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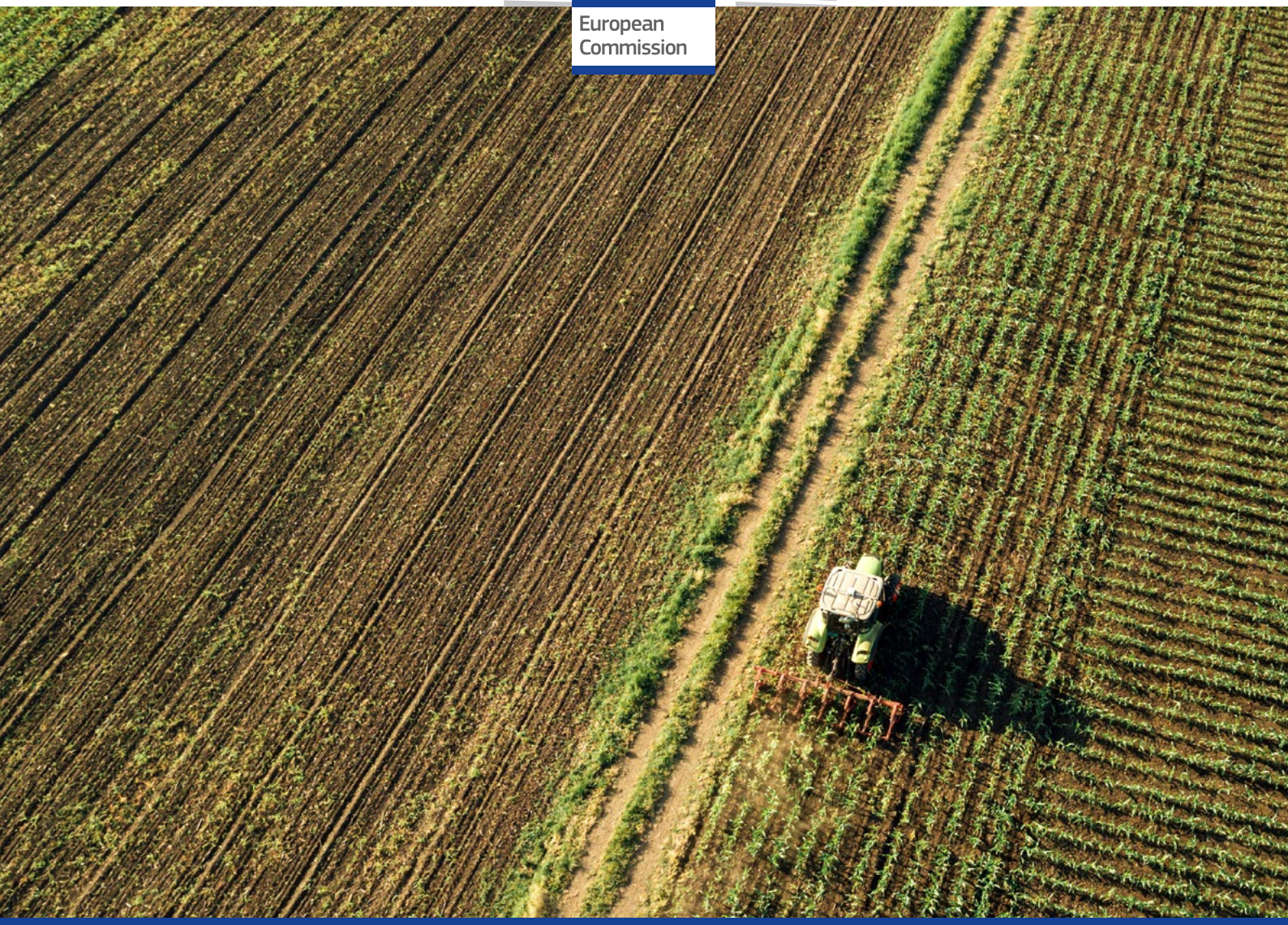

Economic Diversification and Sustainable Agriculture in Stara Zagora

START Sectoral Report

Energy

EUROPEAN COMMISSION
Directorate-General for Energy
Directorate B – Just Transition, Consumers, Energy Security, Efficiency and Innovation
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EC-ENER-JUST-TRANSITION@ec.europa.eu

European Commission
B-1049 Brussels

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Executive summary

This report outlines recommendations for developing a strategic framework to assist the Stara Zagora region in Bulgaria. It focuses on transitioning from its traditional coal-based industry to a more sustainable and diversified economic model including a sustainable and innovative agricultural sector. This is particularly pertinent given Bulgaria's commitment to phasing out coal-based electricity by 2038.

Three key strategic pathways have been identified as particularly promising in supporting such a transition:

1. **Pathway 1: Innovative technologies**. The adoption of cutting-edge agriculture technologies is key to modernising Stara Zagora's agricultural practices. In particular, the integration of hydroponics, precision agriculture tools and digital farming solutions would enhance the productivity and economic value of its agriculture, moving away from traditional labour-intensive and less efficient methods. Hydroponics systems allow for controlled environment agriculture, which maximises crop yields and quality by optimising nutrient delivery and water usage. Digital tools such as drones, automated irrigation systems, and AI-driven analytics, on the other hand, can lead to more informed decision-making and better resource management. All these developments would lead not only to increased efficiency and productivity but also to reduced carbon impact and enhanced environmental performance.
2. **Pathway 2: Renewable energy**. Transitioning to renewable energy sources implies the incorporation of solar panels, wind turbines, and biomass energy systems in the agricultural sector in Stara Zagora. This can significantly reduce the region's reliance on fossil fuels, decreasing both greenhouse gas emissions and energy costs. Additionally, such a transition would enhance the region's energy independence: for instance, solar energy can be used to power farm operations and irrigation systems, while biomass energy can be generated from agricultural waste products. For this to be achieved, this pathway also includes the development of infrastructure and training programs to ensure that farmers and businesses are equipped to implement and maintain these new energy systems effectively.
3. **Pathway 3: Sustainable production of forage crops**. This pathway focuses on sustainable forage crop production, such as lucerne (alfalfa) to leverage the natural benefits of these crops to improve agricultural sustainability. Alfalfa enhances soil fertility and biodiversity through natural processes like nitrogen fixation and deep root systems, leading to better water retention, carbon sequestration, and overall soil health. Integrating green biorefineries into this pathway leverages the biomass from forage crops for additional value creation. Such biorefineries, in fact, process plant materials into biofuels, bioplastics, and other bioproducts, contributing to a circular bioeconomy. Therefore, promoting the cultivation of protein-rich forage crops reduces reliance on imported animal feed, enhances food security, and bolsters local agricultural economies—which can be further enhanced through by-products of green biorefineries.

These pathways are supported by the definitions of activities designed to support the success of pilot projects. Their successful implementation is expected to encourage the widespread adoption of sustainable practices, leading to enhanced agricultural efficiency, reduced environmental impacts, and significant economic growth within the region. The anticipated impact of this strategic shift includes a substantial increase in economic activity within the agricultural sector, fostered by collaborative efforts among farmers, businesses, and educational institutions. This collaboration is crucial for integrating new technologies effectively. Furthermore, the strategy is aligned with the European Green Deal and Bulgaria's national plans, ensuring a just transition for communities previously dependent on coal, while simultaneously creating new job opportunities. This integrated approach underscores the necessity of strategic investments and continuous innovation, aiming to position Stara Zagora as a leading example of sustainable agricultural practices and economic diversification. By focusing on environmentally sound and economically viable methods, the strategy seeks not only to mitigate the socio-economic effects of the coal phase-out but also to bolster the overall resilience and prosperity of the community.

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Introduction

Stara Zagora, a region integral in Bulgaria's electricity production, is at a pivotal juncture due to its reliance on the Maritsa Iztok energy complex. With Bulgaria committed to phasing out coal-based electricity by 2038, this transition presents challenges that could affect an estimated 30% of the region's population by job losses and economic changes. Stara Zagora's vision is to transform its economy by 2038, prioritising the reduction of emissions and ensuring a fair transition for affected communities. To support this transition, the plan focuses – among other pathways – on creating higher value agriculture and food production in the region to leverage existing strengths for sustainable growth amid the challenges of the energy transition.

The agricultural sector plays a key role in Stara Zagora, employing 17.2% of the region's population, and contributing 4.3% to the gross value added (GVA) of the region[1]. Although cereal cultivation and livestock farming are prevalent across the region, variations in crop cultivations within the region exist due to diverse climatic and soil conditions. In the northern part, permanent perennial plantations (e.g. fruit trees), oilseed crops (e.g. sunflower and rapeseed), and oil-bearing roses are grown, while in the southern, flatter part, irrigated vegetables and annual crops are more common[2].

Besides, Stara Zagora is an important centre for **wine production**, with Domain Menada being the most prominent winery in the region. The area is also home to **'Zagorka'**, **Bulgaria's largest brewery**, which is part of the Heineken Group and holds a substantial 30% share of the national beer market. In addition, Stara Zagora has traditionally been the centre of companies producing machinery and equipment for the food industry, including hydraulic parts for agricultural machinery or large-scale **food processing machinery**. The economy of Stara Zagora also includes large companies in the chemical industry, e.g. fertiliser production, as well as the **extraction of essential oils for the cosmetics industry**[3]. This sector has consistently invested in training its workforce and consists of export-oriented companies with markets across the EU. Trakia University is another key player in the region due to their expertise in agriculture, making them well-suited to provide advice and training in the sector.

The objective of the project is to promote economic diversification and sustainable agriculture in Stara Zagora. This involves developing strategies for reducing greenhouse gas emissions, ensuring a just transition for communities affected by the coal phase-out, and focusing on sustainable agriculture and food production as central elements. The project aims to identify priority areas for development, design interventions for sustainability, and engage stakeholders to leverage local strengths in smart agriculture, bioeconomy, and circular economy, thereby creating high-quality jobs and supporting the European Green Deal and Bulgaria's National Plans.

The report is structured into several sections, starting with an analytical framework (AF) describing the strategic planning for the pathways to develop economic diversification and sustainable agriculture in Stara Zagora. The AF details steps from context assessment to strategic pathways, covering inputs, activities, outputs, outcomes, and impacts. This framework describes the process to evaluate the effectiveness of these strategies and their potential redirection based on feedback. It underlines the importance of stakeholder engagement and includes a diagram to illustrate the strategic planning process. The AF is followed by the description of the context of the agricultural sector in the region and the identification of Pathways. The pathways are generally described in terms of inputs, activities for developing the pathway, outputs, outcomes, and impacts. Then, for each pathway, a proposed pilot project goes more in detail on the action plan to develop in collaboration with the stakeholders.

1. Doitchinova, J. & Kanchev, I. (2021). Agriculture in the context of rural development: South-Eastern planning region.
2. Regional Economic Development Agency Stara Zagora. (2023). Investment plan – Stara Zagora.
3. Stara Zagora Municipality. (2020). Integrated Development Plan for the Period 2021 – 2027.

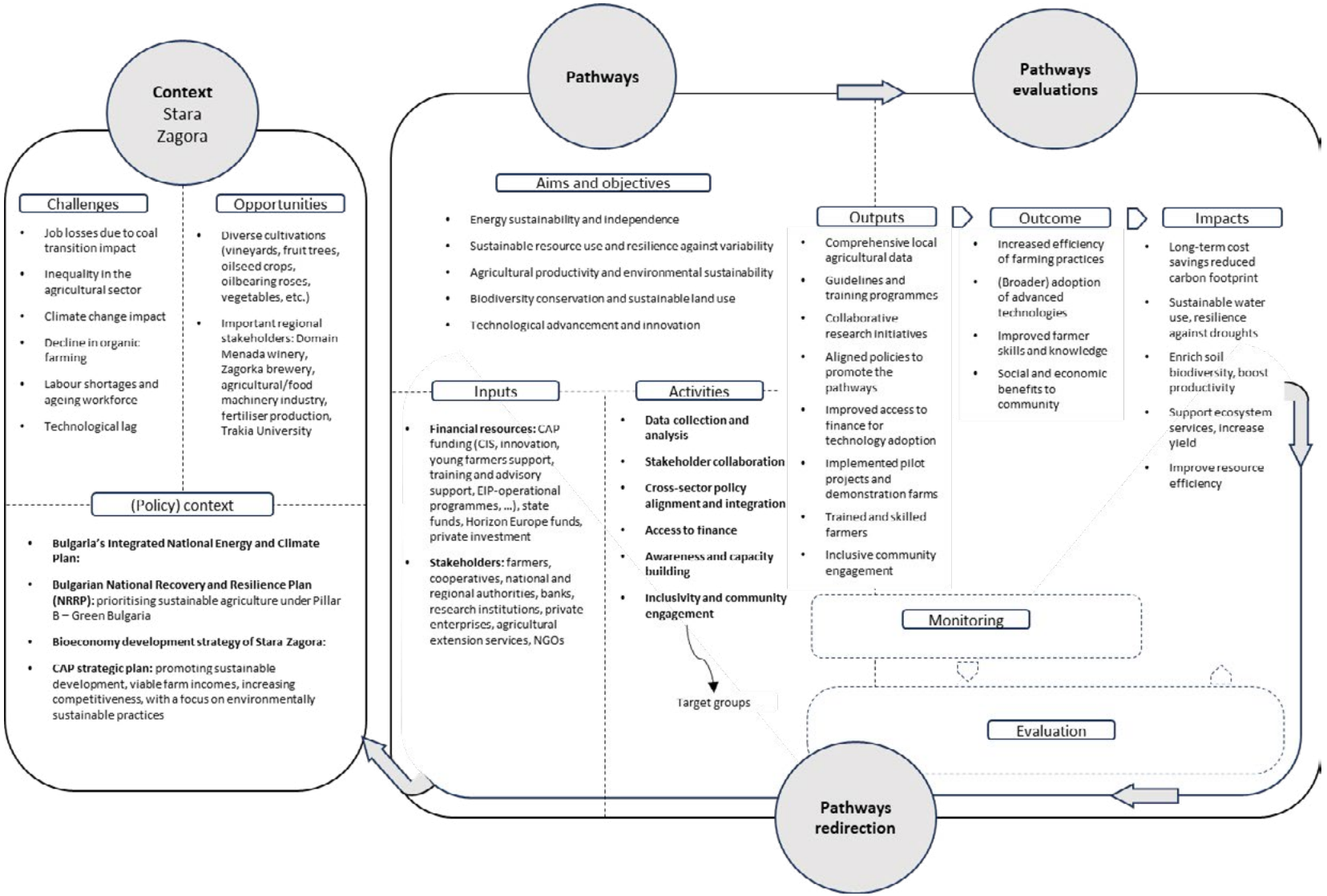
Analytical framework

The AF for Stara Zagora's strategic planning for economic diversification and sustainable agriculture aims to clarify the links between the proposed strategies, the identification of resources, the proposed activities and the expected results, both immediate and long term. By using a systematic approach to developing the strategies, we ensure that the purpose of the activities is clear: it justifies the need for the pathways, what it aims to achieve and how it plans to do so. The AF also acts as a template to be filled in with the specifics of the activity, providing clarity on how the planned activities will directly address the targeted issues in the region. The strategic planning framework builds on the following steps:

1. **Context**: This is the initial assessment phase where the current state of the agricultural sector in Stara Zagora is analysed. It sets the stage by outlining the prevailing conditions, challenges, and potential opportunities within the region. It also includes an assessment of the policy context that influences inputs, activities and ultimately outcomes. It covers the political, economic and social environment in which strategies are developed and implemented.
2. **Pathways**: Following the assessment of the context, several strategic pathways are defined. These pathways represent the courses of action or strategies selected to move from the current situation to desired future outcomes. They are the core strategies devised to tackle the identified challenges and leverage opportunities.
    a. **Inputs**: Inputs are the resources, financial and human, as well as the various stakeholders involved in the strategic process. This includes funding from various sources, such as community initiatives, innovation and young farmer support, and the engagement of a wide range of actors from farmers to NGOs.
    b. **Activities**: These are the actions taken to address the situation in Stara Zagora. While the specific activities are not detailed in the figure, they typically involve the application of inputs to create change, such as programs, projects, and initiatives.
    c. **Outputs**: Outputs are the immediate results of the activities. They represent the tangible deliverables and services produced by the strategic actions.
    d. **Outcome**: The outcome is the short-term effect of the outputs. This could include changes in knowledge, skills, attitudes, behaviours, or the state of the target groups.
    e. **Impacts**: Long-term impacts are the end goals of the strategic planning process, reflecting the deep and lasting changes that are expected to arise from the outcomes. In the context of Stara Zagora, these include environmental sustainability measures such as long-term cost savings and reduced carbon footprint, as well as agricultural improvements like enriched soil biodiversity and increased productivity.
6. **Pathways Evaluations**: This step aims to evaluate the effectiveness of the pathways. It assesses whether the selected strategies are achieving the desired outcomes and whether they are on track towards the long-term goals. This is a crucial step in ensuring that the strategies have the intended impact.
7. **Pathways Redirection**: Based on the evaluations, strategies may need to be redirected. This step aim at fine-tuning or altering the pathways in response to feedback and changing circumstances to ensure continued alignment with goals.

The diagram incorporates feedback loops, which include **monitoring and evaluation activities**. These loops allow for continuous improvement of the strategic process by providing ongoing data on performance, informing necessary adjustments to activities, and refining inputs based on the evaluations conducted.

FIGURE 1. ANALYTICAL FRAMEWORK FOR STRATEGIC PLANNING ON ECONOMIC DIVERSIFICATION AND SUSTAINABLE AGRICULTURE



Source: Own elaboration – adapted from URBACT's intervention logic design

Context and identification of pathways

Significant challenges remain in the Bulgarian agri-food sector, which also impacts the region of Stara Zagora. Since Bulgaria's accession to the EU, the agricultural sector has become heavily dependent on subsidies and funding from European programmes. Unfortunately, this financial support has mainly benefitted large-scale farms and arable crop producers, leading to imbalances where 6% of farmers receive 80% of direct payments from the Common Agricultural Policy (CAP) in Bulgaria[4]. Furthermore, Bulgaria has the highest concentration of agricultural land in the hands of a few farmers, compared to other EU countries, leading to a high degree of political dependency within the sector[4]. Conversely, the prevalence of highly fragmented small-scale agricultural properties hinders the aspirations of small family farmers to expand. The inheritance of land with multiple owners is a significant obstacle to the implementation of large-scale development plans, and access to European funds requires the unanimous consent of all owners. Despite some recent progress, significant inequalities remain within the agricultural sector[4,5]. The absence of robust trade unions, cooperatives and public advisory structures compound these challenges and hinder the overall development of the sector[4].

Farmers in Bulgaria face a series of challenges. Research suggests that factors like climate change, technology advancements and policy changes will significantly impact European agricultural systems. However, South and Eastern Europe could potentially experience lower incomes due to less advanced infrastructure and technologies, as well as harsher effects of climate change, creating a geographical disparity within the EU[6]. Combined with the perceived heavy workload, the volatility of prices, disruptive events such as the War in Ukraine, the imports of low-quality products distorting the market[7] and the rising costs of energy—also due to compliance with EU energy transition requests[8]— this makes the sector relatively unattractive for younger generations. The reluctance of younger family members to take over farming businesses is largely due to the unappealing economic outlook of such enterprises. Farms require substantial and ongoing investments in time and resources, including constant innovation and research and development (R&D) activities[9], which do not always assure sufficient profit margins.

In general, labour shortage risks becoming a significant bottleneck. Smaller farmers face intense competition from larger operations, leading to divergent perspectives within the same community on how to advance common interests[10]. The disparity in viewpoints makes it challenging to agree on unified strategies that could potentially bolster the sector. Associations or cooperatives of producers are to take a key role in developing public or private certification schemes to improve the outlook, especially for those cooperatives counting small farms among their members, potentially more affected by workload issues. However, stakeholders have noted how excessive requirements and inefficient bureaucratic regimes in the context of obtaining licensing and certifications can represent a major drawback, increasing the price of the final product at the cost of competitiveness, especially vis-à-vis non-EU competitors[11].

Another challenge relates to investments in R&D, digitalisation, and new technologies, key to improving competitiveness, allowing adaptation to the demands of consumers and meeting market demands and legal requirements. However, the low profitability of extensive farming[12] does not allow farmers to invest as needed to meet the quality standards required by the markets and legislation[13]; such underinvestment is a danger to the long-term viability of farms. In some cases, the entry costs for taking over the farm are too much for young farmers. The integration of young farmers and planning for long-term investments could be a relevant issue for POs to engage in rather than leaving this to the individual. However, due to differences in the points of view of members (small producers vs big producers) and to their individualistic nature[14], it is rare that the PO designs and implements collective solutions to these issues. Moreover, young farmers need to face the competition of established farmers and the problems linked to the land use system, which is limited in scope and makes the purchase of land particularly expensive.[15]

An additional challenge for farmers is represented by the excessive red tape and my many administrative obstacles caused by inefficiencies in the Bulgarian systems. This is true both at a macro/strategic level (with the funding going to the districts that require them the most) and at a micro level (with the reduction of problems linked to the issuing of permits or to the low institution capacity to approve and accept projects). It has been highlighted that the State Fund "Agriculture" is extremely slow in reviewing and approving projects,

4. Flanders Investment and Trade. (2017). Bulgaria: Agricultural sector report.
5. Atanassova-Kalaydzhieva, T. (2019). Agricultural enterprises in Bulgaria: Structural features and development.
6. Wolf, J. et al (2015), Combined analysis of climate, technological and price changes on future arable farming systems in Europe.
7. Interview with Tivatrade.
8. Interview with Tivatrade.
9. Interview with Agroecological Farmers Association.
10. Interview with Agroecological Farmers Association.
11. Interview with Tivatrade.
12. Temple, D., Manteca, X. (2020), Animal welfare in extensive production systems is still an area of concern.
13. AgMRC (2024), Barriers to entry and exit.
14. Interview with Agroecological Farmers Association.
15. Interview with Agroecological Farmers Association.

making them often unviable despite the attractive financial conditions.[16] Very relevant in this context the need for increasing technical assistance for sound practices and techniques, as well as support in navigating the EU's environment and agricultural policies[17]. The priority is to organise it in person to allow for better socialisation and networking. Promoting the social interaction of the producers organised by associations and cooperatives increases the chances of creating an internal and mutually supportive community. Such an element is particularly important given the relatively low level of know-how and technical knowledge[18].

Climate change will also pose substantial challenges to Bulgaria's agricultural sector, with higher temperatures and possible rainfall deficits affecting, e.g., spring crops. The high dependence of Bulgarian agriculture on freshwater for irrigation combined with improper watering practices adds to these challenges, raising concerns about recurring water shortages, salinisation and soil erosion[19]. To combat these issues, the District of Stara Zagora has implemented an 'Advanced Water Management' strategy focused on sustainable water use and resilience against droughts, aiming for sustainable resource use and resilience against variability.[20] In addition, the domestic organic sector continued to decline in 2021 and 2022, with a decrease in both the organic area and the number of operators. By the end of 2021, the organic area had decreased by 26% compared to the previous year and accounted for only 1.7 % of the total agricultural area in Bulgaria[21]. In the District of Stara Zagora, strategies such as 'Improving Soil Health' and 'Promoting Biodiversity' are being adopted to enhance agricultural productivity and ensure environmental sustainability. These initiatives aim to enrich soil biodiversity, boost productivity, and support ecosystem services, thereby addressing some of the structural challenges of the agricultural sector.[22]

Other challenges include a shortage of agricultural labour, an ageing population, and less innovation in the sector. In Bulgaria, the number of agricultural workers in annual working units (AWUs) fell by 60% between 2007 and 2020[23]. Several reasons are at cause, including a gradual shift of the working force to the service sector, rural-urban migration, and seasonal migration to other EU countries for better wages[6]. These developments, together with the ageing workforce in the sector, suggests that the agricultural sector will face labour shortages in the future. Furthermore, the Bulgarian agricultural sector lags behind to other EU countries in the adoption of new technologies, especially for small farms[24], Expenditure on R&D in the agricultural sciences has also declined in recent years, affecting the development of new technologies and competitiveness of the sector. The 'Leveraging Innovative Technologies' strategy in Stara Zagora seeks to address this through the improvement of resource efficiency and decision-making, fostering technological advancement and innovation to counter the sector's challenges. Furthermore, the emphasis on 'Renewable Energy' within the Stara Zagora regional strategy addresses the initial investment costs and lack of expertise by focusing on long-term cost savings and reducing the carbon footprint, aiming for energy sustainability and independence. This is particularly relevant for agricultural operations seeking to mitigate climate impact and improve energy efficiency.[25]

In response to these challenges, numerous policy priorities are in place at regional, national and EU level. As such, sustainable agriculture and food production is a key element of the European Green Deal and is central to the Bulgarian National Recovery and Resilience Plan (NRRP) (Pillar B – Green Bulgaria, B2 Sustainable agriculture) and Bulgaria's Integrated National Energy and Climate Plan (INECP). It is also a strategic priority sector in Stara Zagora's Territorial Just Transition Plans (TJTP) (Pillar 3, Diversification of the local economy) and figures prominently in the Integrated Development Plans of Galabovo and Radnevo – two of the three municipalities most affected by coal phase-out – and the Bioeconomy Development Strategy of Stara Zagora.

The Bulgarian CAP Strategic Plan aims to promote the sustainable development of the agricultural sector, support viable farm incomes, and increase competitiveness[26]. The plan aims to reduce income disparities, redistribute direct payments to small and medium-sized farms, and set a support ceiling of EUR 100,000 per individual farmer. With a focus on environmentally sustainable practices, the plan introduces eco-schemes to incentivise climate-friendly initiatives beyond legal requirements. It emphasises organic farming, with incentives for organic land cultivation, beekeeping and livestock, with a target of 200,380 hectares to be supported. On social sustainability, the plan addresses depopulation, poverty, and an ageing population in rural areas. It provides funding for job creation, infrastructure investment and social innovation, including support for young farmers and measures for animal welfare and food safety. Knowledge sharing, innovation and digitalisation are key aspects

16. Interview with Agroecological Farmers Association.
17. Interview with Agroecological Farmers Association.
18. Interview with Agroecological Farmers Association.
19. Mihailova, M. (2020). The state of agriculture in Bulgaria – PESTLE analysis.
20. Regional strategy for development of district of Stara Zagora (2014-2020).
21. USDA. (2023). Bulgaria: Organic Market Annual.
22. Regional strategy for development of district of Stara Zagora (2014-2020).
23. Popov, R. & Marinov, P. (2023). Development of Bulgarian agriculture within the CAP in the EU 2007-2020 in the context of the green deal, farms and employed people, relative to location index for rural areas of the South-Central Region.
24. https://ec.europa.eu/assets/rtd/eis/2023/ec_rtd_eis-country-profile-bg.pdf
25. Regional strategy for development of district of Stara Zagora (2014-2020).
26. DG AGRI (2023). At a glance: Bulgaria's CAP Strategic Plan.

of Bulgaria's plan. The Agricultural Knowledge and Innovation System (AKIS) will be strengthened, providing support for education, training and advisory services. The plan also focuses on digital farming technologies, with financial support for more than 8% of farms and a target to ensure high-speed internet access in rural areas by 2030. The regional strategy for development of district of Stara Zagora 2014-2020 is aligned with CAP initiatives on soil health, water management, biodiversity, and innovative technologies, and it underscores the regional commitment to addressing the overarching challenges of the agricultural sector through targeted, sustainable practices.

Table 1 summarises identified sub-sectors and investments that would positively affect the agricultural sector in Stara Zagora. These pathways represent the most critical pathways for the region's agricultural development, as identified through a literature review and validated via consultations with stakeholders, including the University of Trakia. Engaging in discussions with stakeholders and university representatives should aid in identifying the most promising investments, especially those that can best support communities affected by the transition from coal-based electricity to more sustainable energy sources.

TABLE 1. PROPOSED PATHWAYS TO DIVERSIFY THE AGRICULTURAL SECTOR

Type of priority	Pathway	Importance of the sub-sector	Needs to enhance the sub-sector	Sources of fundings	Possible Investments	Synergies with other economic sectors	Synergies with university programmes
Horizontal	Innovative Agricultural Products (vertical farming, hydroponic)	There's a capacity for developing innovative agrifood products, with potential partnerships for new agrifood technologies.	Innovations in agrifood can increase productivity and economic competitiveness of farms.	Innovation in agriculture is supported by EU research initiatives, national innovation funds. CAP Strategic Plan includes interventions for young farmers.	R&D collaborations with universities, innovative product development.	Machinery industry	• Agrotronics • Agricultural economy and trade
Horizontal	Renewable Energy Sources in the Agricultural Sector	Renewable energy is vital for sustainable agriculture. It can significantly reduce carbon footprint and operational costs.	Renewable energy technologies and training for farmers.	EU green initiatives, national renewable energy programs, agricultural sustainability funds.	Solar panels, wind turbines, biomass energy systems.	Energy sector, environmental management.	• Renewable energy sources in the agricultural sector • Environmental Protection and Management
Sectorial	Sustainable production of forage crops and synergies with green biorefineries.	Sustainable forage crops are essential for livestock health and environmental conservation. Diverse climatic and soil conditions are suitable for a range of organic crops, supporting a shift to organic farming and certified products. Additionally, the production of these crops would create synergies with green biorefineries, which result in sustainable products such as biofuel or high-protein food for animals starting from grass, legumes and green crops residues.	Collaboration between research institutes and private farms in sustainable crop practices, improved irrigation systems. Organic and certified products can leverage the region's diverse conditions for economic growth and efficiency and can allow the integration with the beverage industry. Need to link products of biorefineries with the wider supply chain, often distant from the Stara Zagora region.	National agricultural sustainability programs, EU agricultural funds. Protein crops benefit significantly from CIS, which could translate to support for organic and certified plant cultivation, including fruits and vegetables (National programs for organic farming, sustainable rural development), Operational Programmes for both Fruit and Veg and dairy production. Horizon Europe, Bulgarian RFF, eco-schemes.	Drought-resistant crop varieties, efficient irrigation systems, soil health management. Organic and quality certification, market development for organic produce.	Livestock industry, organic food production. Beverage industry Dairy industry Energy sector, biofuels, bioplastics.	• Sustainable production of forage crops • Biological agriculture • Environmental Protection and Management • Agricultural economy and trade

Pathway 1: Innovative technologies

The Bulgarian agricultural sector has the potential to produce affordable, safe, and high-quality products, but it still lags behind the European average in terms of production and lacks the right capacity, technology and knowledge to move further towards a sustainable horticulture sector. Innovative technologies, such as hydroponics – where vegetables are grown in aqueous solutions or substrates such as sheep's wool – offers a promising approach to overcoming some of the challenges associated with traditional farming methods. The transition to growing vegetables without soil can lead to several benefits, including continuous production cycles, higher yields without any climate or weather constraints, space optimisation, reduced use of pesticides, and lower water consumption[27]. Moreover, hydroponics can also provide ergonomic benefits by growing vegetables and fruits at a more appropriate height[28].

These benefits contribute to improved food security, health, employment opportunities, and reduced environmental impact. Hydroponic farming can be established in both rural and urban areas, fostering sustainability and resilience within communities. However, it is essential to address the challenges associated with hydroponic production, such as high energy requirements and the limited variety of crops that can be grown.

Furthermore, while less maintenance labour is required in hydroponics, labour costs are higher than in conventional vegetable production as these advanced systems require scientific and technical expertise. Despite higher labour costs, these advanced technologies have the potential to create new job opportunities for skilled scientists and high-tech positions such as biologists, data scientists, engineers, software developers, etc[29].

Inputs

Financial resources

The European Union has a comprehensive framework for improving innovative technological integration, which could be applicable to the agricultural sector in Stara Zagora. These address different aspects that facilitate the transition, such as testing innovative technologies, (re)skilling of workers, and increasing collaboration to exchange knowledge among various actors.

The European Institute of Innovation and Technology (EIT) has a **Regional Innovation Scheme** (RIS) to close the innovation divide in Europe. Given Bulgaria's low innovation score it is eligible for the RIS where there are also actions in the food system with EIT Food. As such EIT Food supports agricultural startups and individuals with farmers and testing-land through their programme 'Test Farms'[30]. By enabling these links, EIT Food aims to assist innovative agritech ideas in validating and testing their products and services, showcasing their business to customers and investors, and ultimately supporting the technological transformation in European agriculture.

The **Cohesion Fund** consists of different financial initiatives that aim to drive sustainable development. The Just Transition Fund (JTF) represents the main initiative for coal transitioning regions, and funding relevant for the integration of innovative technologies include the upskilling and retraining of workers, skills for smart specialisation and access to employment. Additionally, the European Social Fund Plus (ESF+) earmarks substantial investments for Bulgaria to enhance job accessibility, improve skills for succeeding in the digital and green transition, and ensure equal access to education and inclusive, quality training, including youth employment support. Moreover, the **InvestEU Programme** consolidates EU financial instruments, streamlining access to finance and investments in European companies and projects. It aims to mobilise private investments aligned with the EU's primary policy priorities, including the green and digital transition, innovation, social investments, skills, and social well-being across the EU.

Furthermore, the CAP has several measures in place to strengthen innovation in the agricultural sector.

These measures include:

Support through EIP-AGRI: Almost all Member States plan to implement innovation projects through the European Innovation Partnerships for Agricultural Productivity and Sustainability (EIP-AGRI), aimed at developing new innovations for the agricultural sector.

- Investment in digital technologies: Support for the adoption of digital technologies under the CAP, while relatively low in ambition, indicates a contribution to advancing environmental and climate objectives through eco schemes and other commitments.

27. Nikolov, N.V., Atanasov, A.Z., Evstatiev, B.I., Vladut, V.N., Biris, S.-S. (2023). Design of a Small-Scale Hydroponic System for Indoor Farming of Leafy Vegetables. Agriculture, 13, 1191. https://doi.org/10.3390/agriculture13061191. Kalantari, F., Tahir, O.M., Joni, R.A., & Fatemi, E. (2018). Opportunities and challenges in sustainability of vertical farming: A review. Journal of Landscape Ecology, 11, 1, 35–60. https://doi.org/10.1515/jlecol-2017-0016.
28. de Souza J, Rigatti TM, Dhein W, La Torre M. (2023). Influence of the cultivation model on the posture and back pain prevalence of strawberry producers. Rev Bras Med Trab, 20, 4, 608-614. https://doi.org/10.47626/1679-4435-2022-803.
29. Al-Kodmany K. (2018). The vertical farm: A review of developments and implications for the vertical city. Buildings, 8, 24. https://doi.org/10.3390/buildings8020024.
30. https://www.eitfood.eu/projects/test-farms

- Knowledge exchange and training: More than 6 million people are expected to benefit from CAP support for advice, training, knowledge exchange or participation in EIPs, although the financial allocation for such knowledge-related measures is considered low across the CSPs.
- AKIS coordination and organisation: The new AKIS strategic approach is expected to improve the synergistic combination of interventions to enhance knowledge sharing and promote innovation.
- Broadband investment and smart villages: Interventions are planned to address gaps in skills or infrastructure, in line with Member States' digitalisation strategies and the complementarity of the CAP with other funds.
- Promoting innovation ecosystems: The need to structure knowledge exchange and foster innovation processes is emphasised, including cooperation between different actors such as farmers, advisors, researchers and the identification of end-user needs.
- Encouraging interactive extension functions: Promoting new types of interactive advisory functions is a cornerstone to ensure that advisors are more involved in innovative knowledge and linked to participatory research.
- Strategy for digitisation in CAP strategic plans: Member States are asked to detail their strategy for knowledge sharing and innovation, including their contribution to the digital transition of agriculture and rural areas.
- Investment support: The CAP provides support for restructuring and modernisation to improve the sustainability, competitiveness and resilience of farms.

Investment support for on-farm productive investments, which can promote the adoption of innovative technologies for farm modernisation. **Cooperation support** is also a key tool for improving capacity and innovation, including education, advice, and knowledge transfer. This can be for example achieved through the implementation of the European Innovation Partnership (EIP) Operational Groups. **Knowledge support** is the key tool to underpin education, advice services, training and knowledge transfer in agriculture and rural areas. Underlying the knowledge support, Member States should set up farm advisory services to support farmers and other beneficiaries on farm and land management. The development of Agricultural Knowledge and Innovation System (AKIS) within Member States links widely to the use of this tool. Under the Bulgarian CSP, a total of 290 000 people would benefit from the advice, training, and knowledge exchange or from participating in operational groups of EIP. Besides, opportunities for research and innovation in the agricultural sector are also funded under cluster 6 'Food, Bioeconomy, Natural Resources, Agriculture and Environment' of the **Horizon Europe programme**.

Relevant national initiatives and success stories

Among the success stories and initiatives where innovative technologies have been implemented in the agricultural sector, the most relevant are:

- ONDO Smart Farming Solutions: ONDO has joined AgroHub, the Bulgarian digital innovation hub for agriculture. ONDO provides digitally controlled precision agriculture systems for automated drip irrigation management and control, precise plant nutrition and climate control for various crops. Its smart agriculture solutions are already used by numerous customers in Bulgaria.
- National AI strategy: Bulgaria's national AI strategy outlines several priority areas, including smart agriculture. The strategy was based on the readiness of these sectors to use and develop AI in the next 3-5 years.

Local stakeholders

The table below presents an exemplary list of companies and organisations that could be contacted and whose area of expertise is in line with Pathway 1 on the promotion of innovative technologies.

TABLE 2. KEY RELEVANT STAKEHOLDERS FOR PATHWAY 1

Stakeholder	Description	Contacts
Begrow Substrates	This company specializes in stone wool substrates for hydroponic agriculture. They offer products that support professional cultivation of fruits and vegetables in controlled environments, providing stone wool slabs, cubes, and plugs suitable for all stages of plant growth, from seed germination to maturity.	https://www.begrowsubstrates.eu/en +359879296660 info@begrow.pro
Happy Fruits	A Bulgarian fruit grower, has adopted hydroponics with New Growing System (NGS) to improve strawberry yields in Novo Selo, focusing on high-density planting without artificial lighting. This approach aims to enhance production and expand market opportunities, ensuring a steady, year-round supply31.	https://www.happyfruits.eu/en/ happyfruits.eu@gmail.com +359 2 954 9034
Ultragreens	Ultragreens, a Romanian vertical farming company, has partnered with Kaufland to launch operations in Bulgaria. They're setting up micro greenhouses in Sofia supermarkets and planning a larger hub. Using AI and machine learning, they grow herbs and micro-plants, reducing water usage by nearly half. This initiative highlights the expanding presence of hydroponic technology in Bulgaria.	https://microgreens.ro/ office@microgreens.ro +40764469680

31. https://www.hortidaily.com/article/9356791/bulgarian-fruit-grower-enters-hydroponic-market/

Activities for developing hydroponic technology

TABLE 3. ACTIVITIES FOR PATHWAY 1

Action	Action description	Responsible Party	Supporting Party
Site Selection and Setup	Choose a location in Stara Zagora with access to water, electricity, and relatively close to potential markets like supermarkets or restaurants. Example: Use an existing underutilised warehouse or a plot of land close to urban centres to reduce distribution costs.	Local Government, Agricultural Extension Services	Local Community
System design and technology	Decide on the type of hydroponic system (e.g., Nutrient Film Technique for leafy greens or Dutch Buckets for tomatoes and peppers). Example: Install modular NFT channels in a greenhouse to grow lettuce, which can be easily scaled up.	Agricultural Extension Services, Farmers	Research Institutions, Technology Providers
Resource procurement	Procure hydroponic supplies including growing tools (rockwool, clay pellets), nutrients and seeds from reputable suppliers. Example: Partner with companies such as Begrow Substrates for rockwool and Happy Fruits for high quality seedlings adapted to hydroponic systems.	Farmers, Agricultural Cooperatives	Suppliers, Agricultural Extension Services
Infrastructure development	Build or retrofit greenhouse structures with automated climate control systems. Example: Hire a local construction company to retrofit existing structures with UV protection panels and environmental control systems.	Farmers, Agricultural Cooperatives	Local Construction Companies, Technology Providers
Water and energy management	Install a water recirculation system and solar panels to manage energy costs and sustainability. Example: Installing a rainwater harvesting system and solar panels to offset up to 50% of energy consumption.	Farmers, Agricultural Cooperatives	Energy Providers, Technology Providers
Training and workforce development	Develop a training programme in collaboration with local agricultural schools or vocational training centres. Example: Create a 6-week intensive course for new recruits focusing on hydroponic farm management, delivered by experts from the Trakia Agricultural University.	Agricultural Extension Services, Educational Institutions	Research Institutions, Technology Providers
Marketing and sales strategy	Develop branding and marketing materials that highlight the sustainability and local origin of the produce. Example: Launch a marketing campaign with the slogan “Fresh from Stara Zagora, Straight to Your Table”, focusing on freshness and local pride.	Agricultural Extension Services, Educational Institutions	Marketing Agencies, Local Businesses
Monitoring and evaluation	Implement sensors and monitoring tools to track water use, nutrient levels and plant health. Example: Use IoT sensors connected to a central system that provides real-time data on crop conditions and alerts on anomalies.	Agricultural Extension Services, Farmers	Research Institutions, Technology Providers
Community engagement and feedback	Hold community open days and workshops to raise awareness and gather consumer feedback. Example: Organise a monthly ‘Farm Day’ where locals can tour the facility, taste products and attend workshops on sustainable agriculture.	Regional Authorities, Agricultural Extension Services, NGOs	Local Communities and associations
Expansion planning	Evaluate the success of the pilot project and plan for expansion based on specific criteria such as meeting demand and return on investment. Example: If the pilot crop shows a 20% margin and high demand, replicate the model for other crops such as strawberries or microgreens.	Farmers, Agricultural Cooperatives	Agricultural Extension Services, Financial Institutions

Outputs

The pathway of innovative technologies in Stara Zagora's agricultural sector aims to have a transformative impact through a series of interconnected initiatives. The process begins with acquiring comprehensive local agricultural data, which serves as the basis for informed decision-making. Guidelines and training programs are then designed to facilitate the technology adoption, ensuring that farmers are well-equipped to integrate advanced agricultural technologies. Concurrently, collaborative research initiatives and the creation of 'sustainable clusters' promote innovation and vertical integration. Policies should be aligned to actively promote technology adoption, supported by improved access to finance. This will empower farmers and agricultural enterprises to embrace innovative technologies. The practical benefits of these initiatives are realised through the implementation of pilot projects and demonstration farms, which showcase the effectiveness of technological integration. This approach is complemented by efforts to cultivate a pool of trained and skilled farmers, creating a workforce ready for the demands of modern agriculture. Inclusivity remains at the forefront, with community engagement initiatives ensuring that the benefits of technological advancements are widely distributed, fostering a resilient and progressive agricultural sector in Stara Zagora.

Outcomes

The adoption of innovative technologies is expected to increase the efficiency of agricultural practices while also promoting sustainable and environmentally conscious agricultural practices. In addition to individual advancements, there is a proactive development of innovation ecosystems, nurturing a collaborative environment that accelerates progress in the region. Financially supported technology adoption ensures that barriers are minimised, enabling a broader adoption of innovative technologies throughout the agricultural community. Concurrently, the intervention focuses on enhancing farmer skills and knowledge, creating a workforce adept at navigating the challenges of a just transition while ensuring the sustainability of the agricultural sector. This multifaceted approach aims to benefit not only individual farmers, but also the wider community, leading to social, environmental and economic advantages in Stara Zagora.

Impacts

The transformation of agricultural practices can lead to economic growth in the agricultural sector and promote sustainable, technology-driven farming. This paradigm shift encourages greater cooperation among stakeholders, creating a collaborative ecosystem. These changes are supported by policy frameworks that prioritise technological progress and contribute to improved farmer livelihoods and overall well-being. The farming communities that emerge from these initiatives are inclusive and engaged, signifying a holistic approach to agricultural development. This ensures that the benefits of innovation and sustainability are widely shared, contributing to the resilience and prosperity of the entire (agricultural) community. The transition from coal-based energy production to more sustainable practices in Stara Zagora is not only an environmental necessity, but also a socio-economic imperative. The shift away from coal is expected to affect a significant proportion of the region's population, particularly those employed at the Maritsa Iztok power complex. Ensuring a just transition for these communities is a key priority. The introduction of innovative technologies in the agricultural sector, such as hydroponics, is a promising way to achieve this just transition. By switching to these advanced farming methods, Stara Zagora can create new employment opportunities that can absorb the workforce displaced by the coal phase-out. These jobs would not only be in the actual farming and production, but also in high-tech positions such as biologists, data scientists, engineers and software developers who would be needed to manage and optimise these advanced systems.

In addition, the development of the hydroponics sector could stimulate economic activity in the region, helping to offset the economic changes resulting from the phasing out of coal. By producing affordable, safe and high-quality products, the sector could attract investment and drive growth, contributing to the economic resilience of the region.

In addition, the focus on sustainable agriculture is in line with the broader objectives of the European Green Deal and Bulgaria's National Plans, reinforcing Stara Zagora's commitment to a sustainable and equitable future. By prioritising emissions reductions and ensuring a just transition for affected communities, Stara Zagora can demonstrate how regions can successfully manage the transition away from coal while creating new opportunities for their communities.

Pathway 2: Renewable energy

Renewable energy technologies, such as solar panels, wind turbines and biomass energy systems, offer a sustainable and efficient way to power farms. The transition to renewable energy can lead to several benefits, including reduced greenhouse gas emissions, energy cost savings and increased energy independence. In addition, renewable energy technologies can provide additional income streams for farmers through mechanisms such as feed-in tariffs or power purchase agreements.

For example, agro-photovoltaic projects with photovoltaic systems could be used to support agricultural processes (e.g. by increasing agricultural yields as a result of the shade provided by solar panels over agricultural fields, powering pumping systems for water for agricultural purposes, etc.)". This is in the Stara Zagora JTP.

These benefits contribute to improved sustainability, economic resilience and rural development. Renewable energy systems can be implemented in both rural and urban agricultural settings, promoting sustainability and resilience within communities. However, it is important to address the challenges associated with the adoption of renewable energy, such as high up-front costs, variable energy production, and the need for technical expertise.

While renewable energy systems require an initial investment, they can lead to long-term cost savings and even generate income. In addition, renewable energy production can vary depending on weather conditions, although advances in energy storage technologies are helping to mitigate this issue. Despite these challenges, the adoption of renewable energy technologies has the potential to create new job opportunities in areas such as system installation, maintenance and energy management.

The path to renewable energy technology adoption in the agricultural sector is not only about improving energy efficiency and sustainability, but also about promoting economic resilience and rural development. This approach is in line with the wider objectives of the European Green Deal and Bulgaria's National Plans, and demonstrates Bulgaria's commitment to a sustainable and equitable future.

Inputs

Financial resources

To support the transition towards renewable energy, the European Union has established a comprehensive framework of financial support mechanisms designed to accelerate the adoption of clean energy sources across its member states. This approach integrates financial support with cross-border cooperation, innovation, and the integration of renewable energy projects into the European energy market, facilitating a collective move towards a more sustainable and energy-efficient future. The various funding mechanisms aim to reduce financial barriers to renewable energy projects, foster innovation, and ensure a just transition to a sustainable energy future. By leveraging such funds, projects can access necessary capital, technical support, and infrastructure development needed to integrate renewable energy solutions effectively, marking a significant step towards achieving the EU's ambitious energy and climate goals.

The **Cohesion Fund** focuses on reducing economic and social disparities between EU countries by supporting energy-related projects that have a positive environmental impact, such as those reducing greenhouse gas emissions or improving energy efficiency. Similarly, the **Connecting Europe Facility (CEF)** enhances energy, transport, and digital infrastructure, with a significant budget allocated to energy projects, including those focusing on renewable energy.

The European Investment Bank (EIB), in partnership with the European Commission, provides loans and financial instruments to energy projects through **the European Fund for Strategic Investments (EFSI)**, emphasizing renewable energy, energy efficiency, and modernization of energy infrastructure. Alongside, Horizon Europe, the EU's research and innovation funding program, allocates funds to support the European Green Deal, which includes projects aimed at accelerating Europe's transition towards clean energy and climate neutrality.

The **InvestEU Programme** encourages sustainable investment, innovation, and job creation across Europe, including the energy sector, by bringing together various EU financial instruments under one umbrella. The Just Transition Mechanism offers financial support to regions most affected by the transition towards a green economy, ensuring social and economic sustainability. Further, the **LIFE: Clean Energy Transition** program supports actions to facilitate the transition towards an energy-efficient and renewable energy-based economy across Europe. The **Modernisation Fund** targets lower-income EU countries, supporting investments in renewable energy sources, energy efficiency, and the modernization of energy networks. The **Recovery and Resilience Facility (RRF)** forms a core part of the EU's recovery plan from the COVID-19 pandemic, with a strong emphasis on the green transition. The Innovation Fund provides financial incentives for renewable energy projects and supports Europe's climate neutrality goals by encouraging investment in low-carbon technologies[32].

Relevant national initiatives and success stories

During the preparation of this report, no relevant national initiatives or success stories were identified.

Local stakeholders

The table below presents an exemplary list of companies and organisations that could be contacted and whose area of expertise reflects the needs of the Stara Zagora region in the context of promoting renewable energy.

TABLE 4 KEY RELEVANT STAKEHOLDERS FOR PATHWAY 2

Stakeholder	Description	Contacts
Alpha Mix EOOD	Renewable Energy Sources in the Agricultural Sector Design and equipment of livestock farms, delivery and installation of machinery and equipment, providing farms with consumables and spare parts, service, consulting services.	https://shop.alpha-mix.com/contacts 042/625 335 office@alpha-mix.com
Zagora Sustainable Hydrogen Region (ZAHYR)	This project is a major player in the hydrogen sector, supported by a significant grant from Horizon Europe. It focuses on using hydrogen for various applications, including public transportation and energy generation, showcasing a shift towards cleaner energy sources	https://www.clean-hydrogen.europa.eu/projects-dashboard/projects-repository/zahyr_en

32. https://energy.ec.europa.eu/topics/funding-and-financing/eu-funding-possibilities-energy-sector_en

Activities for developing renewable energy technologies

TABLE 5. ACTIVITIES FOR PATHWAY 2

Action	Action Description	Responsible Party	Supporting Party
Site Selection and Setup	Choose a location in Stara Zagora with access to adequate sunlight and wind, and proximity to existing electrical grid connections. Example: Use underused land suitable for solar panels or wind turbines.	Local Government, Renewable Energy Agencies	Local Community, Energy Consultants
System Design and Technology	Decide on the type of renewable systems (e.g., solar panels, wind turbines, biomass facilities). Example: Install solar arrays capable of powering an entire farm or community.	Renewable Energy Agencies, Farmers	Engineering Firms, Renewable Energy Tech Providers
Resource Procurement	Procure necessary materials for renewable energy systems, including solar panels, wind turbines, or biomass converters. Example: Partner with local companies for photovoltaic panels and installation kits.	Farmers, Agricultural Cooperatives	Suppliers, Renewable Energy Agencies
Infrastructure Development	Build or retrofit structures needed for installing renewable energy systems. Example: Construct tower bases for wind turbines or frames for solar panels.	Farmers, Agricultural Cooperatives	Local Construction Companies, Technology Providers
Energy Management System	Install energy management systems to monitor and optimize energy production and consumption. Example: Implement a smart grid system that adjusts to energy supply and demand dynamically.	Farmers, Agricultural Cooperatives	Energy Providers, Technology Providers
Training and Workforce Development	Develop a training program on renewable energy system maintenance and optimization. Example: Organise a series of workshops conducted by experts.	Agricultural Extension Services, Educational Institutions	Research Institutions, Technology Providers
Marketing and Outreach	Develop marketing strategies to promote the adoption of renewable energy in agriculture. Example: Launch a campaign highlighting the cost savings and environmental benefits of renewable energy.	Agricultural Extension Services, Educational Institutions	Marketing Agencies, Local Businesses
Monitoring and Evaluation	Implement sensors and monitoring tools to track energy efficiency and system performance. Example: Use IoT sensors connected to a central system for real-time data on energy output and savings.	Renewable Energy Agencies, Farmers	Research Institutions, Technology Providers
Community Engagement and Feedback	Organize community events to raise awareness and gather feedback on renewable energy projects. Example: Host a 'Renewable Energy Day' where locals can learn about benefits and provide feedback.	Regional Authorities, Renewable Energy Agencies	Local Communities and NGOs
Expansion Planning	Evaluate the effectiveness of pilot renewable energy projects and plan for broader implementation based on outcomes. Example: If initial installations achieve energy cost reductions, expand to additional farms.	Farmers, Agricultural Cooperatives	Financial Institutions, Agricultural Extension Services

Outputs

The outputs include a comprehensive assessment of the energy landscape, leading to informed decisions on the best renewable options for the area. Guidelines and training programmes will be developed to facilitate the adoption of these technologies, ensuring that local farmers and businesses are well prepared to integrate renewable energy sources such as solar, wind and biomass. Collaborative research initiatives and the creation of 'green energy clusters' will foster innovation and encouraging sustainable practices. Policies may be developed and implemented to support the uptake of renewable technologies, supported by improved financial mechanisms to ease the transition. Pilot projects and demonstration farms will showcase the benefits and effectiveness of these energy solutions, serving as models for wider application. At the same time, community engagement initiatives ensure the equitable distribution of technology benefits and promote a resilient and forward-looking farming community.

Outcome

The adoption of renewable energy technologies is expected to significantly improve the sustainability and efficiency of agricultural practices in Stara Zagora. This strategic shift not only improves individual farm operations, but also fosters the development of a robust innovation ecosystem, increasing collaboration and accelerating regional progress. Financial support for technology adoption minimises barriers and facilitates the widespread adoption of renewable solutions across the agricultural sector. This strategic focus also enhances the skills of local farmers, equipping them with the knowledge and tools they need to effectively use modern, sustainable farming techniques. The comprehensive approach aims to deliver significant benefits not only to individual farmers, but also to the wider community, contributing to social, environmental and economic improvements across Stara Zagora.

Impacts

The transformation of agricultural energy practices is poised to drive significant economic growth within the sector by promoting sustainable and efficient agriculture through the adoption of renewable energy. This shift would strongly encourage collaboration between local stakeholders, including farmers, businesses, educational institutions and government agencies. This cohesive ecosystem is critical to the successful integration of renewable technologies into the agricultural landscape of Stara Zagora. Supported by a policy framework that prioritises sustainable development and technological advancement, these changes are contributing to improved livelihoods and overall well-being within the community. The transition to renewable energy not only meets the environmental objectives set out in the European Green Deal and Bulgaria's national plans but also addresses socio-economic challenges, in particular the impact of coal phase-out in the region. As part of ensuring a just transition, this shift is crucial to creating new employment opportunities and supporting economic stability in communities previously dependent on the coal industry. By redirecting the workforce towards emerging green sectors, Stara Zagora can mitigate the socio-economic impact of the coal phase-out and ensure that no community is left behind. The development of renewable energy sectors thus plays a dual role, reducing the region's carbon footprint while strengthening its economic resilience. This strategic approach ensures that the benefits of innovation and sustainability are widely shared, contributing to the resilience and prosperity of the entire agricultural community and supporting Stara Zagora in its transition to a sustainable and equitable future.

Pathway 3: Sustainable production of forage crops

Forage crops play a crucial role in maintaining agricultural ecosystems, particularly in Bulgaria and southern Europe, where traditional crops such as lucerne (alfalfa) serve as an important source of protein for ruminants[33]. The conversion of land into grassland ecosystems, especially with the cultivation of grasses such as lucerne, contributes significantly to the accumulation of carbon below ground. Grasses have a remarkable ability to sequester carbon below ground, extending their roots to considerable depths and creating soil horizons rich in organic matter[34]. Numerous studies have demonstrated increases in soil organic matter (SOM) following land conversion to grasslands, native prairies and the implementation of conservation tillage, cover crops or perennialization of agroecosystems[35]. This, combined with the intensive mining activity of Stara Zagora, makes the region's soil particularly carbon-rich, making it suitable for growing perennial crops[36]. The accumulation of carbon in the soil not only improves soil fertility, but also increases nutrient retention and water use efficiency, thereby promoting the sustainability of soil-based agriculture and forestry. Grasses such as lucerne are characterised by efficient water use, even in drought conditions, and the ability to fix atmospheric nitrogen, making them environmentally friendly and requiring minimal fertiliser use.

The importance of forage crops becomes even more apparent when considered in the wider context of the European Union's heavy reliance on feed imports, which reached almost 16 million tonnes of soybean meal in 2023[37]. This dependency raises concerns about the use of crops with human-edible proteins for animal feed. In this context, grasses and legumes play a key role in livestock diets, often overshadowed by conventional grains. These natural elements not only improve the nutritional quality of animal products but also contribute to building a sustainable agricultural ecosystem.

The profitability of protein crops such as soybeans is marked by high unpredictability, largely due to the substantial variations in yields from year to year[38]. This volatility in yields significantly impacts farmers' decision-making, as they weigh the economic returns of different crops including wheat, oilseeds, maize, and soybeans. These decisions are influenced by the relative prices of these crops, which can sway planting preferences in favour of those with higher market value at any given time. Additionally, farmers tend to be oriented towards growing typical crops due to difficulties in finding suitable markets for other types of production[39].

Farm profitability is a critical factor in the sustainability of the agricultural sector, prompting farmers to continually assess the financial viability of their crop choices. Cereal and oilseed crops generally present more favourable gross margins when compared directly to alfalfa. This is primarily due to the direct returns these crops generate per unit area. However, alfalfa, despite its lower immediate returns, brings considerable agronomic benefits that can enhance the overall profitability of farms over time[40]. These benefits include the potential increase in yields for the crops that follow and significant nitrogen savings, which reduce the need for synthetic fertilizers[41]. The nitrogen-fixing capability of alfalfa enriches the soil, thereby improving the soil health and reducing input costs for subsequent crops. Thus, while the initial financial assessment might favour cereals and oilseeds, the longer-term benefits of crops like alfalfa contribute to a more sustainable farming practice by enhancing soil fertility and reducing dependency on chemical inputs.

The development of protein crop production in Europe, including crops like alfalfa, is significantly influenced by both national and European Union subsidies. Research has demonstrated a strong correlation between the level of these subsidies and the volume of production across various regions. This is particularly evident with alfalfa[42], where subsidies directly impact the extent of cultivation due to the initial cost and market risks associated with its production. European policies such as the CAP aim to support agricultural diversification and sustainability by providing financial incentives to encourage farmers to cultivate protein-rich crops such as alfalfa, thus enhancing food security and reducing dependency on protein imports. The financial support under CAP not only stabilises income for farmers engaging in potentially less profitable or more experimental agriculture but also promotes environmentally beneficial farming practices, given alfalfa's role in improving soil health and reducing the need for synthetic fertilizers. However, stakeholders highlighted that the excessive reliance on EU subsidies can have a detrimental effect on the overall agricultural sector, with companies not developing on the basis of the market[43]

33. Agricology, Lucerne – an alternative forage crop.
34. Wang, R., Mattox, C. M., Philips, C. L., Kowalewski, A. R. (2022), Carbon sequestration in turfgrass-soil systems.
35. For an overview, see SARE, Cover crops at work: Increasing soil organic matter.
36. Interview with Agroecological Farmers Association.
37. IndexMundi (2023), EU-27 soybean meal imports by year.
38. AEI (2022), Three insights from the 2022 soybean yield guide.
39. Interview with Agroecological Farmers Association.
40. Gaffey, J. et al (2023), Green biorefinery systems for the production of climate-smart sustainable products from grasses, legumes and green crop residues.
41. Wiersma, D. (2021), Alfalfa offers great nitrogen fixation, storage benefits.
42. For instance, see Bruma, I. S., Toader, M., Popescu, G., Petcu, V., Georgescu, Em (2023), The evolution of alfalfa, as important crop in organic farming system in Romania.
43. Interview with Tivatrade.

Given the potential represented by local grasses, Stara Zagora, with its rich agricultural heritage, is well placed to reap significant benefits from adopting sustainable practices. In particular, green biorefineries offer a transformative solution. These are defined as a specific set of biorefineries that "utilise biomass, such as grasses, green crops and immature cereals, as a raw material for obtaining industrial products".[44] Green biorefineries can use also legumes and green plant wastes to extract protein for animal or human consumption while using the residual pulp as cattle feed—which can provide an alternative to imported soy[45]. By converting locally abundant grasses and legumes into valuable livestock feed, while producing bioenergy and bio-based materials, these refineries align with circular bioeconomy principles and could represent an opportunity for the Stara Zagora region,[46] especially when combined with the benefits of alfalfa.

Several initiatives at EU level are trying to leverage the potential of green biorefineries. A key one is the GO-GRASS initiative, which resulted in a White Paper containing the project results[47]. The aim of the project is to create new business opportunities through the valorisation of grassland. In particular, the Danish demo focused on the development of a green biorefinery technology to extract protein from grass to be fed to animals which, as side products, also results in fibrous pulp for ruminant feed, biogas, biomaterial, and a brown juice to be potentially used as fertiliser[48]. Other research initiatives aimed at proving the benefits of green biorefinieries, with the aim to produce more sustainable materials, co-produce local forms of protein, and alleviate sustainability challenges, include Biorefinery Glas, Farm Zero C, Farm4More, Grassification, Green Valley, Grass Green Resources (GR3), Graskracht.[49]

A strategy document dedicated to bioeconomy in the Stara Zagora region[50] acknowledged the Bulgarian findings of the EU Biorefinery Outlook to 2030[51]. While recognising structural challenges linked to the relative isolation of Bulgaria in the context of the EU-wide value chain, the Outlook recognised the feedstock potential and the existence of enough industries whose waste could be a source for the refineries. The specific high-level production of grain of the Stara Zagora region,[52] together with its carbon-rich soil[53] and the abundance of permanent grassland in Bulgaria (around 1.4 million hectares)[54] therefore represent an opportunity for the region. Despite considering the production of green biorefineries more suitable for greenhouses, stakeholders highlighted how biorefineries could further support the transition towards renewable sources thanks to the creation of biofuel as a by-product.[55] This element could combine with the ambitions of Stara Zagora to phase out its coal-related activities.

Inputs

Financial resources

The CAP includes a number of measures that could promote the sustainable production of forage crops within the agricultural sector. An important measure is the **Coupled Income Support (CIS)[56]**, which provides additional income support to specific sectors to improve their competitiveness. In Bulgaria, the *CIS for protein crops* [I.B.19] includes income support for farms producing the following protein crops: beans (for grain), lentils, chickpeas, peas for grain (winter and spring), peanuts, soybeans, broad beans, alfalfa, sainfoin, vetch, clover, vetch, lupin, fenugreek and/or mixtures thereof. Of these, soybeans, lupin, alfalfa (for cattle and goats), sainfoin (for ruminants), clover (for ruminants), and fenugreek (for poultry) could be of particular interest as animal feeds. Agricultural producers can qualify for the annual aid per hectare by applying for a minimum of 0.5 hectares of eligible land.

In addition, **eco-schemes**[57] have been designed to address climate and environmental objectives by offering annual payments for a wide range of practices. Eco-schemes that may be applicable to the sustainable production of forage crops are the *Eco-scheme for organic farming (livestock)* [I.B.1], the *Green fertilisation and organic fertilisation* [I.B.3], the *Eco-scheme for extensive maintenance of permanent grassland* [I.B.6] and the *Eco-scheme for crop diversification* [I.B.8]. A major challenge in implementing eco-schemes lies in the complex interplay between achieving high agricultural productivity and environmental conservation goals. The EU faces the tough task of enhancing eco-efficiency, which involves increasing output while reducing the input of critical resources like water, nutrients, and energy. Moreover, the eco-schemes' effectiveness is often undermined by their voluntary

44. Xiu, S., Shahbazi, A. (2015), Development of green biorefinery for biomass utilization: A review.
45. Damborg, V. K., Jensen, S.K., Johansen, M., Ambye-Jensen, M., Weisbjerg, M. R. (2019), Ensiled pulp from biorefining increased milk production in dairy cows compared with grass-clover silage.
46. As confirmed during the interview with Agroecological Farmers Association.
47. GO-GRASS (2024), White Paper for grassland opportunities.
48. GO-GRASS (2024), White Paper for grassland opportunities, p14.
49. Gaffey, J. et al (2023), Green biorefinery systems for the production of climate-smart sustainable products from grasses, legumes and green crop residues.
50. BE-Rural (2021), Strategy for the development of the bioeconomy in the Stara Zagora region.
51. European Commission (2021), EU Biorefinery Outlook to 2030.
52. Interview with Agroecological Farmers Association
53. As mentioned above, this derives from the extensive mining activities in the region and would be enhanced by the production of protein crops like alfalfa.
54. Gaffey, J. et al (2023), Green biorefinery systems for the production of climate-smart sustainable products from grasses, legumes and green crop residues.
55. Interview with Tivatrade.
56. European Commission, Coupled income support (CIS) explained.
57. European Commission, Eco-schemes explained.

nature, leading to low adoption rates among farmers. This is compounded by the schemes' design, which can be too complex or misaligned with farmers' economic interests and capabilities. For instance, eco-schemes vary significantly between countries, affecting both their uptake and effectiveness in preserving biodiversity and achieving other environmental targets[58] On the other hand, when effectively implemented, eco-schemes can significantly contribute to environmental and biodiversity conservation. They have the potential to reduce nutrient and pesticide emissions, protect landscapes, and enhance biodiversity across Europe's agricultural lands. These schemes represent a crucial investment in environmental sustainability, providing ecological and economic benefits by promoting practices that lead to healthier ecosystems. Positive outcomes have been observed in areas where schemes are well-targeted and offer clear incentives for farmers to change their practices[59].

Similarly to eco-schemes, **environmental and climate support (ENVCLIM)** can be used for the adoption of sustainable farming practices, but in the form of multi-annual support. The intervention for the ***Restoration and maintenance of degraded pasture areas*** [II.AE.3] thereby reinforces the qualitative aspect of the aforementioned eco-scheme [I.B.6] by supporting practices aimed at increasing soil organic carbon (e.g. growing cover crops such as clover), benefiting both the soil and pastures.

The CAP also proposes **agri-environment-climate measures (AECMs)**, which are designed to promote environmentally friendly farming practices beyond standard legal requirements[60]. These schemes have been observed to encourage more environmentally responsible agricultural measures[61], as well as broader adoption to sustainable practices thanks to the perceived transactional costs by farmers.[62]

By diversifying from an exclusive reliance on (imported) soy as the primary ingredient in animal feed, the integration of forage crops such as, for example, clover, alfalfa, lupin and sainfoin can improve the overall nutritional composition of animal feed. Moreover, innovative technologies (e.g. green biorefineries) can encourage the valorisation of forage residues, contributing to a more circular bioeconomy. For the latter, **cooperation support** can be a measure to support innovation, including through the implementation of EIP operational groups. Besides, opportunities for research and innovation in the agricultural sector are also funded under cluster 6 'Food, Bioeconomy, Natural Resources, Agriculture and Environment' of the **Horizon Europe programme**. Lastly, **knowledge support** generally supports education, advisory services and knowledge transfer in agriculture and rural areas. The intervention of ***Consulting services and the enhancement of advisory capacity*** [II.*I*.1] offers advisory packages to – among others – provide advice on the sustainable management of natural practices (water, soil, air) and good practices thereof.

Relevant national initiatives and success stories

Among the initiative at national and supranational level, the most relevant are:

- BE-Rural – Bio-based strategies and roadmaps for enhanced rural and regional development in the EU.
- BIOEAST – Central and Eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy

The success stories for biorefineries and forage crops/ alfalfa producers are listed below:

- Almagest AD (biorefinery): the only Bulgarian producer of bioethanol.
- Essentica Ethanol Factory (biorefinery): one of the largest producers of ethyl alcohol, grain distillate and Distillers' dried grain with solubles.
- AJD Agro (alfalfa producer)

58. Pe'er et al (2020), Action needed for the EU Common Agricultural Policy to address sustainability challenges.
59. Kleijn, D., Sutherland, W. J. (2003), How effective are European agri-environment schemes in conserving and promoting biodiversity?
60. European Commission, Agri-environment-climate measures explained.
61. Popescu, L., Safta, A. (2020), Considerations regarding improving the ecological and environmental performance of agriculture.
62. Riccioli, F., Espinosa Diax, S., Di Iacovo, F., Moruzzo, R. (2023), Exploring the Effect of Perceived Transaction Costs on Farmers' Attitudes toward Participation in Agri-Environment-Climate Measures (AECMs).

Local stakeholders

The table below presents an exemplary list of companies and organisations that could be contacted and whose area of expertise reflects the needs of the Stara Zagora region for the development of green biorefineries or sustainable forage crops.

TABLE 6. KEY RELEVANT STAKEHOLDERS FOR PATHWAY 3

Stakeholder	Description	Contacts
Hranserviceengineering JSC	Hranserviceengineering JSC specializes in the sustainable production of forage crops, employing advanced agricultural practices to enhance yield and quality while minimizing environmental impact.	https://www.hranservice.com/en/ +359 (42) 608015 info@hranservice.com
Association of Agroecological Producers	The Association of Agroecological Producers focuses on ecological agricultural production, promoting environmentally friendly farming practices to support sustainable agriculture.	https://agroecology.bg/ 0887/012 555 agroecology.bulgaria@gmail.com
Vivatrade Ltd	Vivatrade Ltd specializes in the production of high-protein products derived from plant sources, catering to the growing demand for nutritious and sustainable food options.	https://vivatrade.bg/index_en.html +359 56 815180 viva_trade@abv.bg

Activities for forage crops and green biorefineries

TABLE 7. ACTIVITIES FOR PATHWAY 3

Action	Action description	Responsible Party	Supporting Party
Feasibility study and site selection	Collect local agricultural data to understand current forage crop farming practices, challenges, and potential improvements. Example: Collaborate with the local government and Hranserviceengineering JSC to identify a suitable location in Stara Zagora that has access to water, electricity, and is close to potential markets.	Local government, research institutions	Agricultural extension services, farmers
Technology selection and design	Evaluate existing and emerging technologies suitable for forage crop production. Decide on the type of biorefinery technology to be used, taking into account factors such as type of feedstock, desired end products, and environmental impacts. Example: Work with Hranserviceengineering JSC and the Association of Agroecological Producers to design a biorefinery system that is suitable for the local conditions and crop choices.	Research institutions, technology providers	Agricultural extension services, farmers
Environmental impact assessment	Conduct comprehensive EIAs for all new farming and biorefinery projects to assess potential environmental impacts, involve community stakeholders in the assessment process, and develop mitigation strategies for identified risks. This process should ensure projects comply with environmental regulations and support sustainable development goals	Environmental consultants, Government	Crop farmers (implementation of recommendations), Cooperatives, Agricultural Extension Services
Resource acquisition	Procure necessary resources, including raw materials, machinery and technology, from reputable suppliers. Example: Collaborate with Hranserviceengineering JSC and a local construction company to build the biorefinery infrastructure. Example: Procure necessary resources including feedstock from Hranserviceengineering JSC and technology from reputable suppliers.	Farmers, agricultural cooperatives	Suppliers, agricultural extension services
Development of infrastructure	Construction of biorefinery infrastructure, including facilities for raw material processing, product extraction and waste management. Example: Collaborate with Hranserviceengineering JSC and a local construction company to build the biorefinery infrastructure.	Farmers, agricultural cooperatives	Local construction companies, technology providers
Training and Workforce Development	Develop a training programme to equip workers with the skills needed to operate and maintain the biorefinery. Example: Develop a training program in collaboration with the Association of Agroecological Producers and local agricultural schools to equip workers with the skills needed to operate and maintain the biorefinery	Agricultural extension services, educational institutions	Research institutions, technology providers

Action	Action description	Responsible Party	Supporting Party
Marketing and distribution strategy	Develop branding and marketing materials that highlight the sustainability and local origin of the products. Example: Develop branding and marketing materials in collaboration with Vivatrade Ltd that highlight the sustainability and local origin of the products.	Agricultural extension services, educational institutions	Marketing agencies, local businesses
Monitoring and evaluation	Implement monitoring tools to track the performance of the biorefinery and the quality of the products. Example: Implement monitoring tools in collaboration with Hranserviceengineering JSC to track the performance of the biorefinery and the quality of the products.	Agricultural extension services, farmers	Research institutions, technology providers
Community involvement and feedback	Involve all stakeholders within the farming community to promote awareness of the social and economic benefits of sustainable and innovative technologies. Encourage cooperative efforts to adopt and implement these technologies effectively. Organise community open days and workshops to raise awareness of the project and gather feedback. Example: Hold community open days and workshops in collaboration with the Association of Agroecological Producers to raise awareness about the project and gather feedback.	Regional authorities, agricultural extension services, NGOs	Local communities and associations
Extension planning	Evaluate the success of the pilot project and plan for expansion based on specific criteria such as return on investment and market demand. Example: Evaluate the success of the pilot project in collaboration with Vivatrade Ltd and plan for expansion based on specific criteria such as return on investment and market demand.	Farmers, agricultural cooperatives	Agricultural extension services, financial institutions

Outputs

The initial outputs of these initiatives include detailed reports assessing the potential environmental impacts of the proposed biorefineries. These assessments will consider factors such as potential emissions, waste generation, water use and impact on local biodiversity. The EIAs will also include mitigation strategies for any risks identified, ensuring that the projects comply with environmental legislation and contribute to sustainable development objectives.

The building of biorefinery facilities will be completed, including structures for raw material processing, product extraction and waste management. These facilities will be equipped with the necessary machinery and technology for efficient and sustainable operation. The establishment of this infrastructure will enable the conversion of feed crops into valuable products, contributing to the local economy and promoting sustainable agricultural practices.

Outcome

In the short to medium term, farmers will benefit from green biorefineries by diversifying their income streams through contracts to supply biomass feedstocks or by participating in co-operative arrangements with biorefinery operators. This diversification can help mitigate financial risks associated with traditional crop farming and provide additional revenue opportunities. There would likely be an increased adoption of sustainable farming technologies and practices among local farmers, spurred by the training and demonstration of new techniques on pilot farms. Green biorefineries often prioritise the use of sustainable farming practices, such as conservation tillage, cover cropping, and crop rotation, to enhance soil health, minimize erosion, and improve biomass yields. These practices not only contribute to the sustainability of biomass feedstock production but also align with broader environmental goals. This could improve both the efficiency and productivity of forage crop production. Additionally, enhanced collaboration between research bodies, private enterprises, and farmers could lead to further innovations in sustainable agriculture practices. This phase focuses on the application and integration of the initial outputs into everyday farming operations, leading to measurable improvements in agricultural practices and local economic growth.

Impacts

In the long term, the impact of these projects is expected to be substantial and far-reaching. The environmental footprint of agriculture in the region could be significantly reduced, in line with EU environmental objectives such as those highlighted in the European Green Deal, which places sustainable food systems at the heart of environmental and economic policy. The adoption of sustainable agricultural practices associated with biomass production, such as reduced tillage and cover crops, can further enhance environmental sustainability by improving soil health, reducing erosion and promoting biodiversity. The establishment of green biorefineries can strengthen the resilience of rural economies by creating new employment opportunities and increasing the competitiveness of the agricultural sector. These projects stimulate local economic development, particularly in agricultural regions, by attracting investment, promoting innovation and diversifying income streams for farmers. Finally, the development of biorefinery infrastructure and associated supply chains generates employment across a range of sectors, contributing to economic growth and prosperity in rural communities.

Conclusions

This report's exploration of innovative technologies and integration of renewable energy into Stara Zagora's agricultural sector has described the region's adaptive capacity and commitment to sustainability and innovation. As Stara Zagora faces the challenge of transitioning from coal-based energy production, the strategic implementation of the pathways presented in this report provides a comprehensive framework for transformation that includes economic resilience and environmental stewardship.

The initiatives outlined in this report aim at capitalising on the opportunities of the agricultural heritage of the region to drive economic diversification while addressing pressing issues such as climate change and energy sustainability. Advanced agricultural technologies and renewable energy sources will support the local economy, increase the competitiveness of farming practices, and contribute significantly to the overarching objectives of the European Green Deal and Bulgaria's National Plans.

Furthermore, the proposed initiatives will facilitate a just transition for communities affected by the coal phase-out. By creating new opportunities in the sustainable agricultural sector, Stara Zagora is not only mitigating potential socio-economic impacts, but also cultivating a community that is resilient, skilled, and prepared for the challenges of the local economy. The effectiveness of these pathways will depend on sustained collaboration between local stakeholders, strategic investment in technology and infrastructure, and the relentless pursuit of innovation. If these plans go ahead, they could bring huge benefits for Stara Zagora while, also, showing the way for other locations to make their areas more sustainable.

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ec.europa.eu/coal-regions-in-transition

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