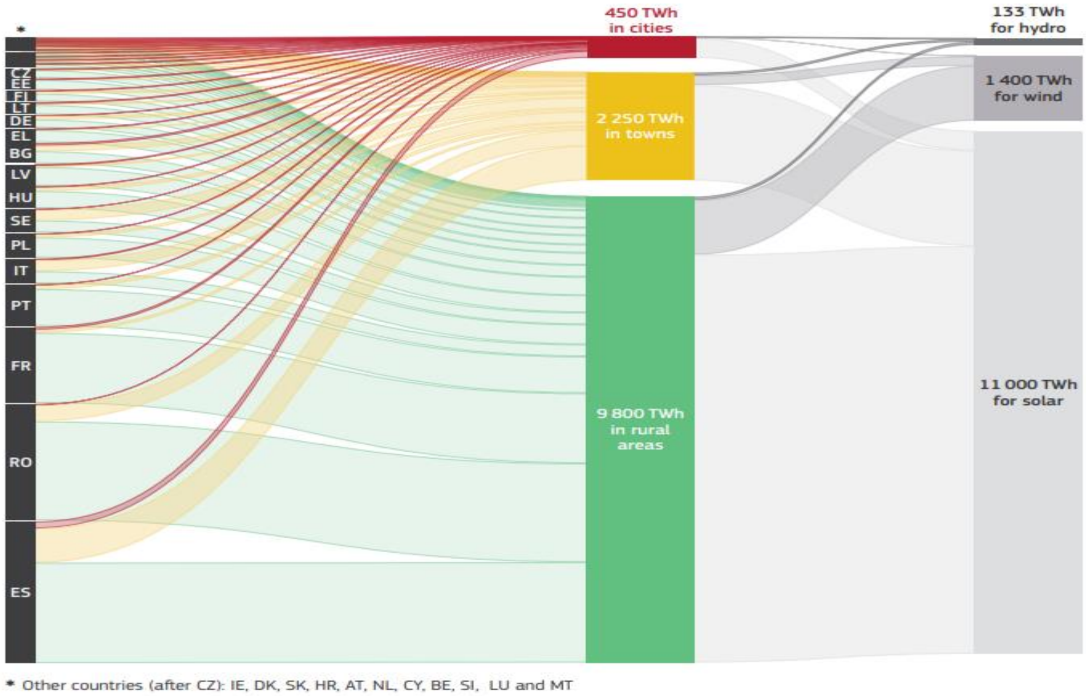
Romania was the only other Member State that registered an increase in the rate of young people living in rural areas. In contrast, the share of young people living in cities who were neither in employment nor in education and training decreased in all Member States.

An essential part of infrastructure delivery is related to ecological and climate resilience and is linked to renewable energy. The green energy transition allows rural areas to benefit from their natural resources. Vision for the Rural Areas (EC, 2021) supports the ‘resilient rural areas’ pillar. The EU will financially support building renovation and contribute to the European Green Deal’s objectives related to renewable energy production.

A study published by Perpiña Castillo et al., 2024 assesses renewable energy in the EU's rural areas with a special focus on solar and onshore wind and hydropower energy. According to the report, solar photovoltaic systems in rural areas provide 136TWh a year but have the potential to generate 60 times more. Rural areas generate 280TWh annually through onshore wind but could produce 1200TWh/year. Hydropower in rural areas ensures 280TWh a year but could generate 25% more.

The EU supports rural areas as essential for achieving Green Pact goals. Renewable energy communities are identified as an essential component of the green transition in the clean energy package. Therefore, the Rural Energy Community Advisory Hub is an initiative to accelerate energy communities in rural areas.

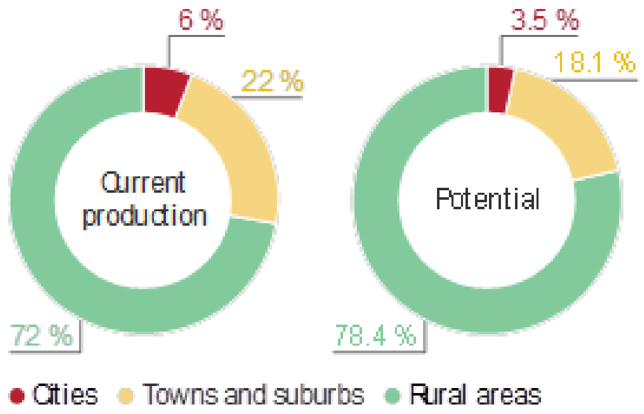
Figure 6-16: Contribution to the EU's annual estimated untapped technical potential production in cities, towns and rural areas



Source: Perpiña Castillo et al., 2024

The report presented by Perpiña Castillo et al., 2024 outlines that the EU has untapped potential for renewable energy around 12500TWh/year. The study shows that 72% of the electricity generated in the EU from renewable sources is produced in rural areas. Despite their already significant contribution to the production of renewable energy, rural areas cover 78% of the total EU's potential, highlighting their central role in contributing to the goals related to climate change and green transformation.

Figure 6-17: Renewable energy production and potential by degree of urbanisation



Source: Perpiña Castillo et al., 2024

However, the production of energy from renewable source should include concerns related to sustainability, balance between a food and energy production. (Sacchelli et al., 2016; Dias et al., 2019). In this regards, land use, environment, agriculture, accessibility and climate conditions are key factors renewable energy infrastructures development.

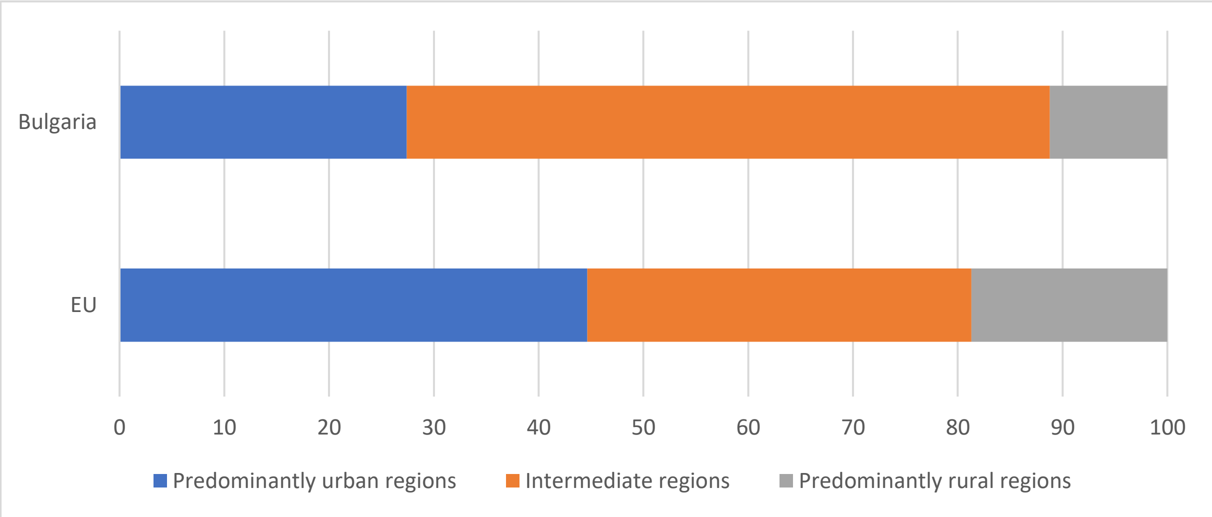
However, producing energy from renewable sources should include sustainability concerns and the balance between food and energy production. (Sacchelli et al., 2016; Dias et al., 2019). In this regard, land use, environment, agriculture, accessibility and climate conditions are key factors in renewable energy infrastructure development.

European Union rural regions are diverse and have specific features that could lead to implementing different technologies to achieve the highest technical potential; according to Perpiña Castillo et al., 2024 in rural areas, almost 80 % of the suitable land for energy projects available is located in rural areas. Therefore, local conditions should also be assessed, and the role of local communities should be vital. The authorities and other stakeholders can integrate key policies related to agricultural policy, rural development and farm modernisation.

Prosperous rural areas are the third priority linked to the Long term vision for rural areas of the EU.

Employment in an economy is an essential factor for national economic development. In 2019, the highest numbers were employed in predominantly urban regions 45 % of the total, followed by intermediate regions 37 % and predominantly rural regions 19%. In Bulgaria, intermediate areas account for 61% of the employed, while 11% are in rural regions.

Figure 6-18: Employment by urban–rural typology, 2019 (share of total employment %)



Source: Eurostat, 2022

While predominantly urban regions accounted for more than half of the GDP in 2019, their employment share is lower, showing higher labour productivity. On the other hand, intermediate regions and predominantly rural regions had higher shares of employment and lower labour productivity. In Bulgaria, the trends are similar.

In Bulgarian rural regions, 30% of the working force is employed in agriculture and forestry compared to 11% in the EU average. The data shows that agriculture is the main source of income in rural territories. Therefore, policymakers should explore the potential of agriculture to maintain social, economic, and ecological resilience.

The EU supports infrastructure and service delivery. Cohesion Policy is a significant source of support for rural areas - the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Social Fund Plus (ESF+) could ensure investments in businesses and infrastructure in rural areas. Cohesion Policy provides a framework for integrated territorial development with multi-level governance.

Member States can benefit from the CAP Strategic Plans and the Cohesion policy programs for the 2021-2027. Recovery and Resilience Facility, InvestEU, and the European Investment Bank should cover the investment gaps in rural areas.

Different measures are directed to increase rural areas' climate and social resilience. In order to contribute to the resilient rural areas, the European Commission proposed support for rural municipalities in energy transition and combating climate change. The Covenant of Mayors for Energy and Climate Change is the world's largest network of municipalities. Restoration and conservation of wetlands and peatlands provide climate benefits, such as emission reductions, while contributing to better water management and maintaining biodiversity.

This transition can be achieved by implementing territorial and local approaches. The EU provides support under the Just Transition Fund, the Farm-to-Fork Strategy, a new EU carbon farming initiative, CAP, the Cohesion Policy and the LIFE program.

The proposed EU rural vision mission of "Soil health and food" related to Horizon Europe is directed towards tackling soil challenges in rural areas and building connections between rural and urban practices.

The CAP is one of the key funding opportunities for rural areas, as it ensures resilient and diversified agriculture, presents climate action and strengthens the socio-economic development of rural areas.

6.3. Community Engagement and Empowerment

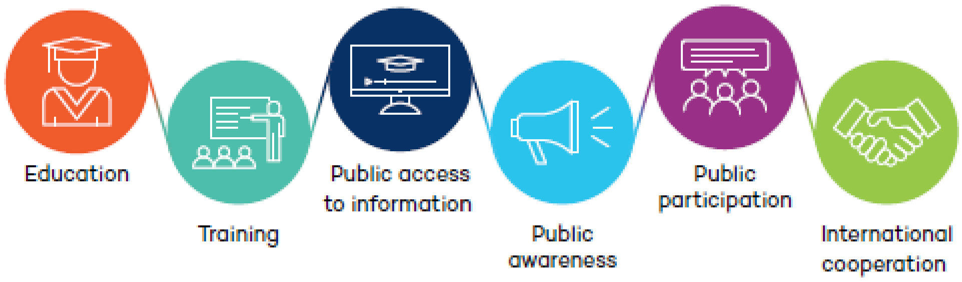
Climate resilience and infrastructure building in rural areas cannot be achieved without bringing rural communities into the discussions. Advancing priorities requires communication and active public engagement. The lack of these can lead to the risk that people will ignore them or be against implementing climate resilience and adaptation policies and strategies.

The government should coordinate its actions with NGOs and other organisations, address the gap, and involve the wider community. The Paris Agreement, through

Article 12 on Action for Empowerment (ACE), outlined that there is "an obligation for meaningful action on education, training, public awareness, public access to information, public participation, and international cooperation" (United Nations, 2015).

Climate change effects are visible, and resilience and adaptation are necessary. Adaptation and resilience require overcoming structural challenges like poverty and inequality. Receiving public support and engaging rural communities are crucial for actions related to climate change.

Figure 6-19: Six interlinked elements of Action for Climate Empowerment



Source: UNESCO, 2016.

The UNFCCC, in Article 6, recognises the importance of "education, training and public awareness" to enable global climate action (UNFCCC, 1992). These areas are defined as Action for Climate Empowerment (ACE).

Including climate change impacts in curriculums at all levels could be essential in empowering people. Building skills and capacity with the help of training is a critical element of achieving resilience. Training programs based on gaining knowledge for adaptation and climate resilience are also important.

Community empowerment and engagement are crucial for local climate change vulnerabilities and could facilitate better resilience (Dumaru, 2019).

The EU provides different measures and supports rural engagement and empowerment. The 2023-2027 CAP supports rural areas under the financial aid of the Rural Development strategic plans. The funding allocated to rural development is EUR 24.6 bn., or 8% of the total CAP financial is directed to rural areas beyond agriculture.

These instruments are linked to the Long-term rural vision. As the President of the European Commission, Ursula von der Leyen has said, rural areas play an essential role in addressing social and environmental challenges. One of the horizontal actions in the long-term vision for rural areas is the Rural Pact, which encourages actions from all stakeholders. In 2022, the European Commission introduced the Rural Pact. It includes a framework for cooperation between authorities, society, businesses, and academia at all levels.

Objectives of the Rural Pact are: (1) Amplifying rural voices and bringing them higher on the political agenda (2) Structuring and enabling networking, collaboration, and mutual learning (3) Encouraging and monitoring voluntary commitments to act for the vision.

Rural development cannot be achieved without the strong involvement of rural communities. Policies design and implementation are more successful through the application of the bottom approach. The involvement and engagement have to be regular and provide participation of the stakeholders.

The CAP LEADER tool is essential to the empowerment of rural communities and is applied to overcome rural needs in different areas. LEADER was first introduced as a Community Initiative in 1991. The approach was a part of the rural development policy in 2007-2013, covering 2416 rural territories in the EU. According to EC, 2023, the budget support was 5% in EU-15 and 2.5% in EU-12. For 2014-2020, the LEADER approach was extended to Community-Led Local Development (CLLD) in rural, fisheries, and urban areas. The National Rural Networks and the European Network for Rural Development provide support and services for LAGs.

LEADER's idea is to engage resources and people in local organisations, empowering them to help in the future development of rural areas by establishing a Local Action Group (LAG). LEADER is directed towards all local actors and aims to integrate different stakeholder's ideas, resources and energy.

LEADER is provided through Rural Development Programmes (Measure 19), and the main goal is the local development of rural areas. However, it additionally helps in achieving other objectives. LEADER/CLLD also contributes to the EU2020

Strategy's objective for smart, sustainable and inclusive growth.

The CLLD principles, as defined in Article 32 (2) of the Common Provisions Regulation (EU) No 1303/20132, are as follows: A focus on specific sub-regional areas and territories; A public-private partnership; an area-based strategy; Multisector local development strategy; Innovation; Networking; Cooperation among local actors and among LAGs from different territories.

Article 34(c) of the horizontal regulation for ESI Funds specifies the **tasks** of the Local Action Groups (figure 6-20):

Figure 6-20: Tasks of the LAGs

- building the capacity of local actors to develop and implement operations including fostering their projectmanagement capabilities
- drawing up a non-discriminatory and transparent selection procedure and objective criteria for the selection
- ensuring coherence with the community-led local development strategy when selecting operations, by prioritising those operations according to their contribution to meeting that strategy's objectives and targets
- preparing and publishing calls for proposals or an ongoing project submission procedure, including definingselection criteria;
- receiving and assessing applications for support;
- selecting operations and fixing the amount of support and, where relevant, presenting the proposals to thebody responsible for final verification of eligibility before approval;
- monitoring the implementation of the community-led local development strategy and the operationssupported and carrying out specific evaluation activities linked to that strategy.

Source: ESI and EC, 2023

According to the framework by the European Evaluation Helpdesk for Rural Development in the Guidelines for evaluating LEADER, the added value of LEADER approach is related to three elements:

- Improved social capital
- Improved governance
- Enhanced results and impacts of projects

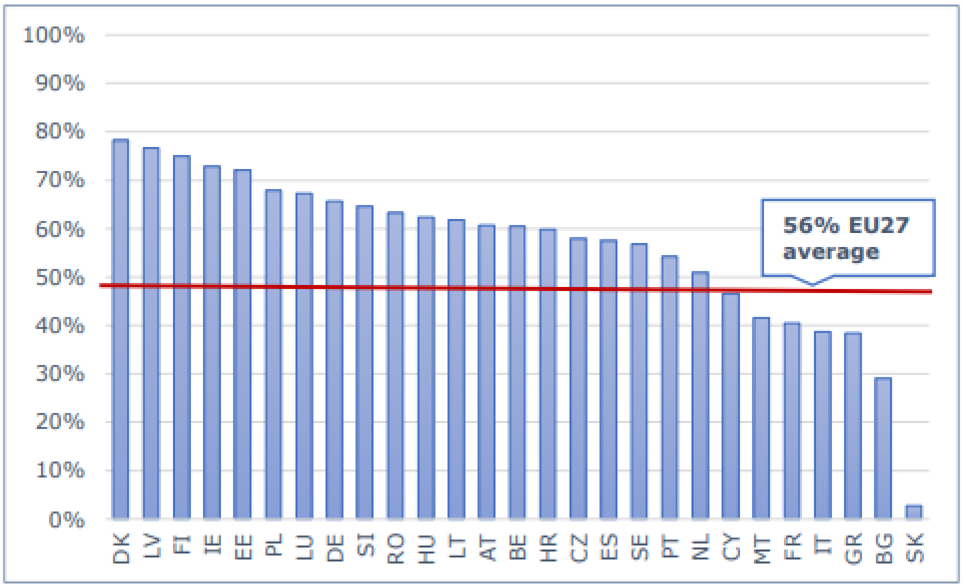
Community-led local development as a policy instrument boosts local potential and empowers people in rural areas. CLLD is related to projects based on local partnerships and area-based, multi-sector local development strategies.

Figure 6-21: CLLD in the architecture of the 2014-2020 programming period

Source: European Evaluation Helpdesk for Rural Development (2017) Guidelines: Evaluation of LEADER/CLLD

During 2014-2020, under Pillar II RDP Measure 19-LEADER, 9.7 billion EUR was concentrated at the EU27 level. Considering the 2021-2022 extension, the total financial support for 2014-2022 is around 12 billion EUR.

Figure 6-22: Financial execution M19-LEADER, 2015-2022 (EU-27) (total public expenditure % of total financial aid)



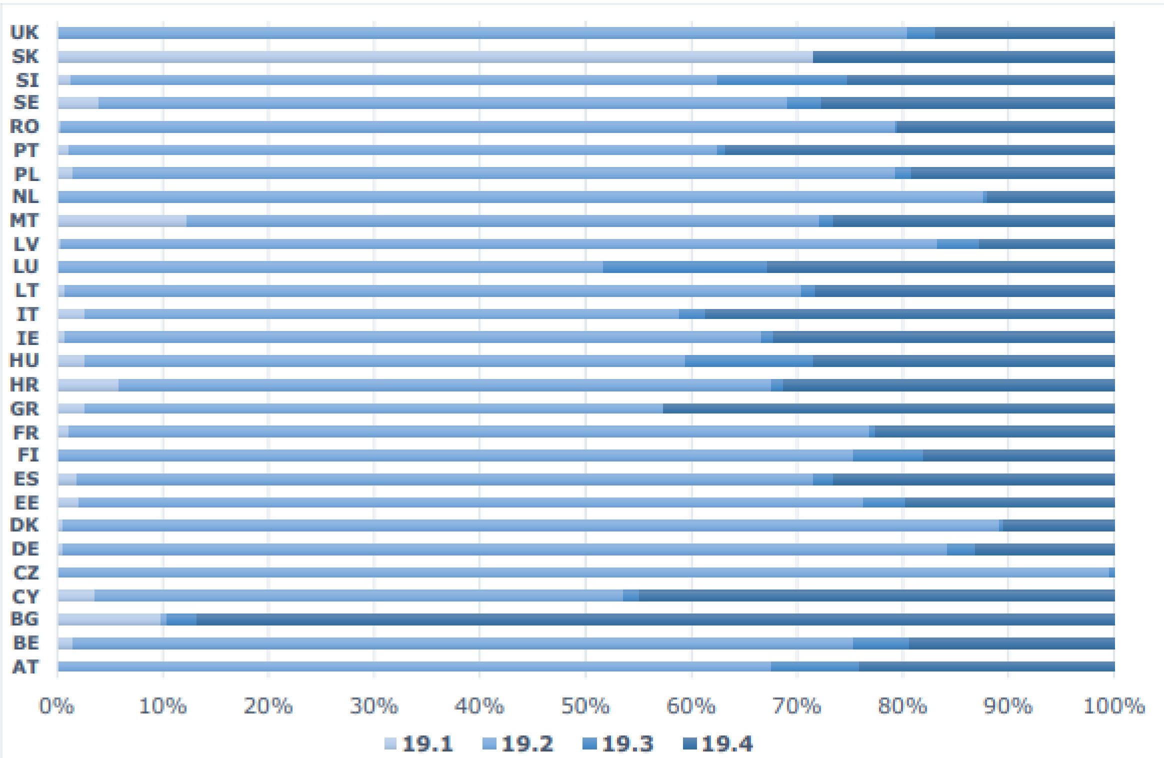
Source: DG AGRI - ESIF Finance Implementation, 2014-2022

LEADER allocated under 6 % of EAFRD financial resources at the EU level. By the end of 2022, M19 reached 56 % at the EU27 average level.

Most member states allocated more than the EU average, with the highest share registered in Denmark, Latvia, Finland, Ireland and Estonia. It can be concluded that Baltic countries play a central role. The lowest shares are recorded in Bulgaria and Slovakia, with indicators considerably lower than the average for EU-27.

According to DG-AGRI data, LAGs started projects and spending between 2018 and 2019. Only a few countries (Denmark, German federal states, Romania, and Spain) implemented LEADER earlier than 2018.

Figure 6-23: Rate of financial execution by sub-measure, in %, 2015-2021



Source: DG AGRI - ESIF Finance Implementation, 2014-2022

Based on DG AGRI data, the total public expenditure for management and animation (19.4) is 22 % of the total M19 expenditure. In some Member States, the ratio is higher than the average for - Bulgaria, Greece, Italy, and Cyprus. In these countries, the trend can be explained by the low spending levels on sub-measure 19.2.

The financial support of 11.96 billion EUR is concentrated in 2783 LAGs. The total population covered by local strategies is nearly 172 million people for EU27.

The highest number of LAGs is registered in France and Germany. In addition, the total public expenditure is concentrated in Germany.

Table 6-2. LEADER financial and physical execution up to 31/12/2021

Member States	Number of LAGs	Total public expenditure EUR	Number jobs created	Rural population covered by LAGs	% of rural population benefiting from new/improved service
AT	77	166 340 300	2114	4 672 784	94.4
BE	32	38 081 431	389	2 959 817	64.2
BG	64	20 233 778	0	1 646 588	46.1
CY	4	4 397 849	48	106 723	0
CZ	178	92 380 096	1002	6 331 635	0
DE	321	1 164 006 117	2173	30 359 352	35.7
DK	26	82 457 937	1032	2 347 169	5.6
EE	26	75 463 451	1453	499 457	0
ES	253	644 034 941	7423	11 947 950	15
FI	55	244 924 226	3221	2 722 463	88
FR	335	457 329 248	1832	26085157	2
GR	50	118 332 239	867	4150184	11.2
HR	54	39114429	71	2446694	1.4
HU	190	112 826 445	405	5365000	40.2
IE	29	178 910 446	1397	3082317	61.1
IT	200	377 850 452	1649	18956210	0
LT	49	52 402 306	848	1075726	10.3
LU	5	6956581	29	177925	29
LV	35	68 074 307	234	964909	0
MT	3	2 785 295	3	283284	3.6
NL	20	34 534 099	227	3391728	0
PL	291	559 741 614	12240	20126294	0
PT	56	134 564 879	2862	5029295	14.1
RO	239	426 252 808	3660	8726539	0
SE	44	112 264 377	662	4261701	40.6
SI	27	30 249 422	66	1420504	27.7
SK	110	1 539 061	0	2837385	0
EU-27	2783	5 246 048 133	45907	171 974 790	9.1

Source: Annual Implementation Reports (AIR), 2014-2021

Austria has recorded the highest share of the rural population benefiting from new or improved services, while Poland has created the most significant number of jobs creation.

DG AGRI (EC, 2023) conducted a study related to the Evaluation support study of the costs and benefits of implementing LEADER. The study shows that LEADER reduced the time beneficiaries spend on administrative tasks because of the support from LAGs. The implementation of LEADER established multi-level governance. The survey indicates that LAGs have improved social capital in the organization, in LEADER areas, and among the Member States.

According to DG AGRI analysis, LEADER projects are less expensive than similar projects under Pillar 2 and more sustainable based on the ratio of expenditure/jobs created. LAG assistance and training improved the performance of local enterprises.

LEADER effectively boosts economic activity in rural areas by establishing new enterprises and infrastructures, increasing the number of agricultural holdings with diversified activities, and helping support projects that would be much more difficult to develop.

Despite the small scale of the projects, LEADER has impacted small firms, the tourism sector, rural actions, improved services and infrastructures, and the development of rural livelihoods.

Engaging and empowering rural institutions, stakeholders, and communities in multi-level governance is essential for integrating local knowledge and meeting challenges and needs at the local level. In the EU, after 2000, there was a process of decentralization and measures directed closer to local communities based on bottom-up and participatory approaches, such as LEADER and rural networking. European Communication on the Long-term Vision for Rural Areas and the introduction of the Rural Pact as a new instrument are the next steps in this direction. Based on the survey of SHERPA (Moodie et.al., 2023), the Cohesion Policy supports rural areas in the following directions : (1) Preserving and protecting the environment and promoting resource efficiency; (2) Promoting sustainable transport and removing bottlenecks in key network infrastructures; (3) Enhancing the competitiveness of small and medium-sized enterprises.

Bottom-up approaches are essential for balanced territorial development in rural areas. (Matti et al., 2022). Authorities, enterprises, and community groups working together can support activities that help overcome local challenges, especially those related to climate change and maintaining biodiversity. LEADER and LAGs can define the issues at a local level. LEADER's main characteristics include local actors' empowerment to tackle challenges.

In addition, networking was presented in 2007 with National Rural Networks and the European Network for Rural Development, known as the CAP Support Network. These networks linked stakeholders at the EU level. They are factors of change, stimulating local capacity to overcome territorial challenges (ENRD, 2022).

The long-term vision for rural areas and the Rural Action Plan highlighted the importance of rural engagement and empowerment. (European Commission, 2021c). Rural Pact (European Commission, 2022) is directed at rural communities' needs and maximizing the collective efforts to create stronger, prosperous, resilient, and connected rural areas. This instrument for engagement intends for rural stakeholders from different levels and organizations to interact, stimulating synergies, cooperation and integration.

The Rural Pact will ensure a bridge between the multiple levels of governance and stimulate collaboration. The European Commission states territorial governance is vital for empowering rural areas (Schmitt, Van Well, 2016).

The Long-term vision for rural areas outlines that "empowered communities can determine their development path. This requires an appropriate governance system, promoting subsidiarity, connected, and coordinated across the different levels." (EC, 2021c)

Slätmo et al. (2021) suggest that place-based approaches aim to strengthen the resilience of rural areas to global challenges. Rural strategies applying collaborative approaches provide incentives for more sustainable rural development. Miller et al. (2022) state that the local focus on policies and strategies empowers local actors and communities through flexible measures designed to address local needs in different areas.

The Commission highlights that "maintaining and improving public transport services and connections, as well as deepening digital infrastructures, are essential to ensure better-connected EU rural areas." (EC, n.d.). Two flagship initiatives have been formed on the topic: improving mobility and digital infrastructure.

Digitalization offers opportunities for the revitalization and resilience of rural areas but is dependent on digital and broadband services. The Commission (EC, 2021c) noted that "digital infrastructure is an essential enabler for rural areas to contribute to and make the most of the digital transition." The development of digital infrastructure in rural areas will improve access to essential services, emergency assistance, waste management solutions, smart and renewable energy, and resource efficiency. The improved digital connectivity encourages younger people to remain in rural areas.

Better possibilities for rural areas are linked to the involvement of local communities. The Commission indicated proactive engagement of rural citizens. "Rural areas should be home to empowered and vibrant local communities. Enabling all individuals to take an active part in policy and decision-making processes, involving a broad range of stakeholders and networks as well as all levels of governance, is key to developing tailor-made, place-based and integrated policy solutions and investments." (EC, 2021c).

The awareness of younger people of EU goals, especially those related to climate and environmental issues, is essential for the future of sustainable local development.

The EC pointed out the significant role of rural hubs as a platform for local stakeholders to be part of the policymaking processes. The EU has been making efforts to empower local communities through the development of LAGs as part of the LEADER and actions that bring stakeholders together to design the EU rural strategies.

The EC outlined that 'there is a strong need to foster and support capacity building, engaging local actors and easing access to knowledge and solutions to unlock the innovation potential, that in rural areas is often collective.' (EC, 2021c).

Empowering and engaging the regional and local actors is vital for boosting the opportunities for revitalization, green transformation and digitalization. The new knowledge, best practices and shared experience of the local community can help in stimulating sustainable solutions in combating climate change and implementation of strategies and policies for adaption and resilience.

6.4 Public Participation

"The local level is the bedrock of adaptation, so EU support must help increase local resilience."

The new EU Strategy on Adaptation to Climate Change, 2021

6.4.1. Public participation theory and practice

Adaption to climate change at the local level is a multifaceted challenge often seen as a responsibility of national and/or local governments (Whitmarsh et al., 2013). However, the public bodies' adaptation efforts need to be complemented by individuals, businesses and community organisations by both adapting their private spaces and by avoiding contribution to maladaptation in public spaces (Uittenbrroek et al., 2019).

Community engagement and empowerment concept and practice is situated at the top end of the diversity of public participation 'ladders' (Table 1), which have been conceptualised since 1969 and Arnstein's seminal paper addressing the disputes over "citizen participation" and "maximum feasible involvement" in public decision making (Arnstein, 1969). While contexts, conditions and concepts have evolved since 1969, the key elements in Arnstein's paper are ever more relevant in the context of governance of the adaptation to climate change.

Citizen empowerment is an inseparable part of the democratic process irrespective of whether they are disadvantaged or privileged citizens, or urban or rural, in that matter.

Citizen and community engagement is a deliberative process irrespective of its initiation form: top-down (official public requirement) or bottom-up (grassroots initiative).

Citizen and community engagement and empowerment ensure that the participants have the "real power needed to affect the outcome of the process" as opposed to "the empty ritual of participation" (Arnstein, 1969).

There is mutual co-dependence of public bodies / local municipalities and citizens / communities for participation as both have to be willing to participate to achieve the benefits from participatory processes (Uittenbrroek et al., 2019).

The type and content of public participation is highly influenced by the policy problem that has to be addressed and the degree of trust and shared values in the community (Hurlbert and Gupta, 2015). Their public participation “ladder” is split by the nature of the policy problem (unstructured, moderately structured or structured), the degree of trust (low-high continuum) and the level of participation (low-high continuum) in the respective community.

Hurlbert and Gupta (2015) posit that adaptation to climate change is an unstructured policy problem because it lacks consensus on science and values; therefore, they claim that public participation will be mostly on discussing different perspectives and values, and that consensus may be difficult to reach. However, they acknowledge that some aspects of the climate adaptation problems may be more structured or moderately structured. The examples they use are related to municipal infrastructure against floods for which there is sound knowledge, i.e. structured problem and the adaptive capacity of rural producers against droughts (both problems are valid for rural areas in Bulgaria too).

Table 6-3. Public participation “ladders”

8-step ladder of citizen participation	
Citizen control	Degrees of citizen power
Delegated power	
Partnership	
Placatio	Degree

The spectrum of public participation
Empower
Collaborate
Involve

The split ladder of participation [unstructured – structured] problem	
	Self management
Consensus may be out of reach	Achieve consensus
Debate on diff. values	Seek consensus
Discuss	Increasing

n	s of tokenism
Consultation	
Informing	
Therapy	Non-participation
Manipulation	
Source: Arnstein, 1969	

Consult
Inform
Source: IAP2, 2014

diff. perspectives	citizen power
Consult, test ideas, seek advice	
Information	
Placation	Educate
Therapy	Delegated power
Manipulation	Take decision
Source: Hurlbert& Gupta, 2015	

Source: Compilation by Y.Kazakova-Mateva

Some of the benefits of public participation and community empowerment for climate adaptation (Nickel &Schnurr, 2024; Samaddar et al., 2021; Uittenbrroek et al., 2019) from local governance perspective include:

Access to and integration of knowledge about local places and challenges can enable the co-design and co-creation of more effective climate adaptation that acknowledge the social and cultural context, needs and barriers.

The meaningful engagement provides for greater ownership and participation in adaptation action by citizens and communities.

The empowerment of the disadvantaged groups for climate adaptation action leads to more equitable and just solutions, building community connections and positivism, which in turn can reduce eco-anxiety.

The barriers to effective climate change adaptation (Khatibi et al., 2021; Moser & Pike, 2015) relate to

The lack of motivation for participation and difficulties of organising a representative and accountable citizen's group.

Resistance to power redistribution and rigidity of traditional bureaucratic systems.

Financial issues, inadequacies of socioeconomic infrastructures and knowledge base.

Time consuming. Hassenforder hypothesise that “a minimum engagement period of two years, with regular events and local coordination, is more likely to lead to the achievement of the desired participatory objectives” (Hassenforder et al., 2015).

6.4.2. The policy framework of public participation for adaptation to climate change

The theoretical frameworks for both organising and evaluating public participation have mushroomed particularly after the 1992 Earth Summit. The Rio Declaration from the UN Conference on Environment and Development adopted 27 principles including the explicit goal of citizen participation and engagement in environmental action and policy.

Box 1. Rio Declaration on Environment and Development

…. “With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

…….

Principle 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.”

…

Source: https://www.cbd.int/doc/ref/rio-declaration.shtml

The right for public participation, access to information and community engagement is included in all environmental and climate conventions and agreements since the Rio Declaration (Few at al., 2007).

Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) requires from the nation-states to “promote and facilitate at the national, subregional and regional levels … the public access to information on climate change and its effects, and the public participation in addressing climate change and its effects and developing adequate responses”. Several environmental non-governmental organisations referred to Article 6 as the “Action for Climate Empowerment” article, while its formal title is “Education, Training and Public Awareness” (CIEL, NatureCode, FOE, TAI, 2016).

The European Climate Law (EU 2021/Reg.1119) underlines the “powerful role” of citizens and communities in driving the transformation towards climate neutrality, thus encouraging the strong public and social engagement on climate action at all levels – national, regional and local. The European Commission aims to empower the social partners, academia, the business community, citizens and civil society at all levels to take action forward to a climate-neutral and climate-resilient society (Article 9). The EU Climate Law requires from member states to enhance their adaptive capacity, strengthen resilience and reduce vulnerability as well as maximize the co-benefits with other policies and legislation at both national and regional levels. Local governments thus became increasing important actor to prepare and act on climate adaptation (Kazakova-Mateva, 2024).

The New Climate Adaptation Strategy in the EU specifies that adaptation awareness and planning needs to spread to every single local authority, company and household; and adaptation implementation needs to be well underway for those most affected, which requires local adaptation action. In order to engage and empower the citizens to take direct adaptation action, the Commission will use climate initiatives to inform, inspire and connect.

6.4.3. Public participation in Bulgarian climate legislation

The Bulgarian Law on Limiting Climate Change, adopted in 2014, covers predominantly the mitigation aspects of climate change policy and thus regulates only the right to access to information. Climate change adaptation is address in the National Climate Adaptation Strategy. The strategy refers to the public participation procedure established by the framework Law on the Environment in Bulgaria.

The Council of Ministers also adopted Standards for Public consultations in 2009. They comprise six steps: (1) preliminary planning for the consultations, (2) identification of the stakeholders, (3) preparation of the documents for the consultation, (4) selection and implementation of consultation approach, (5) response analysis and integration in the policy document, and (6) providing feedback to the stakeholders.

As the name of the document suggests the concept of public participation in Bulgarian public bodies focuses at the mid-section of the “ladders” – consult, preventing the benefits from the higher participation levels of engagement and empowerment.

6.4.4. Public participation in the integrated municipal development plans

The integrated development plans of a municipality (PIRO) for the period 2021-2027 combine within a single document the elements of the municipal development plans and the integrated urban regeneration and development plans, which were in force for the period 2014-2020. The Methodological Guidelines for their development are based on Article 17 of the Regional Development Act and the new approaches of regional policy implementation and strategic planning of regional and spatial development. Thus, they aim to integrate in one document all strategic plans for each municipality, including climate mitigation and adaptation actions. Additionally, the PIROs should be developed in line with the objectives of the EU Cohesion Policy for the period 2021-2027 and contribute to the maximum extent to Policy Objective 5 "A

Europe closer to citizens by promoting the sustainable and integrated development of urban, rural and coastal areas and local initiatives".

A key requirement for PIROs 2021-2027 is the implementation of an integrated development approach, i.e. an approach of close coordination of different public policies based on local specificities. PIROs should ensure integrated environmental protection, including climate change mitigation and adaptation, and environmental issues should be reflected and addressed at the earliest possible stage in the strategic planning process, i.e. during the situation analysis, so that they are appropriately embedded in the defined strategic objectives, priorities and measures.

The public participation requirements in the Methodological Guidelines for the development and implementation of PIROs are very detailed and seems to reach to higher stages in the public participation “ladder”:

The main objective in developing the PIRO is to ensure the application of the principle of partnership and cooperation.

Identify the stakeholders and participants in the process of forming and implementing the local policy for integrated sustainable development, including interested authorities and organizations, economic and social partners, individuals and representatives of legal entities related to the development of the municipality.

It is mandatory to ensure the participation of the relevant organizations representing civil society, environmental partners and organizations responsible for promoting social inclusion, fundamental rights, and the rights of people with disabilities, gender equality and non-discrimination, operating in the territory of the municipality.

Transparency and information about the expected results and benefits for the local community as a whole must be ensured,

The public has to be motivated to participate actively in the process of preparing and implementing the PIRO.

It is important that stakeholders are included both at the stage of developing and adopting the PIRO, and in the implementation of the goals and priorities set out in the plan.

The municipality has to ensure the necessary publicity and to take all possible measures to maintain the interest and motivation for the participation of local communities in determining and implementing the goals and priorities of the document.

6.4.5. Climate change adaptation in the integrated municipal development plans of rural municipalities

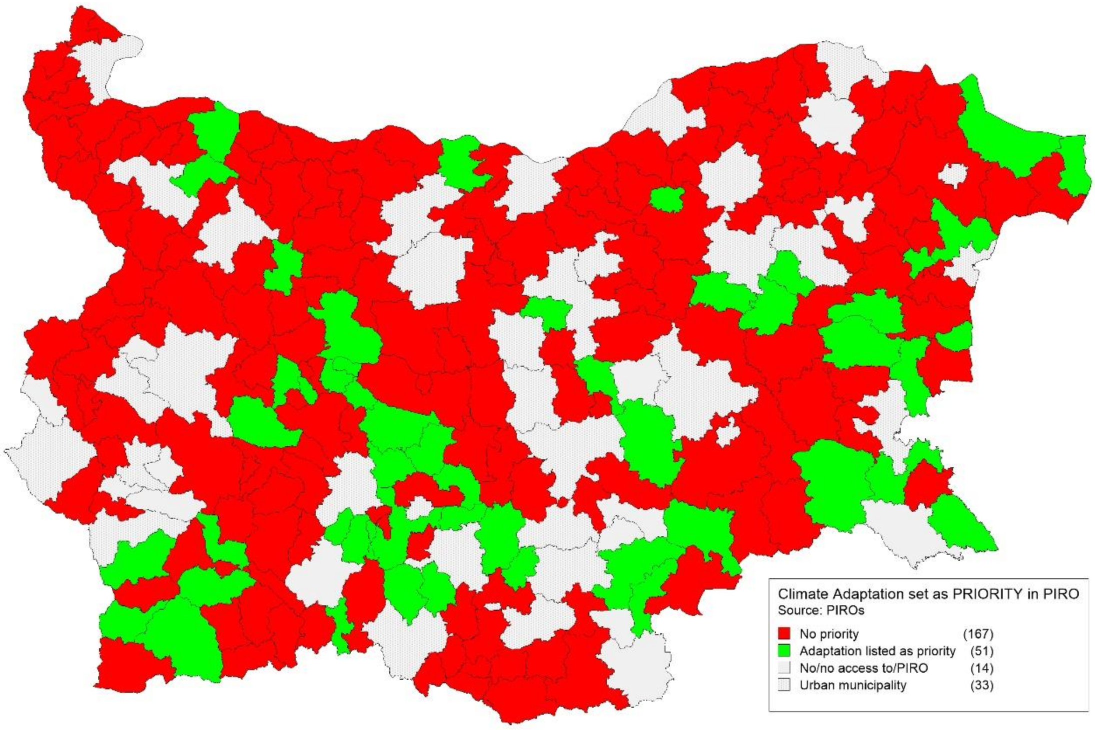
Climate change mitigation and adaptation are one of many local strategic and development issues that need to be addressed in the integrated municipal development plans (PIRO). Our analysis aims to assess how many of the 232 rural municipalities in Bulgaria have prioritized climate change adaptation. For this, we have developed a scoring indicator for assessing the priority strength (Table 6-4):

Table 6-4. Criteria and assessment scores for the prioritization of climate adaptation

Criteria	Assessment scores
Adaptation is recognised as a priority or strategic objective in PIRO	[2] Clear, top priority [1] Listed in overall environmental priority [0] No priority given

Source: Kazakova-Mateva, 2024

Figure 6-24. Rural municipalities with climate adaptation priority (in green)



Source: Kazakova-Mateva, 2024

The results of the analysis reveal that 218 rural municipalities have PIROs and 14 have not yet adopted PIRO or it is not available in the public (online) space.

No rural municipality identified climate adaptation as a clear, top priority. The information in PIRO documents does not allow assessing whether it was proposed at some stage of the PIRO development and consultation. One can only see the result assuming there was effective public participation process based on the guidance from the Methodological Guidelines.

The Green municipalities (Figure 6-24) are the rural municipalities, which have listed climate adaptation among their overall environmental priorities. They cover 51 municipalities and are predominantly located in southern Bulgaria. These municipalities (except three of them) all achieved score "Good" for adaptation readiness (Kazakova-Mateva, 2024) meaning that alongside prioritizing adaptation among their environmental priorities have planned both technical and soft measures as well as allocated budgets and responsibilities for climate adaptation action.

The Red municipalities (Figure 6-24), the majority of rural municipalities (167 or 72% of the rural municipalities) have not listed adaptation to climate change among their priorities in the 2021-2027 integrated development plans. The result is not altogether negative since 92 rural municipalities (55% of the 167) have identified measures and allocated budgets to address climate adaptation needs; just they are not prioritized and thus the funding is most likely insufficient to address the adaptation needs. The biggest concern is for the 75 municipalities that have neither prioritized nor budgeted for climate adaptation needs in their local territory.

Overall, public participation on climate adaptation action in the rural municipalities in Bulgaria is in its infant steps. More training and capacity building is required for both the staff at the rural municipal administrations and rural decision makers as well as the citizens and stakeholders to be able to participate in an efficient and effective manner.

Chapter 7: Climate Adaptive Design Case Study

This chapter presents a detailed case study on climate adaptive design in rural Bulgaria, focusing specifically on heat risks identified through the comprehensive analysis of climate hazards in the preceding chapters. The selected sites—Samokov, Rayovo, Shirokidol, Relovo, Dragushinovo, and Dospei—represent diverse rural settings that are particularly vulnerable to heat-related climate risks. These sites were chosen based on their distinct geographical, climatic, and socio-economic characteristics, which collectively highlight the multifaceted challenges posed by rising temperatures and changing precipitation patterns. The study aims to provide context-specific adaptation strategies to enhance resilience and mitigate the impacts of heat risks in these rural areas.

7.1 Site Description

The sites selected for this study are located in the Samokov region of Bulgaria, a diverse area with significant agricultural, industrial, and touristic activities. The detailed site descriptions provide the necessary context for understanding the specific challenges and opportunities for climate adaptation in each location.

(1) Samokov

Geographical Location: Samokov is a town in the southwest plain region of Bulgaria, situated in the Sofia District. The town covers an area of 6.5 square kilometers, with a residential area of approximately 5 square kilometers as measured by Google Earth. It is located at a latitude of 42° 20′ N and a longitude of 23° 33′ E, with an elevation ranging from 881 to 1332 meters above sea level. Samokov is approximately 65 kilometers from the capital, Sofia.

Population: As of 2022, Samokov has a population of 11,957 people.

Figure 7-1 Samokov Satellite Image

Source: Google Earth

Economic Activities: Samokov is a significant agricultural and industrial centre in Bulgaria. It is renowned as the largest potato-producing region in the country. The town's economy is primarily driven by industrial activities, including wool, cotton, and flax textile industries, wood processing, and electrical machinery. Tourism also plays a crucial role, with the town being a gateway to several ski resorts, including Borovets, and cultural landmarks such as the Rila Monastery.

Climate Conditions: Samokov experiences a humid temperate continental climate, characterized by an average annual temperature of approximately 9° C and an annual precipitation of around 100 mm. Summers are hot and dry, while winters are relatively wet and cold, with substantial snowfall that supports winter sports.

(2) Rayovo

Geographical Location: Rayovo is a village located in the Samokov municipality, within the Sofia District. The village covers a total area of 38.901 square kilometers, with a residential area of approximately 1.46 square kilometers. It is situated at a latitude of 42.3829994 and a longitude of 23.5000000, with an elevation ranging from 700 to 999 meters. Rayovo is approximately 36.572 kilometers from Sofia by air.

Population: As of March 15, 2024, Rayovo has a population of 655 people.

Economic Activities: Rayovo's economy is primarily based on agriculture and forestry. The village benefits from its proximity to the Samokov municipality and the surrounding natural environment, which supports both logging and mountain tourism. The village is known for its high altitude, making it a suitable location for summer retreats and winter sports.

Figure 7-2 Rayovo Satellite Image

Source: Google Earth

Cultural Heritage: Rayovo is home to a 17th-century Eastern Orthodox church, "St. Nicholas," reflecting the village's rich cultural and religious history. All residents of Rayovo are Eastern Orthodox Christians.

(3) Shirokidol

Geographical Location: Shirokidol is a small village located in the Samokov municipality. It covers an area of 0.871 square kilometers and has a population of 699 people. The village is situated at a latitude of 42° 24′ N and a longitude of 23° 31′ E, with an elevation of 956 meters (3,136 feet).

Population Density: The population density of Shirokidol is approximately 2,079 people per square mile.

Figure 7-3 Shirokidol Satellite Image

Source: Google Earth

Economic Activities: Shirokidol's economy is primarily agricultural, with a focus on small-scale farming and livestock rearing. The village benefits from its fertile soil and favorable climate, which support the cultivation of various crops and the raising of dairy cattle.

Cultural Heritage: Shirokidol retains a strong sense of traditional Bulgarian culture, evident in its architecture and community practices. The village's close-knit community and traditional lifestyle contribute to its unique character.

(4) Relovo

Geographical Location: Relovo is a village in the Samokov municipality, covering a total area of 971,428 square meters. The village is situated at a latitude of approximately 42.4° N and a longitude of 23.51667° E, with an elevation ranging from 700 to 999 meters.

Population: Relovo has a population of 284 people, primarily engaged in agricultural and forestry activities.

Economic Activities: The village's economy is predominantly agricultural, with a focus on small-scale farming and livestock rearing. The surrounding forests support logging activities, contributing to the local economy.

Cultural Heritage: Relovo maintains a strong connection to traditional Bulgarian culture, with many residents engaged in traditional crafts and practices. The village's close-knit community structure supports a rich cultural life.

Figure 7-4 Relovo Satellite Image

Source: Google Earth

(5) Dragushinovo

Geographical Location: Dragushinovo is a small village in the Samokov municipality, with a population of approximately 696 people. The village covers an area of 0.54 square kilometers and is situated at a latitude of 42° 24′ N and a longitude of 23° 31′ E, with an elevation ranging from 700 to 999 meters.

Figure 7-5 Relovo Satellite Image

Source: Google Earth

Population Density: The population density of Dragushinovo is approximately 1,284 people per square kilometer.

Economic Activities: Dragushinovo's economy is primarily based on agriculture and livestock rearing. The village is known for its fertile soil, which supports the cultivation of wheat, corn, and vegetables. Livestock farming, particularly dairy and poultry, is also a significant economic activity.

Cultural Heritage: Dragushinovo has a rich cultural heritage, with many residents engaged in traditional crafts such as weaving and wood processing. The village's traditional architecture and community practices reflect its deep historical roots.

(6) Dospei

Geographical Location: Dospei is a village located approximately 3 kilometres from the town of Samokov. It covers an area of 0.48 square kilometres and is situated at an elevation of approximately 984 meters (3,228 feet). The village is located at a latitude of 42° 24′ N and a longitude of 23° 31′ E.

Figure 7-6 Dospei Satellite Image

Source: Google Earth

Population: Dospei has a population of approximately 604 people.

Economic Activities: Dospei's economy is primarily agricultural, with a focus on small-scale farming and livestock rearing. The village benefits from its fertile soil and favorable climate, which support the cultivation of various crops and the raising of dairy cattle.

Cultural Heritage: Dospei is known for its picturesque landscapes and proximity to the Rila Mountains, making it a popular destination for tourists seeking natural beauty and outdoor activities. The village's traditional architecture and community practices reflect its rich cultural heritage.

7.2 Heat Risks Distribution Simulation

7.2.1 Data Sources

To assess future heat risks in Bulgaria, we utilized data from the Coupled Model Intercomparison Project Phase 6 (CMIP6). The selection of models was guided by three criteria: accuracy, applicability, and data availability, specifically tailored for the Bulgarian context. Thirteen CMIP6 global climate models were selected for this study, as detailed in Table 7-1.

Tab 7-1. Global model information sheet

Serial number	Model name	Organization	Spatial resolution
1	ACCESS-ESM1-5	CSIRO	1.875°×1.25°
2	BCC-CSM2-MR	Beijing Climate Center	1.120°×1.120°

3	CanESM5	the Canadian Centre for Climate Modelling and Analysis	2.810°×2.770°
4	CMCC-ESM2	CMCC	1.120°×1.120°
5	CNRM-CM6-1	CNRM	1.406°×1.389°
6	CNRM-ESM2-1	CNRM	1.406°×1.389°
7	INM-CM4-8	Russian Institude for Numerical Mathematics Climate Model	2.000°×1.500°
8	INM-CM5-0	Russian Institude for Numerical Mathematics Climate Model	2.000°×1.500°
9	IPSL-CM6A-LR	IPSL	2.5°×1.27°
10	MIROC6	MRI(Meteorological Research Institute)	1.400°×1.400°
11	MRI-ESM2-0	MRI	1.4°×1.4°
12	NorESM2-LM	NCC	
13	NorESM2-MM	NCC	

7.2.2 Downscaling of Statistics

Given the high spatial resolution of global climate model data, downscaling is essential for community-level climate predictions. We employed the Delta method for downscaling, which effectively reduces systematic biases between global climate models and regional climates while retaining the fluctuation characteristics of the global model. The Delta method corrects the global model's prediction data by comparing differences between historical global model data and observational data. The calculation methods are shown in formulas (1), (2), (3), and (4).

Climate：

$$delta_{ymoni\_tmax} = gcm_{ymoni\_tmax} - obs_{ymoni\_tmax} \quad (1)$$

$$gcm(downscaled)_{dailyi\_tmax} = gcm_{dailyi\_tmax} - delta_{ymoni\_tmax} \quad (2)$$

precipitation：

$$delta_{ymoni_p} = obs_{ymoni_p} / gcm_{ymoni_p} \quad (3)$$

$$gcm(downscaled)_{datlyt_p} = gcm_{datlyt_p} \times delta_{ymont_p} \quad .$$

（4）

Wherein, gcm_{ymoni_tmax} is the long-term monthly average of daily maximum temperature from historical global model data. obs_{ymoni_tmax} is the long-term monthly average of daily maximum temperature from meteorological station observational data, and gcm_{dailyi_tmax} is the daily maximum temperature from global model temperature prediction data. gcm_{ymoni_p} is the long-term monthly average of precipitation from historical global model data. obs_{ymoni_p} is the long-term monthly average of precipitation from meteorological station observational data, and gcm_{dailyi_p} is the daily precipitation after downscaling of global model data.

7.2.3 Heat risks distribution simulation results

The distribution of heat risk areas across the Samokov town area and various villages such as Dospei, Prodanovtsi, Rayovo, Relovo, and Shirokidol exhibits distinct patterns. In Samokov, the heat risk areas are primarily concentrated on the periphery of the town, suggesting that urban sprawl and the surrounding landscape may contribute to higher temperatures in these locations. Conversely, high-risk areas for waterlogging are predominantly found in the northern part of the town, indicating potential issues with drainage and flood management in that region.

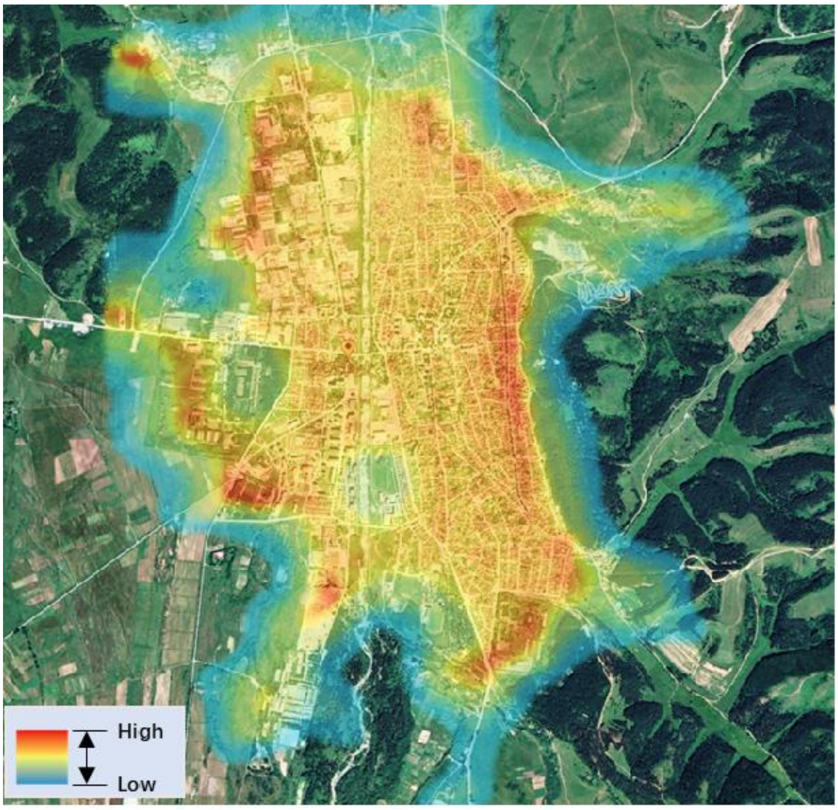
Moving to the villages, the heat risk areas in Dospei and Shirokidol are centered around the village cores, indicating that the built-up areas and possibly higher population densities may be contributing factors. Similarly, the heat risk areas in Prodanovtsi are also primarily located in the village center, suggesting that urban development patterns and infrastructure may play a role in elevating temperatures.

In Rayovo and Relovo, the heat risk areas are similarly situated on the periphery of the villages. This could be due to a combination of factors, including agricultural activities, land use patterns, and possibly the influence of surrounding natural landscapes that may modify local microclimate conditions.

The primary reasons for these differences in the distribution of high-risk areas can be attributed to the varying building densities and the distinct microclimate wind conditions in each village. Urbanization, population density, infrastructure, and land use patterns all contribute to the creation of urban heat islands, where temperatures are higher than in surrounding rural areas. Additionally, local wind patterns and microclimate conditions can exacerbate or mitigate heat risks, depending on the specific geography and climate of each location.

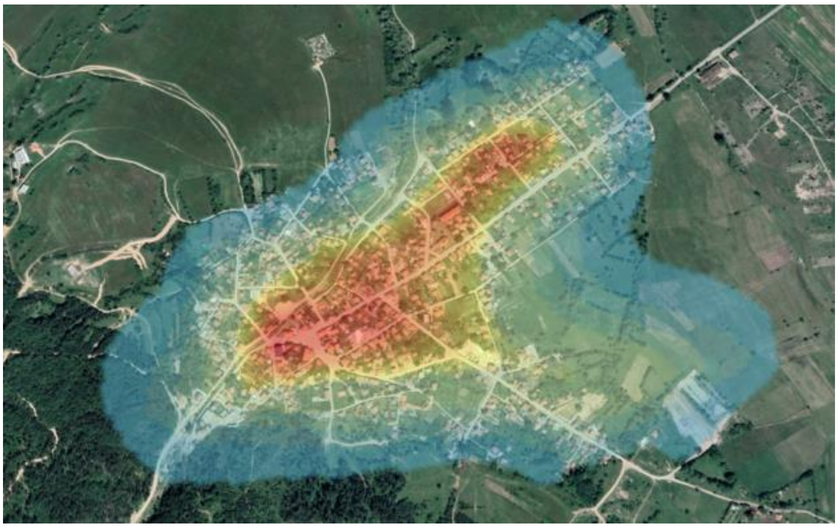
Overall, the distribution of heat risk areas in these communities highlights the importance of considering local urbanization patterns, population densities, and microclimate conditions in order to develop effective strategies for mitigating heat risks and improving public health outcomes.

Figure 7-7 The distribution of heat risk areas in Samokov



Source: authors

Figure 7-8 The distribution of heat risk areas in Dospei

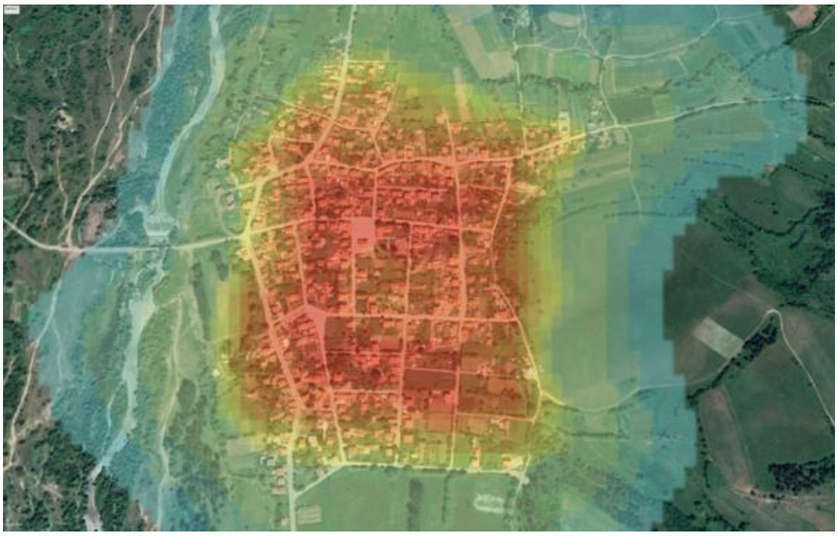


Source: authors

Figure 7-9 The distribution of heat risk areas in Prodanovtsi

Source: authors

Figure 7-10 The distribution of heat risk areas in Dragushinovo

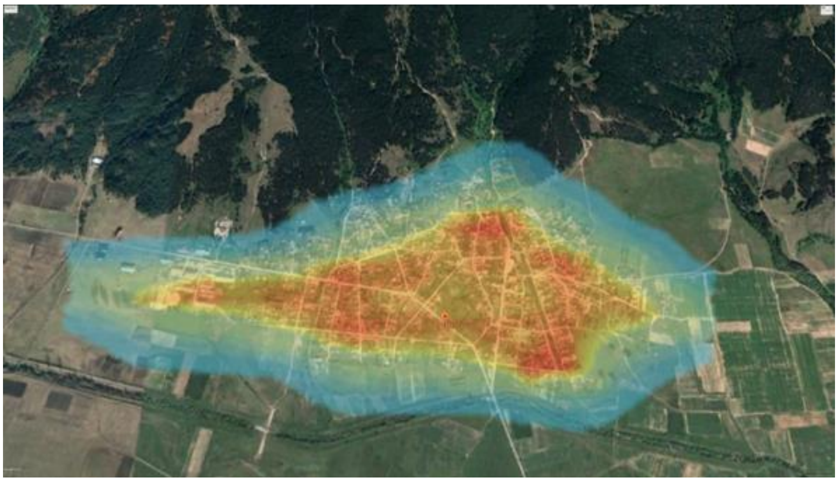


Source: authors

Figure 7-11 The distribution of heat risk areas in Prodanovtsi

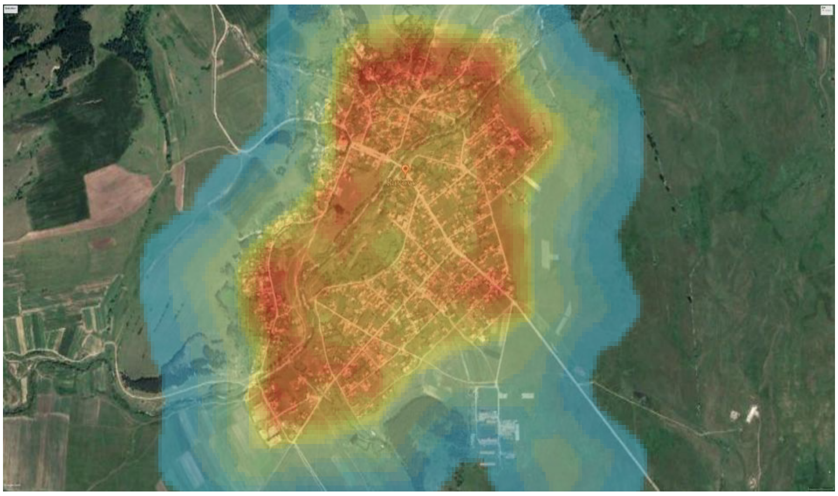
Source: authors

Figure 7-12 The distribution of heat risk areas in Relovo



Source: authors

Figure 7-13 The distribution of heat risk areas in Rayovo



Source: authors

Figure 7-14 The distribution of heat risk areas in Shirokidol

Source: authors

7.3 Microclimate Heat Risk Analysis

Drawing upon the comprehensive analysis conducted previously, we pinpointed high-risk areas and subjected them to detailed ENVI-met simulations. These simulations allowed us to delve deeper into the heat risk associated with these specific locations, providing a nuanced understanding of the microclimate conditions and potential threats posed by extreme heat events.

7.3.1 The Process of ENVI-met Simulation

Based on in-depth previous thermal risk assessment research, we meticulously selected specific areas with significantly elevated thermal risks as the focus of our ENVI-met simulations. To ensure the accuracy and practical application value of the simulations, we extensively gathered and meticulously organized a series of basic data for these areas. These data comprehensively documented the topography, building arrangements, vegetation cover, and soil types, providing a solid geographical and ecological foundation for the simulation models.

Additionally, we meticulously collected comprehensive meteorological data for 2024-07-22, covering core indicators such as temperature, humidity, wind speed, and wind direction. These data are crucial for accurately capturing the dynamic evolution of the regional microclimate. During the model construction phase, we fully leveraged the powerful capabilities of the ENVI-met software to meticulously build the simulation models based on the collected basic data. The models not only precisely incorporated key elements such as buildings, vegetation, and surface cover but also ensured that the physical properties of these elements closely matched the actual environment.

Specifically, we accurately set the morphology, height, and materials of the buildings, as well as the types, density distribution of vegetation, and the types and roughness of surface cover, striving to replicate the real environment to the greatest extent possible. In setting the simulation parameters, we fully considered the regional characteristics and actual needs, specifying the specific date of the simulation (2023-07-22), the duration (covering representative periods from morning, noon to evening), and the initial meteorological conditions (such as temperature, humidity, and wind speed), aiming to comprehensively reveal the microclimate characteristics and variation patterns of the region at different times of the day.

After the simulation ended, we utilized the visualization capabilities of ENVI-met to conduct a detailed analysis and intuitive presentation of the simulation results. By generating visual charts such as temperature distribution maps and humidity distribution maps, we clearly demonstrated the temperature and humidity distribution conditions of the region at different times of the day.

7.3.2 Simulation Results

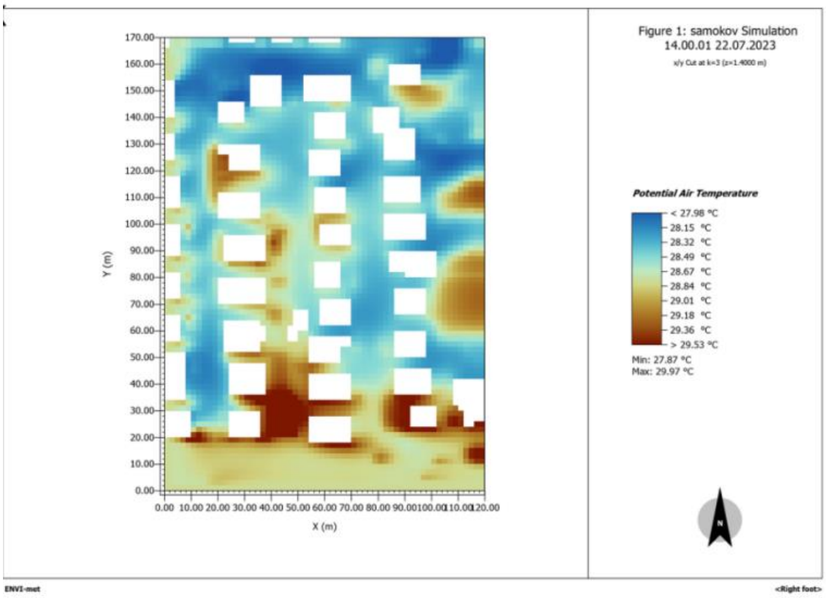
The poor thermal performance of the Samokov is mainly due to the dense construction, insufficient greening and lack of effective ventilation system, High temperatures and humidity make life less comfortable for residents and can lead to health problems. To improve this situation, cooling measures such as increased green space coverage, optimized building layout and improved ventilation are needed to mitigate the heat island effect and improve quality of life.

The wind environment of the village is not good, mainly manifested in insufficient wind speed and unstable wind direction. This situation leads to poor air circulation, which is easy to form air retention areas, affecting the comfort and air quality of residents. In order to improve the wind environment, it is recommended to carry out wind and wind direction assessment in the village, and consider increasing air duct design, green belt and building layout optimization to enhance the natural ventilation effect.

Figure 7-15 The location of the simulation area in Samokov S1

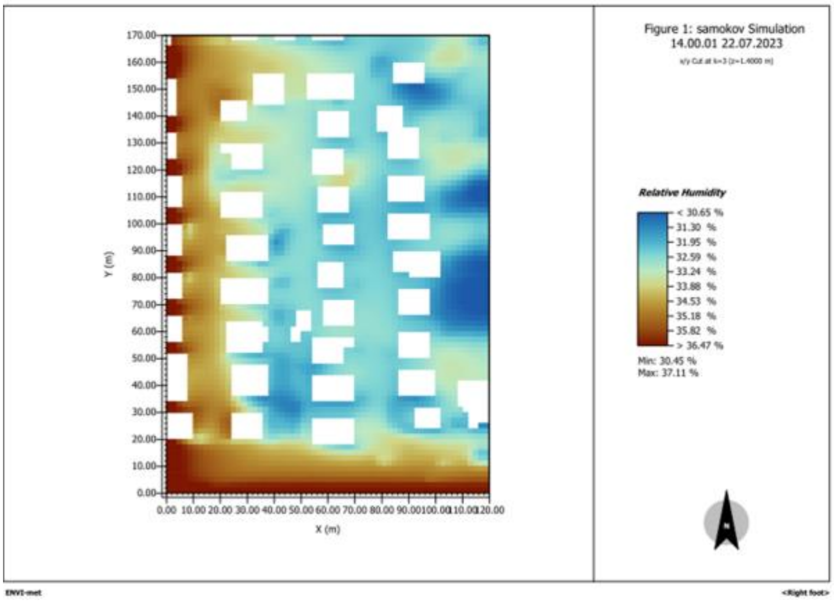
Source: authors

Figure 7-16 The temperature environment of the simulation area



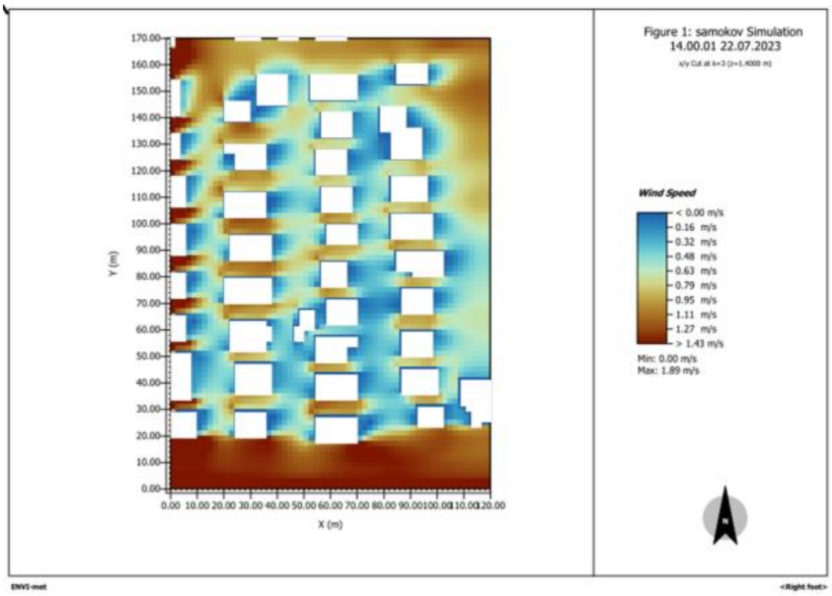
Source: authors

Figure 7-17 The humidity environment of the simulation area



Source: authors

Figure 7-18 The wind environment of the simulation area



Source: authors

The temperature environment of the Shirokidol village has great problems, mainly manifested as frequent high temperature in summer, cold in winter and no effective measures to keep warm, Such extreme temperatures cause residents to feel discomfort in their daily lives,increase energy consumption for heating and cooling, and also pose a potential threat to health. in order to improve the temperature environment, it is recommended to take comprehensive measures.

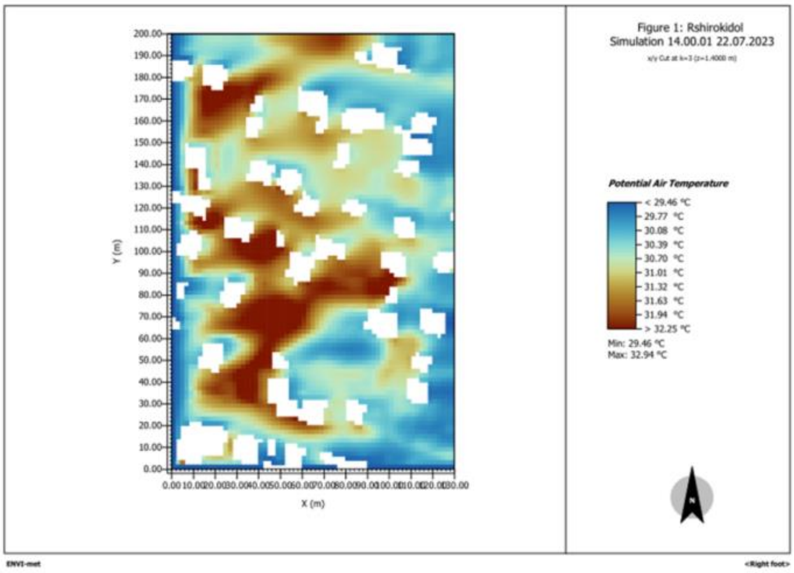
The addition of green belts and flower beds uses the evaporation of plants to balance humidity. Introducing water features such as fountains or small lakes to beautify the environment and regulate humidity through the evaporation of water. For the building structure, the optimal design uses materials with good permeability to ensure air circulation and effectively control humidity problems. Setting up an awning or shade plant can also improve overall comfort while avoiding excessive evaporation.

the poor wind speed environment in the public space of the Shirokidol village leads to poor air circulation. which affects the comfort level an activity experience of residents. Consider adding air ducts or vents to promote airflow, and the insertion of appropriate green belts and trees can naturally direct the flow of wind and provide shade, thus improving the ventilation effect of the space. Finally, the proper layout of buildings and facilities to avoid obstructing the flow of wind also helps.

Figure 7-19 The location of the simulation area in Shirokidol S2

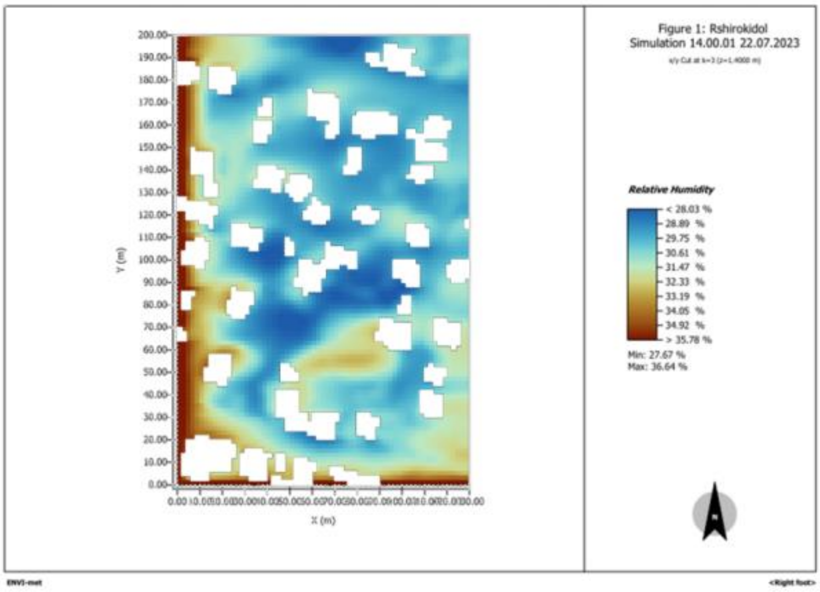
Source: authors

Figure 7-20 The temperature environment of the simulation area



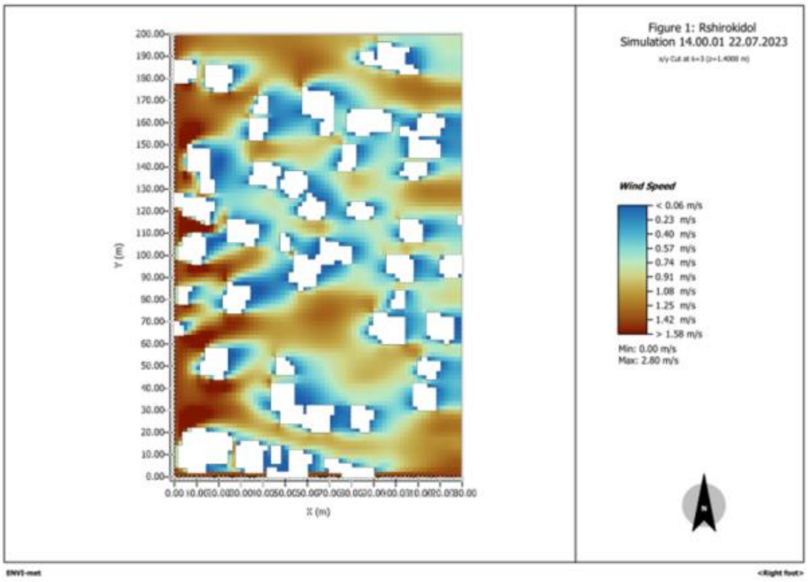
Source: authors

Figure 7-21 The humidity environment of the simulation area



Source: authors

Figure 7-22 The wind environment of the simulation area



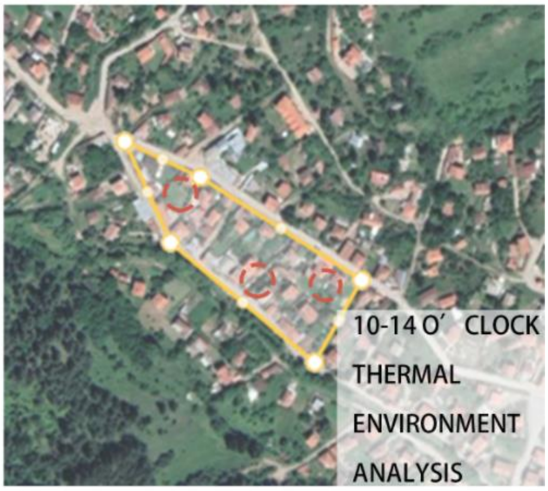
Source: authors

The temperature environment of the village has great problems. Mainly manifested as frequent high temperature in summer, cold in winter and no effective measures to keep warm. Such extreme temperatures cause residents to feel discomfort in their daily lives increase energy consumption for heating and cooling, and also pose a potential threat to health. in order to improve the temperature environment, it is recommended to take comprehensive measures.

The poor thermal performance of the village is mainly due to the dense construction, insufficient greening and lack of effective ventilation system. High temperatures and humidity make life less comfortable for residents and can lead to heath problems. To improve this situation, cooling measures such as increased green space coverage, optimized building layout and improved ventilation are needed to mitigate the heat island effect and improve quality of life.

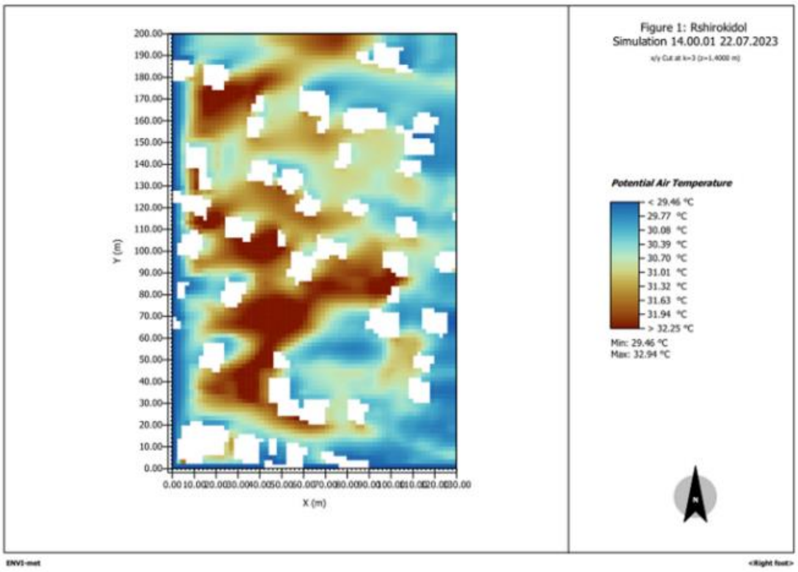
The wind environment of the village is not good, mainly manifested in insufficient wind speed and unstable wind direction. This situation leads to poor air circulation, which is easy to form air retention areas, affecting the comfort and air quality of residents, in order to improve the wind environment, it is recommended to carry out wind and wind direction assessment in the village, and consider increasing air duct design, green belt and building layout optimization to enhance the natural ventilation effect.

Figure 7-23 The location of the simulation area in Shirokidol S3



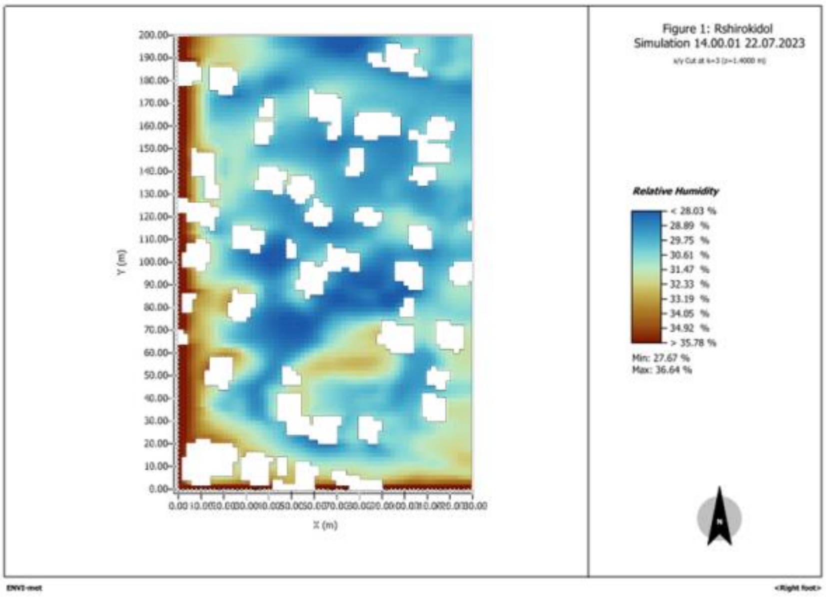
Source: authors

Figure 7-24 The temperature environment of the simulation area



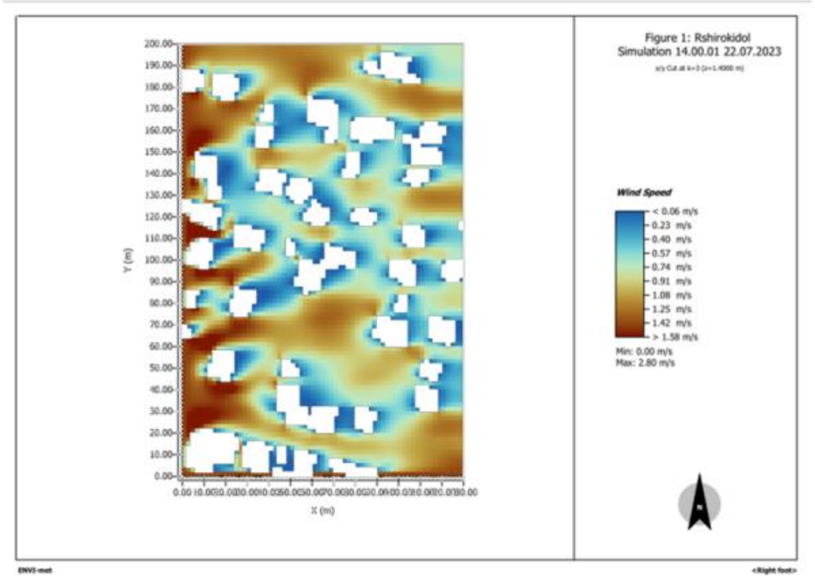
Source: authors

Figure 7-25 The humidity environment of the simulation area



Source: authors

Figure 7-26 The wind environment of the simulation area



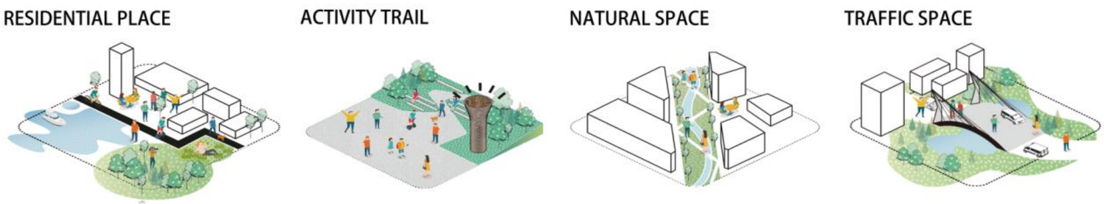
Source: authors

7.4 Climate adaptation strategies

Location S1 is located in the heart of the Samokov township and is surrounded by well-preserved historic buildings such as quaint houses and churches that reflect the cultural heritage of the area. At the same time, the town is equipped with modern facilities to meet the needs of residents and tourists.

The picture shows the four types of environment in S1: residence, activity place, natural space and traffic space, representing the residential area, the path of People's Daily activities, the natural area within the town and the transportation facilities.

Figure 7-27 The four types of environments in Samokov S1



Source: authors

In addition, the real photos of Samokov Township further show the architectural style, street layout and natural landscape of the township, providing rich site information and research background.

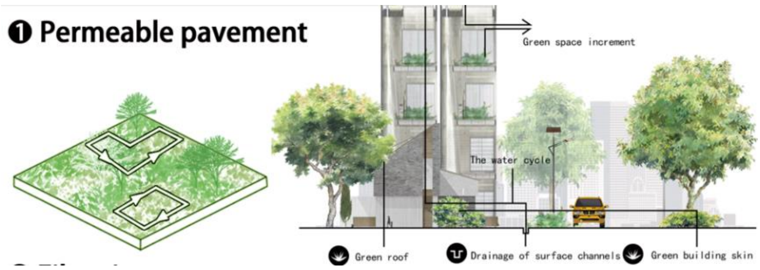
Figure 7-28 The photos of environment in Samokov S1

Source: authors

Regional impacts of higher temperatures include increased heat waves, reduced water availability, and adverse effects on health and agriculture. The heat island effect and climate change caused by urbanization in the region aggravate and prolong the high temperature period. In addition, a lack of green space exacerbates the effects of high temperatures.

For Site S1 in Samokov, the adaptation strategies focus on integrating natural ecological design to mitigate the urban heat island effect and enhance water use efficiency. Permeable paving allows rainwater to infiltrate the ground, reducing surface runoff and recharging groundwater.

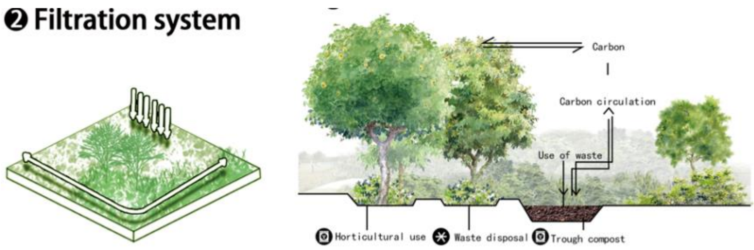
Figure 7-29 Permeable pavement



Source: authors

Filtration systems purify surface runoff to minimize pollution entering water bodies.

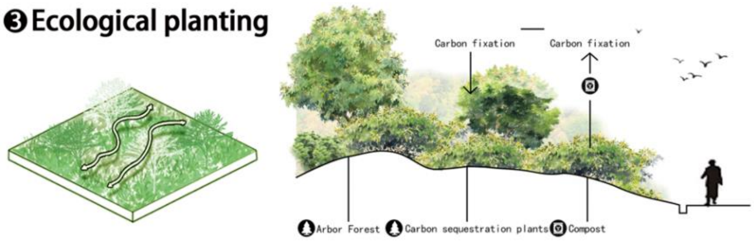
Figure 7-30 Filtration system



Source: authors

Ecological planting with trees and vegetation provides shade, absorbs carbon dioxide, and releases oxygen through transpiration, which helps cool the surrounding environment.

Figure 7-31 Ecological planting



Source: authors

Additionally, the utilization of natural rainfall is promoted to decrease reliance on groundwater and further reduce the urban heat island effect. These measures collectively aim to improve the overall microclimate and quality of life for residents and visitors in the township.

Figure 7-32 Usage of natural rainfall

Source: authors

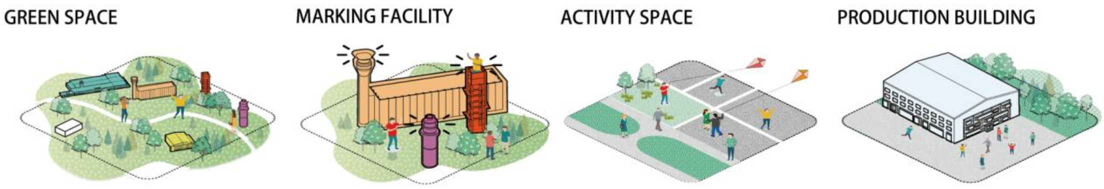
Climate adaptation strategies for coping with the effects of high temperatures and urbanization at Samokov Site S1 highlight the importance of natural ecological design in reducing heat island effects and increasing the efficiency of water use.

The village of Shirokirol near Samokov is located in a peaceful natural environment surrounded by rolling hills and dense forests. The village is built in the traditional Bulgarian architectural style, including charming stone houses harmoniously blending rural architecture with picturesque landscapes. The setting is characterized by its tranquil atmosphere, providing a peaceful haven for hiking and exploring the landscape.

The picture shows four types of environment in S2. Green space refers to natural green Spaces around the village, including parks and forests; Marking facilities, such as road signs and information boards, for indicating and marking; Event Spaces, areas for people to carry out various activities, including squares and small sports fields;

Production buildings, buildings used for production and processing, including farm houses and factories.

Figure 7-33 The four types of environments in Shirokidol S2



Source: authors

The live photos show the actual scene of the village of Shirokidor, showing the buildings, streets and natural landscape of the village.

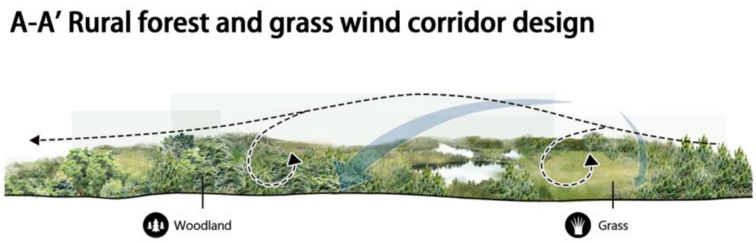
Figure 7-34 The photos of environment in Shirokidol S2

Source: authors

The temperature and humidity levels at Samokov's study site S2 show seasonal variations, especially in the warmer months when high temperatures and moderate to high humidity are common, especially if there is limited air circulation or precipitation.

Rural forest and grassland wind corridors guide cool air through the village, reducing temperatures.

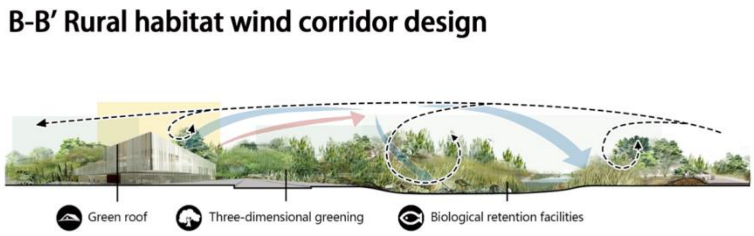
Figure 7-35 Rural Forest and grass wind corridor design



Source: authors

Residential areas are enhanced with three-dimensional greening and bioretention facilities to improve air circulation.

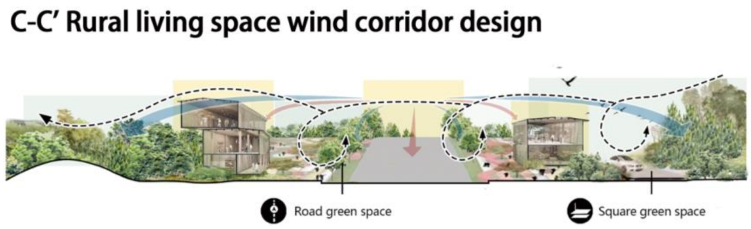
Figure 7-36 Rural habitat wind corridor design



Source: authors

Green spaces are increased around roads and plazas to provide shade and enhance ventilation.

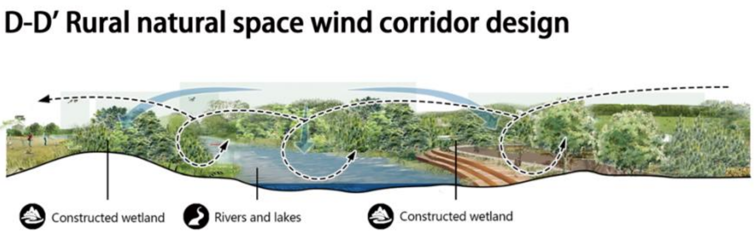
Figure 7-37 Rural living space wind corridor design



Source: authors

Natural spaces are developed with wetlands, rivers, and lakes to leverage the cooling effect of water, which helps lower surrounding temperatures.

Figure 7-38 Rural natural space wind corridor design



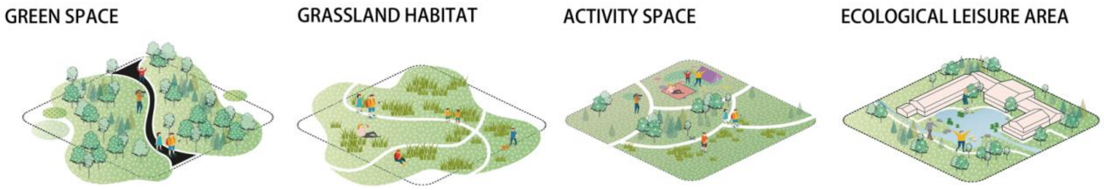
Source: authors

The strategy focuses on the use of wind direction design to improve microclimate and residential comfort, through a combination of natural and artificial means to improve the climate adaptability of the village.

The Village of Shirokidor study site S3 has a temperate continental climate with cold winters and mild to warm summers. The landscape of the area is marked by lush forests and rolling hills, offering picturesque views and a peaceful atmosphere. The natural beauty of the area benefits from its clear, fresh air as well as seasonal changes that add to the charm of its landscape throughout the year.

The picture shows four environmental types in study site S3. Green space refers to grassy areas in villages, including parks or forests; Activity space refers to grassy areas in villages that provide habitat for wildlife. Activity space refers to the area for people to carry out various activities, including squares and small sports fields; Eco-leisure area refers to an area specifically designed for leisure and eco-tourism.

Figure 7-39 The four types of environments in Shirokidol S3



Source: authors

Included in the image are several actual photos of the village of Sirokidor S3, showing the village's architecture, streets and natural landscape.

Figure 7-40 The photos of environment in Shirokidol S3

Source: authors

The climate adaptation strategy of S3, a study site in the village of Shilokidor, focuses on highlighting the application of eco-design to hydrological treatment. The village's natural landscape includes rolling hills and forests that influence local climate conditions, potentially trapping heat and moisture. Study sites have experienced urbanization, and the heat island effect of buildings and infrastructure can raise local temperature and humidity levels. For Site S3 in Shirokidol, the adaptation strategies focus on eco-design principles for hydrological treatment and flood protection. Sod ditches guide and filter rainwater, reducing runoff.

Green roofs are implemented to lower building temperatures and absorb rainwater.

Figure 7-41 Urban land, grass-ditch and green roof

Source: authors

Sunken green spaces collect and infiltrate rainwater, minimizing flood risks. Rain gardens use plants and soil to absorb and filter rainwater. Vegetation is increased to enhance water infiltration and evaporation, thereby reducing surface temperatures.

Figure 7-42 Sunken greenbelt, rainwater garden and vegetation

Source: authors

Permeable paving allows rainwater to penetrate the ground, while storage tanks are built to collect and store rainwater for irrigation or other purposes. These integrated measures aim to improve the hydrological cycle and enhance the village's resilience to climate change through ecological design.

Figure 7-43 Permeating, storage pond and low elevation

Source: authors

The illustration shows how the study area's flood protection capacity can be enhanced through ecological design, including rainwater collection, infiltration and storage.

Chapter 8: Economic Considerations and Financing Adaptation

8.1 Economic Impact Assessment

The economic impacts of climate change in rural Bulgaria are multifaceted and significant, affecting various sectors including agriculture, forestry, water resources, and energy. Understanding these impacts is crucial for developing effective adaptation strategies and policies. This section provides a comprehensive assessment of the economic consequences of climate change, drawing on the insights from previous chapters and the specific context of rural Bulgaria.

8.1.1 Overview of Economic Impacts

Climate change poses substantial risks to the Bulgarian economy, particularly in rural areas where agricultural and forestry activities are dominant. The impacts are evident in reduced agricultural productivity, increased frequency of extreme weather events, and changes in water availability. These factors not only affect the rural economy but also have broader implications for national economic stability and food security.

8.1.2 Impacts on Agriculture

Agriculture is a cornerstone of the rural economy in Bulgaria, contributing 6% to the Gross Value Added (GVA) and employing 18.3% of the workforce. Climate change exacerbates existing challenges in the sector, such as water scarcity, soil degradation, and increased pest and disease prevalence. The economic consequences include:

Reduced Crop Yields: Climate hazards such as droughts and heatwaves have led to significant reductions in crop yields. For instance, droughts could caused substantial losses in wheat, maize, and sunflower production, impacting farmers' incomes and increasing food prices (Popova et al., 2014; Radeva et al., 2020). These losses not only affect individual farmers but also contribute to broader economic instability, as agriculture is a significant contributor to the national economy.

Increased Production Costs: Farmers face higher costs for irrigation, fertilizers, and pest control due to climate-induced stresses. These increased costs reduce profitability and can lead to financial instability for small-scale farmers. The financial burden on farmers is further exacerbated by the need for new technologies and infrastructure to adapt to changing conditions.

Livestock Productivity: Higher temperatures and water scarcity affect livestock health and productivity, leading to reduced milk yields and increased mortality rates. This impacts the income of farmers and the availability of animal products, with potential knock-on effects on related industries such as dairy processing and meat production.

8.1.3 Impacts on Forestry

Forests cover 37.4% of Bulgaria's land area and play a vital role in the economy. Climate change poses significant risks to forest health and biodiversity, including:

Increased Fire Risks: Higher temperatures and prolonged dry periods increase the likelihood of forest fires, leading to substantial economic losses from timber damage and firefighting costs. The economic impact of forest fires extends beyond the forestry sector, affecting tourism and local economies that rely on forest resources.

Reduced Timber Production: Climate-induced stresses such as droughts and pests reduce the growth rates of trees, impacting timber yields and the forestry sector's economic contribution. This reduction in timber production can lead to job losses and decreased revenue for forestry companies.

Biodiversity Loss: Changes in temperature and precipitation patterns threaten the survival of various tree species and wildlife, reducing the ecosystem services provided by forests. The loss of biodiversity can have long-term economic consequences, affecting sectors such as tourism and pharmaceuticals that rely on natural resources.

8.1.4 Impacts on Water Resources

Water scarcity is a critical issue in Bulgaria, with climate change exacerbating the problem. The economic impacts include:

Reduced Hydropower Generation: Decreased river flows and water availability affect hydropower generation, leading to higher energy costs and potential energy shortages. This can impact industrial and commercial activities, leading to reduced productivity and increased operational costs.

Increased Irrigation Costs: Farmers face higher costs for irrigation due to reduced water availability, further straining agricultural profitability. The increased costs of irrigation can lead to reduced investment in other areas, such as new equipment or improved farming techniques.

Environmental Degradation: Water scarcity leads to soil erosion and degradation, reducing agricultural productivity and increasing the costs of land reclamation. The long-term economic impact of soil degradation can be significant, affecting not only agriculture but also other land-based industries.

8.1.5 Impacts on Energy

The energy sector in Bulgaria is also vulnerable to climate change, with implications for energy security and costs:

Reduced Hydroelectric Power: Changes in precipitation patterns and river flows reduce the efficiency of hydroelectric power plants, increasing reliance on fossil fuels and higher energy costs. This can lead to increased greenhouse gas emissions and environmental degradation.

Increased Cooling Demands: Rising temperatures increase the demand for cooling, leading to higher energy consumption and costs for households and businesses. The increased energy demand can strain the energy grid and lead to higher prices for consumers.

Infrastructure Vulnerability: Extreme weather events such as storms and floods pose risks to energy infrastructure, leading to increased maintenance and repair costs. The economic impact of damaged energy infrastructure can be significant, affecting not only the energy sector but also other industries that rely on a stable energy supply.

8.1.6 Economic Vulnerability and Adaptation Needs

The economic impacts of climate change in rural Bulgaria highlight the urgent need for adaptation strategies. The costs of inaction are significant, with potential losses in agricultural productivity, forestry revenues, and water resources. Adaptation measures such as improving water management, adopting climate-resilient agricultural practices, and enhancing forest health can mitigate these impacts and ensure economic stability.

The economic assessment underscores the importance of integrating climate resilience into rural development policies. By addressing the vulnerabilities of key sectors and investing in adaptation measures, Bulgaria can reduce the economic risks associated with climate change and build a more sustainable future for its rural communities. This includes not only direct adaptation measures but also broader policy frameworks that support economic diversification and resilience.

This assessment sets the stage for the subsequent sections, which discuss the role of governance in enhancing agrarian resilience and strategies for leveraging private sector investment in climate adaptation. The insights from this economic impact assessment provide a foundation for understanding the broader context of climate adaptation in rural Bulgaria and the need for comprehensive, multi-sectoral approaches to address these challenges.

8.2 Financing Climate Adaptation and Rural Development in Bulgaria

Changing weather patterns caused by global warming threaten ecosystems, the sustainability of agricultural yields, and the stability of farmers' incomes in rural Bulgaria. Vulnerability to climate change in these areas is further exacerbated by limited resources, including land, soil, water, and labour. As a result, climate adaptation in rural areas should be seen as a complex economic, social, and environmental transformation that requires an integrated financial approach.

The primary financial instrument supporting climate adaptation and rural development in Bulgaria is the Common Agricultural Policy (CAP), with its two key funding pillars: the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD). These funds, administered through Bulgaria’s CAP Strategic Plan, aim to enhance rural resilience, support sustainable agricultural production, and encourage green investments. However, given the budgetary constraints of the CAP, additional financing sources are needed to bridge investment gaps and accelerate climate adaptation.

Addressing climate change and environmental challenges has increased demand for green and sustainable finance, requiring a shift beyond CAP funding to include national public funds, private capital, and international financial institutions. A diversified financial strategy, incorporating grants, preferential loans, public-private partnerships (PPPs), and crowdfunding, can enhance investment opportunities for farmers, agribusinesses, and rural enterprises. Expanding access to finance in rural areas can help stabilize local economies, mitigate economic disparities between urban and rural regions, and promote climate-resilient development.

Despite these efforts, financial support remains disproportionately focused on traditional agricultural investments, such as farm modernization and agri-food processing, while rural infrastructure, business development, and climate-resilient agriculture receive comparatively lower funding. Moreover, rural local administrative units often face financial constraints, including low levels of own resources, weak credit ratings, and high indebtedness, limiting their capacity to finance adaptation projects.

Another key challenge is that financing climate adaptation differs from traditional commercial financing due to its long-term return on investment and higher risk profile. The main financial sources for adaptation include bank loans, state aid, international grants, private investments, and co-financed financial schemes under the EAFRD. However, bank lending to agriculture and agri-food processing remains low compared to other economic sectors, with financial institutions perceiving agriculture as a high-risk sector due to fluctuating income levels, collateral constraints, and climate-related uncertainties.

To overcome these financial barriers, Bulgaria must leverage innovative financial instruments, including risk-sharing mechanisms, guarantee funds, blended finance, and specialized climate adaptation funds. These mechanisms can help de-risk private investment, improve credit access for farmers, and incentivize green financing in rural areas.

This section explores the current financial landscape for climate adaptation in rural Bulgaria, evaluating available funding instruments, their effectiveness, and the challenges that hinder broader financial access. It highlights the importance of an integrated financing strategy that aligns climate adaptation efforts with rural economic development, ensuring that Bulgaria’s rural regions remain economically viable, socially inclusive, and environmentally sustainable in the face of climate change.

8.2.1 General economic performance of rural areas in Bulgaria

The economic, demographic, and social profiles of rural and urban areas in Bulgaria exhibit significant divergence. Economic activities in rural areas are primarily concentrated in the agricultural sector, with limited manufacturing presence. The main sources of local development are small and family-owned businesses in retail trade and services. The comparison of macroeconomic indicators between rural and urban areas highlights key differences (Table 8-1).

Table 8-1. Comparison of economic indicators: rural vs. urban areas in Bulgaria (2016-2022)

Indicator	**Rural areas**	**Urban areas**
Number of enterprises	Decreased by 1.2%	Increased by 2.3%
Average annual growth in net sales revenues	EUR 95,000 thousand	EUR 1.4 million
Share of budget capital expenditure in total budget capital expenditure (investment activity) (%)	39%	61%
Expenditure on tangible fixed assets (2022 vs. 2016)	Increased by 23%	Increased by 43%

Source: NSI and authors' calculations

The economic profile of rural areas is shaped by agricultural firms, micro-enterprises, and small businesses engaged in retail trade, repair services, and other local activities. In contrast, medium and large enterprises are predominantly located in urban areas, where the economy is more diversified.

Capital investment in rural municipalities remains limited, as local governments often face financial constraints due to low levels of own resources, weak credit ratings, and high indebtedness. These factors significantly reduce their ability to invest in infrastructure, services, and business development. Despite these challenges, rural areas have shown similar output value dynamics to urban areas and even recorded higher growth in 2021. However, the number of enterprises in rural areas continues to decline, while capital investments have remained relatively stable between 2016 and 2022. The higher standard deviation of capital expenditures further underscores the greater financial volatility in rural areas compared to urban areas (Table 8-2).

Table 8-2. Standard deviation of capital expenditures in rural and urban areas in Bulgaria (2016–2023, %)

	2016	2017	2018	2019	2020	2021	2022	2023
Rural areas	8.92	8.81	10.17	10.37	8.47	9.05	8.87	10.17
Urban areas	5.37	4.75	5.97	6.16	5.65	4.23	4.08	6.26

Source: NSI and authors' calculations

The budgetary constraints of rural municipalities make them more vulnerable to internal economic shocks than larger, well-developed municipalities. Compared to urban areas, rural communities lag in infrastructure, services, and business development. The limited capacity of local governments to restructure budgets and increase capital investments, including in green and climate adaptation projects, remains a significant barrier to economic growth.

Beyond EU financial support, the government could strengthen local development and facilitate the transition to a climate-neutral economy by mobilizing private sources through public-private partnerships (PPPs). A PPP model, integrating public funds (local or state budgets), private investments, and EU co-financing, could enhance investment opportunities in rural areas.

Rapid economic growth necessitates the development of infrastructure and public services. Financial instruments supported by the EAFRD offer an alternative means to achieve the CAP's objectives for financing the sustainable management of natural resources, climate actions, and balanced territorial development in Bulgaria.

8.2.2 Review of the current finance in the rural development in Bulgaria

The Common Agricultural Policy (CAP) and its key financial instrument – the Bulgaria CAP Strategic Plan – serve as the primary funding source for climate change management in the agricultural sector. The plan includes interventions aimed at reducing greenhouse gas emissions from agriculture, increasing organic carbon in soils, improving soil and water quality, and promoting renewable energy production.

A new feature under CAP is the eco-schemes, which allow farmers to receive payments for implementing environmentally and climate-friendly practices, including organic farming. Approximately 39% of total financial allocations for rural areas are directed toward activities aimed at fulfilling environmental and climate objectives. However, this financial support remains insufficient, and farmers and small and medium-sized enterprises (SMEs) generally require additional funding to fully implement sustainable agricultural practices.

The EU taxonomy classifies agricultural activities – such as the production of perennial and non-perennial crops, livestock farming, and related industries – as contributing to key environmental objectives, including: climate change mitigation and adaptation, protection of water and natural resources, transition to a circular economy, biodiversity conservation and ecosystem restoration.

Public subsidies and investments under Bulgaria's CAP Strategic Plan play a crucial role in modernizing agriculture, enhancing competitiveness, stabilizing farm incomes, and promoting non-agricultural activities in rural areas. However, despite a well-developed banking system, bank lending to agriculture and agri-food processing remains low compared to other economic sectors. On average, credit to the agricultural sector accounts for only 3% of total bank loans, and when compared to loans to non-financial enterprises, agricultural lending stands at just 6.5%.

Table 8-4. Loans to Non-Financial Enterprises in Agriculture (2018-2024)

Bank loans to agricultures	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Average number of non-financial corporations with active agricultural loans per year	11 521	12 055	12 999	12 961	13 378	14 017	14 513

average loan size (thousand BGN)	2110277	2254814	2357008	2385927	2580763	2807151	2978568
% change in average loan volume	6.61%	6.85%	4.53%	1.23%	8.17%	8.77%	6.11%
% change in average number of non-financial corporations	3.36%	4.64%	7.83%	-0.29%	3.21%	4.78%	3.54%

Source: BNB

The average annual growth rate of credit recipients was 6.0% between 2018 and 2024 (Table 8-4). However, a decline was observed in 2021 due to the impact of the COVID-19 pandemic on the sector. Despite this temporary slowdown, total lending volume has increased, primarily due to a rising number of loan recipients.

Agricultural producers borrow credit primarily for machinery purchases, technological modernization, and innovation. In addition to capital investments, farmers require working capital to cover production costs. However, agricultural enterprises continue to rely less on bank financing than businesses in other sectors, mainly due to uncertain income levels and collateral constraints.

Financial institutions often perceive agriculture as a high-risk sector due to its vulnerability to climate change, natural disasters, and their impact on crop yields. Farmers and agricultural companies are exposed to considerable market risks, including price fluctuations for inputs and the possibility of crop failures.

Lending to the agricultural sector requires detailed borrower information and a comprehensive evaluation of the proposed investment project. Banks typically assess net loan returns, collateral capacity, present and projected cash flows, borrower credit history, and other financial indicators. However, banks often struggle to accurately assess borrower performance and credit repayment capacity in agriculture due to the sector’s inherent uncertainties.

As a result, farmers are generally reluctant to apply for loans for climate mitigation and adaptation measures, as well as for the adoption of environmentally friendly technologies. Despite this, major Bulgarian banks offer credit products for agricultural producers and agri-food enterprises, with many providing loans that incorporate EAFRD grants. These loans are typically approved when farmers secure investment approval from the Managing Authority.

In Bulgaria, the main providers of rural finance are commercial banks. However, in other EU Member States, agricultural financing is often provided through specialized agricultural banks, as seen in Germany, Denmark, Romania, and Spain. According to the survey "Financial Needs in Agriculture and Agri-Food in the EU", Bulgarian farmers face significant barriers to accessing long-term loans[3]. The main obstacle to securing such financing is the lack of sufficient collateral assets.[4]

Several impediments related to the demand and supply of agricultural credit in Bulgaria are summarized in table 8-5.

Table 8-5. Obstacles to accessing finance in Bulgaria

Demand side	Supply side
Insufficient collateral – Farmers and agricultural entities cannot provide sufficient collateral required by banks.	Lack of credit history – Many farmers and small enterprises have no credit records, making it difficult for commercial banks to assess their creditworthiness.
Low financial literacy – Agricultural holders lack financial knowledge and awareness of available financing options.	Limited agricultural expertise – Banks lack specialized expertise in providing financial products tailored to agriculture.
Weak business planning – Farmers struggle with business planning and	Loan rejection due to business plans – Banks often reject business plans for

[3]Summary report „ Financial needs in the agriculture and agri-food sectors in the European Union “, fi_compass , EU 2020 , https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_eu_summary.pdf

[4] Summary report “Financial needs in the agriculture and agri-food sectors in Bulgaria” , fi_compass , EU 2020 https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_Bulgaria.pdf

financial management, leading to loan rejections.	agricultural projects, resulting in denied credit applications.
Preference for own resources and EU funding – Farmers prefer to use personal savings or EU funding rather than apply for loans.	High investment risk – Banks perceive agri-food business investments as high-risk, often avoiding loans due to default risks and low returns on climate and agri-ecological investments.
Uncertainty in interest rate payments – Banks can change credit terms, discouraging farmers from applying for finance.	Lack of specialized financial institutions – There is no dedicated financial institution specializing in lending to farmers and rural businesses.
Lack of credit history – Many farmers lack prior borrowing records, which affects their eligibility for financing.	Collateral challenges for medium and long-term lending – Many farmers lack assets of sufficient value to pledge for loans.
Lack of specialized technical support – Farmers need expert assistance to navigate loan application processes.	High transaction costs – Lending to agriculture involves high costs for risk analysis, credit management, and loan monitoring, making it less attractive for banks.

The lack of sufficient capital and investment capacity makes it difficult for farmers to adopt new technologies and climate adaptation measures without additional public and private financial support. Banks tend to favor larger farms for lending due to their stronger solvency and lower default risk, leaving small and medium-sized farmers with limited financing options.

The integration of Environmental, Social, and Governance (ESG) criteria has become increasingly important for reducing agriculture's environmental and climate impact while enhancing transparency and accountability in investment decisions.

However, Bulgarian farmers have limited experience in implementing ESG-based financial practices, making it challenging to comply with the ESG reporting frameworks required by commercial banks. As a result, the demand for green loans remains low, and farmers are reluctant to borrow for sustainable or climate-friendly investments.

Despite continuous growth in agricultural lending, scarcity of financial resources remains a major barrier to technological innovation and climate-neutral agricultural activities. Farmers and rural businesses are often hesitant to take on debt due to the complexity of risk management, particularly in climate adaptation strategies designed to protect against climate-related shocks.

Additionally, banks do not always accept agricultural assets as collateral or apply significant reductions in asset valuations when assessing loan applications. Best practices in financial lending typically require justification based on expected revenues, but in the agricultural sector, income fluctuations and climate vulnerabilities make revenue forecasting more complex.

8.2.3 Mobilizing private finance through EAFRDP support

The European Commission (EC), in collaboration with the European Investment Bank (EIB), has developed additional funding models to mobilize private financial resources through specialized financial funds and loan guarantee instruments. Financial engineering instruments[5], jointly designed by the European Investment Fund (EIF) and the EC, offer non-traditional financing solutions, including venture and equity funds, portfolio guarantee schemes, and other innovative financial mechanisms.

[5] Financial instruments are type of blending finance, implemented in partnership with public and private institutions such as banks, financial institutions, venture investors, the EAFRD through financial instruments ensure loans, microcredit, guarantees to recipients in agriculture and rural areas. Financial instruments provide support to investments in both tangible and intangible assets and working capital.

In Bulgaria, the Agricultural Guarantee Loan Scheme was established in 2013 to provide public guarantees for bank loans granted to farmers and agro-processing enterprises. The implemented portfolio guarantee scheme covers up to 80% of each individual loan, secured by funds from the National Guarantee Fund (NGF), which is part of the Bulgarian Development Bank. The remaining 20% is guaranteed by the beneficiary. This scheme was introduced to support beneficiaries with contracts under the RDP 2007–2013 who were unable to secure co-financing for their projects. The Bulgarian guarantee schemes implemented under the RDP 2007–2013 were successful, encouraging investment among beneficiaries who lacked sufficient accumulated capital.

A risk-sharing financial instrument, supported by the EAFRD and based on the experience from the 2007–2013 period, was launched during the 2014–2020 programming period. Financial instruments were provided by the Fund Manager of Financial Instruments in Bulgaria (FMFIB)[6], with the Rural Development Program (RDP) allocating EUR 20 million from its budget to these risk-sharing financial instruments. Farmers and agricultural entities had the possibility to apply for credit, with the RDP covering 70% of the loan amount, while the remaining 30% was financed by the bank. Another financing option allowed 50% of the loan to be funded by the bank.

However, Bulgaria has not achieved significant success in implementing these financial instruments during the 2014–2020 programming period. Compared to CAP investment grants, financial instruments have a revolving and leverage effect, meaning that the accumulated financial resources can be reused. [7] Consequently, the two previous credit guarantee schemes, implemented by the National Guarantee Fund and the Fund Manager of Financial Instruments in Bulgaria, in conjunction with the Rural Development Program, continue to be applied.

An ex-ante assessment of financial instruments under the CAP Strategic Plan

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6 https://www.fmfib.bg/en

7 Following the art. 62 REGULATION (EU) 2021/1060 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy/ https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1060

indicates a financial gap in the agriculture and agri-food processing sectors of approximately EUR 1.2 billion, representing 36% of Gross Value Added (GVA) in agriculture. According to the assessment, the most suitable financial instrument is a guarantee scheme for investment loans and working capital loans[8].

The current financial instruments have been developed based on the type of eligible beneficiaries and the investment targets. The scope of financing has been expanded to cover agricultural holders, micro-enterprises, young farmers, and small farms. Additionally, 50% of the financial resources allocated through the financial instrument should be directed toward young farmers and very small farms. A new financing possibility allows for the combination of National CAP Strategic Plan support with financial instruments within a single funding agreement[9]. An integrated approach combining grants and financial instruments could significantly improve access to financial resources for rural infrastructure development, particularly in cases where both financial instruments and grants are implemented within a single operation.

According to the National Strategic Plan, agricultural and non-agricultural investments under the LEADER program could be supported through a combination of grants and guarantee loans within a single operation. Following the CAP's green transition objectives, financial instruments applied during the 2023–2027 programming period will include requirements for environmental and green components[10]. The loan guarantee scheme includes: capped portfolio guarantee credits – up to 80% guarantee coverage for unsecured loans[11]; a guarantee scheme - 80% guarantee for secured loans,

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8 Summary report "Financial needs in the agriculture and agri-food sectors in Bulgaria", fi_compass , EU 2020 https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_Bulgaria.pdf

9 Article 58(5). REGULATION (EU) 2021/1060 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Instrument for Financial Support for Border Management and Visa Policy/ https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1060

10 Article.80 REGULATION (EU) 2021/2115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013

11 Capped portfolio guarantee, the maximum liability of the guarantor for losses is limited to a percentage (referred to as the 'cap rate') of the guaranteed share of the portfolio volume. Guarantee rate: up to 80% on loan and 20% credit risk retains by the financial intermediary,20% of the total loan portfolio value, therefore limiting the total

and working capital loans – eligible for a 50% subsidized interest rate. Guarantee financial instruments provide some advantages for the involved stakeholders that can be grouped as shown in Table 8-6.

Table 8-6. Advantages of guarantee financial instruments for the key stakeholders

Advantages for the managing authorities	**Advantages for the banks**
Revolving nature of the finance – Ensures continuous reinvestment of financial resources.	Well-established lending processes – Banks can leverage existing credit structures.
Mobilization of private financial resources – Encourages private sector participation in rural financing.	Improved lending capacity – Enables banks to issue more loans with lower risk.
Alignment with rural development goals – Financial instruments are integrated into the Rural Development Program (RDP).	Reduced risk aversion – Banks become more willing to lend due to shared risk mechanisms.
Lower risk of unutilized funds – Reduces the risk of low absorption of allocated resources into financial instruments.	Guarantees reduce default risk – Banks receive assurances against loan defaults.
More attractive lending conditions – Allows beneficiaries to access better loan terms compared to standard market financing.	
Advantages for the beneficiaries (farmers and agricultural enterprises)	
Facilitates access to finance – Improves farmers' ability to secure funding.	
Improved lending conditions – Offers lower or no guarantee fees and reduces or eliminates collateral requirements.	
Interest rate subsidies – Provides reduced interest rates for borrowers, often below	

exposure of the guarantor to losses; https://www.fi-compass.eu/sites/default/files/publications/ERDF_Guarantees_factsheet_RTW.pdf

market levels.
Ensures long-term investments – Supports both capital investments and working capital needs for farmers and micro/small enterprises.
Supports working capital needs – Ensures liquidity for agricultural operations and expansion.
Attracts additional private financial resources – Encourages financial institutions to invest in rural businesses and communities.

Source: Authors

The use of financial instruments could support the development of specialized financial products, including short-, medium-, and long-term loans, as well as overdrafts, tailored to the needs of small-sized farms. Additionally, such instruments could increase the interest of banks that are currently not operating in the sector, thereby reducing market concentration and promoting competition among banks in financing agriculture and rural municipalities.

8.2.4 Conclusions

The CAP supports climate and sustainability-related activities, but its efficiency depends on the effectiveness of mobilizing additional private funds. Financial instruments serve as a complementary financing model to the European Agricultural Fund for Rural Development (EAFRD). Their successful implementation requires a well-defined assessment of financial needs, as both oversupply and underestimation of demand can hinder their effectiveness.

Bulgarian agricultural entities and rural business development rely primarily on CAP public subsidies and state-funded investments, with limited dependence on bank credit or direct state budget transfers. Although financial instruments under the Rural Development Program have been beneficial, experience has shown that private sector capital accumulation remains insufficient to fully support rural investment needs.

Guarantee loan schemes have enabled farmers and agri-food enterprises to access funding under preferential conditions, including reduced collateral requirements and lower interest rates compared to market-based financing. Financial instruments facilitate the implementation of investments contracted under the Rural Development Program (RDP) and help mitigate the risk of losing EAFRD funding due to incomplete projects.

The EAFRD-funded financial instrument, designed to complement grant-based support, enhances the leverage effect of the EAFRD budget and remains a preferred financing tool for many EAFRD managing authorities. Further expansion of public-private finance mechanisms will help ensure the necessary investments in climate adaptation and green initiatives. The combination of public and private resources will increase the efficiency of agricultural production, strengthen insurance mechanisms, and improve financial resilience against climate-related disasters.

8.3 Incorporating Sustainability for Holistic Assessment of Agrarian Governance Quality

There have been numerous uni or multidisciplinary studies on content and levels of agrarian sustainability around the globe since 1970s (Lampridi et al., 2019). The importance of governance as a critical factor for achieving sustainability has been also long recognized and widely accepted (Liao et al., 2024). What has been new for the first decade of twenty first century is the identification of a “new” governance pillar of agrarian sustainability along with social, economic and environment ones (FAO, 2011). Furthermore, in the last several years sustainability has been increasingly included as an important component of agrarian governance along with its agent, means, process and order elements (World Bank, 2022).

The importance of governance and the efficiency of diverse governing mechanisms and modes have always been at the center of modern economic analysis of the agri-food and rural sector. In the last few years, there have been “renewed” intensive debates on the content and role of the governance of agri-food systems involving policymakers, agro-business managers, professional organizations, interest groups, international organizations, researchers, and the public (Bachev, 2024; Bers et al., 2019; Canfield et al., 2021; Cotula, 2022; Dring at al., 2023; Dongyu et al., 2022; FAO, 2023; FMECD, 2023; Leeuwis at al., 2021; Miranda et al., 2021; Shah and Riemer, 2023; Termeera et al., 2018; UN, 2023; Yap, 2023). Simultaneously, there has been a huge growth in the number of publications by scholars in different disciplines on different aspects of agri-food governance around the globe (Herrera, 2023; Hospes and Brons, 2016; Gillespie and Nisbett, 2019; Liljeblad and Kennedy, 2018; Martínez and Rivera, 2018; Miranda et al., 2021; Shah and Riemer, 2023; Torres-Salcido and Sanz-Cañada, 2018; Vignola et al., 2021; Vinnari and Vinnari, 2019). All these interests have been associated with the "novel" challenges related to agri-food security and safety, inequity, power distribution, environmental conservation, climate change, and the recognized need for "food system transformation" (Canfield et al., 2021; Chen et al., 2021; Shah and Riemer, 2023; FAO, 2023; FMECD, 2023; Gillespie and Nisbett, 2019; Leeuwis at al., 2021; Vignola et al., 2021; UN, 2023).

Currently, there is a principle understanding that the quality of governance is the main factor that is responsible for the agri-food system state as well as its potential, challenges, and prospects of development (Bachev, 2023; Martínez and Rivera, 2018; Yap, 2023). It has also been shown that governance largely determines the ability of agri-food systems to transform in response to contemporary challenges like climate change, environment conservation etc. (Cotula, 2022; Delaney et al., 2018; Yap, 2023). Nevertheless, several recent reviews on the governance of agri-food systems showed that it is under-researched, and there are multiple issues in the research in this area (Bers et al., 2019; Delaney et al., 2018; Hospes and Brons, 2016; Oñederra-Aramendi et al., 2023; Vignola et al., 2021; Yap, 2023). Still, there is no common approach for defining the content and components of a governance system, and an acceptable framework for a comprehensive assessment of the governance is lacking. Most agri-food governance studies are at a conceptual level and follow the unidisciplinary tradition of politics, economics, management, sociology, and law sciences in that area. Furthermore, agri-food governance studies are usually restricted to a particular level or mode of governance (public, corporate, urban, and international), a specific social (economic, environmental, and healthcare) goal, or objectives of implementing (governing, donor, and stakeholder) organizations. In addition, agri-food governance assessments are predominately qualitative, incomplete, or with arbitrarily selected indicators. In the agri-food governance assessment systems, specific indicators are used depending on the applied approach, the type of agri-food system (agri-food chain; geographical or administrative region; farming; food distribution), the functional area (inputs supply and environmental and waste management), or the critical resource (water, lands, and innovation). Finaly, there is no acceptable way for incorporating sustainability and climate change (mitigation and adaptation) issues in the system of assessment of agrarian governance quality. This can cause confusion and controversies and impede the process of understanding and improvement of agri-food governance.

This paper tries to answer important academic and practical (business- and policy-related) questions related to agri-food governance: how to define the system of agri-food governance and include sustainability in its understanding, and how to measure how good agro-food governance system is. It suggests a holistic approach for an adequate understanding of the system of agri-food governance and for assessing its quality, and evaluates the quality of agrarian governance in Bulgaria at present stage of development.

8.3.1 GAMPOS framework for understanding and assessing the agrarian governance

Agri-food governance is easily defined and understood since that is the governance of agri-food system(s). Since there is not one but diverse types of agri-food systems, there is no unified agri-food governance but a system of multiple specific governances of individual agri-food systems (Bachev and Ivanov, 2024). For instance, there is governance of a particular food chain, like coffee and fair-trade and organic Bulgarian yogurt; governance of a major component of food systems, like farming, processing, and distribution, governance of food systems in a specific geographical or administrative region, like the global North, EU, and urban areas; governance of a particular functional area of food systems like input supply, and environmental and climate change management.

The main traditions for understanding and studying governance can be summarized in five directions, all of which have to be incorporated into the modern framework for defining and assessing agri-food system governance. First, the political science approach understands governance as agents (individuals, agencies, and organizations) who govern and/or participate in governance - the president, the parliament, etc. (Fukuyama, 2016). Traditional narrower understanding of this approach sees it as a synonym for government (public authority and administration), while a broader understanding includes new actors such as non-sovereign and informal agents outside the state system - international and non-governmental organizations, supra-national institutions like the European Union, etc. (Higgins, 2005). Modern understanding of governance includes all interested agents (authorities, organizations, groups, and individuals) related to the agri-food system who de factor govern it or participate in its governance (FAO, 2023; UN, 2021).

Second, the economic science (political economy) tradition approach defines governance as a means (rules, mechanisms, and modes) that governs agents' behavior, activity, and relationships (Furubotn and Richter, 2005; Scmitter, 2018; Vymětal, 2007; Vignola et al., 2021; Williamson, 2005; Yap, 2023). Modern economics sees governance as a humanly devised instrument or means (like law, trust, and organization) for structuring agents' behavior, activities, and relations and for minimizing the costs of transactions (North 1991; Williamson, 2005). In addition to institutions (formal and informal rules of the game), it studies markets, hybrids, firms, and bureaus as alternative forms of governance.

Third, the management science approach defines governance as a process of governing - the process of decision-making and the process by which decisions are implemented or not implemented in society, country, industry, and organization (Ali, 2015; Chen et al., 2021; IoG, 2003; Oñederra-Aramendi et al., 2023; Planas et al., 2022; UNDP, 1997; Wolman et al., 2008 World Bank, 2022 UN, 2021). For instance, for the

United Nations food systems, governance is the process by which societies negotiate, implement, and evaluate collective priorities while building a shared understanding of synergies and trade-offs among diverse sectors, jurisdictions, and stakeholders (UN, 2021).

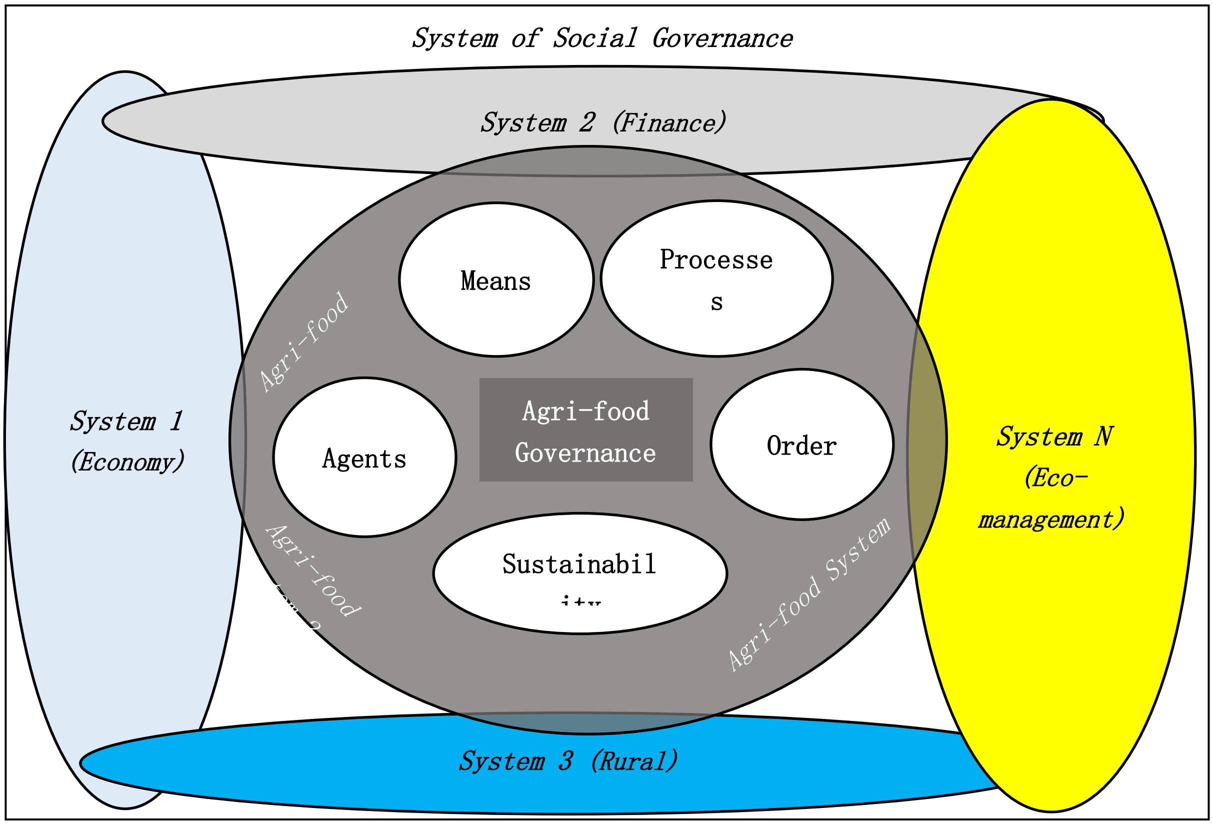
Fourth, the legal and sociological science approach sees governance as a specific formal and informal social order and the result of a process of management - the state of being governed and conducting work by mobilizing collective resources (Dixit, 2016; Fukuyama, 2016; Scmitter, 2018; Vymětal, 2007). Accordingly, in a given country, region, and industry, different types of social order are identified - e.g., the rule of law, rule of money, rule of force, rule of multinationals, and domination of informal and grey rules and activities (Bachev, 2023). Moder economics calls for analyzing all types of social orders dominating the agri-food sector - formal, informal, institutional, market, contract, private, public, and international.

Fifth, the most recent sustainability science approach relates governance to the (maintenance of or transition toward) sustainability of agri-food systems and the efficiency (impacts) of actions for achieving one or higher universal sustainability goals (such as fair income, distribution, nutrition, healthcare, environment conservation, and fighting climate change) related to and (often) beyond the agri-food system (Chen et al., 2021; Dongyu et al., 2022; Hospes and Brons, 2016; Gillespie and Nisbett, 2019; Vignola et al., 2021; Yap, 2023). According to this novel view of governance for implementation (Fukuyama, 2016; Osabohien et al., 2020; Ronaghi et al., 2020), if multiple social goals (sustainability) are being successfully achieved, there is governance (governance works well); otherwise, there is no governance (governance does not work). This understanding is largely related to the multi-actors' efforts to improve the governance system. Diverse desired goals of development (sustainability-related states) like efficient, honest, equitable, inclusive, transparent, and democratic development are identified with the governance (including agri-food governance) (Hospes and Brons, 2016; EU, 2019; UN, 2015; World Bank, 2022). Simultaneously, there has been a fundamental shift in policies and strategies of public, international, professional, civic society, and agri-business organizations in this normative direction

(Bayyurt et al., 2015; DFID, 2010; EU, 2019; Fukuyama, 2016; Higgins and Lawrence, 2005; OECD, 2015; Weiss, 2000; World Bank, 2022).

Therefore, agri-food governance is to be studied as a complex system that includes five principal components: (1) agri-food and related agents involved in the governance of decision-making, (2) means (rules, forms, and mechanisms) that govern the behavior, activities, and relationships of agri-food agents, (3) processes and activities related to making managerial decisions in the agri-food sector, (4) a specific social order resulting from the governing process, and (5) outcomes of the functioning of the system in terms of maintaining sustainability and the realization of sustainable development goals (Bachev and Ivanov, 2024). The agri-food governance system is a part (subsystem) of the social governance system and other important governance systems, such as the economy, rural or urban, ecosystem, and energy systems (Figure 8-1). On the other hand, agri-food governance consists of different governance subsystems, differentiated depending on the type of agri-food system (farming, food processing, food distribution, and food consumption), type of product (plant, livestock, and wine), the type of resources (land, water, and finance), the functional area (inputs supply, innovation, marketing, and risk management), geographical and administrative region (rural, urban, ecosystem, sector, national, transnational, European, and global).

Figure 8-1. Components of agri-food governance



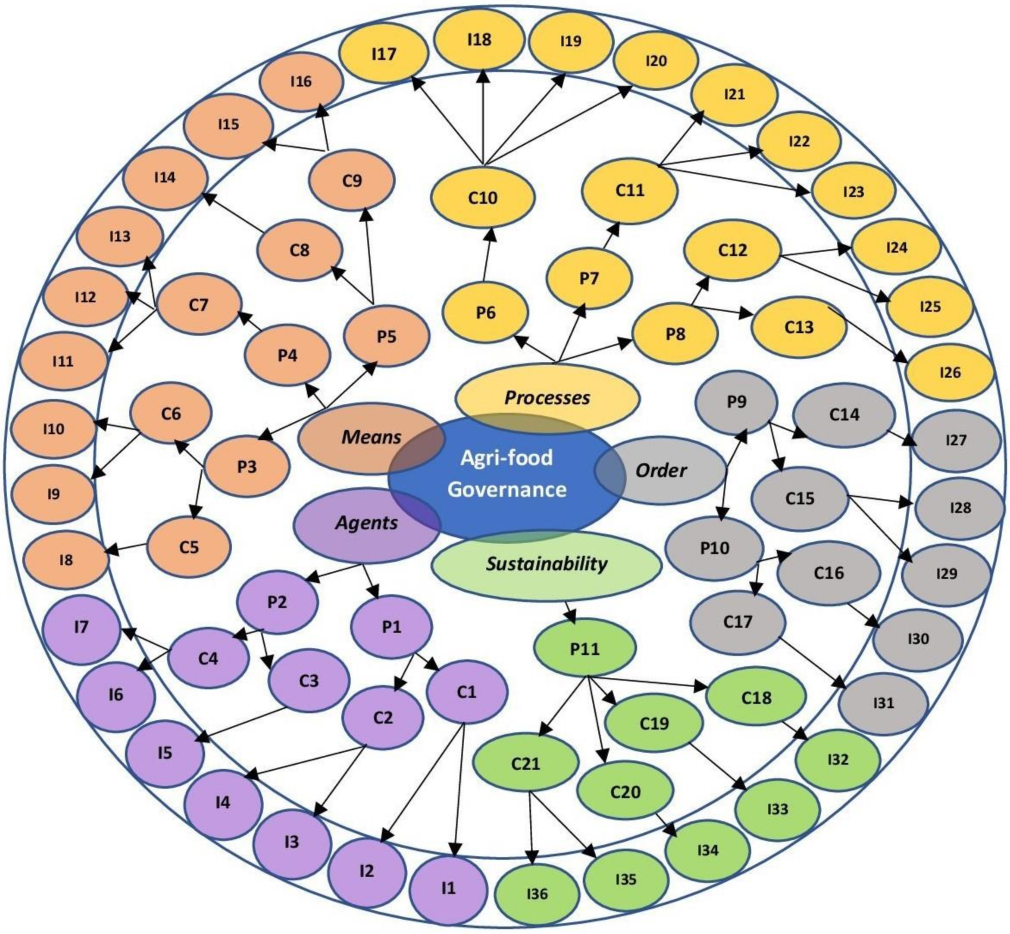
Source: authors

To assess the quality of agri-food governance, we suggest a holistic GAMPOS framework (Good, Agents, Means, Processes, Order, Sustainability). It includes the following steps (Bachev and Ivanov, 2024): defining the components of the agri-food governance system; formulating the principles of good quality agri-food governance; specifying the assessment criteria for each principle of agri-food governance; identifying the best indicators for measuring the quality of agri-food governance for each criterion; selecting the reference values for assessing the quality of agri-food governance for each indicator; deriving the agri-food governance quality score; determining the quality of agri-food governance.

The agri-food governance system has five components - agents, means, processes, order, and sustainability. The principles of quality governance are formulated for each of the components of the agri-food governance system. Governance quality principles are universal and relate to the best (socially desirable) state of the individual components of agri-food governance and the governance system as a whole. They are based on the universal principles of good governance, which have been formulated by international organizations (EU, UN, FAO, and the World Bank) and are widely accepted (written or unwritten social contract) by national governments, civil society organizations, and agri-businesses.

Eight leading Bulgarian experts in agrarian governance contributed to the assessment framework elaboration and calculated some of the estimates related to qualitative indicators. Three of the invited experts were internationally recognized scholars in agrarian governance from the Agricultural Academy, the University of National and World Economy, and the Agrarian University. Three experts were long-time leaders of major professional organizations of agricultural producers in the country. Two experts were experienced top officials from the Ministry of Agriculture and Food. The selected panel of experts represents all stakeholders, has good expertise on agrarian governance in Bulgaria and the European Union, and involves most of the qualified specialists in the country. The panel of experts selected eleven equally important good governance principles related to the individual component of agri-food governance in the European Union (and Bulgaria), including: for agent component of governance: Good Leadership (P1) and Equity and Solidarity (P2); for means component of governance: Good Working Public Sector (P3), Good Working Private Sector (P4), and Good Working Markets (P5); for process component of governance: High Transparency (P6), Good Involvement (P7), and High Efficiency (P8); for order component of governance: Good Legislation (P9) and Respectful Informal Rules (P10); for sustainability component of governance: Good Sustainability (P11) (Figure 8-2).

Figure 8-2. Multidimensional hierarchical system of principles, criteria, and indicators for assessing the quality of farming component of agri-food governance in Bulgaria



Source: authors

The assessment criteria of quality governance are specified for each of the quality governance principles. Governance quality criteria are precise standards (quality measurement approaches) for each of the principles of agri-food governance. They represent a resulting state of the evaluated system when the relevant good quality governance principle is realized. The criteria are less universal and more adapted to the characteristics of analyzed (evaluated) agri-food systems. For instance, for the specific conditions of the farming component of the agri-food system in Bulgaria, for the governance quality principle of the Good Working Public Sector, two assessment criteria were selected - No administrative deadweight and Supportive administration. For contemporary conditions of Bulgarian (and principally for the European Union) agri-food systems, twenty-one specific criteria were identified by a panel of experts. For instance, for good sustainability principle four criteria have been selected for the specific conditions of Bulgarian agriculture - Stable employment (C18), High GAV (C19), Competitive trade (C20), and Resilient environment (C21).

The assessment indicators of quality governance are selected for each of the quality governance criteria. Governance quality indicators are quantitative and qualitative variables of different types that can be assessed in the specific conditions of the specific agri-food system, allowing the measurement of compliance with a particular criterion. They have to be specific to the socio-economic, behavioral, institutional, agronomic, technological, and ecological conditions of a particular agri-food system. For instance, for the specific conditions of the farming component of the agri-food system in Bulgaria, for the Criteria Resilient environment (C21), two indicators have been selected as most appropriate - Climate change mitigation (I35) and Soil protection (I36). The final set of assessment indicators gives an all-inclusive multidirectional picture of the state of individual components of agri-food governance and the governance of the evaluated specific agri-food system.

For the selection of the best indicators from the prepared list of (all) possible governance indicators identified from the literature (Chen et al., 2021; Delaney et al., 2018; Dring et al., 2023; Hospes and Brons, 2016; Katsamunska, 2010; Ronaghi et al., 2020; Termeera et al., 2018), international assessment practices (Cigna et al., 2017; EC, 2021; World Bank, 2022), and experts' suggestions, a multicriteria assessment was performed by the panel of experts for Relevance, Discriminatory power, Analytical soundness, Intelligibility and synonymity, Measurability, Governance and policy relevance, and Practical applicability (Bachev et al., 2020). Consequently, thirty-six indicators were selected for the specific conditions of the "farming" component of the Bulgarian agri-food system (Table 8-7).

Table 8-7. System for assessing the quality of governance of Bulgarian agriculture.

Component	Principles	Criteria	Indicators	Description of indicators	Estimation	Units

nts						
Agents	Good Leadership (P1)	Good will (C1)	Taking advantage on others expense (I1)	Level of achieving own advantage on the expense of others through legal and illegal means	Experts assessment	Ranking score
			Correctness and decency in business relations (I2)	Correctness and decency in business relationships in agriculture	Experts assessment	Ranking score
		High competency (C2)	Competency of agents (I3)	Degree of competency and expertise of agrarian agents	Experts assessment	Ranking score
			Entrepreneurship abilities (I4)	Agents' entrepreneurship abilities and self-improvement	Experts assessment	Ranking score
	Equity and Solidarity (P2)	Gender equity (C3)	Level of discrimination (I5)	Level of discrimination on ethnical, religious and bigotry causes	Experts assessment	Ranking score
		Fair distribution (C4)	Fairness in remuneration of employees (I6)	Compensation of employees in agriculture/Factor income	RCA method	Share
			Balance in public support (I7)	Gini coefficient	RCA method	Coefficient
Mean	Good	No	Unlawful	Level of unlawful	Experts	Rankin

s	Working Public Sector (P3)	administrative deadweight (C5)	payments (I8)	payments and embezzlement	assessment	g score
		Supportive administration (C6)	Satisfaction from administrative services (I9)	Satisfaction degree from administrative services	Experts assessment	Ranking score
			Public spending for agrarian administration (I10)	Agri-governmental expenditure unto total governmental spending	RCA method	Percent
	Good Working Private Sector (P4)	Efficient private sector (C7)	Effectiveness of agrarian contracting (I11)	Effectiveness of contracting among agents in agriculture	Experts assessment	Ranking score
			Opportunities for different organizations (I12)	Equality in opportunities for development of different organizational forms	Experts assessment	Ranking score
			External contracting (I13)	Contractual work to total output of farms	RCA method	Ranking score
	Good Working Market (P5)	Accessible market (C8)	Market entry and exit costs (I14)	Level of entry and exit market costs	Experts assessment	Ranking score
		Fair	Competition fairness (I15)	Competition fairness and avoiding price	Experts assessment	Ranking score

		competition (C9)		rigging		
			Market orientation (I16)	Farm use and farm households' consumption unto total output	RCA method	Share
Processes	High Transparency (P6)	Confident level of awareness (C10)	Information awareness (I17)	Information awareness of agrarian agents and stakeholders	Experts assessment	Ranking score
			Costs for information access (I18)	Costs level for information access of stakeholders and agents	Experts assessment	Ranking score
			Decision-making transparency (I19)	Decision-making transparency extent	Experts assessment	Ranking score
			Symmetry of decisions to public expectations (I20)	Symmetric between decisions taken and public expectations in agriculture	Experts assessment	Ranking score
	Good Involvement (P7)	Participatory decision -making (C11)	Plurality in decision –making (I21)	Plurality level in decision –making process in agriculture	Experts assessment	Ranking score
			Unacceptable lobbying (I22)	Level of unacceptable lobbying impairing third parties	Experts assessment	Ranking score

			Access to public support (I23)	Share of farms with direct payment in the total number of farms	RCA method	Percent
	High Efficiency (P8)	High return (C12)	Costs for dealing with other agents (I24)	Total efforts and costs for dealing with other private and public agents in agriculture	Experts assessment	Ranking score
			Price rewarding potential (I25)	Price index outputs/Price input index	RCA method	Index
		Low transaction costs (C13)	Transaction costs (I26)	Total farm overhead costs/Total input	RCA method	Share
Order	Good Legislation (P9)	Comprehensive legislation (C14)	Completeness of legislation (I27)	Completeness of legislation	Experts assessment	Ranking score
		Justified enforcement (C15)	Implementation and compliance with legislation (I28)	Degree of implementation and abide with legislation	Experts assessment	Ranking score
			Costs for study and enforce rules (I29)	Level of regulation costs for get acquainted and to be enforced	Experts assessment	Ranking score
	Respe	Mutual	Trust in	Level of trust	Experts	Rankin

	ctful Informal Rules (P10)	trust (C16)	agriculture (I30)	between agrarian subjects	assessment	g score
		Good manner (C17)	Conflicts in community (I31)	Conflict level and contradiction state within agriculture community	Experts assessment	Ranking score
Sustainability	Good Sustainability (P11)	Stable employment (C18)	Engagement in agriculture (I32)	Share of population employed in agriculture	RCA method	Percent
		High GAV (C19)	Economic significance of agriculture (I33)	GAV of agriculture per capita	RCA method	Euro
		Competitive trade (C20)	Trade importance of agriculture (I34)	Agriculture export/Agricultural import	RCA method	Index
		Resilient environment (C21)	Climate change mitigation (I35)	Stare of greenhouse gases from agriculture in total greenhouse gases in the country	RCA method	Percent
			Soil protection (I36)	Quantity of nitrogen fertilizers use	RCA method	Kg/ ha

Source: authors

To assess the quality level of agri-food governance, a system of appropriate good quality governance reference values is to be specified - one for each governance quality indicator. Reference values are the best norms, range, standards, and practices defined by science, Bulgarian and European Union regulations, practices, and social contracts related to the agri-food system. They are the desired and feasible levels for indicators for the conditions of the evaluated agri-food system. For instance, for the specific conditions of the farming component of the national agri-food system in Bulgaria, a system of thirty-six good quality governance reference values is used. The reference values are determined by the European Union levels - legislated, recommended, or average depending on the specificity of the assessment indicator. The justification for using the European Union standards as reference values for assessing the quality of agri-food governance in Bulgaria is that the European Union has the world's highest agri-food system (quality, food safety, labor, animal welfare, environmental, etc.) standards, which have also been broadly adopted in many countries around the globe.

Compliance with the good quality agri-food governance principles is evaluated for each indicator. That allows us to identify the areas where agri-food governance is of superior quality and the areas where the quality of governance is not good and improvements have to be made. Often, levels of individual governance quality indicators for each criterion and/or different criteria and principles of governance are unequal and controversial. Therefore, a transformation of diverse values of indicators into a unitless governance index is needed, and individual estimates are integrated. Methodological details of the process of integration and interpretation of the governance quality indices depend on the specificity of the evaluated agri-food system.

8.3.2 Quality of agrarian governance in Bulgaria

The suggested GAMPOS framework of quality governance principles, criteria, indicators, and reference values have been adapted to the specific (socio-economic, institutional, international, and natural) conditions of contemporary Bulgarian agriculture and experimented upon to assess the quality level of its major components and the governance system as a whole. The agrarian (farming) sector of the agri-food system in Bulgaria is an important part of the national economy and employed resources, accounting for four percent of the Gross Value-Added Product, six percent of the overall employment, seventeen percent of the export, and forty-seven percent of the total land area in the country in 2022 (Agrarian paper, 2023). While in other parts of the agri-food system (food processing, distribution, and transportation retailing), the modern European Union governance standards prevail (due to the domination of multinationals, high competition and mobility of resources, stricter and easier external control from the EU), farming governance is still quite specific (due to tradition, path dependency, domination of local modes and informal institutions, and the Bulgarian way of implementing CAP of EU) (Bachev, 2023). That is the main reason to assess the farming component of the agri-food governance in Bulgaria separately.

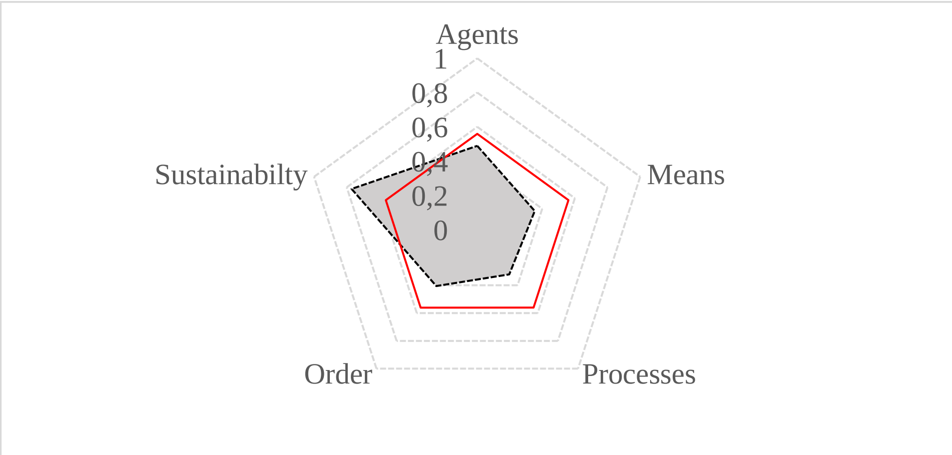
The first-in-kind evaluation of agrarian governance was performed in the beginning of 2023 using data from European and national statistical and other official sources as well as assessments of an eight-member panel of experts including leading scholars and representatives of governmental and major farmers' organizations in the country. The quality of agrarian governance is relatively stable in short periods of time (Bachev, 2023). The goal of this study was to assess the quality of agrarian governance for the period before the introduction of the new EU Common Agricultural Policy (2023–2027). The available statistical data used in this assessment were for 2019–2021. The experts were instructed to use the same period in their estimates.

For the calculation of some quality governance indicators, the Relative Comparison Assessment (RCA) Method (Ivanov and Bachev, 2024) is employed - e.g., Government spending for agricultural administration and Degree of market orientation. Eurostat and FADN statistical data were used and averaged for three years. The calculation of the remaining governance quality indicators was based on expert estimates from a five-level ranking scale - very low, low, middle, high, and very high. The common reference values used in this assessment are the average EU level and the medium EU situation, which provides the measurability and comparability of the assessment scores.

The integral governance index of Bulgarian agriculture is computed by weighting the principal score, number, and components and is represented by a qualitative score ranging from zero to one. Five categories for governance index are distinguished: very good, good, moderate, satisfactory, and bad governance, linked to range eighty-one hundredths to one, fifty-six hundredths to eight-tenths, forty-six hundredths to fifty-five hundredths, twenty-one hundredths to forty-five hundredths, and less than two tenths, respectively. The justification for the suggested approach for the calculation, integration, and interpretation of indicators is presented by Ivanov and Bachev (2024).

The holistic assessment has found that the overall quality of agrarian governance in Bulgaria is at a moderate level, with an integral governance quality index of forty-seven hundredths (Figure 8-3). There is a significant differentiation in the quality of individual elements of the governance system. Only in terms of sustainability, the agrarian governance in the country is at a good (European) level. At the same time, for the process, means, and order components, the agrarian governance is at a satisfactory level.

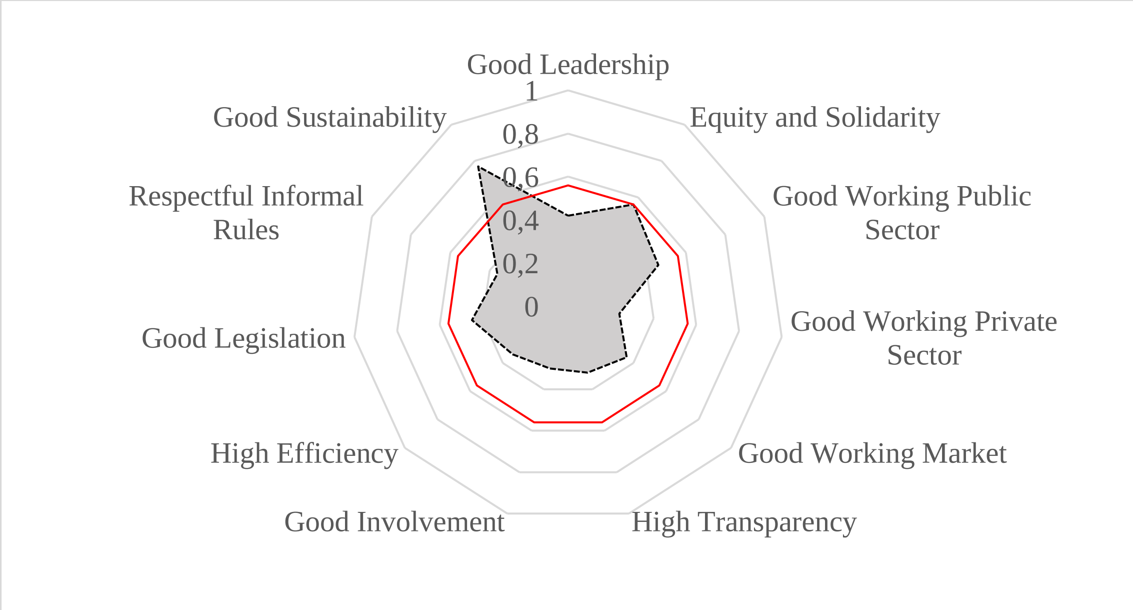
Figure 8-3. Quality of agrarian governance in Bulgaria



Source: authors calculation

The quality of agrarian governance in Bulgaria is highest in terms of equity and solidarity (good European level) and the Good Working Public Sector. In terms of the functioning of the public sector, agrarian governance is at a medium level, while for all other principles, it is at a satisfactory (European) level. The poorest performance of agrarian governance in the country is for the stakeholder’s involvement and the Good Working Private Sector (Figure 8-4).

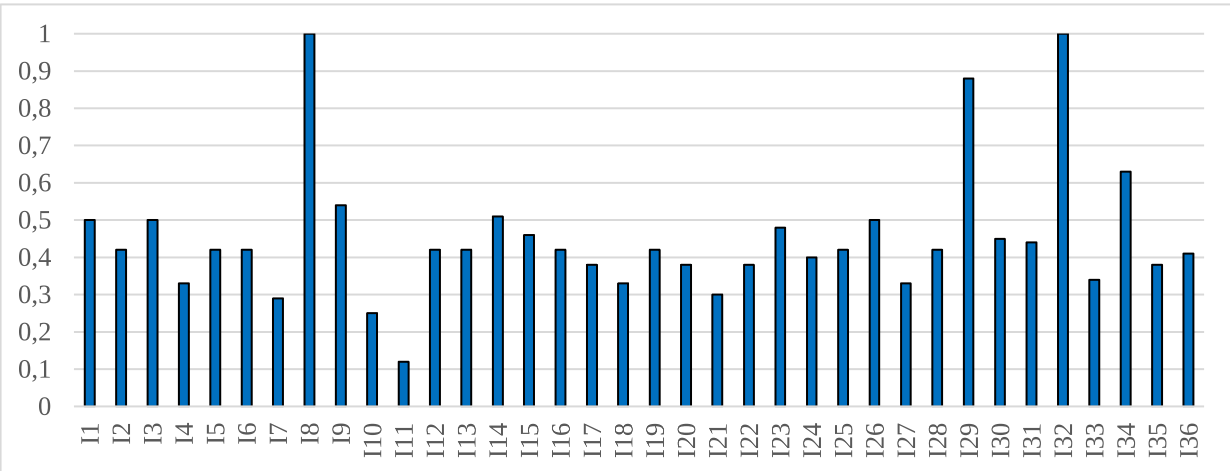
Figure 8-4. Quality of governance of Bulgarian agriculture for good governance principles



Source: authors calculation

The strongest points of the agrarian governance system at the present stage of development are people's engagement in agriculture, the level of discrimination, and the importance of agriculture in trade (Figure 8-5). These three areas show the comparative potential and advantages of Bulgarian agriculture and agri-food systems in terms of good (European) quality level of governance, and they have to be maintained and further enhanced.

Figure 8-5. Quality of governance of Bulgarian agriculture for good governance indicators



Source: authors calculation

There is a moderate quality of agrarian governance in terms of market orientation, correctness and decency in the business relationships, price rewarding potential, and information awareness of stakeholders and agents in agriculture. In these areas, the quality of governance is to be enhanced, and the existing potential for improvement must be explored.

In all other areas, the quality of governance is at a satisfactory level but is especially weak in decision-making transparency, level of unacceptable lobbying, costs and efforts for dealing with other private and public agents in agriculture, the contribution of agriculture to climate change mitigation, the significance of agriculture in the economy, symmetry between decisions taken and public expectations in agriculture, competency and expertise of agents in agriculture, and farm access to public agricultural support. In all these inferior quality areas, the efforts of agribusiness managers, public officers, and interested agents have to be directed in the future to improve the governance of the agrarian and agri-food sectors in the country. The latter can consist of new efficient policy support and regulation measures, restructuring of public organizations and administration, improvement of the governance of agricultural farms, contracts and organizations, adequate assistance from non-governmental and international organizations, or fundamental institutional reforms.

8.3.3 Conclusion

This section demonstrated that sustainability and climate issues are to be integrated into the modern understanding and assessment of agrarian governance. The latter is to be studied holistically as a complex system consisting of agrarian and related agents, diverse means directing their actions, multiple processes of decision-making, resulting social order, and outcomes in terms of sustainability. Furthermore, a more precise assessment of the quality of governance of the agri-food system as a whole and its diverse subsystems is possible using multidimensional hierarchical system GAMPOS. The later consists of systematically and well-defined good governance principles, criteria, indicators, and reference values, avoiding the arbitrary selection of measurements of the quality of agri-food governance. At the same time, this framework allows calibration according to the specificity of the evaluated agri-food system and judgment according to the best feasible standards.

The first-in-kind testing of suggested GAMPOS system has found that the quality of agrarian governance in Bulgaria is far beyond the desirable European Union level. Therefore, in the future, combined public, private, and collective efforts are to be made to improve the farming component of agri-food governance in the country. This study showed that particular attention is needed to improve currently inferior decision-making transparency, unacceptable lobbying, and high transaction costs for dealing with other agents, mitigate agricultural contribution to climate change, increase the significance of agriculture, match management decisions to public expectations, increase the competency and expertise of agrarian agents, and improve farm access to public support.

In addition, the GAMPOS framework is to be further adapted to the specificity of different agri-food systems and applied more broadly in a particular country, region, subsector, agri-food systems, and international comparisons between (different EU, EU and China, etc.) countries. The widespread application of this novel framework requires the systematic collection of new types of micro and macro data about the characteristics of governance agents, means, processes, order, and sustainability in different agri-food systems, including through official national, EU, and international statistical systems as well as the cooperation of all participating and interested parties.

8.4 Leveraging Private Sector Investment

Climate has never been constant. It has been always changing. These changes have greatly influenced the development of human society. Civilizations have arisen and disappeared, large groups of the world's population have left their places of residence in search of more favorable environments, etc. All this happened by taking into account the dynamics in the climate. People have adapted to the changed living conditions - they have introduced innovations in their life style, in their household, in their production and commercial activities. Some of these changes have had an organized nature - they have been initiated and realized by official governance authorities using public funds. The term we use in such case is funding. Others had a completely private character. They are of two types. The first one consists of private investments for adaptation of rural areas coming from other economic sectors and geographical regions. These are typical business investments. Typical are also the means for attract such investments – tax reductions, compensations in land, rights to use natural resources. The second source includes investments (money, time, efforts) of local people and communities. Such as: choice of cultivated agricultural crops and livestock, organization of water supply, manner of eating and dressing, interaction and behavior in small communities, and etc. Our study is directed to this second type of private investments. It seeks the answer of the question: How to attract local people for more intensive their own investments for adaptation of rural areas to climate change?

8.4.1 Why Adaptation?

In the second half of the last century, human society achieved an unprecedented high level of economic development based on technological innovation and institutional modernization. People's incomes and well-being rose significantly. But, the negative sides of industrial growth and urbanization quickly appeared. Among them, the pollution of nature stood out. People reacted with high concern. Unfortunately, the lessons of the past were forgotten. The inevitable impact on the environment of any human activity was declared the cause and source of climate changes, which, as always, had a natural character and followed their own independent cycle. Dazzled by technological advances politicians and administrators decided they could alter processes (of cosmic origin) and halt or at least oppose climate change.

The practice of adaptation, known for millennia and always giving positive results, was not simply forgotten. It was rejected and stigmatized. In 1992, the US Senator[12] Albert Gore declared it as a *kind of laziness* (Gore, 1992, p. 240). Astute researchers responded quickly: *How adaptable a system is to climate change—i.e. to what extent are adjustments in practices, processes, or systems structures possible in response to projected actual climate changes? This question is important for both ecological and social systems, as it is crucial to recognize that both types of systems have capacities*

[12] Later Vise President of the USA (1993-2001) and Nobel Peace Prize laureate (2007).

that will allow them to withstand the adverse effects of new conditions or take advantage of new opportunities (Watson at all, (ed.) 1995, Preface). But not politicians and bureaucrats. For a long period of time, other terms and practices dominated their thinking and decisions - risk management, mitigation, etc. Pointless restrictions were imposed and silly incentives introduced. Serious scientific research demonstrates not just its futility, but also its harmfulness. Some societies (mostly Europe) paid (and continue paying) a high social price – economic degrowth, under development, job losses, high prices, and etc., without achieving a positive environmental outcome. Voices for a return to the tried and tested practice of adaptation have grown stronger. Bureaucratic structures are gradually beginning to react. Professor Roger Pielke (University of Colorado at Boulder and Colorado State University) presents and analyzes this process of paradigm shift in details (Pielke at all, 2007). Finally, the adaptation to climate change become a modern and widely accepted concept. It is recommended today by The United Nations Organization, the European Union, The World Bank, the Organization for Economic Co-operation and Development, and others, including many national governments.

That is why we use the term adaptation to climate changes and work to make it happen in practice.

8.4.2 How Adaptation? The Case of Rural Areas

The authors of the Report of the Intergovernmental Panel on Climate Change, cited above, state that *Adaptation can be spontaneous or planned...* (Watson at all, (ed.) 1995, Preface). But, the option in which economic agents themselves (spontaneously) initiate and finance their own (but not only) adaptation to climate change was quickly forgotten. National administrations and international organizations monopolized the idea of adaptation, seeking the right to spend more and more public funds. It took a long time to understand that there is a difference between funding and financing for adaptation (Keenan at all, 2019). Even when the importance of private investment is understood, support for it consists mainly in financial incentives with public funds. In its thirtieth year, the Global Environment Facility[13] reports the mobilization of $88 million private capital for investment in environmental protection by each $1 million of their funding (Global Environment Facility. 2021).

This approach is important when adaptation to climate change requires large investments. This is the case in industry, construction, transport, urban development. The situation in rural areas is different. Investments are also needed there - in infrastructure, for example. But along with that, small steps to adapt are possible. Local people can perform such steps themselves, as they are not expensive. What they need is an institutional environment and active local society that make these steps attractive. Our study is dedicated to this problem and the results we achieved are presented here.

8.4.3 The Study

During the past five years we have intensively studied the private initiatives of agrarian agents in Bulgaria. In the last two years of this period, we paid serious attention on such kind of activities directed especially for rural adaptation to climate changes in the country. We developed our study in two stages. Firstly, acquaintance and analysis on the practice of attracting private initiatives and investments in rural adaptation all over the world. Secondly – field research on the problem in chosen regions in Bulgaria.

From methodological point of view (Terziev, 2024), we followed the ideas of Nobel Prize in economic science laureates: a) Angus Deaton – individual choice could not be explained by aggregated indicators (Deaton, 1992), b) Elinor Ostrom – there are advantages to use mostly typical cases rather than a statistically representative sample (Ostrom, 1990) and c) Oliver Williamson – qualitative comparative analysis instead of traditional mathematical applications (Williamson, 1996). In the first stage of our study, we applied the method of literature investigation. In the second – Discrete Structural Analysis. Farmers from six villages[14] were visited and interviewed face to face. These villages are in an area: a) affected by climate change (rising temperatures and dwindling water supplies) from one hand, and b) typically rural (having limited other option out

[13] Organization operating with public money

[14] Godlevo, Dolno Draglishte, Ortsevo, Gostun, Obidim, Banichan

of agriculture) from other.

Institutional Modernization for Leveraging Private Sector Investment in Adaptation to Climate Change in Rural Areas

The literature research revealed to us two main mechanisms for attracting rural people to perform initiatives and invest their money, time and efforts in adaptation to climate change. These are: a) Meso-institutions and b) Polycentric Governance.

The modern economic science is institutional by character. Just in the days of writing this text, was announced the Nobel Prize for Economic science for 2024 year. Daron Acemoglu, Simon Johnson and James Robinson share it for their explanation of the *vast differences in prosperity between nations* … by the …*persistent differences in societal institutions* (The Nobel Prize, 2024). The work of these three scientists is a direct continuation of the idea of Douglas North (Nobel prize for 1993) that: *Institutions are the rules of the game in a society* (North, 1990, p.3). They *are the humanly devised constraints that structure political, economic, and social interaction... Institutions provide the incentive structure of an economy; as that structure evolves, it shapes the direction of economic change towards growth, stagnation, or decline* (North, 1991, p. 97). But even after North, even today institutions remain somewhat mysterious. That is why Geoffrey Hodgson asked his famous question: *Generally, how do people understand rules and choose to follow them? We have to explain not only the incentives and disincentives involved but also how people interpret and value them* (Hodgson, 2006, p. 6). The problem is becoming more important year after year due to the increasing complexity of law, policy and regulations. This is especially true for rural people. For them, climate change is primarily a political issue. In formal institutions, they see no incentive to take steps towards adaptation. These institutions are too complicated for them.

This is how the need for meso institutions emerges. *Meso-institutions are the set of devices and mechanisms through which specific rules (embedded in the general ones) are delineating the domain of transactions that are possible and allowed and the modalities of their enforcement. 'Mechanisms' are here understood as the procedures through which coordination and monitoring are processed, while 'devices' are the* *organizational modalities through which mechanisms operate. For example, a regulation is a mechanism; a regulatory agency is a device* (Ménard, 2018, p. 3). We found the following meso-institutions as the most frequently used in practice around the world (Table 8-8)

Table 8-8. Meso-institutions in practice

Formal (established by parliament, government or other official bodies)	Informal (established by economic agents)
Specialized courts Arbitration mechanisms Regulatory and funding agencies Agencies, monitoring infrastructures without being their operator (irrigation, for example) Competition defending departments Mandatory standards Informational campaigns Studies, polls, surveys Educational initiatives and training programs Official meetings and discussions on policy formation	Private arbitration mechanisms Voluntarily developed and enforced standards Private forms for information exchange Community based education and training Lobbying groups for policy formation Campaigns for promotion of local products Cross border development initiatives

Source: Author's survey

The analysis of publications in the field of meso-institutions highlighted their main functions:

- translation and adaptation of general rules;
- provision of incentives or disincentives for desired behavior;
- its monitoring.

The second mechanism is Polycentric Governance.

Polycentric Governance as a term and as a practice has a long story. And many definitions. Elinor Ostrom (Nobel Prize, 2009) is the scientist turned the idea into a working economic model for governance of complex systems. She has said: *By 'polycentric' I mean a system where citizens are able to organize not just one but multiple governing authorities, as well as private arrangements, at different scales* (Cole and McGinnis, (eds). 2015, p. 61). Later, Polycentric Governance become popular approach suitable for coping with climate change (Ostrom, 2009).

During our literature investigation, the following applications of Polycentric Governance approach was discovered in various countries (Table 8-9):

Table 8-9: Polycentric Governance Modes

Modes	
Build-operate-transfer	Agri-technologies innovations
Operational/service contracts	Nature-based educations
Loose joint ventures	Agri tourism
Build-operate-own	Complementary Currency
Informal p-p co-operation	Organizational
Safety food movements	Contractual
	Social

Source: Author's survey

Many researchers underlined the potential of Polycentric Governance to copy with environmental issues especially in rural areas. Its main advantages are (Marshall, 2009):

- high adaptive capacity to social and environmental change;
- risk reduction by decreasing error proneness and promoting learning;
- providing good "institutional fit" for complex natural resource systems.

Private Sector Activities for Adaptation to Climate Change in Bulgarian Rural Areas.

Bulgarian rural people, as the rural people in other countries, are conservative, strongly oriented to self-interest, believers in traditions, relying primarily on their own actions. That is true not only for their production activities but also for entire life, including reaction to climate change. Our study showed the following picture of their experience (initiation or participation) with the modern mechanisms for adaptation (Table 8-10):

Table 8-10: Experience of Bulgarian rural people with the modern mechanisms for adaptation to climate change

Meso Institutions	Experience	Polycentric Govern nave	Experience
Formal			
Specialized courts	No	Build-operate-transfer	Yes
Arbitration mechanisms	No	Operational/service	Yes
Regulatory and funding	Yes	contracts	No
agencies		Loose joint ventures	No
Agencies, monitoring		Build-operate-own	Yes
infrastructures without	Yes	Informal p-p co-operation	Yes
being their operator	No	Safety food movements	Yes
(irrigation, for example)	Yes	Agri-technologies	Yes
Competition defending	Yes	innovations	No
departments	No	Nature-based educations	No
Mandatory standards		Agri tourism	No
Informational campaigns	No	Complementary Currency	Yes
Studies, polls, surveys		Organizational	Yes
Educational initiatives	No	Contractual	
and training programs		Social	
Official meetings and	No		
discussions on policy			
formation	Yes		
Informal			

Private arbitration mechanisms	Yes		
Voluntarily developed and enforced standards	Yes		
Private forms for information exchange	No		
Community based education and training	Yes		
Lobbying groups for policy formation	No		
Campaigns for promotion of local products			
Cross border development initiatives			

Source: Author's survey

The real steps for adaptation to climate change consist of (Table 8-11):

Table 8-11: Actions for adaptation to climate change

Actions for adaptation to climate change
From business point of view Changes in land cultivation methods Modernization of the organization for irrigation Production stricture's innovations – both in crops and livestock From life style point of view New technics and technologies for heating and cooling Saving clean water Home construction adjustments

Source: Author's survey

The incentives and information needed to perform these steps came from (Table 8-12):

Table 8-12: Sources of incentives and knowledge for steps to adaptation

Sources
Family traditions
Own experience
Discussions with neighbors and relatives
Formal informational campaigns
Specialized training
Examples seen around
Communal decisions for collective actions
Official authorities' initiatives

Source: Author's survey

Interviewed rural people are ready to accelerate their activities and investments for adaptation to climate change. To do this they need (Table 8-13):

Table 8-13: Options for more private activities and investments for adaptation to climate change

Options
External funding (full or significant percentage of costs)
Better market conditions (allowing costs to be covered by sales)
Lowering bureaucracy
Rising the capacity of communities for collective actions
More reliable information and modern know how transfer
Adequate recognition from general society

Source: Author's survey

8.4.4 Conclusions

Bulgarian rural people do understand to problem of climate change. Over more, they are taking steps to adapt. In capital intensive cases they prefer external funding. That is understandable as they are not rich and the return of such kind of investments is low and slow. But in other cases, they are ready to invest their own money, time and efforts to adapt themselves, their family, homes, residential places, and what is more important – their business. To continue to do so in increasing volume they need a stimulating institutional environment and more active local societies. In this, they do not differ from the rural people in other countries. Our study shows that the state's authorities could support the leveraging of local private investment for adaptation of rural areas to climate change by initiating and supporting both positive Meso Institutions and fair Polycentric Governance.

Chapter 9: Conclusion and Future Directions

9.1 Synthesis of Key Messages

This book has provided an analysis of the climate risks and adaptation opportunities in rural Bulgaria. Through an in-depth examination of climate hazards, sectoral impacts, and adaptation strategies, the book has highlighted the urgent need for proactive and integrated approaches to climate adaptation. The key insights from each chapter are synthesized below:

Climate Change Impacts: Rural Bulgaria is highly vulnerable to climate change, with significant impacts on agriculture, water resources, forestry, and infrastructure. These impacts are exacerbated by the climate reliance of the region and limited adaptive capacity.

Adaptation Strategies: Effective adaptation requires a multi-sectoral approach that integrates agricultural resilience, water management, forestry protection, and community engagement. Chapters 3 through 8 have outlined specific strategies, including the adoption of climate-resilient agricultural practices, sustainable water management, and community-based adaptation initiatives.

Policy and Governance: Strengthening policy frameworks, enhancing institutional capacity, and fostering public participation are critical for building climate resilience. The National Climate Change Adaptation Strategy and Action Plan of the Bulgarian government provides a foundation for these efforts, but implementation remains a significant challenge.

Economic Considerations: Climate adaptation must be economically viable, with strategies that promote sustainable development and social equity. The economic impacts of climate change in rural Bulgaria are substantial, affecting agricultural productivity, water availability, and infrastructure stability. Effective adaptation can mitigate these impacts and ensure long-term economic viability.

9.2 The Path to a Climate-Resilient Rural Bulgaria

Achieving a climate-resilient rural Bulgaria requires a concerted effort from all stakeholders. The following sections outline the key priorities and strategic directions for climate adaptation:

9.2.1 Enhancing Agricultural Resilience

Agriculture is a cornerstone of rural Bulgaria’s economy, contributing 6% to the Gross Value Added (GVA) and employing 18.3% of the workforce. Climate change exacerbates existing challenges such as water scarcity, soil degradation, and increased pest and disease prevalence. The economic consequences are significant, with reduced crop yields and increased production costs impacting farmers’ incomes and food security.

Key Strategies:

Adopting Climate-Resilient Practices: Promote the use of drought-resistant crop varieties, improved irrigation techniques, and sustainable land management practices. These strategies can help mitigate the impacts of changing weather patterns and enhance agricultural productivity. For example, the use of drought-resistant crops such as sorghum and millet can provide a more stable yield under water-limited conditions.

Strengthening Infrastructure: Invest in modernizing irrigation systems, water storage facilities, and rural roads to enhance resilience to extreme weather events. Upgrading irrigation infrastructure can significantly improve water use efficiency and reduce the vulnerability of agricultural systems to droughts.

Building Farmer Capacity: Provide training and technical support to farmers on climate adaptation strategies, including access to weather forecasting and market information. This can help farmers make informed decisions about crop selection and planting schedules, thereby reducing the risks associated with climate variability.

9.2.2 Protecting Water Resources

Water scarcity is a critical issue in Bulgaria, with climate change exacerbating the problem. The economic impacts include reduced hydropower generation, increased irrigation costs, and environmental degradation. Effective water resource management is crucial for ensuring food security and supporting economic activities in rural areas.

Key Strategies:

Integrated Water Management: Develop and implement integrated water resource management plans that balance agricultural, domestic, and industrial needs.

This can involve the construction of water storage facilities, such as reservoirs and dams, to ensure a reliable water supply during dry periods.

Promoting Water Conservation: Encourage the adoption of water-saving technologies and practices in agriculture and households. For example, drip irrigation systems can reduce water use by up to 50% compared to traditional flood irrigation methods.

Investing in Water Infrastructure: Upgrade and maintain water supply and sanitation systems to ensure access to clean water and reduce contamination risks. This includes the installation of water treatment plants and the rehabilitation of aging water distribution networks.

9.2.3 Strengthening Forestry Management

Forests cover 37.4% of Bulgaria’s land area and play a vital role in the economy. Climate change poses significant risks to forest health and biodiversity, including increased fire risks, reduced timber production, and biodiversity loss.

Key Strategies:

Sustainable Forestry Practices: Promote sustainable logging practices and reforestation efforts to enhance forest health and biodiversity. This can involve the use of selective logging techniques and the planting of native tree species to restore degraded forest areas.

Fire Risk Mitigation: Implement proactive measures to reduce the risk of forest fires, including early warning systems and controlled burns. Early detection and rapid response can significantly reduce the economic and environmental impacts of forest fires.

Community Engagement: Involve local communities in forestry management decisions to ensure long-term sustainability and resilience. This can be achieved through community-based forestry initiatives and the establishment of local forest management committees.

9.2.4 Building Climate-Resilient Infrastructure

Rural infrastructure is vulnerable to climate impacts, with significant economic consequences. Strategic actions are needed to enhance the resilience of critical infrastructure, including energy, transportation, and communication networks.

Key Strategies:

Upgrading Critical Infrastructure: Invest in modernizing energy, transportation, and communication networks to withstand extreme weather events. This can involve the construction of flood-resistant bridges and roads, as well as the installation of resilient energy distribution systems.

Promoting Renewable Energy: Expand the use of renewable energy sources, such as solar and wind power, to reduce reliance on fossil fuels and enhance energy security. Renewable energy projects can also create new economic opportunities in rural areas.

Enhancing Digital Connectivity: Improve broadband access and digital infrastructure to support economic development and climate adaptation efforts. Digital technologies can facilitate the dissemination of climate information and support the implementation of adaptive measures.

9.2.5 Fostering Community Engagement and Empowerment

Engaging rural communities is crucial for effective climate adaptation. Priorities include strengthening local governance, promoting public participation, and building social capital.

Key Strategies:

Strengthening Local Governance: Empower local authorities to lead climate adaptation efforts and integrate resilience into their planning processes. This can involve the development of local climate action plans and the establishment of climate adaptation funds.

Promoting Public Participation: Encourage community involvement in climate adaptation projects through consultations, workshops, and collaborative decision-making. Public participation can enhance the acceptance and effectiveness of adaptation measures.

Building Social Capital: Foster partnerships between government, NGOs, and the private sector to leverage resources and expertise for climate adaptation. Social capital can facilitate the sharing of knowledge and best practices, enhancing the overall resilience of rural communities.

9.3 Integrating Climate Risk Management into Policy

Effective climate adaptation requires integrating climate risk management into all levels of policy and governance. Strategic directions include developing comprehensive climate strategies, mainstreaming climate adaptation, and enhancing monitoring and evaluation.

9.3.1 Developing Comprehensive Climate Strategies

Align national and regional climate adaptation strategies with EU frameworks, such as the European Green Deal and the Paris Agreement. This involves setting clear targets for reducing greenhouse gas emissions and enhancing resilience to climate impacts.

Key Actions:

Setting Emission Reduction Targets: Establish ambitious targets for reducing greenhouse gas emissions in line with the Paris Agreement. This can involve the implementation of sector-specific emission reduction measures, such as promoting renewable energy in the energy sector and improving energy efficiency in agriculture.

Enhancing Resilience Targets: Set targets for enhancing the resilience of critical sectors, such as agriculture, forestry, and water resources. This can involve the development of sector-specific adaptation plans and the allocation of resources for resilience-building initiatives.

9.3.2 Mainstreaming Climate Adaptation

Ensure that climate resilience is a cross-cutting priority in sectoral policies, including agriculture, forestry, water management, and energy. This involves integrating climate considerations into all stages of policy development, implementation, and evaluation.

Key Actions:

Policy Integration: Integrate climate adaptation into all relevant policies and regulations, ensuring that climate considerations are addressed in a coherent and consistent manner. This can involve the development of climate-proofing guidelines for policymakers and the establishment of climate adaptation funds.

Capacity Building: Strengthen the capacity of policymakers and practitioners to integrate climate considerations into their work. This can involve the provision of training and technical support, as well as the development of climate adaptation tools and resources.

9.3.3 Enhancing Monitoring and Evaluation

Establish robust mechanisms for monitoring climate adaptation efforts and evaluating their effectiveness. This involves the development of climate adaptation indicators and the establishment of monitoring systems to track progress and identify areas for improvement.

Key Actions:

Developing Indicators: Develop a set of climate adaptation indicators to measure the progress of adaptation efforts and assess their effectiveness. These indicators can include measures of resilience, such as the proportion of agricultural land under climate-resilient practices, and measures of vulnerability, such as the frequency of extreme weather events.

Establishing Monitoring Systems: Establish monitoring systems to track the implementation of climate adaptation measures and evaluate their impact. This can involve the use of remote sensing technologies and climate models to assess the effectiveness of adaptation strategies.

9.4 Long-Term Vision for Rural Bulgaria

The long-term vision for rural Bulgaria is one of resilience, sustainability, and prosperity. This vision involves the diversification of rural economies, the promotion of sustainable development, and the enhancement of social equity.

9.4.1 Economic Diversification

Support the diversification of rural economies through initiatives that promote agro-tourism, renewable energy, and small-scale enterprises. This can help reduce the vulnerability of rural communities to climate impacts and enhance their economic resilience.

Key Actions:

Promoting Agro-Tourism: Develop agro-tourism initiatives that leverage the natural and cultural assets of rural Bulgaria. This can involve the establishment of eco-lodges, farm stays, and agritourism experiences that provide new income streams for farmers and rural communities.

Supporting Renewable Energy: Expand the use of renewable energy sources, such as solar and wind power, to create new economic opportunities in rural areas. This can involve the development of community-owned renewable energy projects and the provision of financial incentives for renewable energy investments.

9.4.2 Sustainable Development

Promote sustainable land use and resource management practices to protect the environment and ensure long-term economic viability. This involves the adoption of sustainable agricultural practices, the conservation of natural resources, and the enhancement of ecosystem services.

Key Actions:

Adopting Sustainable Practices: Promote the adoption of sustainable agricultural practices, such as conservation tillage, crop rotation, and integrated pest management. These practices can help reduce the environmental impact of agriculture and enhance its resilience to climate change.

Conserving Natural Resources: Implement measures to conserve natural resources, such as water, soil, and biodiversity. This can involve the establishment of protected areas, the restoration of degraded ecosystems, and the promotion of sustainable forestry practices.

9.4.3 Social Equity

Address social inequalities and ensure that climate adaptation efforts benefit all segments of the rural population, including vulnerable groups. This involves the provision of social protection measures, the enhancement of access to education and healthcare, and the promotion of gender equality.

Key Actions:

Providing Social Protection: Develop social protection measures to support vulnerable groups, such as small-scale farmers, women, and the elderly. This can involve the provision of financial assistance, insurance schemes, and access to credit.

Enhancing Access to Education and Healthcare: Improve access to education and healthcare services in rural areas to enhance the well-being of rural communities. This can involve the construction of new schools and clinics, as well as the provision of mobile healthcare services.

9.5 Conclusion

This book delves into the intricate challenges and potential avenues for climate adaptation in Bulgaria's rural areas. By analyzing climate risks, their effects on various sectors, and potential adaptation measures, the research underscores the critical importance of adopting forward-thinking and comprehensive strategies to mitigate the diverse consequences of climate change. The main findings from each chapter are summarized below, accompanied by an exploration of the study's constraints and potential future research paths.

Rural Bulgaria faces substantial consequences from climate change, particularly in agriculture, water systems, forests, and infrastructure. These effects are intensified by the area's dependence on rainfall for agriculture and its limited ability to adapt. A successful adaptation strategy must encompass a holistic approach that combines enhancing agricultural durability, managing water resources, safeguarding forests, and involving local communities. Effective adaptation requires a multi-sectoral approach that integrates agricultural resilience, water management, forestry protection, and community engagement.

While this study provides a comprehensive analysis of climate adaptation in rural Bulgaria, it is not without limitations. First, the study primarily focuses on the impacts of climate change on agriculture, water resources, and forestry, with limited attention to other sectors such as health and energy. Future research should explore the broader impacts of climate change on these sectors to develop more holistic adaptation strategies. Second, the study relies on existing data and models, which may not fully capture the complexity and uncertainty of climate change impacts. More sophisticated predictive models and scenario analyses are needed to better understand the potential outcomes of different adaptation strategies. Third, the recommendations are based on the current policy and institutional landscape, which may evolve over time. Continued monitoring and evaluation of policy effectiveness are essential to ensure that adaptation measures remain relevant and effective.

Looking ahead, several key areas require further attention to enhance climate resilience in rural Bulgaria. Technological innovation will play a crucial role in climate adaptation. Advances in artificial intelligence, big data, and renewable energy can provide more accurate and timely forecasting of climate risks, as well as more efficient solutions for managing water resources and agricultural production. For example, AI-driven systems can improve the effectiveness of disaster warning and response, while precision agriculture technologies can help farmers optimize resource use and mitigate climate-induced risks.

Sustainable land-use practices should be prioritized to ensure the long-term viability of rural livelihoods. Conservation agriculture techniques, such as crop rotation, cover cropping, and reduced tillage, can improve soil health and water retention, enhancing resilience to droughts. Agroforestry systems, which integrate trees into agricultural landscapes, can provide additional income streams for farmers while sequestering carbon and protecting biodiversity. Similarly, the restoration of degraded ecosystems, such as wetlands and riparian zones, can enhance water regulation services and reduce the risk of flooding.

Community engagement and empowerment are fundamental to the success of climate adaptation efforts. Local communities possess valuable traditional knowledge and are often the first to experience the impacts of climate change. Involving them in the planning and implementation of adaptation measures can ensure that these strategies are context-specific, culturally appropriate, and widely accepted. This can be achieved through participatory approaches such as community workshops, citizen science initiatives, and collaborative decision-making processes. Strengthening social networks and fostering partnerships between government agencies, non-governmental organizations, and the private sector can also enhance the overall resilience of rural communities.

Policy and governance frameworks must be strengthened to support climate adaptation efforts at all levels. Aligning national and regional strategies with international frameworks such as the Paris Agreement and the European Green Deal is essential to ensure coherence and consistency in climate action. Setting clear, measurable targets for reducing greenhouse gas emissions and enhancing resilience can provide a roadmap for progress. Integrating climate considerations into all stages of policy development, from planning to implementation and evaluation, can ensure that adaptation measures are effective and sustainable. Additionally, addressing social inequalities and ensuring that adaptation efforts benefit all segments of the population, particularly marginalized groups, is crucial for building an equitable and resilient society.

In conclusion, achieving climate resilience in rural Bulgaria requires a concerted effort from all stakeholders, including policymakers, researchers, communities, and the private sector. By prioritizing agricultural resilience, protecting water resources, conserving forests, modernizing infrastructure, and fostering inclusive governance, Bulgaria can mitigate the impacts of climate change and build a sustainable future for its rural populations. The recommendations outlined in this study provide a foundation for action, but their success will depend on continued collaboration, innovation, and commitment. As climate change continues to pose unprecedented challenges, the need for proactive, integrated, and equitable adaptation strategies has never been more urgent. The journey toward resilience is not just a local or national imperative—it is a global responsibility, reflecting the interconnectedness of climate risks and the shared commitment to a sustainable future.

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