

How Can Development Strategies Foster Agri-digitalisation in the Era of Climate Change?

A Common Agriculture Policy based Consistency Analysis in Hungary

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Abstract

In recent years, several forward-looking initiatives have been taken in the direction of digital and sustainability transitions. Digitalisation is also gaining importance in EU, national agricultural and rural development policies, as it can enhance all three dimensions of sustainability and can lead to more efficient agricultural production and development. In this study, we conducted a consistency analysis to identify the interdependencies, impacts, and possible contradictions between the strategic objectives. The analysis compares the EU Common Agricultural Policy objectives with the Second Climate Change Strategy of Hungary (NCCS-2), the National Framework Strategy on Sustainable Development (NFSSD), the National Digital Agricultural Strategy (NDAS), and the National Rural Strategy (NRS) and explores the policy linkages between digital and sustainability transitions. The strategy documents are examined hierarchically between the EU and national levels, with a particular focus on the sector's important role in climate change mitigation and adaptation-related processes. The results can support the emergence of innovative solutions and activities in rural areas and can contribute to improving the competitiveness of the agricultural sector, thereby supporting both the decision-making process and the achievement of rural sustainability ambitions.

Keywords

sustainability, agricultural sector, rural development, climate innovation, agri-digitalisation, consistency analysis

1 Introduction

Climate change is one of the most critical economic and social challenges of the 21st century, and its impact on environmental sustainability has been confirmed in several documents (IPCC, 2019; 2021; Stern, 2006; WWF, 2011). All sectors must work together in a coordinated and comprehensive way to be able to tackle climate change effectively (Zoldy et al., 2022), which can be supported by a holistic approach considering the life cycle theory. Furthermore, the life cycle concept can enhance the socio-economic and environmental dimensions of sustainability in line with mitigation and adaptation goals. The Paris Agreement (United Nations Framework Convention on Climate Change (UNFCCC), 2015), adopted in December 2015, is a landmark in addressing climate change by accelerating the transition to a low-carbon economy. Anthropogenic greenhouse gas emissions

are increasing worldwide, and a significant share of these emissions is linked to the corporate sector.

Several initiatives have been taken to achieve carbon neutrality as a way for companies to demonstrate their corporate social responsibility. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) clearly shows that climate change will intensify in all regions in the coming decades. Increasing heat waves, longer warm seasons, and shorter cold seasons are expected. At 2 °C global warming, extreme heat events would reach critical tolerances for agriculture more frequently. The Sixth Assessment Report is the first to provide a more detailed regional assessment of climate change. It also underlines that human activity is still having an impact on climate change. Carbon dioxide is the main driver of climate change, even if other greenhouse gases also affect the

climate. Limiting methane from agriculture could be beneficial for climate protection (Gyarmati, 2021; IPCC, 2021).

As a result of the COP26 climate summit, the Glasgow Climate Pact was adopted, in which the countries of the world agreed to a global average temperature increase of 1.5 degrees Celsius by the end of the century. The Parties have adopted comprehensive and new climate finance packages and commitments on nature and land use, as well as promoting sustainable agriculture and advancing food security. Promoting innovation and sustainable development has become a key element of European development policies. The European Commission is increasingly promoting its commitment to sustainable agriculture and food production, as reflected in the European Green Deal (European Commission, 2019). The European Commission, as part of the Fit for 55% package aims to help develop sustainable solutions for carbon removal which is the first step towards a certification framework for decarbonisation (European Commission, 2021a).

The EU's Common Agricultural Policy (CAP) also supports the environmental objectives of the European Green Deal's "Farm to fork" strategy and the Biodiversity Strategy, highlighting the importance of food security and the shift toward sustainable food production (European Commission, 2020a). In 2021, the new EU Adaptation Strategy (European Commission, 2021b) was published, focusing on achieving a climate-resilient European Union in line with the EU's green economy and sustainability ambitions. The main objective of the EU Adaptation Strategy is to make the EU a climate-resilient society by 2050, with a key role for climate innovation efforts in rural areas and the implementation of measures and improvements in the agricultural economy.

2 Problem statement

Agriculture is an important strategic sector of the Hungarian national economy; however, it must deal with high vulnerability due to the possible impacts of climate change, so mitigation and adaptation measures are essential. In the context of Hungarian agriculture, several studies have highlighted the importance of adaptation to the expected impacts of climate change (Biró and Szalmáné Csete, 2021a; 2021b; Farkasné Fekete, 2009; Fűr and Csete, 2010; Gaál et al., 2021; Li et al., 2018). There are several examples where the importance of climate change impacts, mitigation and adaptation in agriculture is presented from different perspectives (Erdélyi and Boksai, 2019; Karakasné Morvay and Erdélyi, 2020).

Adaptation is gaining attention as a necessary and inevitable response to the challenges of climate change. Future climate modelling will help to identify the potential impacts on agricultural production. Erdélyi (2016) shows the importance of case studies in agriculture, showing that rising temperatures can have a positive impact on yields, but if they rise too much or are coupled with other weather extremes, yield levels can be significantly reduced. Aryal et al. (2019) provide an overview of the impacts of climate change on the agricultural sector and adaptation options in smallholder production systems in South Asia. From an analysis of 720 farming households in Nepal, Khanal et al. (2017) found that climate change adversely affects agriculture and farmers have adopted different adaptation practices to minimise climate impacts.

Climate change mitigation may require smart and innovative technologies that can address the complex problems that will arise in the future (OECD, 2021). Digital transformation is an increasingly prominent issue in the European and in the domestic agricultural policy, which can enhance all three dimensions of sustainability:

1. increasing farmers' incomes,
2. reducing production risks and environmental pressures, and
3. reducing critical labour shortages in agriculture (Szóke and Kovács, 2020).

The research aims to identify interdependencies, impacts, and possible contradictions between strategic objectives of relevant policy development processes. The following research questions were posed in the study:

- What sustainability and climate innovation aspects are reflected in national agricultural strategies?
- In Hungary, which climate-smart agricultural measures are supported and in line with the objectives of the new EU Common Agricultural Policy (CAP)?

The objective-based assessment of the CAP will focus on the following 4 relevant strategies:

1. Second Climate Change Strategy of Hungary (NCCS-2) 2018–2030 (Ministry for Innovation and Technology, 2018);
2. National Framework Strategy on Sustainable Development (NFSSD) (National Council for Sustainable Development (NFFT), 2013);
3. National Digital Agricultural Strategy (NDAS) (Government Resolution 1470/2019, Government of Hungary, 2019);

4. National Rural Strategy (NRS) (Ministry of Rural Development, 2012).

Thus, the strategic documents are considered hierarchically between the EU and national levels, given the important role of the sector in climate change mitigation and adaptation. There is no single Member State in the EU whose agricultural sector can be considered fully adapted to climate change, so adaptation efforts need to increase across the sector (Mutua Ndue and Goda, 2021). Research can contribute to the realisation of sustainable agriculture and can support the increase of the sector's competitiveness, added value, and income-generating capacity, as well as highlight the importance of agri-digitalisation.

3 Consistency analyses

In the environmental assessment of policy measures and strategies at the EU and national levels, there are many cases of consistency focused examinations, where the objectives of the document under review are considered in terms of their consistency (Department of National Parks and Landscape Protection, Ministry of Agriculture, 2016; Duwe and Spasova, 2021; Ladoneczki and Kósi, 2014; Ministry of National Development, 2013; SKV Csoport, 2003; t33 Srl, 2015).

Consistency analysis reveals the links between strategic objectives and their direction as mutually reinforcing/weakening/repelling/neutral relationships. By exploring the relationships, strategic recommendations can be formulated to prevent conflicting trends. Consistency analysis can also be used to compare development goals, environmental priorities, and objectives. The analysis focuses on the coherence of the strategy's objectives and lines of intervention with other strategies and their objectives. Based on the literature review and previous research, consistency analysis was chosen as the way to compare the national and EU strategies from the research question's perspective.

The European Green Deal (EU Green Deal) targets at least 55% net greenhouse gas emissions by 2030 compared to 1990 levels, and for the EU to become a climate-neutral economy by 2050. Sustainable agriculture and farmers can play an important role in meeting the challenges of the European Green Deal. The EU Emissions Trading Scheme (EU ETS) puts a "price" on carbon dioxide and reduces the emission limit for certain sectors of the economy each year. EU countries have a shared responsibility to remove carbon dioxide from the atmosphere, so the Land Use, Forestry and Agriculture Regulation set overall

EU targets for the removal of carbon dioxide through natural sinks, equivalent to 310 million tons of carbon dioxide emissions, by 2030.

The EU's Common Agricultural Policy (CAP) is key to securing the future of agriculture and forestry and to achieving the goals of the European Green Deal. The new CAP (European Commission, 2020b), which starts in 2023, sets out a series of measures to encourage farmers to adopt greener farming practices. The CAP aims to promote a more sustainable and competitive agricultural sector that can support farmers' livelihoods and provide healthy and sustainable food for society and rural areas. The CAP focuses on nine objectives linked to the EU's common objectives for the social, environmental, and economic sustainability of agriculture and rural areas. Member States design their national CAP Strategic Plans around these objectives.

The Common Agricultural Policy plans should be in line with the Paris Agreement of 2015 (United Nations Framework Convention on Climate Change (UNFCCC), 2015), which stresses the need for a balance between mitigation and adaptation measures on several points. The objectives of the CAP (European Commission (2020b) are:

1. A fair income for farmers to enhance food security.
2. Increase competitiveness, with a greater emphasis on research, technology, and digitalisation.
3. Improving farmers' position in the value chain.
4. Increase climate change measures (mitigation and adaptation).
5. Promoting sustainable development and efficient natural resource management.
6. Contribute to halting and reversing biodiversity loss, the enhance ecosystem services.
7. Supporting generational renewal and business development in rural areas.
8. Stimulating the economy of rural areas: local development (bioeconomy, sustainable forestry).
9. Food quality and health protection: sustainable food production, reducing food waste (European Commission, 2020b).

The selected Hungarian national development strategies were examined for each of the nine CAP's strategic objectives. The consistency analysis aims to identify how the strategic objectives fit together and what their effects and possible contradictions are. The content of the EU strategy is compared with four national strategies (listed

in Section 2), examining the links between the objectives. For the analysis, we have selected the most relevant national strategies that consider agricultural digitalisation and sustainability issues. Focusing on the areas of sustainability and climate innovation, we present the main linkages and identify critical points where potential interventions are needed. The links and trade-offs between the objectives are assessed in a tabular format. The nine CAP headline objectives presented above form the columns of the table and the rows are based on the objectives of the national agricultural strategy. Each cell is an attempt to show the strength and direction of the relationship between the objectives.

By direction of the interrelation, we mean how each objective relates to the sustainable development and climate innovation objectives. First, the direction of the interrelation is defined: as positive (+, there is a relationship between the targets) or negative (-, there is a contradiction between the targets). It may be that each objective has both a positive and a negative effect, in which case the interrelation is neutral (+/-). The strength of the relationship between objectives is indicated by a single (+ or -) or double (++ or --) sign. In some cases, there is no link between the examined objectives, this is indicated by a separate "0" or not relevant (NR).

3.1 Second Climate Change Strategy of Hungary

The Second Climate Change Strategy of Hungary 2018–2030 (NCCS-2), which is based on a decarbonisation and adaptation vision in line with mitigation and adaptation objectives, has been developed to look ahead to 2050. The strategy has three pillars. The Hungarian Adaptation Strategy is the first pillar of the NCCS-2. Another pillar

of the NCCS-2 is the National Decarbonisation Roadmap (NDR), and the third pillar of the Strategy is the Horizontal Tools which include the Climate Awareness Plan (Ministry for Innovation and Technology, 2018). The biggest challenge for adaptation is the pace and scale of climate change. Rapid changes may not be able to be accommodated dynamically and flexibly by social and economic systems, and may even threaten systemic stability, making it essential to study and understand the likely impacts of climate change, identify the associated intervention options, and disseminate and implement solutions as widely as possible.

NCCS-2 sets specific targets for decarbonisation, climate partnership, and adaptation. The consistency analysis has been carried out along these specific objectives (Table 1), as they provide the strategic objectives. For agriculture, adaptation measures are the key focus, but there are also mitigation measures that promote adaptation and increase the sector's productivity, competitiveness, food security, and rural resilience by creating jobs and contributing to sustainable agricultural production (Ministry for Innovation and Technology, 2018).

The agriculture-related objectives in the Hungarian Decarbonisation Roadmap (HDR) include the development of production systems with lower energy and more efficient use of fertilisers (e.g.: organic farming), promotion of precision farming technologies and organic farming practices, reduction of methane production, life cycle assessments for technologies and farming practices, fertiliser management and energy recovery, revision of production structure such as organic farming, and increased but sustainable use of geothermal energy. In the NCCS-2, climate adaptation is addressed as a separate strategy in the National Adaptation Strategy (NAS). The decarbonisation and adaptation objectives are

Table 1 Consistency analyses of the strategic objectives of the Second Climate Change Strategy of Hungary

Second Climate Change Strategy of Hungary	Common Agricultural Policy								
	S1. Supporting viable farm income	S2. Increasing competitiveness	S3. Improving farmers' position in the value chain	S4. Contributing to climate change mitigation	S5. Efficient natural resource management	S6. Halting and reversing biodiversity loss	S7. Generational renewal	S8. Jobs, growth, and equality in rural areas	S9. Responding to societal demands on food and health
S1. Decarbonisation	0	++	NR	++	++	++	0	++	+
S2. Climate partnership	0	0	NR	++	++	+	0	+	+
S3. Adaptation and preparation	++	+	NR	++	++	++	+	++	+

LEGEND: there is a strong (++) , weak (+) , neutral (+/-) , strong (- -) , weak (-) discrepancy between the strategic objectives in terms of sustainability and climate innovation, either no relationship (0) or not relevant (NR).

complemented by a Climate Action Programme (Partnership for Climate Action - Climate Action Plan). The objectives set out long, medium-, and short-term action lines, broken down by sector. The target areas are energy, transport, agriculture, industry, and waste management.

The medium-term action lines of the Hungarian Decarbonisation Roadmap include a complete overhaul of the agricultural production structure, an increase in organic farming, and the development of a rural economy that is adaptable to changing climatic conditions and provides a good living for rural areas, in many cases consistent with EU food security objectives. Environmental and territorial objectives, such as sustainable use of natural resources and combating climate change and ensuring the economic and social dynamism of rural areas, are prominent among the CAP objectives (European Commission, 2020b). In line with the EU objectives, the environmental objectives are directly linked to the NCCS-2 objectives, while the territorial objectives are indirectly linked to the NCCS-2 objectives, and climate policy aspects are also included. The co-financing scheme for rural development supports competitiveness growth, innovation, the creation of "knowledge-based" agriculture, and the sustainable management of natural resources, the latter being also of crucial importance for the NCCS-2. The objectives of the NCCS-2 are partly consistent with the strategic objectives of the EU Common Agricultural Policy (Table 1). There is a strong interaction with the strategic objectives for agriculture and rural development. The decarbonisation objectives are supported by research, development, and innovation, in particular the use of material and energy-saving technologies, renewable energy sources, biomass utilisation, and environmentally friendly agri-techniques as climate innovative tools. Climate change awareness aims to integrate climate awareness and sustainability into planning, decision-making, and action at all levels of society.

3.2 National Framework Strategy on Sustainable Development

Climate change and population growth challenge the agricultural sector to meet society's food needs while preserving the environment and natural resources. Innovation has a key role to play to achieve more sustainable and solution-oriented agriculture. And innovative solutions aim to support the UN Sustainable Development Goals (SDGs). The basic idea and guiding principle of the framework strategy are that "*A good life is unthinkable without the right quantity and quality of natural resources.*" (National Council for Sustainable Development (NFFT), 2013:p.22).

The National Framework Strategy on Sustainable Development (NFSSD) aims to contribute to a national consensus on the concept of sustainability; support the transition towards sustainability and serve as a long-term concept for policy-making processes (National Council for Sustainable Development (NFFT), 2013). The Framework Strategy sets out strategic objectives and instruments for the four national resources – human, social, environmental, and economic – for the period 2012–2024. Since its adoption, the Framework Strategy has already produced four Progress Reports, which assess the last two years and focus on the four national capitals (environmental, economic, social, and human) of sustainability. Given the horizontal nature of sustainability, the Progress Reports are the most comprehensive general country assessments to date, covering our human resources, social capital, the natural environment (land use, material flows: extracted minerals, pollution and waste, and climate change) and our economic capacity (employment, innovation, public debt, intergenerational accounts).

The National Framework Strategy on Sustainable Development specifically addresses the current state of the environment and sustainability targets. It highlights biodiversity conservation, the protection of renewable natural resources, the maintenance of species richness unique in Europe, the preservation of landscape and natural assets, and the prevention of the depletion of ecosystem services as aspects of sustainability. Another important objective is to maintain soil fertility, reduce the rate of encroachment on natural areas and manage renewable resources based on sustainable yields.

The results show that the sustainability objectives interact positively with the CAP's strategic objectives, with a particular focus on contributing to climate change and natural resources protection. Although the preparation of the NFSSD also predates the EU, it can be considered largely consistent with it (Table 2).

3.3 National Digital Agricultural Strategy

The National Digital Agricultural Strategy of Hungary (hereinafter: NDAS) was created to increase the digitalisation and competitiveness of agriculture, aiming at the spread of digital solutions and precision farming in agricultural production. Modern technologies contribute to increasing food security and the profitability of agricultural production (Government Resolution 1470/2019, Government of Hungary, 2019). Agri-informatics tools, data collection sensors, and robotic solutions support production, increase the profitability and food safety of the food economy, and reduce the sector's environmental

Table 2 Consistency analyses of the strategic objectives of the National Framework Strategy on Sustainable Development

National Framework Strategy on Sustainable Development		Common Agricultural Policy								
		S1. Supporting viable farm income	S2. Increasing competitiveness	S3. Improving farmers' position in the value chain	S4. Contributing to climate change mitigation	S5. Efficient natural resource management	S6. Halting and reversing biodiversity loss	S7. Generational renewal	S8. Jobs, growth, and equality in rural areas	S9. Responding to societal demands on food and health
T1. Human		+	NR	NR	+	+	NR	+	+	++
T2. Social		+	+	+	+	+	+	++	++	+
T3. Environmental	S1. Limiting the use of natural resources	NR	-	NR	++	++	++	+	-	0
	S2. Enforcing production technology constraints or product standards	NR	--	NR	++	++	NR	NR	NR	NR
	S3. Appropriate pricing of natural resource use	NR	+/-	NR	++	++	++	NR	NR	NR
	S4. Promoting environmentally sound technologies and land-use patterns	NR	+/-	NR	++	++	++	+	NR	+
	S5. Biodiversity, soil fertility, and ecosystem services	NR	NR	NR	++	++	++	NR	NR	NR
	S6. Reducing human pressures on the environment	NR	NR	NR	++	++	++	NR	NR	+
T4. Economic		++	++	++	+	NR	NR	+	++	0

LEGEND: there is a strong (++) , weak (+) , neutral (+/-) , strong (- -) , weak (-) discrepancy between the strategic objectives in terms of sustainability and climate innovation, either no relationship (0) or not relevant (NR).

impact, thereby contributing to rural development. The overall objective of the NDAS is to contribute to increasing the competitiveness of agricultural production through information gathering, processing, automation, and robotisation of technological operations while making efficient use of environmental resources.

The achievement of the overall objectives is supported by eight horizontal objectives in three strategic areas (agricultural production; agricultural holding; production trajectory) and four horizontal areas (human resources; research, development, and innovation; public administration and services; development policy and aids) (Table 3). The Strategy's programmes are not only targeted at large enterprises, but micro, small and medium-sized enterprises are the main beneficiaries of digital support. To increase incomes, it is crucial that digital agri-technologies are developed based on farmers' needs and respond to real challenges (Government of Hungary, 2019). Precision farming can be an innovation for sustainability that directly contributes to achieving sustainable agriculture also at the EU level. The wider application of precision farming will bring significant competitiveness and efficiency gains to the sector.

The new Common Agricultural Policy will also include the need to design Agricultural Knowledge Sharing and

Innovation Systems, which will allow the development of support schemes and programmes that apply climate-smart tools in response to sustainability challenges and help the sector to become more agri-digital. Technological innovation and knowledge transfer will provide solutions to address sustainability challenges, and digitalisation and precision farming will play a significant role in this.

3.4 National Rural Strategy

At the national level, there is a growing focus on the conservation of natural resources and values, sustainable management, agriculture, and rural development. The National Rural Strategy of Hungary aims to define the objectives, principles, and implementation measures for the national rural policy up to 2020, focusing on sustainable development, viable agricultural and food production, and the values of rural life. Instead of a sectoral approach, it provides a common strategic framework for specialised areas such as rural development, nature and environment protection, water, agribusiness, and food production.

The CAP essentially defines the scope for national agricultural and rural strategy. The EU's rural development policy is the second pillar of the CAP and aims to support rural areas in the EU. Under Government Resolution 1003/2021 (Government of Hungary, 2021), the Government has

Table 3 Consistency analysis of the strategic and horizontal objectives of the National Digital Agricultural Strategy

National Digital Agricultural Strategy	Common Agricultural Policy								
	S1. Supporting viable farm income	S2. Increasing competitiveness	S3. Improving farmers' position in the value chain	S4. Contributing to climate change mitigation	S5. Efficient natural resource management	S6. Halting and reversing biodiversity loss	S7. Generational renewal	S8. Jobs, growth, and equality in rural areas	S9. Responding to societal demands on food and health
S1. Wider use of precision farming	+	++	+	++	++	+	+/-	++	+
S2. Farm management	+	+	0	NR	+	0	+	+	+
S3. Development of product tracking systems and online business	+	++	+	- -	0	0	NR	+	0
H1.1 Developing digital competencies of agribusiness actors	+/-	++	++	0	0	0	+	++	+
H1.2 Available digital agricultural advice to farmers	+	++	+	0	0	0	+	++	+
H2.1 Development of digital agri-innovation environment	NR	++	+	0	0	0	+	++	+
H2.2 Development of digital agri-startup ecosystem	NR	++	+	0	0	+	+	+	+
H3.1 Reducing the cost of access to public data and digital services	+	+	+	NR	NR	NR	NR	+	NR
H3.2 Legal deregulation to exploit the potential of digital technology	NR	++	++	NR	NR	NR	+	++	+
H3.3 Improving the collection and processing of sectoral data	NR	+	+	NR	NR	NR	+	+	+
H4. Supporting the uptake of precision farming	+	++	+	0	++	+	+	++	+

LEGEND: there is a strong (++) , weak (+) , neutral (+/-) , strong (- -) , weak (-) discrepancy between the strategic objectives in terms of sustainability and climate innovation, either no relationship (0) or not relevant (NR).

increased the domestic co-financing of the rural development pillar of the Common Agricultural Policy from 17.5 percent to 80 percent over the next seven years.

A key objective of the National Rural Strategy is to ensure the sustainability of rural areas. The global challenges facing Hungary's rural areas include climate change, increasing climatic extremes, food security and the food chain, environmental sustainability, biodiversity, and landscape-sustainable agriculture. In response to these global challenges, the overall objective is to improve the population absorption and retention capacity of rural areas, considering three horizontal aspects: sustainability, territorial and social cohesion, and urban-rural linkages. It sets out five strategic objectives to achieve the overall objective (Table 4).

The objectives of the National Rural Strategy are in many ways consistent with the EU's objectives on sustainability, highlighting the conservation of our landscapes' natural values and resources, which contributes significantly to the CAP objectives.

However, the targets to stimulate the rural economy, increase employment and improve the quality of life can also have a negative impact on the conservation of landscapes and biodiversity. Creating new jobs and increasing the number of farms could jeopardise the achievement of sustainable development and carbon neutrality objectives.

4 Conclusion

In line with the European Green Deal and the UN Sustainable Development Goals, digital transformation should be linked to the green transition. The challenge of digitalisation is a transformation that strongly affects agricultural enterprises and rural communities. The objectives and implementation model of the new CAP lay the foundations for sustainable digitalisation: a socio-technical transformation process that reduces inequalities and pressure on resources improves workers' conditions, increases farmers' incomes, and stimulates bottom-up innovation. This requires the creation of basic infrastructure, the adaptation of technical and organisational solutions to different contexts, and the active promotion of digital inclusion. The analysis shows that the national strategies provide the necessary support to achieve the EU's climate goals and strategic objectives for sustainable development. The consistency assessment has identified the interrelations between the EU CAP and the selected national development strategies, which can help decision-makers to shape relevant policies. The results of the research show that the examined national strategies form a coherent system with the EU's Common Agricultural Policy objectives from a sustainability and climate innovation perspective. There are only a few inconsistencies between the objectives of the National Framework Strategy on

Table 4 Consistency analyses of the strategic objectives of the National Rural Strategy

National Rural Strategy	Common Agricultural Policy								
	S1. Supporting viable farm income	S2. Increasing competitiveness	S3. Improving farmers' position in the value chain	S4. Contributing to climate change mitigation	S5. Efficient natural resource management	S6. Halting and reversing biodiversity loss	S7. Generational renewal	S8. Jobs, growth, and equality in rural areas	S9. Responding to societal demands on food and health
S1. Protection the natural values and resources of the landscapes	NR	-	NR	++	++	++	NR	-	+
S2. Diverse and viable agricultural production	+	++	+	0	++	+	++	++	+
S3. Food security	++	+	++	+	++	++	+	+	++
S4. Securing the livelihoods of the rural economy, increasing rural employment	++	+	++	+/-	+/-	-	+	++	+
S5. Strengthening rural communities and improving the quality of life of rural people	+	+	++	+/-	+/-	+/-	++	++	+

LEGEND: there is a strong (++) , weak (+) , neutral (+/-) , strong (- -) , weak (-) discrepancy between the strategic objectives in terms of sustainability and climate innovation, either no relationship (0) or not relevant (NR).

Sustainable Development, and it is not in line with the EU's innovation ambitions. This is due to the preparation of the NFSSD, which predates the EU's CAP, but it can be considered consistent with it. The other analysed strategies show that the main strategies affecting the agricultural sector form a complex system that considers social, economic, and environmental impacts and is in line with EU objectives. The result of the consistency analysis confirms that there is a strong link between climate objectives and the sustainability of the sector, i.e., the application of climate-smart agricultural solutions can effectively contribute to sustainable agricultural and rural development,

thereby increasing the competitiveness of the sector and stimulating the economy of rural areas.

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References

- Aryal, J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., Jat, M. L. (2019) "Climate change and agriculture in South Asia: adaptation options in smallholder production systems", *Environment, Development and Sustainability*, 22(6), pp. 5045–5075.
<https://doi.org/10.1007/s10668-019-00414-4>
- Biró, K., Szalmáné Csete, M. (2021a) "A klímainnovációs törekvések vizsgálata a dunántúli tervezési-statisztikai régiókban" (Examination of climate innovation targets in the Transdanubia Planning-Statistical Regions), *Gazdálkodás: Scientific Journal on Agricultural Economics*, 65(5), pp. 375–396. (in Hungarian)
https://doi.org/10.53079/GAZDALKODAS.65.5.t.pp_375-396
- Biró, K., Szalmáné Csete, M. (2021b) "Corporate social responsibility in agribusiness: climate-related empirical findings from Hungary", *Environment, Development and Sustainability*, 23(4), pp. 5674–5694.
<https://doi.org/10.1007/s10668-020-00838-3>
- Department of National Parks and Landscape Protection, Ministry of Agriculture (2016) "Nemzeti Tájstratégia (NTS) Környezeti Vizsgálat" (National Landscape Strategy (NTS) Environmental Assessment), Department of National Parks and Landscape Protection, Ministry of Agriculture, Budapest, Hungary. (in Hungarian)
- Duwe, M., Spasova, D. (2021) "Measuring progress towards climate neutrality. Part II: Integrating net zero indicators in EU governance processes", Ecologic Institute, Berlin, Germany, IDDRI, Paris, France.
- Erdélyi, É. (2016) "Thinking of Production while Dealing with Climate Change, Efforts of Taiwan and Hungary", In: Vándor, J., Beke, J. (eds.) *The Current Issues of Economic and Social Integration in Hungary and Taiwan: Proceedings of the scientific conference of Budapest Business School University of Applied Sciences 22-23 February 2016*, Budapesti Gazdasági Egyetem (BGE), pp. 256–277. ISBN 9786155607712

- Erdélyi, É., Boksai, D. (2019) "How Can CO₂ Emission Be Reduced During Food Production?", In: Palocz-Andresen, M., Szalay, D., Gosztom, A., Sáros, L., Taligás, T. (eds.) *International Climate Protection*, Springer, pp. 283–289. ISBN 978-3-030-03815-1
https://doi.org/10.1007/978-3-030-03816-8_36
- European Commission (2019) "Communication from the Commission: The European Green Deal", 11 December 2019, COM(2019) 640 final.
- European Commission (2020a) "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system", 20 May 2020, COM(2020) 381 final.
- European Commission (2020b) "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Recommendations to the Member States as regards their strategic plan for the Common Agricultural Policy", 18 December 2020, COM(2020) 846 final.
- European Commission (2021a) "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Empty: 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality", 14 July 2021, COM(2021) 550 final.
- European Commission (2021b) "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Empty: Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change", 24 February 2021, COM(2021) 82 final.
- Farkasné Fekete, M. (2009) "A mezőgazdasági területek érzékenysége és adaptációs képességének mérési lehetőségei" (Measurement possibilities of the sensitivity and adaptive capacity of agricultural land), *Gazdálkodás: Scientific Journal on Agricultural Economics*, 53(3), pp. 222–232. (in Hungarian)
- Für, A., Csete, M. (2010) "Modeling methodologies of synergic effects related to climate change and sustainable energy management", *Periodica Polytechnica Social and Management Sciences*, 18(1), pp. 11–19.
<https://doi.org/10.3311/pp.so.2010-1.02>
- Gaál, M., Molnár, A., Illés, I., Kiss, A. Lámfalusi, I., Kemény, G. (2021) "Chapter 11 - Where do we stand with digitalization? An assessment of digital transformation in Hungarian agriculture", In: Bochtis, D., Achillas, C., Baniyas, G., Lampridi, M. (eds.) *Bio-Economy and Agri-production: Concepts and Evidence*, Academic Press, pp. 195–206. ISBN 9780128197745
<https://doi.org/10.1016/B978-0-12-819774-5.00011-4>
- Government of Hungary (2019) "1470/2019. (VIII. 1.) Korm. határozat a magyar agrárium digitalizációjának előmozdításáról és összehangolásáról, Magyarország Digitális Agrár Stratégiájáról" (Government Resolution 1470/2019. (VIII. 1.) on the Promotion and Coordination of the Digitization of Hungarian Agriculture, on Hungary's Digital Agricultural Strategy), Budapest, Hungary. (in Hungarian)
- Government of Hungary (2021) "1003/2021. (I. 11.) Korm. határozat a vidéki Magyarország megújításáról, a hazai mezőgazdaság és élelmiszeripar versenyképességének, valamint a gazdák támogatási szintjének a 2021-2027-es időszakban történő megőrzéséről" (Government Resolution 1003/2021. (I. 11.) on the Renewal of Rural Hungary, on the Preservation of the Competitiveness of the Hungarian Agriculture and Food Industry and the Level of Support for Farmers in the Period 2021-2027), Budapest, Hungary. (in Hungarian)
- Gyarmati, G. (2021) "A mezőgazdasági szén-dioxid-kibocsátást befolyásoló legfőbb tényezők vizsgálata" (Analysis of main factors affecting agricultural carbon dioxide emissions), *Gazdálkodás: Scientific Journal on Agricultural Economics*, 65(6), pp. 517–535. (in Hungarian)
https://doi.org/10.53079/GAZDALKODAS.65.6.t.pp_517-535
- IPCC (2019) "Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems", Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, 2019.
- IPCC (2021) "Summary for Policymakers", In: Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., ..., Zhou, B. (eds.) *Climate Change 2021: The Physical Science Basis*, Cambridge University Press, Cambridge, UK, New York, NY, USA, pp. 3–32.
<https://doi.org/10.1017/9781009157896.001>
- Karakasné Morvay, K., Erdélyi, É. (2020) "Az élelmiszer, mint veszélyes hulladék" (Food as hazardous waste), In: Marton, Z., Németh, K., Pelesz, P., Péter, E. (eds.) *IV. Turizmus és Biztonság Nemzetközi Tudományos Konferencia Tanulmánykötet, Pannon Egyetem Nagykanizsai Kampusza*, pp. 220–231. ISBN 9789633961322 (in Hungarian)
- Khanal, U., Wilson, C., Hoang, V.-N., Lee, B. (2019) "Impact of community-based organizations on climate change adaptation in agriculture: empirical evidence from Nepal", *Environment, Development and Sustainability*, 21(2), pp. 621–635.
<https://doi.org/10.1007/s10668-017-0050-6>
- Ladoneczki, G., Kósi, K. (2014) "Makroszintű nemzeti stratégiák konzisztenciavizsgálata a biodiverzitás tükrében" (Consistency Analysis of National Strategies in View of Biodiversity), *Gazdálkodás: Scientific Journal on Agricultural Economics*, 58(4), pp. 331–340. (in Hungarian)
<https://doi.org/10.22004/ag.econ.206091>
- Li, S., Juhász-Horváth, L., Pintér, L., Rounsevell, M. D. A., Harrison, P. A. (2018) "Modelling regional cropping patterns under scenarios of climate and socio-economic change in Hungary", *Science of the Total Environment*, 622–623, pp. 1611–1620.
<https://doi.org/10.1016/j.scitotenv.2017.10.038>
- Ministry for Innovation and Technology (2018) "Második Nemzeti Éghajlatváltozási Stratégia" (The Second Climate Change Strategy of Hungary (NCCS-2)), Ministry for Innovation and Technology, Budapest, Hungary, Annex to Parliamentary Resolution 23/2018 (X. 31.). (in Hungarian)

- Ministry of National Development (2013) "Nemzeti Éghajlatváltozási Stratégia Stratégiai Környezeti Vizsgálata - A környezeti jelentés egyeztetési változata" (Strategic Environmental Assessment of the National Climate Change Strategy - Consultation version of the Environmental Report), Terra Studio Kft., Budapest, Hungary. (in Hungarian)
- Ministry of Rural Development (2012) "Nemzeti Vidékstratégia 2012–2020" (National Rural Strategy 2012–2020), Ministry of Rural Development, Budapest, Hungary. (in Hungarian)
- Mutua Ndue, K., Goda, P. (2021) "Multidimensional assessment of European agricultural sector adaptation to climate change", *Studies in Agricultural Economics*, 123(1), pp. 8–22. <https://doi.org/10.7896/j.2095>
- National Council for Sustainable Development (NFFT) (2013) "Nemzeti Fenntartható Fejlődési Keretstratégia" (National Framework Strategy on Sustainable Development (NFSSD)), Nemzeti Fenntartható Fejlődési Tanács (NFFT). ISBN 978-963-08-7737-4 (in Hungarian)
- OECD (2021) "OECD Economic Outlook, Volume 2021 Issue 1: Preliminary version", OECD Publishing, Paris, France, No. 109. <https://doi.org/10.1787/edfbca02-en>
- SKV Csoport (2003) "Stratégiai Környezeti Vizsgálat a Regionális Operatív Program környezeti szempontú ex-ante értékelésének megalapozásához" (Strategic Environmental Assessment to establish the ex-ante environmental evaluation of the Regional Operational Program), VÁTI Kht., Környezetvédelmi és Vízügyi Minisztérium, Regionális Környezetvédelmi Központ, Hungary. (in Hungarian)
- Stern, N. (2006) "The Economics of Climate Change: The Stern Review", HM Treasury. ISBN 0-521-70080-9
- Szőke, V., Kovács, L. (2020) "Mezőgazdaság 4.0 - relevancia, lehetőségek, kihívások" (Agriculture 4.0 – Relevance, Opportunity, Challenges), *Gazdálkodás: Scientific Journal on Agricultural Economics*, 64(4), pp. 289–304. (in Hungarian) <https://doi.org/10.22004/ag.econ.305196>
- t33 Srl (2015) "Two Seas Programme – Final Report (updated version April 2015): Ex-ante evaluation", t33 Srl, Ancona, Italy, 27/04/2015.
- United Nations Framework Convention on Climate Change (UNFCCC) (2015) "The Paris Agreement", [pdf] Report of the Conference of the Parties on its twenty-first session, UNFCCC, Paris, France, FCCC/CP/2015/10/Add.1. Available at: https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_pdf [Accessed: 03 May 2022]
- WWF (2011) "Enabling the Transition: Climate Innovation Systems for a Low-Carbon Future", WWF. ISBN 978-91 89272-19-4.
- Zoldy, M., Szalmáné Csete, M., Kolozsi, P. P., Bordas, P., Torok, A. (2022) "Cognitive Sustainability", *Cognitive Sustainability*, 1(1). <https://doi.org/10.55343/cogsust.7>