

The lived experiences of farming under profound landscape transformation – The case of the Sand Ridge, Hungary

MELINDA MIHÁLY¹ and SZABOLCS FABULA²

Abstract

Food production became particularly challenging in our current food system under the conditions of the ecological crisis, including climate change. According to our political-ecological approach, landscape transformations and the everyday experiences of agricultural producers are partly the result of uneven geographical development and vice versa, industrial agriculture contributes to uneven development through the production of nature and landscape. By focusing on one of Hungary's most vulnerable landscapes undergoing profound land use transformation, the Sand Ridge within the Danube–Tisza Interfluvium, we aim (1) to trace the production of nature and accompanied landscape transformation caused by extractivist practices (industrial agriculture, forestry, solar extractivism) and the integration into global food systems; (2) to reveal the experiences of farmers and (3) the ways farming can contribute to landscape regeneration and food system transformation. Based on documentary and GIS data analysis, expert (11), oral history (23) and focus-group (2) interviews with farmers and farmworkers our research shows that the aridification of the Sand Ridge is not only caused by seemingly “external” processes of climate change, but by “internal” processes of extractivist agricultural production which is interlinked with the world economy through trade. Historically, agricultural landscapes have been produced through trade relations integrated into the global economy, increasing aridification through drainage and large-scale afforestation, both resulting in the marginalization of pasturing as a livelihood system. The recent emergence of the Sand Ridge as an energy periphery under solar extractivism contributes to the further marginalization of pasturing and small-scale food production. Landscape regeneration and food system transformation goes hand in hand. Regenerative practices in agriculture are hindered by how the Sand Ridge is integrated to the global economy. Still, small-scale farmers (and pastoralists) have agency in regenerating the landscape through building regionally more embedded food system alternatives.

Keywords: production of nature, uneven development, landscape transformation, food system, agriculture, everyday life, lived experiences

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Introduction

Food production became particularly challenging in our current food system. The increased integration into the global economy both transformed landscapes and caused livelihood challenges to pastoralists, small-scale farmers and farmworkers (TRAUGER, A. 2022). Due to these

occupational stressors it is not surprising that farmers and farmworkers globally face high levels of depression, anxiety, burnout, suicide ideation, and suicide (BRYANT, L. 2022; KNEŽEVIĆ HOČEVAR, D. and SLOVENC GRASSELLI, M. 2023; JONES, A.Q. *et al.* 2024). Agrarian change in Central and Eastern Europe (CEE) was especially rapid and devastating for the livelihoods of

¹ ELTE Centre for Economic and Regional Studies, Institute for Regional Studies, Békéscsaba, Hungary; ELTE Eötvös Loránd University, Institute of Geography and Earth Sciences, Department of Social and Economic Geography, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary. E-mail: mihaly.melinda@rtk.elte.hu

² University of Szeged, Faculty of Science and Informatics, Department of Human Geography, Egyetem u. 2, H-6722 Szeged, Hungary. E-mail: fabula.szabolcs@geo.u-szeged.hu

farmers and farmworkers after 1989. In spite of mobilizing for an alternative food system, the decline of agricultural prices and production in connection with the process of European integration (which forced new member states of the EU to open their borders to import products) contributed to further fragmentation of those engaged in agricultural production (farmers and farmworkers), including the emergence of anti-liberal and anti-Roma sensibilities among independent agricultural producers (SZOMBATI, K. 2018, 3). Beyond marginalizing producers industrial agriculture along with other extractivist practices driven by an increased integration to the global economy degrade landscapes.

We analyse the relationship between landscape transformation through extractivist practices, particularly industrial agriculture and its lived experiences in one of Hungary's most climate-vulnerable regions, the Sand Ridge of the Danube–Tisza Interfluvium. In the Sand Ridge, accounting one tenth of Hungary's territory, the forest steppe landscape was intensively transformed through the introduction of industrial production systems in agriculture and forestry and the increased integration of these production systems to the global economy. The extractive uses of the landscape for forestry and industrial agriculture, supported by productivist policies, such as the EU's Common Agricultural Policy (CAP) (TILZEY, M. and POTTER, C. 2016; KOVÁCS, A.D. *et al.* 2024), not just contribute to the ecological crisis of the region (including water scarcity and groundwater decline, desertification and soil degradation, the increasing frequency and intensity of droughts), but are constrained by it. The loss of profitability of forest management and industrial agriculture intersecting with the global solar boom and the rise of the region as an energy periphery³ results in an

even more intensified land use transformation in the region (FARKAS, J.Zs. *et al.* 2023; MIHÁLY, M. and FABULA, Sz. Forthcoming) displacing local land-users.

In this study we explore landscape transformation from a world ecology perspective. World ecology is a concept that views the world as a single, interconnected system where humans are part of nature, and capitalism is intertwined with the web of life (MOORE, J.W. 2016). We address the following research questions:

1. How is landscape transformation driven in the Sand Ridge in modern capitalism by extractive practices?
2. What are the lived experiences of farming under the conditions of profound landscape transformation?
3. In what ways can farming contribute to landscape regeneration and food system transformation?

To answer our research questions we engage in the following section with world ecology perspectives incorporating reflections on the production of nature thesis (developed in the political economic theory of uneven development) driving landscape transformation through extractive practices. We also rely in our conceptual framework on the feminist critique of political economic approaches to integrate the lived experiences of farmers and farmworkers into larger debates of food system transformations. We outline then why we are convinced that selecting the Sand Ridge (and two – formerly – agricultural settlements within it) to study landscape transformation and its lived experiences with a wide range of qualitative methods helps us in answering our research questions. In the sections presenting the results, we first focus on how extractive practices drove landscape transformation in the Sand Ridge from the Middle Ages onwards. To better understand everyday life under conditions of profound landscape transformation, we contrast the lived experiences of farming in two (formerly) agricultural settlements within the Sand Ridge, Inárcs and Kecel. To grasp the agency of farmers in an inten-

³ Energy peripheries are defined as places that are systematically disadvantaged through the whole energy system due to their inferior position within the asymmetrical spatial distribution of material, economic, political and symbolic resources and capabilities (GOLUBCHIKOV, O. and O'SULLIVAN, K. 2020, 1).

sively transforming landscape we present some potentials for landscape regeneration and food system transformation in/from the Sand Ridge. Finally, we conclude our study on how landscape transformation is driven by extractive practices in modern capitalism and what potentials emerge for regeneration and food system transformation.

Landscape transformation and its lived experiences

In this study, we investigate the connections between landscape transformation, extractivist production practices (industrial agriculture, forestry and solar energy) and climate change in the Sand Ridge (Hungary) from a world ecology perspective. In a world ecology approach, humans are considered to be part of nature and capitalism is seen as operating through the web of life. Capitalism is not merely defined as an economic system, but also as an “ecological regime”, uniting capital accumulation, power, and environmental transformation into a single, continuously evolving historical process (MOORE, J.W. 2016). The focus is on understanding the complex relationships between human society, the environment, and the production of nature. The “*production of nature*” thesis as a core component of world ecology, refers to the human creation and shaping of environments and landscapes on various scales through historically and geographically specific processes (LOFTUS, A.J. 2017), fundamentally challenging the idea of pristine, untouched nature. Capital circulates through nature, but nature also circulates through capital, for example through biotechnology (e.g. hybrid seeds), as such products appear in the soil, in different bodies, in food, etc. (CASTREE, N. 2000; SMITH, N. 2007).

Landscape transformation in modern capitalism is driven by *extractive* practices serving capital accumulation. To understand the dynamics of accumulation in modern capitalism David HARVEY (2001) developed the concept of the “*the spatial fix*”. Spatial fix re-

fers to the (temporal) strategies and solutions that capitalism undertakes to transcend its inherent crises of overaccumulation (ibid.). In concrete contexts, the fix may materialize in investment in new geographical territories, opening new markets, technological innovations with spatial features, and pursuit of cheaper inputs (EKERS, M. and PRUDHAM, S. 2017). To grasp how global capitalism pursues to continue accumulation and profit-seeking from curing ecological crises, including climate change, the concept of “*the socioecological fix*” was developed (CASTREE, N. and CHRISTOPHERS, B. 2015; EKERS, M. and PRUDHAM, S. 2015, 2017; MCCARTHY, J. 2015). The socioecological fix takes spatial fixes as metabolic processes whereby not only is space restructured but also nature has been transformed (EKERS, M. and PRUDHAM, S. 2017). Although socioecological fixes may help capitalism overcome the accumulation crisis temporarily (MCCARTHY, J. 2015), the consequences could be profoundly disturbing (EKERS, M. and PRUDHAM, S. 2017, 16). Therefore, rural land markets are important for the survival of capitalism as crises can be overcome or shifted over time by reworking the circulation of capital in ecological processes and landscapes (EKERS, M. and PRUDHAM, S. 2015). This process is inherently political, as it involves the direct participation of states, particularly when land is not available on the market, such as in the case of dispossession of protected areas (KORFIATI, I.P. 2019).

Scholars increasingly recognize that *extractivism* has not only featured extractive activities in resource-abundant places in the shadow of colonialism (e.g. Latin America where the term originates, HU, Z. 2023, 3), but has also become a modality and ideological rationale of contemporary global capitalism (DUNLAP, A. and JAKOBSEN, J. 2020; YE, J. *et al.* 2020; SHAPIRO, J. and MCNEISH, J.A. 2021; CHAGNON, C.W. *et al.* 2022). As GUDYNAS, E. (in HU, Z. 2023, 3) conceptualized, extractivism is mainly confined to the practices of resource extraction and has three defining dimensions: 1. Extraction of natural resources; 2. Environmental degradation; 3. Extraction for export with little

domestic processing. Landscape transformations based on extractivist practices are realized through *accumulation by dispossession*, the enclosure of public assets by private interests for profit, resulting in greater social inequality (HARVEY, D. 2007). In terms of landscape transformation of the Sand Ridge industrial agriculture, industrial forestry and solar extractivism are the most relevant. *Industrial agriculture* is considered an extractive land use because it is based on the appropriation, extraction and degradation of natural resources – such as soil nutrients, water, and biodiversity – vital to present and future generations (ANDERSON, M.D. and RIVERA-FERRE, M. 2021, 22). Industrial agriculture also extracts people from their communities, to serve as cheap labour in other countries (PATEL, R. and MOORE, J.W. 2017), cheapens labour by de-skilling and replacing people with chemicals and machines, and extracts territory itself in the inexorable quest for greater profits (ANDERSON, M.D. and RIVERA-FERRE, M. 2021, 22; REIGADA, A. and CASTRO, C.D. 2022). *Industrial forestry*, a reductionist approach simplifying complex forest ecosystems into quantifiable, monetizable traits (SCOTT, J.C. 1999) can also be considered an extractive land use. As an intensive, (often) export-oriented model focused on the large-scale harvesting of timber or plantation monocultures for industrial use (PARK, C. and ALLABY, M. 2012), industrial forestry often results in significant environmental degradation, biodiversity loss, and conflicts with local or indigenous communities over territorial rights (HOLZ, J.R. and SAAVE, A. 2025; BELTRÁN-VÉLIZ, J. et al. 2026). Extractive practices of renewable energy generation emerge with recent land-intensive climate policy measures built on discourses of green transition and inclusive development (GARCÍA-DORY, F. et al. 2022; HU, Z. 2023; BROWN, D. et al. 2024; MIHÁLY, M. 2025) often involving green grabbing, a specific form of *accumulation by dispossession*. Among them is *solar extractivism*, which is characteristic of the Sand Ridge. It is featured by large-scale land acquisition, prioritization of solar electricity production, domination of renewable industries, deep engagement from state power,

violence associated enforcement and neglect of local socio-ecological systems (HU, Z. 2023, 11). Beyond being deeply rooted in transnational commodity flows extractivist practices are also part of the territorial unevenness of global capitalism (RIOFRANCOS, T. 2020).

Uneven development leads to significant investment and higher incomes in industrial agriculture (and forestry) in some areas, while in other areas it results in disinvestment and a crisis in traditional agriculture (BALAKRISHNAN, S. 2019). In terms of labour, uneven development plays out in the migration flows at the production-end of the food system supply chain where cheap (low-skilled, low-waged, often gender and racially segregated TRAUGER, A. 2022, 151) labour flows to places with relatively higher development (PATEL, R. and MOORE, J.W. 2017). The global agro-industrial complex and the linkages between uneven development involve multidimensional and multi-scale processes, from the everyday to long cycles of macroeconomic systems (BLYTH, M. and MATTHIJS, M. 2017; GIRAUDO, M.E. 2017).

As the theory of uneven development can be applied on various scales it can be fruitfully combined with the everyday life approach (BERKI, M. and SÁGI, M. 2026; TIMÁR, J. and TRÓCSÁNYI, A. 2026). *Lived experience* refers to the activities and embodied forms of consciousness of situated socially marginalized groups (such as farmers and farmworkers) that are either at some distance from, or different from, official and dominant accounts and consciousness (ALCOFF, L. 2006; FANON, F. 2008). If discourse refers to the successful political ability to bring elements together into a stable unity, “lived experience” characterises a situation in which this has not been possible (NGCOYA, M. and KUMARAKULASINGAM, N. 2017, 486). As such, lived experience as a form of consciousness can be understood to be partial, or fragmentary and unable to be articulated into a political project or movement (ibid.). At the same time, lived experience directs us to take seriously the subjectivity of socially marginalized actors. It emphasizes how subjectivity

should be thought of in terms of constrained choices, as opposed to outright resistance to, or escape from, power (KRUKS, S. 2014). This, we argue, allows us to conceive mobilizations for alternative food systems as a situation produced by historical constellations of power, and the response to that situation under conditions of constraint. Based on the post-Cartesian approach of world ecology (and production of nature), we believe that landscapes could be regenerated through agroecologically-minded agriculture and a regional food system building on the characteristics of the landscape.

We write this paper from a political ecology (GIRALDO, O.F. 2019; PAIN, A. and HANSEN, K. 2019; JIMENEZ-SOTO, E. 2021) perspective that incorporates reflections on the production of nature thesis (developed in the political economic theory of uneven development) driving landscape transformation through extractive practices and integrates the lived experiences (the feminist critique of political economic approaches) of farmers and farmworkers into larger debates of food system transformations (Figure 1). With this approach, we combine

the political ecology of landscape transformation through extractive practices, the political economy of uneven development, and the cultural geographical notion of everyday life and space-related experience. In this way, it is possible to grasp the connection between historical landscape transformations, the multiscalar historical processes of economic development / underdevelopment, and the experience of and resistance to changing spatial inequalities that can be understood by retrospective analysis of personal memories.

Methodology

Climate change and extractive land use practices not fitting to the ecological characteristics of the region result in profound landscape transformation. The Sand Ridge of the Danube–Tisza Interfluve, a lowland forest-steppe landscape (80–120 m a.s.l.), once rich in surface waters is now heavily affected by declining ground-water level and salinisation (BIRÓ, M. *et al.* 2008, 2013). Due to the low water retention capacity of its soils (mainly

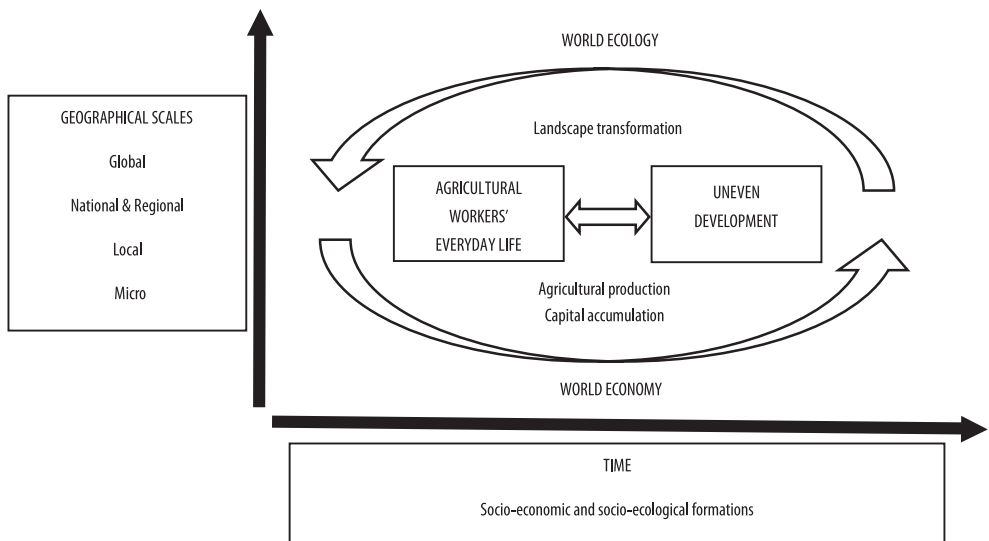


Fig. 1. Conceptual framework: The relationship between uneven development and agricultural workers' (farmers' and farmworkers') everyday life in the context of world ecology. Source: Compiled by FABULA, Sz.

sand and sandy loam, *Figure 2*), the region is highly vulnerable to drought (LENNERT, J. *et al.* 2024a, b). Its sandy soils are suitable only for either labour-intensive agricultural production, notably wine and fruit production, or extensive types of cultivation, such as forestry or grazing (LENNERT, J. *et al.* 2024b, 10). Intersecting with the global energy boom of the 2010s, and the increased abandonment of agricultural land since the 1980s (CSATÁRI, B. and FARKAS, J.Zs. 2008), the region is becoming a hot spot for solar energy generation.

To better understand (1) *how landscape transformation is driven in modern capitalism by extractive practices*, we started with reviewing the literature on local and regional history of the Sand Ridge, public policy and newspapers (Arcanum online database), and relied on GIS-based analysis of agricultural statistics (e.g. KSH TIMEA, Corine). We conducted 11 semi-structured interviews with experts of the region and/or alternative food systems. Researchers, farmers, rangers, community organizers, alternative food system activists, politicians and water management officials were among our interview partners from the field of ecology, hydrology, nature conservation, geography, ethnography, agroecology and rural development (*Table 1, Appendix 1*).

To better understand (2) *the lived experiences of farming under conditions of profound landscape transformation* and (3) *the agency of farmers in landscape regeneration and food system transformation* we compared the lived experiences of farming in two contrasting cases from the region (Kecel and Inárcs). Towards the end of the 18th century, prior to the large-scale afforestation of the Great Hungarian Plain and

the introduction of labour-intensive agricultural production, pastoralism and grasslands characterised the landscape of both Inárcs and Kecel (BÁRTH, J. 1984; CZAGÁNYI, L. and KULCSÁR, G. 1995). Recently, agriculture⁴ has been abandoned at a rapid rate in Inárcs, on the northern edge of the Sand Ridge in its „Budapest Gateway” sub-region (see *Figure 3*). Urban sprawl around Budapest (KOVÁCS, Z. *et al.* 2019) intensifying after 1989 and the renewable energy boom after 2018 (MIHÁLY, M. and FABULA, Sz. Forthcoming) results in the displacement of remaining small-scale farmers in Inárcs. Agricultural production is being hindered by a significant groundwater-level loss (6–7 m) in Kecel (LADÁNYI, Zs. 2010), located on the highest ridge (172 m) of the Sand Ridge in its „Agriculture and Food Production” sub-region (*Figure 3*). Grape and fruit cultivation has been characteristic here as the deeper root systems of these plants are able to reach the moisture in the soil. In addition to 14–16 semi-structured and oral history interviews with integrators, farmers and farmworkers from Inárcs and Kecel we organized a walk-along focus group discussion with 4 farmers affected by a solar power plant built on previously agricultural land in Inárcs and a sociodrama workshop with ten farmers from Kecel (see *Table 1*).

With the guidance of two sociodrama experts, Cecília KOVAI and György MÉSZÁROS,

⁴ Being depopulated during the Ottoman Rule the territory of Inárcs was used as a “puszta” for grazing cattle, horse and sheep (CZAGÁNYI, L. and KULCSÁR, G. 1995). The development of the capitalist agricultural economy accompanied by the revolution of trade (Budapest–Lajosmizse railway line reaching Inárcs in 1889) introduced rapid land use transformation here. Grape and wine (CZAGÁNYI, L. and KULCSÁR, G. 1995, 326), fruit (apple, plum, sour cherry, pear, later strawberry) and vegetable (potato, cauliflower already in the turn of the 20th century and asparagus later, during state-socialism CZAGÁNYI, L. 1995) provided a livelihood to people living in the settlement.

Table 1. Interviews conducted during the research

Interviews	Inárcs	Kecel	SUM
Expert (local)	4	5	9
Oral history (farmers)	7	9	16
Oral history (farmworkers)	2	4	6
Focus groups (walk along / sociodrama)	1	1	2
SUM	14	17	31
Expert (Sand Ridge)	–	–	11
SUM	–	–	41

Source: Compiled by MIHÁLY, M.

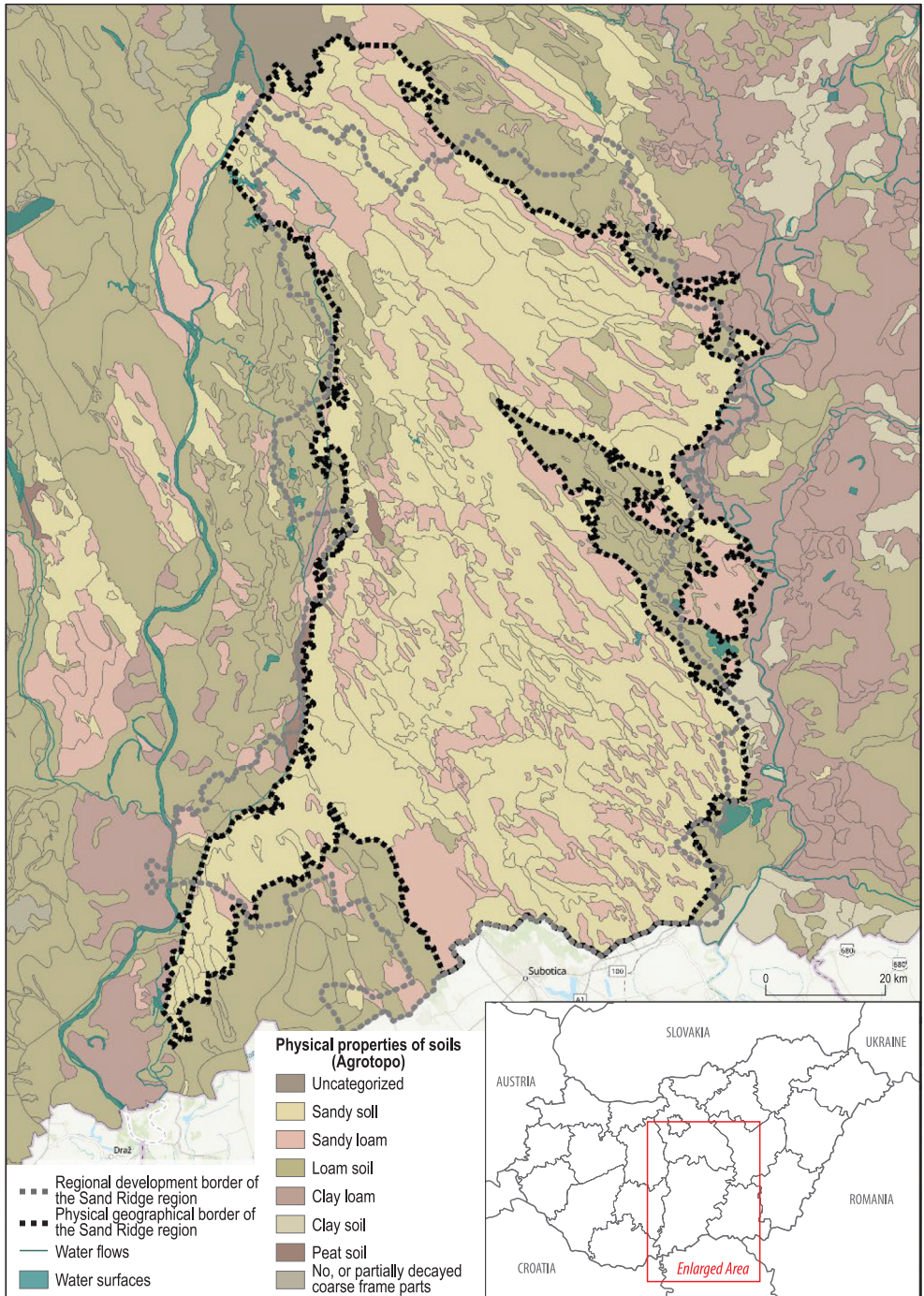


Fig. 2. Boundaries of the Sand Ridge: Regional policy (grey) and physical geography (black).
 Source: TAGAI, G. based on the AGROTOPO database.

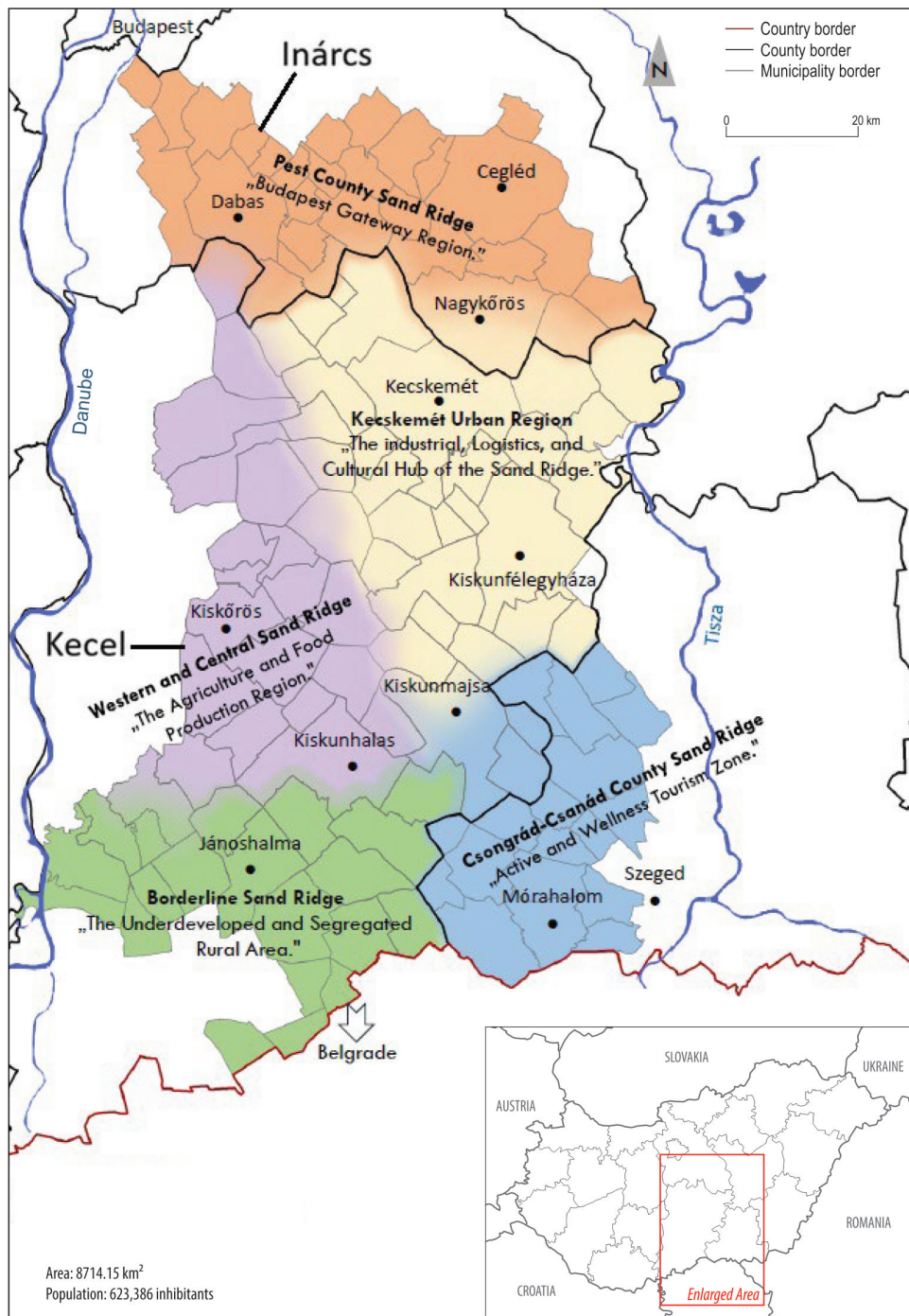


Fig. 3. The position of Inárcs and Kecel within the Sand Ridge. Source: Authors' own compilation, based on Kovács, A.D. et al. 2024, p. 6. The original map was produced by Vasárus, G.

we invited farmers from Kecel and the surrounding area to perform scenes from their daily lives and reflect on their position of power within the food system. This experiential group work, which is used in participatory, action-based research (STERNBERG, P. and GARCIA, A. 2000; IUS, M. 2020) enabled us to explore farmers' emotions and lived experiences of the ongoing climate crisis in the Sand Ridge, as well as their marginalized positions within the global food system. It also allowed us to uncover traits of their transformative/regenerative agency. Unlike with farmers, interviews and focus groups only gave us a limited insight into the perspectives of farmworkers, who could not spend much time participating in the research.

We analysed documents, our notes and verbatim transcripts of the interviews collaboratively in a shared platform (google drive). The main concepts, namely production of nature, uneven development, everyday life, were operationalized by inductive analysis and coding of the interviews (*Appendix 2*).

Landscape transformation in the Sand Ridge through extractive production

Although the medieval period did not produce nature in the capitalist sense theorized by Neil SMITH, medieval societies were heavily involved in reshaping and socially organizing nature through agricultural, technological, and symbolic practices. These processes laid the groundwork for the more intensive and commodified 'production of nature' that emerged during the 19th, consolidated in the 20th century, when interaction between states, land, and landowners underwent changes that facilitated the maximisation of extraction, be it through industrial agricultural production, forestry (BALOGH, R. 2026, 43), or recently renewable energy generation (HU, Z. 2023; BROWN, D. *et al.* 2024; MIHÁLY, M. and FABULA, Sz. Forthcoming). Through the case of the Sand Ridge we identify how landscape transformation is driven through extractive practices in modern capitalism, historically

through industrial agriculture, forestry and more recently renewable energy generation.

Pre-capitalist integration to the global economy

The original Holocene forest-steppes and their diverse habitats disappeared due to deforestation during Medieval times (BIRÓ, M. *et al.* 2013). Grazing was benefited by both deforestation, which increased the amount of land available for cultivation and grazing (FERENCZ, Á. *et al.* 2019, 65) and climatic conditions, such as the cool, wetter period in the Carpathian Basin during the 17th century (RÁCZ, L. 2001). To increase pasture zones in response to the needs of the growing number of their livestock, in the late 14th and early 15th century, major market towns in the Great Hungarian Plain (GHP) started buying up and renting abandoned farmlands (referred to as 'puszta' – deserted land) in their neighbourhood (CSIPPÁN, P. and FERENCZI, L. 2020, 3). Extensive livestock husbandry, one of the most profitable economic sectors of the GHP, which made Hungary the biggest exporter of livestock in Europe between the mid-15th and 18th centuries, relied on the abundance of water in the GHP (PINKE, Zs. 2014; DEMETER, G. *et al.* 2022). The most characteristic of the extensively kept species in the GHP – including the Danube–Tisza Interfluve – was the Hungarian grey cattle (SURÁNYI, B. 2020). As one of the major meat producers (both in quality and quantity) in Central Europe, they were a significant export item (SURÁNYI, B. 2020, 285).

The increasing Western European meat demand driven by processes of urbanization was largely covered from cattle grazed in Eastern Europe. In the "golden age" of the Hungarian grey cattle (between 1540s and 1620s), built on a well-organized logistical background, several hundreds⁵ of cattle were yearly driven on foot to Western European

⁵In the 16th century approximately 100,000 cattle were exported annually from Hungary, with peaks of up to 200,000 cattle in exceptional years to Venetian markets (FARA, A. 2022, 655).

cities (such as Nuremberg, Augsburg, Vienna, Venice, see CSIPPÁN, P. and FERENCZI, L. 2020) from the GHP. As a result of this early integration into the global economy, landscapes of the GHP, including the Sand Ridge faced overgrazing (VARGA, A. 2018). It is important to emphasize that overgrazing was not caused by pastoralists' improper approach to land management or by traditional ecological knowledge that was insufficiently adapted to local ecological conditions (VARGA, A. 2018), but rather by the pressure to overexploit resources imposed on them through an export-oriented model of animal husbandry.

Industrial agricultural production

The cultivation of *vineyards and orchards* on farmsteads came as a response to the pre-capitalist integration of the Sand Ridge to the world economy. Alongside large-scale afforestation in the GHP, the emergence of smallholder farming in the 19th and 20th centuries formed part of a *socioecological fix*, introducing a labour-intensive agricultural production system while mitigating the effects of sand drift caused by overgrazing resulting from an export-driven animal husbandry. The territorial expansion of small-scale farmsteads in the 19th century was facilitated by both ecological factors, such as the phylloxera epidemic (to which the sandy soils of the Danube–Tisza Interfluve [see *Figure 2*] were immune), and economic factors, such as the fruit boom at the turn of the century (RIGÓ, R. 2023, 41–42). In addition to grapes, fruit and small-scale grain production, farmsteads also played an important role in cattle breeding, milk production, pig, sheep and poultry farming, which attracted an increasingly significant food industry to the towns of the region (RIGÓ, R. 2023, 43).

Small-scale farmsteads survived state socialism and, although they have lost much of their agricultural function (TAKÁCS, A. 2005), they still characterise the Sand Ridge, with an average of 16 percent of the population living on the outskirts of farmsteads (FARKAS,

J.Zs. *et al.* 2023, 34). Soil quality helps explain why smallholdings remain more common in the Danube–Tisza Interfluve than elsewhere in the country (Interview E_05, E_04, E_06). Land concentration took place on good-quality land after 1989 (CSATÁRI, B. *et al.* 2019; LENNERT, J. and FARKAS, J.Zs. 2020). These areas are highly mechanized and characterized by labour-efficient monoculture crop production (wheat, corn, sunflower, rapeseed) (SZABÓ, D. 2020). As sandy soils are not ideal for growing these crops (not least because of drought), smallholdings growing vegetables and fruit, mainly for the domestic market (KSH TIMEA; SZABÓ, D. 2020) characterize agricultural production in the area. In vegetable production, small-scale farmers compete with imported agricultural products and to maintain their profitability they use chemicals, fertilizers, and water (for irrigation). Vegetables require more water than cereals, but the water retention capacity of sandy soils is much poorer than that of better quality soils (SZABÓ, D. 2020; LENNERT, J. *et al.* 2024a; Interview E_02, E_01). Similar to vegetables, beyond increasingly frequent frost damage and hailstorms resulting from climate change, fruit trees now often need to be watered if farmers want to achieve acceptable yields (LENNERT, J. *et al.* 2024a, I_01, I_06). Thus, labour-intensive agricultural production, such as fruit and vegetable production, both contributes to the aridification of the region and is constrained by it.

Even though the ecological characteristics of the region made highly mechanized, labour-efficient monoculture crop production difficult, an important milestone in the transformation of the forest steppe habitats of the Sand Ridge was the European grain boom of 1850s–1870s. As Hungary had been self-sufficient in cereals even before the river controls of the 19th century (PINKE, Zs. 2014, 93), the transformation of floodplains into arable land served to increase Hungary's grain export. An increased demand driven by the geopolitical interests of Austria waging wars throughout the 18th century and a wave of industrialization from the 19th century in-

tersected with favourable ecological conditions for grain production⁶ in the Sand Ridge. Both mass armies of the Austro-Hungarian Monarchy and workers migrating from rural to urban areas in Western Europe relied on bread as staple food. To serve the goals of capital accumulation, food provision for the mass armies and workers had to be solved at the lowest possible price in order to ensure that money spent on food would not push wages up (SIDÓ, Z. and SZARVAS, M. 2020). Through increasing the navigability of the Danube (ANDRÁSFALVY, B. 1973; IHRIG, D. *et al.* 1973) and developing the Carpathian Basin's railway network⁷ (SZILÁGYI, Zs. 2021), technological developments revolutionised transport, fostered capital accumulation, increased the integration of the SR to the global economy, drove regional economic growth and allowed farmers of the GHP to benefit from the European grain boom (BELUSZKY, P. 2000; GYÓRI, R. 2003; RIGÓ, R. 2023).

The increased global economic integration of the Sand Ridge came at an ecological and social price. New frontiers for capital accumulation (further arable land) were gained through water and river regulation and drainage (RIGÓ, R. 2023; Interview E_02). The biggest river regulation of the 19th-century Europe (Tisza) significantly transformed the landscape of the GHP. Through the elimination of the majority of floodplains of Hungary (23%), the megaproject was based on *accumulation by dispossession*, as it transformed commons-based extensive animal husbandry contributing to the peasant and pastoralists livelihoods in various ways to an individual

property-based cropland farming of large-scale landowners (PINKE, Zs. 2014; DEMETER, G. *et al.* 2022). Land speculation characteristic in the area east of the Tisza drove the project even after the American grain invasion of the 1870s through forcing the state to take an even larger stake in river regulation (PINKE, Zs. 2014, 94). The systematic drainage of the Sand Ridge served the production of further arable land and occurred relatively late in the 1940s (UJHÁZY, N. and BIRÓ, M. 2018; Interview E_05) and continued after World War II. Drainage, together with irrigation and drinking water extraction resulted in a serious decrease in groundwater levels between 1968–1972, and 1993–1997 (0.92 m in average with a maximum of 5–6 m [KOVÁCS SZÉKELY, I. and SZALAI, J. 2009]). Agricultural production was most intensive during the 1980s, when fertilizer use in the region reached a peak too⁸. Processes of aridification caused profitability challenges in agriculture, resulting in the abandonment of agricultural areas from the 1980s (CSATÁRI, B. and FARKAS, J. Zs. 2008). An answer to aridification and the worsening soil quality on dry sand was to move cropland “downwards” into previously wet depressions. Areas with high ground-water level decrease were more prone to ploughing and afforestation contributing to further grassland loss (BIRÓ, M. *et al.* 2013).

Industrial forestry

The systematic afforestation of the GHP, after the Treaty of Trianon is another important milestone in the transformation of the landscape in the Sand Ridge. As a mosaic-like forest steppe habitat the Sand Ridge (BIRÓ, M. *et al.* 2008) did originally not consist of contiguous forest, but rather an alternation of open sandy grasslands, sandy scrublands, and smaller and larger patches of forest (poplar-juniper and sandy oak) (BIRÓ, M. *et al.* 2013).

⁶ The warmer, drier period of the 18th century caused the water-covered areas of the Sand Ridge to recede, allowing for the renewed expansion of arable land and grain production (SZILÁGYI, Zs. 2021).

⁷ The construction of railways was cheaper and faster in the GHP, so the railway line reached the main cities of the Sand Ridge early (Szolnok, 1847; Kecskemét, 1853) and by the end of the Monarchy, almost every inhabited farmstead was within eight kilometres or a day's journey by horse-drawn carriage of a railway station, enabling farmers, to sell grain, wine and fruit produced in the area on the markets of Budapest and abroad (RIGÓ, R. 2023).

⁸ In 1980 120,860 tons of fertilizers were used (in 1970 78,500 tons, in 1990 63,300 tons, and in 2000 only 15,700 tons – KSH database, for more details see CSATÁRI, B. and FARKAS, J. 2008).

The systematic afforestation of the region started in 1923 (under law no. XIX of 1923), when Hungary lost significant forest areas and struggled with a shortage of wood (BALOGH, R. 2026). Beyond alleviating the acute and expected chronic shortage of wood, the program was expected to increase the resilience of farming to periods of water scarcity too (BALOGH, R. 2026, 111). Károly Kaán (1867–1940) a prominent Hungarian forest engineer, economic policy expert, and member of the Hungarian Academy of Sciences, is credited with launching the afforestation program in the GHP. Kaán's ideas about the historical ecology, forest cover, and waterlogging of the GHP appear exaggerated in the context of current scientific thought, and imagined the relationship between soil water levels and the physiological processes of trees too schematically, while underestimating the importance of grasslands (BIRÓ, M. and MOLNÁR, Zs. 2009; TÖLGYESI, Cs. *et al.* 2020; BALOGH, R. 2026, 111). Large-scale afforestation was accompanied by *accumulation by dispossession* and the re-negotiation of state power and development (SCOTT, J. 1999). It contributed to the further decline of common pastureland, in which land and resources were collectively managed by communities (VARGA, A. 2018).

Afforestation in state-socialist Hungary can be understood as a dual *spatial fix* and *socio-ecological fix*. As the most ambitious forestry undertaking of the socialist era, it was embedded in the scalar logic of central planning: Article 33 of Act XXV of the 1949 Five-Year Plan mandated a substantial increase in timber extraction (by 300,000 cubic metres) alongside the establishment of 50,000 cadastral acres of new forest in the GHP (BALOGH R. 2026, 129). These targets reveal an attempt to spatially redistribute resources and expand the productive landscape, displacing pressures associated with timber scarcity onto newly afforested zones.

At the same time, afforestation functioned as a *socio-ecological fix*, grounded in Soviet agronomic science, which framed ecological transformation as a prerequisite for stabilizing and intensifying agricultural produc-

tion (BALOGH, R. 2026, 132). As articulated in *Erdészeti Lapok* (Forestry Gazette) (N.N. 1949), forest belts and windbreaks were expected to regulate microclimates, reduce aeolian processes, and gradually transform soil conditions, thereby engineering more productive agro-ecological systems. In this sense, the programme sought not only to reorganize space, but to actively reconfigure ecological processes in ways that would secure long-term accumulation and food production. However, from a contemporary perspective, these fixes (nationally, a response to timber shortages; regionally, mitigation of drought-related instabilities, and an attempt to control drifting sand) appear partial and temporally bounded. Ongoing processes of aridification – now intensified by climate change (LADÁNYI, Zs. 2010) – expose the limits of earlier socio-ecological interventions and call into question the durability of afforestation as a stabilizing strategy, necessitating a rethinking of land use practices in the region (TÖLGYESI, Cs. *et al.* 2020; Interview E_03, E_07).

Solar extractivism

Since 2015 a new land use pattern, land for renewable energy-generation has been gaining ground in the region (SZGK 2023, Interview E_03). The emergence of the Sand Ridge as an energy periphery in the current phase of global capitalism is driven by international Green New Deal policies, the Hungarian state advocating for the peripheral re-industrialisation of Hungary (NAGY, E. *et al.* 2021) and global investors seeking cheap energy. The fact that solar energy has become one of the cheapest energy sources worldwide (EHSAN, R. and S. RAVI, P.S. 2025) has driven interest for land available for renewable energy production. In Hungary, for example, the number of solar power plants installed has grown exponentially in recent years and reached 7,550 MW by 2025. Eighty percent of this capacity has been installed since 2020, and there has been an annual increase of at least 1,200 megawatts since 2022

(BBJ 2025). The geography of the Sand Ridge, flat terrain, high sunshine duration and poor quality soils (cheap land), make the region to become particularly targeted by such projects. Solar power plants are established as greenfield investments dominantly on formerly agricultural land, and often result in the displacement of remaining small-scale farmers and pastoralists (Focus group_walk along_Ináracs – MIHÁLY, M. and FABULA, Sz. Forthcoming). The renewable energy boom pushes land prices up, thus, limiting pastoralists, agroecologically-minded, small-scale or subsistence farmers' access to land. As the case of renewable energy shows the economic crisis of the region resulting in the abandonment of agricultural land since the 1980s is temporarily tackled through *socioecological fix*, in which social and environmental relations are reorganized in the Sand Ridge through solar PV development. The region emerges as a new location for renewable energy production, a place, where the environmental costs of renewable energy transition are unevenly shifted to the rural landscape and its marginalized rural inhabitants (BROWN, D. *et al.* 2024).

The main milestones of landscape transformation in the Sand Ridge accompanied by *spatial fixes*, *socioecological fixes* and *accumulation by dispossession*, can be linked to (pre)capitalist global economic integration, industrial agricultural production, industrial forestry and renewable energy generation through solar extractivism. Pastoralism, a sustainable agricultural practice traditionally fit to the ecological constraints of the Sand Ridge got marginalized through the mechanization of agriculture and forestry leading to the transformation of the landscape (the production of arable land through drainage, elimination of wooded grazing systems) (UJHÁZY, N. and BIRÓ, M. 2018, VARGA, A. 2018). The emergence of the region as an energy periphery further marginalizes pastoralists and small-scale farmers, as climate policy measures are land-intensive and renewable energy transition is reliant on large-scale appropriation of land (GARCÍA-DORY, F. *et al.* 2022; BROWN, D. *et al.* 2024).

The rise and fall (?) of grape production in the region – and its lived experiences

Both Ináracs and Kecel are part of the Kunság wine region (Figure 4), a sub-region of Hungary's largest wine region (the Danube wine region), spanning between the Danube and Tisza rivers. Wine cultivation was established in the region together with other labour-intensive agricultural production systems, such as fruit and vegetable production often undertaken on farmsteads on the outskirts of settlements (more characteristic to Kecel). Although wine cultivation has almost disappeared from Ináracs, it is still prevalent in Kecel (Figure 5). Grapes were first mentioned in the town's charter in 1734, and significant vineyards were established there in the 1740s ("Öregszöllők") (BÁRTH, J. 1984). These vineyards provided a livelihood for serfs and an income for the archbishop (BÁRTH, J. 1984; BENYÁK, F. 2021).

The rising importance of the Kunság wine region can be interpreted through the lens of uneven development as a process shaped by shifting spatial configurations of capital. The phylloxera epidemic that swapped across Europe in the late 19th century devastated most of the vineyards in Hungary, while sparing those located on sandy soils, including Kecel and Ináracs. This ecological differentiation created a sudden spatial disparity in value, as areas previously considered marginal – such as the pasturelands of Ináracs – were redefined in 1895 as suitable for viticulture due to their resistance to the disease. Consequently, land prices increased dramatically from 20–60 Hungarian crowns/cadastral acre to 800–1,000 Hungarian crowns/cadastral acre (CZAGÁNYI, L. and KULCSÁR, G. 1995, 326), reflecting a rapid revaluation driven by new opportunities for capital accumulation. This transformation attracted external investors, who redirected capital into these newly advantageous areas and introduced more modern production methods (CZAGÁNYI, L. and KULCSÁR, G. 1995, 325; BENYÁK, F. 2021).

By the beginning of the 19th century, the quantity of grapes and wine produced in

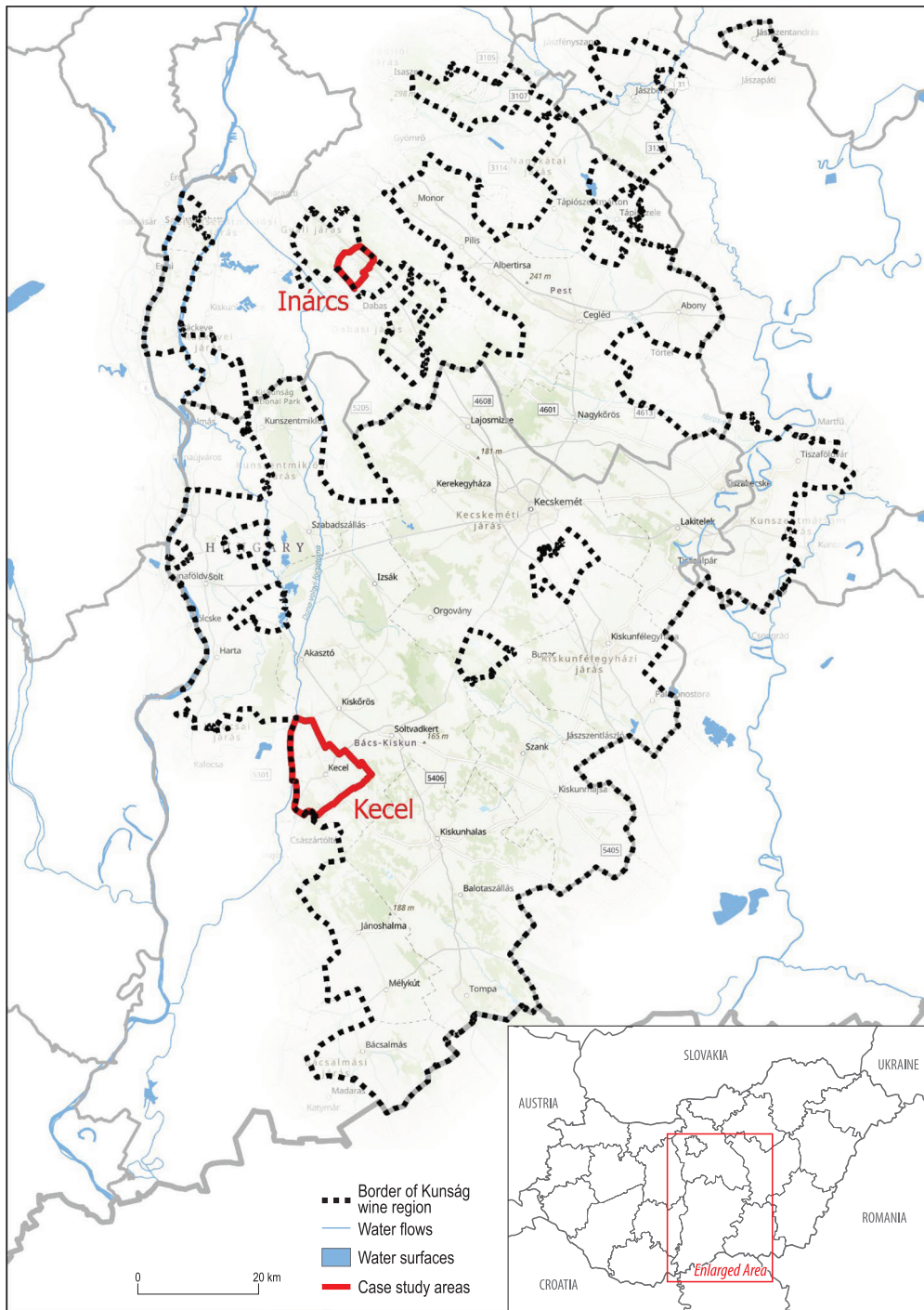


Fig. 4. Map of the Kunság wine region. Source: TAGAI, G. based on the territorial code system of the HSCO.

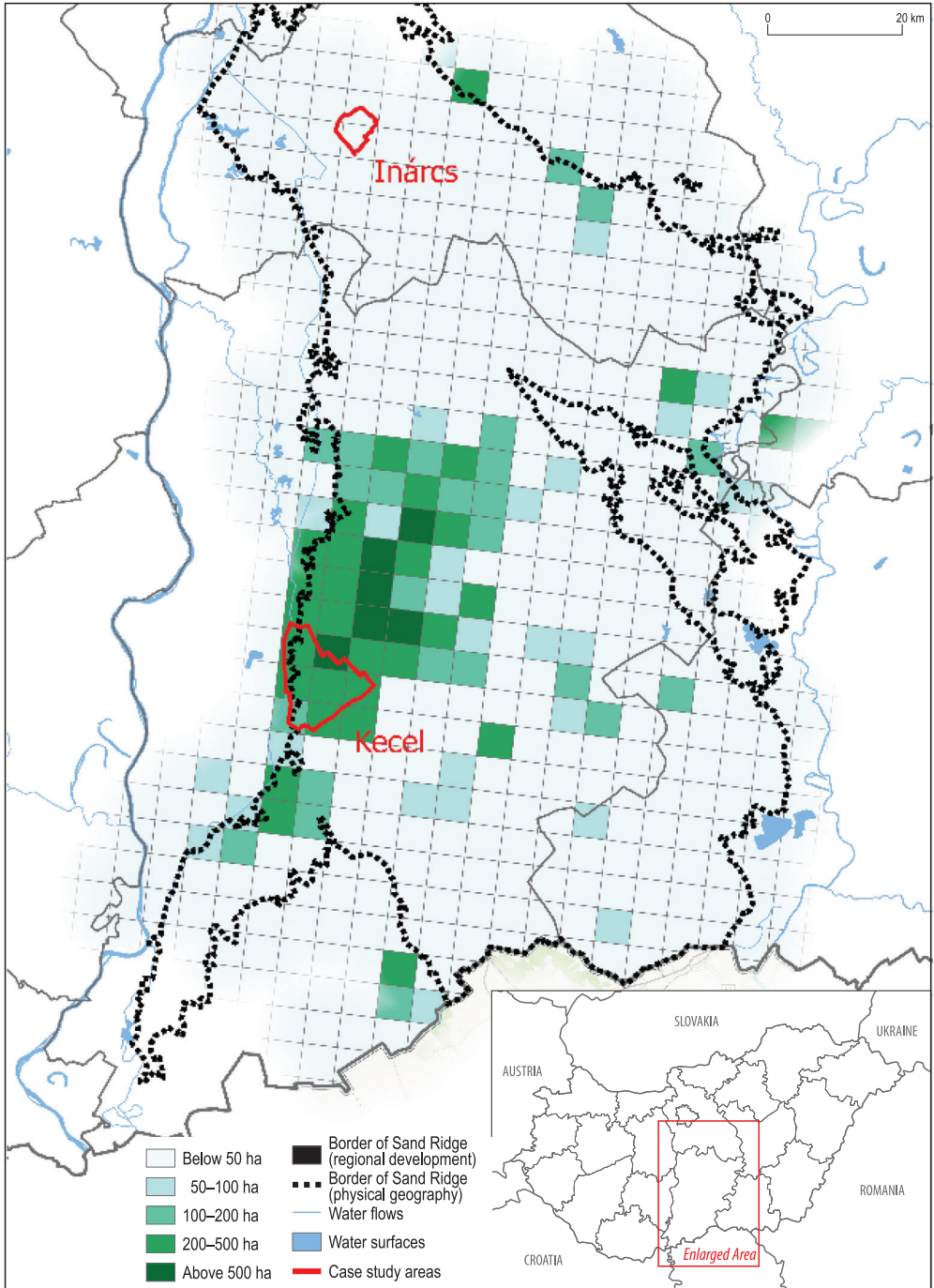


Fig. 5. Grape production in the Sand Ridge (in hectares). Source: TAGAI, G. based on the Agricultural Census of 2020 downloaded from KSH TIMEA.

Kecel had increased significantly (BENYÁK, F. 2021). The case of Lajos Tolnay, a prominent figure in the Hungarian Royal State Railways, illustrates how infrastructural development and capital investment intersected spatially: his acquisition of extensive landholdings in Inárcs was closely tied to the expansion of the railway network, embedding the region within broader circuits of exchange⁹. In this way, local wine production became integrated into the global economy, mediated largely through Jewish merchant networks. From the perspective of uneven development, these processes highlight how ecological crises such as phylloxera do not produce uniform decline, but rather reconfigure landscapes by concentrating investment and growth in specific locations while marginalizing others. However, this integration remained historically contingent. Following World War II, attempts to restore export-oriented intensive grape and fruit production were constrained by the reorganization of Hungary's political economy, as integration into the Soviet sphere reshaped the conditions of production and exchange (RIGÓ, R. 2023, 45). Thus, the region's trajectory reflects the cyclical and spatially uneven dynamics of capitalist development emphasized by Neil SMITH (2008).

Following World War II, Hungary got integrated to the global economy through the Soviet Union (GÁL, I. *et al.* 2021). Consequently, 1945 brought the reorganization of agriculture through land redistribution and forced collectivization. The existence and agency of the prevailing peasantry of Kecel during the period of state-socialist forced collectivization achieved the establishment of a specialised cooperative (Szőlőfürt Szakszövetkezet, 1974) (BENYÁK, F. 2021). As a unique form of forced collectivization specific to the Sand Ridge, specialized cooperatives provided more autonomy for their members

than producer cooperatives and allowed peasant farming to continue in a hidden form (RIGÓ, R. 2023, 45). From the mid-1970s, specialized cooperatives developed more dynamically in the region than production cooperatives, with revenue from the sale of products produced by smallholdings tripling between 1976 and 1984, with particularly significant growth in the sale of labour-intensive production, such as pork, poultry, fruit, vegetables, and wine (ROMÁNY, P. 1987).

In contrast to Kecel, apart from a small number of peasant landowners, the vast majority of the population of Inárcs were landless agricultural workers, in some cases without even a house or a place to live, thus, had a limited attachment to land (CZAGÁNYI, L. 1995, 15). Forced collectivisation went relatively easy in this settlement, resulting in the foundation of the region's first cooperative farm (Március 21 Termelőszövetkezet, established in 1958). All of Inárcs' agricultural properties have been consolidated into a single large farm nearly covering the entire village with 2,500–3,000 acres (CZAGÁNYI, L. 1995, 151)¹⁰.

From the end of the 1960s, the improved economic performance of the cooperatives, both specialised and production cooperatives, was reached without large-scale infrastructural investments through the economic integration of backyard farming to global food systems through cooperatives (also characteristic in other parts of CEE during state-socialism, see JEHLIČKA, P. *et al.* 2020). In exchange of a financial incentive the farm and village population was willing to use their existing stables, barns, grain stores, vineyards, cellars and the equipment necessary for grape processing, as well as their expertise and diligence on their own

¹⁰ Beyond the Március 21 Cooperative Farm, the State Farm of Felsőbabád, covering approximately 450 acres, and the Inárcs Célgazdaság (Inárcs Target Farm) established on abandoned vineyards, covering approximately 90 acres also existed. A target farm is a specific state-owned or state-managed agricultural unit (state farm, collective farm) whose primary task is the high-quality production and propagation of a specific product, plant variety, or animal breed for experimental or breeding purposes.

⁹ Lajos Tolnay, the first president and director of the Hungarian Royal State Railways bought 2,500 cadastral acre land in 1895 for wine production in upper Inárcs, close to the soon to be finished (in 1889) railway line (CZAGÁNYI, L. and KULCSÁR, G. 1995).

backyard farmsteads for agricultural production (RIGÓ, R. 2023, 49). While income supplement through backyard farming was generated from intensive animal husbandry, such as poultry (I_02), cattle (I_03) and pig (I_03, I_04) and vegetable production (I_09) in Inárcs, backyard grape growing was the basis of additional income generation in Kecel. The Eastern Bloc provided an unlimited market for the agricultural products (mainly fruits, grapes/wine) of Kecel, bringing "unprecedented prosperity" to the people living there (BENYÁK, F. 2021). Grapes were typically grown within the framework of a state-owned farm in Inárcs (State Farm of Felsőbabád) on vineyards planted with state support between 1962 and 1963 (I_04 and GANCAUGHNÉ ALBERT, K. 1999, 682) and the Inárcs Target Farm in the system of sharecropping, but – partially due to the limited social embeddedness of grape production to the settlement – both agricultural facilities struggled with intensive grape production in the 1980s (I_01, I_04). While grape production lost its significance in Inárcs after 1989 in terms of the local economy and landscape, it is still a characteristic land use type in Kecel, one of the representative cities of the wine region (K_11, K_14, K_15, and see Figure 5).

Being integrated into global supply chains after 1989

During the transition period, the Eastern markets of domestic agriculture and food industry collapsed. It was challenging to find new markets, as the potential target countries of Hungarian agroexport also struggled with overproduction (RIGÓ, R. 2023, 52). Both the concentration of the retail sector (NAGY, E. and NAGY, G. 2020) and Hungary's European integration, which forced new member states of the EU to open their borders to import products, resulted in a decline of agricultural prices. Declining prices, increasing production costs along with processes of aridification reduced the profitability of agriculture in grape- (K_01, K_05, K_08, K_09, K_10, K_11), fruit- (K_01,

K_04, K_05, I_01), vegetable production (I_05, I_07, I_08, I_12), arable farming (I_03), hay-making (I_03) and animal husbandry (K_02).

The global wine industry has undergone a fundamental transformation since the 2000s. In key production zones, principally Western Europe, there has been a reduction in the area dedicated to producing cheaper 'bulk' wines, as they have faced fierce competition from countries and regions such as China, Australia, Chile, South Africa and Oceania in export markets (OVERTON, J. and MURRAY, W.E. 2013, 704). However, Western European producers of premium bottled wines in higher price brackets have been active and successful in lobbying for the continuation and extension of laws recognising and protecting the geographical indications of their wines (OVERTON, J. and MURRAY, W.E. 2013, 704; SZAMOSKÖZINÉ KISPÁL, G. 2018, 4). In Eastern Europe and countries such as Argentina and Chile, where long-established wine industries had focused on the local market with low-cost wines, many producers were unable to compete with imports after state protection ended (OVERTON, J. and MURRAY, W.E. 2013, 704). While both Western and Eastern Europe, including Hungary, has experienced a decrease in vineyard areas (SZAMOSKÖZINÉ KISPÁL, G. 2018, 4), in the 'New World' (Australia, California and New Zealand), trade liberalisation opened up possibilities for expansion. The wine industries in these locations developed using modern industrial viticultural and winemaking techniques. This export-driven 'Fordist' approach to wine production enabled the production of high-quality wines in large quantities at a low cost, with little variation in style from one year to the next and a significant expansion of trade relations (OVERTON, J. and MURRAY, W.E. 2013, 704). Kecel within the Kunság wine region integrates to the global wine industry as a producer of cheaper 'bulk' wines. Its competitive advantage is based on the scale-efficient production of large quantities and sale on consignment (K_14, K_15). A fierce global competition is entered by wine producers of Kecel, through the intermediation of integrators:

“Now, when we negotiate with someone in the US or Canada, they say that they will bring this much from South America and New Zealand. New Zealand has the opposite climate, so it’s winter here, and the harvest is just beginning there. So it’s already clear how prices will develop on the world market. So if I see that there will be fewer grapes in New Zealand (...), then that information spreads around the world (influencing our business too).” (Grape integrator, K_14)

The integration into the global markets, of which the EU accession was a step pushed the price of grapes down, while the costs of production keep increasing:

“In 1999, so before 2000 (...) we sold a kilogram of Kékfrankos grapes for 100–110 HUF. (...) If you look at the 2023 price list, we’re still at 100 HUF. (...) Now let’s see what price increases there have been (on the production side) since then. Diesel is now, I don’t know, 650 HUF, and back then it was around 120 HUF. That’s six times as much.” (K_11)

Productivist pressures push grape producers towards extractive practices in land use and employment: “The profitability of grape production is so low (...) I would say that we are practicing soil-robbing farming, because we don’t have the money for it (nutrient replenishment).” (K_11) In terms of land use, the decline of animal husbandry in the region from the 2000s onwards prompted grape producers to switch from organic to artificial fertilizer (K_11).

In response to the labour shortage that has been growing since 2015, where possible, mechanization has been introduced (K_01, K_04, K_07, K_08, K_09, K_10, K_11, K_12, K_13, I_01, I_03, I_12) and where manual labour cannot be replaced, the work is done by the producers and their families (e.g. I_07, I_08) or by agricultural guest workers (e.g. from Romania, see I_01, I_06, K_10, K_03, K_06). Even if the price of grape did not rise significantly in the past decades, its market is considered more stable than for fruits (K_15).

In Inárcs, a significant proportion of farmers have now abandoned agricultural activities due to its low profitability (to which processes of aridification also contributed) and the emergence of land as investment (I_01, I_03, I_05, I_07, I_10, I_11). Land in the village is revalued

through housing financialisation¹¹ (I_01, I_08, I_09, I_11), while in the outskirts it is revalued for renewable energy generation and industrial park development (I_01, I_02, I_09, I_10, MIHÁLY, M. and FABULA, Sz. Forthcoming). Displacement of small-scale animal husbandry through housing financialisation and infrastructural development is remembered as follows:

“Well, in the end, the reason (for us to give up sheep farming) was that they (the municipality) started to divide up the Százholdas (for housing purposes), and then there was a plot of common land there partially belonging to my father, too. He asked for the edge of it, specifically for the animals to be driven in and out to the field. But then somehow the edge was given to someone else, and then they built the motorway, so grazing became impossible there.” (I_07)

Under intensifying productivist pressures and declining profitability, smallholders are increasingly forced into a process of differentiation in which they must either expand or exit production (K_07, K_14, K_15). This dynamic contributes to the restructuring of the agrarian landscape in uneven ways: in Kecel, it manifests simultaneously in the spread of abandoned vineyards (K_11) and the growing concentration of land in the hands of larger grape producers (K_14, K_15). Such patterns reflect a broader tendency toward the consolidation of resources and the marginalization of less competitive actors. In Inárcs the emergence of land as investment manifests in the displacement of small-scale agricultural actors.

Climate change and aridification

Climate change results in higher mean annual temperatures, longer drought periods and a

¹¹ Housing financialisation is driven by liberal housing policies, such as the promotion of mortgage-backed home loans since the 2000s and subsidies encouraging new home construction, such as „szocpol”, later CSOK (Family Home Creation Subsidy), which involves a high level (70%) of borrowing. Land in Inárcs got revalued through a surge in construction activity, driven by the „szocpol”, later CSOK program introduced in early 2016, the reduced 5 percent VAT rate on new home construction in effect between 2016 and 2019, and the acceleration in mortgage lending (GAGYI, Á. *et al.* 2019, 221).

highly uneven precipitation in the Sand Ridge (LENNERT, J. *et al.* 2024a, b; Interview E_07). There is less rainfall in spring and early summer, when it is most needed (FERENCZ, Á. *et al.* 2019, 67). This means that irrigation periods are becoming longer, which leads to significant cost increases for farmers (FERENCZ, Á. *et al.* 2019, 67) and groundwater loss for the region (LADÁNYI, Zs. 2010; Interview E_01). Increased evaporation in drought periods causes significant water loss in sandy soils (Interview E_02, E_01). Through their production practices (ploughing or disc harrowing, E_08, E_09, E_10) farmers exacerbate evaporation. Therefore both experts (E_09, E_10) and certain small (and large) scale farmers living in the Sand Ridge (E_08, K_16) are arguing for regenerative agriculture¹². Regenerative agriculture is a widely accepted practice in the agroecology movement, applied mainly in arable crop production (BALÁZS, B. *et al.* 2020), also emerging in viticulture (PERNIOLA, R. *et al.* 2024). It plays a key role in improving the structure of sandy soils, increasing their water-holding capacity, and building up their nutrient content, primarily by increasing their organic matter content and stimulating soil life (BALOG, E. *et al.* 2025).

Extensive drought periods (such as those experienced in 2022, 2024 and 2025) put higher pressures on drought-tolerant plants. Grapes tolerate drought due to their Mediterranean origin and adaptable physiology, which includes developing deep root systems to access water. According to one of our grape producer and integrator interview partner:

“2024 was a watershed year, there has never been such a drought. (...) If it gets this dry again, only the old plantations will survive, planting new vines is risky.” (K_15)

Atmospheric (or meteorological) drought occurs when a region experiences a prolonged period of below-average precipitation, such as rain or snow, compared to long-term averages. This deficit in rainfall, which can last for several months or more, is the first stage of drought and leads to reduced air humidity, increased average temperatures, and higher rates of evaporation and transpiration. Irrigation may be considered as a short-term solution in both cases of drought and atmospheric drought, but it contributes to further groundwater loss. In cases of grapes it encourages the development of a shallow root system that is less resistant to drought and highly dependent on continuous irrigation (K_15). Top watering may reduce the stress grapes are facing in times of atmospheric drought, but they also increase the risk of fungal growth (K_15).

Climate change has further weakened the position of Hungarian producers in the global market. It has resulted in an earlier and shorter grape harvest period (reduced from six-seven weeks to one month). As the air does not cool down at night before 20 August wine producers and integrators incur higher cooling costs (K_15). In 2024, grapes could be harvested from 1 August, making Hungary the first EU country to start harvesting, before prices had been set.

Earlier harvesting cannot be used as a competitive advantage in the fruit sector either. Even if processing plants could spread out the processing period, integrators would keep fruit prices low (K_11). Climate change (decreasing precipitation levels) and the liberalization of trade (Polish apple imports) have led to a decline in apple production in the Sand Ridge (K_11). Elderberry, as a more resistant, low-maintenance plant, replaced apple, but producers of Kecel are highly exposed to the volatility of its price in the global market.

“The price was around 600 HUF for elderberries (in 2020, during COVID), and now it’s zero HUF, you could say. They said they started at 90 HUF on the

¹² Regenerative agriculture is a soil-restoring farming system that builds on natural processes to restore soil health, increase biodiversity, improve water management, and sequester atmospheric carbon dioxide. The term was coined in the United States by Robert Rodale, a pioneer of organic farming, in the 1980s and is recently gaining ground in Europe as well (BALOGH, E. *et al.* 2025). The concept was introduced in Hungary by Attila Kökény (TMMG, <https://www.tmmg.hu/>) in 2010, and the interests of soil-regenerating farmers is represented by the Association of Soil-Regenerating Farmers (TMG, <https://tmg.hu/>) since 2018.

first day, then 80 HUF on the next day, and 70 HUF on the third day. (...) If elderberries are under 150 HUF, or under 100, then you should not even pick them. (...) It is picked (by migrant workers in vulnerable situations) for 50 HUF per kilo." (K_08)

Due to the challenges posed by climate change, especially the aridification of the Sand Ridge and the increased integration into global supply chains and the resulting loss in profitability of agricultural production, many farmers are giving up farming in both settlements, with less remaining in Inárcs. The financialisation of land (through rural gentrification and industrialization) makes it especially challenging for small-scale farmers of Inárcs to access land for food production.

Potentials for landscape regeneration and food system transformation

As the previous chapter showed integration to the current food system pushes "bulk" wine producers to keep extractive practices („soil-robbing farming"). If grape producers manage to position their wines as premium bottled wines in higher price brackets, like our interview partners in Hajós (neighbouring village of Kecel, E_11), they are able to ask extra prices for environmentally friendly (organic or natural wine production) or less exploitative labour practices. Cover crops among others, reduce evaporation, retain moisture in the soil and enable deep rainwater infiltration (PERNIOLA, R. *et al.* 2024). However, it is important to schedule lawn mowing carefully, as the mulch may compete with young grape plants (E_11). Landscape variety fruit trees, such as sour cherry and peach, do not necessarily compete with grape plants and are also more resistant to arid conditions than their hybrid counterparts. Planting them in the grape lines may improve microclimate, reduce sunburn, filter light, and bring up water and nutrients from the soil (E_11). One of the most common white grape varieties of Hungary, *vitis vinifera* ("Olaszrizling" in Hungarian), also highly demanded on the market, arrived in Hungary from France in

the mid-19th century to replace the vines that were destroyed during the great phylloxera epidemic. This water-intensive variety grows little foliage and small vines in the Sand Ridge. Balkan varieties ("Kövödinka"), a late-ripening white grape variety, probably native to the Carpathian Basin and "Kadarka", an extremely undemanding, hardy variety, whose roots grow strongly even in poor soil) are more traditional in the region and are more drought-tolerant. Climate change does not favour organic plant protection either, as many of the oils and teas burn the grapes above 25 °C (E_11).

Based on our interviews we can state that food system transformation is quite challenging from the margins. After losing Eastern markets many of the small-scale farmers got engaged with the full vertical of wine production and sold wine made from their own grapes directly to the consumers. In the process of Hungary's EU accession, its wine legislation had to be made compatible with EU legislation, i.e. equivalent to Community law (CSOMA, Zs. 2012, 67). This was also necessary because the wine sector is heavily export-oriented. As a result of the European legal harmonization the wine excise tax law came into effect on 1 August, 2000. The tax sparked many legitimate objections and protests, as it made small-scale production of grapes and the direct sales of own wines impossible:

"The problem was not with the regulation itself, but with the administrative burden it placed on farmers, which made it almost impossible for them to operate. We managed to do this for a few years, but I can say that this constant harassment and intimidation was too much for us to bear. (...) They (Lawmaking) lumped us together with wine counterfeiters, large factories, and others. So, in essence, this is the end of the vertical structure that was created through the diligence of the people here." (K_11)

The official representative bodies of small-scale grape producers (such as local wine councils, which were established in 1894, discontinued after 1949 and reorganized after 1994) were not able to represent their interest and apart from fragmented resistance

small-scale farmers could not make decision-makers to integrate their interest better into lawmaking.

The farmers in Kecel are familiar with initiatives that shorten the food supply chain, but they find it challenging to integrate into basket communities and other organised direct sales projects of civil society (K_11, Sociodrama_Kecel). Members of the food sovereignty and alternative food network movements need to develop a better understanding of the constraints faced by small-scale farmers hindering the transition of their products from the global to regional and local economies.

Even though the current food system disempowers them, small-scale farmers have an agency in regenerating landscapes and relocalizing food systems. In order for agro-ecologically-minded practices to survive, alternative trading channels must be developed so that the aim of landscape regeneration does not take precedence over the right to quality food for lower classes.

Conclusions

Laying the foundation of our analysis on the dialectics of world ecology and world economy we aimed to show how the current climate vulnerability of the Sand Ridge is not only caused by seemingly “external” processes of climate change, but by “internal” processes of agricultural production which is interlinked with the world economy through trade. We pointed out in our analysis how agricultural landscapes have been produced through trade relations integrated into the world economy embedded into processes of uneven development and how that increased the recent vulnerability of these landscapes. The production of arable land through drainage, the marginalization of pasturing as a livelihood system and large-scale afforestation all contribute to the aridification of the Sand Ridge. Both the Europe-wide historic drought of 2022 and the more severe, less-known regional droughts of 2024 and 2025 pointed out the climate-vulnerability of the Sand Ridge and urged the

radical transformation of agriculture. Agricultural utilization of these sensitive areas should be based on sustainable landscape management. Heterogeneity of the soil and mosaic pattern of landscapes are not favourable for intensive, large-scale farming from the point of view of sustainability. It is not enough to involve farming models based on the utilization of drought resistant crops but it is essential to merge water retention with an agriculture adaptive to the landscape into a complex (SZILÁGYI, Zs. 2020) and resilient system, such as pastoralism, a traditional livelihood system in the Sand Ridge, marginalized by industrial agriculture (MENDLY, D. *et al.* Forthcoming).

We also aimed to grasp the lived experiences of farming under profound landscape transformation. Both the marginalization of small-scale farmers within the food system embedded into the processes of uneven development and the ecological crisis resulting in the ongoing aridification of the region which is partially exacerbated by the production of nature for the purposes of intensive agriculture make farming in the Sand Ridge precarious and highly stressful.

Beyond their vulnerabilities we look at the agency of farmers in regenerating the landscape through building regionally more embedded food system alternatives. Our results show that the “bulk” production of cheap wine limits the scope for regenerative agriculture. Regenerative agricultural strategies can only be paid for if grape producers manage to position their wines as premium bottled wines in higher price brackets, but in this case the challenge of a two-class food system need to be tackled (TRAUGER, A. 2022). In terms of building food system alternatives, small-scale farmers of Kecel managed to develop direct sales after the regime change and the loss of Eastern markets, but as their resistance was fragmented lawmaking linked to European integration disabled this practice with the wine excise tax law. It remains a task for food sovereignty struggles to link remaining small-scale farmers and pastoralists of the Sand Ridge to consumers and to strengthen their voice in decision-making.

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Appendix 1

Interview code		Interviewee's profile	Date	Length (min.)	Status
1.	E_01	Expert on the geography of the Sand Ridge with a focus on groundwater level decrease, University of Szeged.	18.05.2023	90	transcribed
2.	E_02	Water management expert from the Southern part of the Sand Ridge.	20.06.2023	73	transcribed
3.	E_03	Expert on the ecology of the Sand Ridge, with a focus on forest steppe rehabilitation and ecovoltaics, University of Szeged.	13.12.2024	88	transcribed
4.	E_04	Expert on the geography of the Sand Ridge, with a focus on land use transformation, KRTK, Kecskemét.	09.12.2024	89	transcribed
5.	E_05	Expert on the historical political ecology of the Sand Ridge, University of Nottingham.	11.04.2025	81	transcribed
6.	E_06	Leader of a civil society organization fighting for small-scale farmers' rights. The interviewee also runs a farmstead in the Sand Ridge, where the groundwater level is 9–10 m deep.	24.04.2025	54	transcribed
7.	E_07	Expert on the geography of the Sand Ridge with a focus on aridification, KRTK, Kecskemét.	28.04.2025	57	transcribed
8.	E_08	Expert on regenerative agriculture at the Farmers' Association for Regenerative Agriculture (TMG).	12.05.2025	120	transcribed
9.	E_09	Expert on regenerative agriculture at the Hungarian Research Institute of Organic Agriculture (ÖMKi).	17.06.2025	107	transcribed
10.	E_10	Expert on organic farming at MATE.	04.09.2025	45	transcribed
11.	E_11	A focus group interview in Hajós (a neighbouring village of Kecel) including a local forester, a nature conservation ranger and a natural winemaker.	04.04.2025.	240	transcribed
12.	K_01	Large scale farmer in Kecel, male, engaged in grape and fruit production, age: 80+	30.09.2023	158	transcribed
13.	K_02	Large scale farmer in Kecel, female, engaged in poultry production, age: 40+	30.09.2023	53	transcribed
14.	K_03	Seasonal worker with migration background (born in Romania), male, Kecel.	30.09.2023	60	transcribed
15.	K_04	Small-scale farmer, female, Kecel, engaged in fruit production, age: 60+	21.10.2023	83	transcribed
16.	K_05	Small-scale farmer, female, Kecel, engaged in grape and fruit production, age: 40+	21.10.2023	71	transcribed
17.	K_06	Seasonal worker with migration background (born in Romania), female, Kecel.	21.10.2023	55	transcribed
18.	K_07	Integrator, Kecel, fruit sector.	07.11.2023	60	notes, did not consent to audio recording
19.	K_08	Small-scale farmers, wife and husband, engaged in grape production in Kecel, age: both 65+	07.11.2023	76	transcribed

20.	K_09	Small-scale farmer, female, engaged in grape production, her husband works full time in the winery, she has a full-time position, age: 50+	07.11.2023	78	transcribed
21.	K_10	Small-scale farmers, wife and husband, Kecel, age: both 60+	08.11.2023	93	transcribed
22.	K_11	Small-scale farmer, female, university-educated grape grower, technical advisor in addition to grape growing.	08.11.2023	59	transcribed
23.	K_12	Seasonal worker, age 50+, agricultural machine operator.	11.11.2023	54	transcribed
24.	K_13	Seasonal worker, age 30+, agricultural machine operator, but has land too together with his father where they produce fruit.	11.11.2023	84	transcribed
25.	K_14	Integrator, Kecel, grape, sells wine in the global market	14.02.2025	55	transcribed
26.	K_15	Integrator, Kecel, grape, sells wine in the global market.	14.02.2025	90	notes, did not consent to audio recording
27.	K_16	Small-scale farmer (male, 45+) of Kecel engaged in water retention and food self-provisioning.	01.09.2025	74	transcribed
28.	Sociodrama_Kecel	A sociodrama workshop organized with ten farmers from Kecel.	21.02.2025	300	notes
29.	I_01	The ex-leader of a former socialist agricultural cooperative, one of the leaders of a successor organization of the former agricultural cooperative, age 75+	24.05.2024 28.05.2024	233	transcribed
30.	I_02	Local community organizer, member of the representative body within the municipality of Inárcs, age: 65+	24.05.2024 03.06.2024 16.07.2024	220	transcribed
31.	I_03	Small-scale farmers, husband and wife, 10 ha arable land +5 ha meadow, age: 65+, both.	30.05.2024	280	notes
32.	I_04	Agricultural worker between 1960–1998, was engaged in backyard farming and grape and fruit production at the local agricultural cooperative, age: 75+	04.06.2025	60	transcribed
33.	I_05	Small-scale farmers engaged in vegetable production, father and son, age 80+ and 50+	05.06.2024	180	transcribed
34.	I_06	Seasonal workers with migration background (ethnic Hungarians, born in Romania) organized migrant seasonal workers for the successor organization of the former agricultural cooperative (fruit sector). They also produce strawberries on 0,5 ha land, age: 30+, both.	09.06.2024	78	transcribed
35.	I_07	Small-scale farmer, female, Inárcs, engaged in greenhouse vegetable production, age: 60+	24.06.2024	64	transcribed
36.	I_08	Small-scale farmer, engaged in potato and flower production. Age: 60+	04.07.2024	90	notes
37.	I_09	Small-scale farmer, male, grew vegetables on a small-scale between 1980 and 1990, was a member of ÁFÉSZ (Hungarian Agricultural Producers' Association) and also sold his produce at markets. Another former ÁFÉSZ member (female, age: 70+) was also present at the interview.	23.07.2024	90	transcribed

38.	I_10	Former local leader, was responsible for agriculture and land affairs after 1989, age: 75+	06.08.2024	168	transcribed
39.	I_11	Former local leader, member of the Local Heritage Committee, where he focuses on the agricultural history of the village, age: 75+	23.08.2024	127	transcribed
40.	I_12	Vegetable producer in the neighbouring settlement of Inárcs, the Solar Park of Inárcs and the high-voltage overhead cable limits the cultivation technology options that have been used in vegetable production, age: 60+	11.10.2024	125	transcribed
41.	I_13	Small-scale farmer, engaged in husbandry and feed production through arable farming, the high voltage overhead cable passes through his land, age: 50+	11.10.2024	55	transcribed
42.	Focus group_ walk along_ Inárcs	A focus group, walk along interview with three small-scale farmers (female), stakeholders of the solar power plant project in Inárcs.	26.07.2024	240	transcribed

Source: Authors' own compilation.

Appendix 2

The main concepts of the study and their relation to the interview codes

Main concepts	Codes	Examples: Interview excerpts
Agricultural production / Production of nature and Uneven development	Extreme weather events (e.g. drought, spring frost); Accelerating crop growth, reducing development time; De-/Re-valuation and transformation of agricultural land (e.g. solar farms).	<i>"2024 was a watershed year, there has never been such a drought. (...) If it gets this dry again, only the old plantations will survive, planting new vines is risky."</i> (K_15)
Agricultural production / Everyday life	Declining profitability; Increasing costs (e.g. energy, fertilizers, water); Farmers abandon agriculture; Alternative practices (e.g. irrigation, mechanisation); Regulation and subsidies (EU, national); Self-organisation and resistance is sporadic, random, and largely local in scale.	<i>"In 1999, so before 2000 (...) we sold a kilo of Kékfrankos grapes for 100–110 HUF. (...) If you look at the 2023 price list, we're still at 100 HUF. (...) Now let's see what price increases there have been (on the production side) since then. Diesel is now, I don't know, 650 HUF, and back then it was around 120 HUF. That's six times as much."</i> (K_11)

