Annex 2: Sand Ridge – The Hungarian Report

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MOSAIC

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Abstract

This report investigates land-use decision-making in the Sand Ridge (Homokhátság) region of Hungary, a semi-arid socio-ecological landscape characterised by groundwater decline, increasingly unpredictable rainfall and high evapotranspiration. Agriculture remains central to local livelihoods, yet production systems face escalating hydrological, economic and institutional pressures. The study draws on 31 farmer interviews, 14 expert interviews, 10 policymaker interviews, transect walks, observations at local water-related events, non-systematic media review, four Policy Lab workshops, three Photovoice sessions, and a fifth validation workshop. Interviews were transcribed and thematically analysed, enabling a mixed evidence base that combines experiential knowledge, participatory mapping and system interpretation.

Three farm types were examined: traditional mixed smallholder systems, conventional medium-scale farms, and emergent regenerative producers. Across these systems, water scarcity emerged as the most decisive driver of land-use change. Participants rarely invoked the vocabulary of climate change; rather, they expressed lived experience of disappearing surface moisture, declining groundwater tables, spring frost risk, and yield instability. Water was consistently framed as the boundary condition of farming—its absence determining not only what can be grown, but whether farming remains viable at all.

Subsidies surfaced as the strongest behavioural mechanism, shaping farmer choices more than ecological reasoning or technological opportunity. State and EU support was perceived as systematically favouring large-scale operators, with mid-scale farms structurally disadvantaged in accessing development incentives. Several medium-scale farmers withdrew from agri-environmental schemes due to administrative burden, illustrating how current funding models can demotivate rather than encourage land-use change. Smallholders displayed high ecological adaptability but low institutional recognition, while regenerative farms exhibited future-oriented practices without stable policy support.

Social drivers proved equally significant. The ageing of the farming population, low succession rates, labour shortages and weak cooperation emerged as key constraints. Although farmers acknowledged the value of collective action, cooperation was widely described as socially impossible, often attributed to historical patterns of mistrust. Meanwhile, region-specific knowledge exists in the region but is under-utilised, and farmers commonly expect solutions to arrive via external actors rather than internal adaptation or collective agency.

A comparative analysis revealed that each farm type holds a different implicit theory of change: smallholders rely on continuity and inherited knowledge; regenerative farmers depend on experimentation and learning networks; medium-scale farms prioritise operational stability and gradual shifts. Yet all are equally exposed to hydrological pressures and equally constrained by policy structures.

One key outcome of the participatory process was a re-ordering of the initial theoretical driver framework. Rather than separate domains (policy, climate, market, knowledge), farmers conceptualised three intersecting fields of influence: (1) water–ecology, (2) governance–subsidies, and (3) cooperation–knowledge.

Drivers such as biodiversity loss or invasive species, emphasised in earlier models, were downplayed when confronted with lived priorities, while previously under-recognised drivers, particularly lack of flexible agricultural strategy and failure of knowledge uptake, rose to prominence.

Methodologically, Policy Labs generated rich insight but required careful facilitation. Time constraints and dominant voices limited exploration of personal motivations, which appeared in interviews and media narratives but were largely absent in workshop discussions.

Overall, the Sand Ridge emerges as a test landscape for European drought adaptation, illustrating that transformation potential lies not in generating new technical solutions but in enabling farmer agency, promoting water retention over extraction, redesigning subsidy structures, enhancing cooperation, and activating existing knowledge systems. The region does not lack innovation capacity; it lacks the social and governance conditions that would allow such capacity to scale.

Key words: Water scarcity, Agricultural policy, Knowledge transfer

1 Socio-economic, ecological and hydrological context of a semi-arid landscape

The Danube–Tisza Interfluve, known as Sand Ridge (Homokhátság in Hungarian), is one of the driest and most climate-sensitive regions of Hungary, where the lowering of groundwater levels, the increasing frequency of droughts, and the vulnerability of agricultural systems have long shaped landscape functioning. Precipitation and water distribution are increasingly unbalanced, while formerly extensive marshes, wetlands and small lakes have either contracted significantly or disappeared altogether. The 8715 km^2 region is home to 623,386 inhabitants, representing 6.6% of the national population, with a relatively low population density of 71.53 people per km^2 typical of rural areas, although nearly 15% of these residents live in outskirts of settlements (Farkas et al., 2024). Climate change has intensified extreme undermining agricultural production and reducing environmental security in a landscape where nearly two-thirds of the area is under agricultural use. At the same time, the proportion of the population engaged in traditional small-scale farming and the number of agriculturally active farmsteads are declining. Despite these processes the share of farmsteads remains high in both national and European comparison, and pronounced territorial disparities persist, particularly in the southern and border regions, where several districts are characterised by weak functional centres and structural disadvantages (ibid.). Taken together, these dynamics point to a region where environmental vulnerability, shifting land use practices and socio-spatial inequalities reinforce one another, making the Homokhátság a critical case for understanding how climate stress and agrarian change shape rural livelihoods in Hungary.

The negative water balance is the outcome of decades of cumulative processes: evapotranspiration regularly exceeds the recharge that can be supplied by precipitation, and groundwater reserves cannot regenerate at the pace required by agriculture, forest cover and climatic stressors. Almost ten years ago the area was described as a semi-arid region facing complex hydrological and socio-economic stressors (Kovács, Hoyk, and Farkas 2017), indicating that aridification is not a recent phenomenon but a well-documented long-term trajectory. Water scarcity is therefore structural rather than episodic, and it will strongly shape future land-use decisions.

The original vegetation of the region was forest-steppe, characterised by mosaic grasslands interspersed with scattered tree stands. However, in the 19th–20th centuries, large-scale afforestation was implemented to stabilise shifting sand. Tölgyesi et al. (2021) demonstrated that these closed-canopy plantations intercept a significant proportion of rainfall, and their evapotranspiration exceeds natural input, resulting in almost no groundwater recharge beneath forests, whereas recharge still occurs under native grasslands (Tölgyesi et al., 2021, p. 133). This finding is reinforced by groundwater recharge research on the Great Hungarian Plain, which confirms that closed forest cover significantly reduces infiltration and contributes to long-term groundwater decline (Szabó et al. 2023). Historically, the landscape

was therefore not a continuous forest but a semi-open vegetation mosaic that aligned more closely with the region's hydrological regime.

Hydrological dynamics are further detailed by Szkolnikovics-Simon (2022). Winter infiltration is the only substantial source of groundwater recharge, yet forest cover and intensive soil disturbance limit percolation; in summer, evapotranspiration may exceed infiltration by a factor of three to four (Szkolnikovics-Simon et al. 2022:37). Water scarcity is thus not purely a biophysical condition, but also a function of land-use, soil management, and institutional decisions. The hydrological system of the Sand Ridge currently displays low inertia: it loses water rapidly and regains it slowly, making all interventions long-lasting in effect. Past decisions, drainage, afforestation, field consolidation, are therefore still visibly embedded in the present landscape.

This hydrological context directly influences social and economic structures. Large-scale arable agriculture remains dominant, mainly based on wheat, maize and sunflower monoculture, yet its high input and water demand render it increasingly fragile. Fruit cultivation has declined in some areas while re-emerging elsewhere with new varieties and technologies (e.g., apricot, small tomato cultivars). Many holdings rely on poultry, sheep and cattle husbandry, occasionally aquaculture, viticulture or small-scale winemaking. This indicates high livelihood diversification, where income is often stabilised through supplementary activities such as workshops, machinery services, rural tourism or seasonal labour. Farm structures can be grouped into three broad types:

- **Conventional medium-scale farms:** This is still the prevailing agricultural model in the Sand Ridge, based on cereal – oilseed rotations, high fertiliser and pesticide input, heavy machinery use, and strong integration into commercial markets. Such farms provide short-term income stability when yields are high, but they are vulnerable to drought. A growing subset of farmers have already recognised that long-term irrigation development is uncertain or unfeasible, which may open pathways toward more adaptive soil- and water-saving practices, though adoption remains gradual.
- **Traditional mixed small farms:** These post-peasant smallholdings combine livestock and crop production grounded in local ecological knowledge. They operate with low capital and mechanisation yet often display high ecological flexibility. Production focuses on self-sufficiency: vegetables, fruit, fodder, small orchards; while surplus is sold locally or informally, contributing modestly but continuously to household income. Economically fragile, culturally resilient, these farms remain important to local social fabric and agrobiodiversity.
- **Medium-scale farms transitioning to regenerative farming:** These holdings increasingly adopt soil-conserving methods, no-till, minimal disturbance, diversified cover crops, and in some cases the re-integration of livestock, with the explicit aim of retaining water and rebuilding soil structure. They are typically innovative and experimental, trying new crop varieties and marketing channels, but remain socially marginal: while respected, most

farmers in the region still view regenerative practices with caution or scepticism, perceiving them as risky under current subsidy and market conditions.

In addition to the farm types described above, three further farm types were identified: large-scale arable crop farms, waterfowl breeding facilities, and intensive greenhouse vegetable production systems. The latter two currently face pronounced economic pressures: waterfowl farms are increasingly exposed to risks associated with avian influenza outbreaks, while rising energy prices have significantly reduced the economic viability of greenhouse vegetable production. Large-scale arable farms showed limited willingness to engage in Policy Lab activities; as a result, the validation of findings for this farm type could not be carried out.

Ecosystem services are increasingly recognised as central to regional wellbeing. Kelemen et al. (2015) found that locals identified water availability as the most important ecosystem service (p. 116–118), followed by pollination, soil fertility and genetic resource maintenance. This indicates that water scarcity is not only a scientific or policy concern, but it is also a lived experience. People observe the disappearance of ponds, declining hay yields, weakening bee colonies and reduced forage biomass. In this sense, water functions as a foundational ecosystem service, upon which others depend. When water declines, every associated service, provisioning, cultural, regulating, weakens accordingly.

Recent media and policy discourse reflects this shift in perception. Sand Ridge is no longer portrayed merely as a marginal agricultural zone, but as a real-time test site for climate adaptation in the Carpathian Basin. Three municipalities appear prominently as pilot territories: Jászszentlászló, Szank and Móricgát, where farmers and local actors have initiated bottom-up water-retention solutions, including weir construction, sluice restoration and small-scale impoundment along the Dong-ér-Kelő-ér water system. These micro-projects represent a conceptual departure from earlier drainage-driven thinking: water is no longer an excess to be removed, but an asset to be retained. The guiding question for the coming decades is therefore not how to bring water back, but rather, how not to lose it again.

Policy goals at local/regional level

While the formal government programme currently targets land-use transition or drought adaptation in the Sand Ridge - as the existing proposal is merely a techno fix: a large-scale water replenishment of the area - an emerging vision is taking shape among researchers, municipalities and farming communities. The most clearly articulated objective is *the creation of landscape-scale planning and governance,* replacing fragmented plot-level responses. The proposal emphasises water retention as the primary design principle and calls for agricultural subsidies to shift away from uniform hectare-based allocation towards incentives for small and medium-sized farms, soil-conserving practices, and hydrologically adaptive land-use. Instead of large-scale water transfer infrastructures, the envisioned approach prioritises keeping water within the landscape through infiltration enhancement, micro-reservoirs and cooperative management of drainage channels. In this interpretation, the Sand Ridge is not primarily an unbalanced system to be repaired, but a region

where integrated hydrology–agriculture policy could stabilise ecosystem services and rural livelihoods.

2 Methodology

Between December 2023 and August 2025, we conducted extensive qualitative fieldwork in the region. In total, 31 interviews with farmers, 14 expert interviews (independent specialists, National Park representatives, civic organisations, and public institutions), and 10 interviews with policymakers (Agricultural Chamber, Water Agency, County Council, Local Councils) were completed. In several cases, interviews were accompanied by transect walks, allowing direct observation of farming practices, water management structures, and landscape-level decision making. The research team also attended local events, particularly those addressing drought and water challenges, engaged with parallel research projects, and conducted non-systematic media analysis to capture wider public discourse and general attitudes surrounding land use and resilience. In addition to interviews, we organised four Policy Lab (PL) meetings and three Photovoice workshops, enabling participatory reflection, peer-learning, and multi-level knowledge exchange across farmer communities and institutional actors.

All interviews were fully transcribed and analysed using qualitative thematic coding. Recurring drivers, narratives and perceptions were identified inductively and then compared with outputs from PL sessions, Photovoice discussions and transect observations. Triangulation across these methods—individual interviews, collective deliberations, field observations, and external societal signals—enhanced both analytical depth and interpretive validity. This mixed-method approach enabled us not only to identify key drivers but also to understand how these dynamics manifest within the analysed part of the Sand Ridge farming system, and under which ecological, social and institutional conditions they gain significance.

To ensure robustness, a fifth Policy Lab meeting was conducted after the analysis, dedicated to validating and discussing the results with participants. Insights from this final workshop exercise were incorporated directly into the interpretation of findings. A detailed description of the full methodological process of the validation workshop; including participants and workshop design, can be found in Section 6 and in the Appendix.

2.1 Structural external drivers for land-use change

Figure 1: Mindmap for understanding land-use decision making in the case study area – external drivers

Based on the interviews, the first four Policy Lab workshops and the reviewed literature, we identified a broad set of drivers that shape climate-related land-use change in the Sand Ridge region. These drivers reflect both long-term structural forces and more immediate pressures influencing farmers' decisions, production strategies and adaptation pathways. The complete list of drivers is presented in the Appendix, grouped according to the typology proposed by the MOSAIC framework. We visualise the full driver structure in Figure 1. to offer an integrated overview of how the individual drivers relate to one another and cluster into broader domains.

In the section below, we provide a concise analysis of these drivers, focusing on how each category influences land-use decisions in general, and how they collectively influence land-use decisions in the case study area. Rather than isolating individual factors, the aim is to illustrate the web of interacting pressures: economic, regulatory, social and climatic, through which landscape transformation occurs. By briefly unpacking each category, we highlight not only the sources of vulnerability, but also the potential leverage points for future adaptation.

Structural external drivers comprise the socio-economic, political, technological and ecological forces that operate outside the direct control of land-users, yet fundamentally shape the conditions under which they make land-use decisions. In the Sand Ridge region, these drivers were grouped into four main categories — Market & Technology, Instruments & Policies, Social Environment, and Climate Change — each exerting distinct but interacting pressures on farming strategies, land allocation and long-term viability.

Market & Technology drivers reflect persistent economic uncertainty and structural capital constraints. Farmers describe agricultural returns as low and unpredictable, with high input prices, volatile product markets and limited bargaining power. Access to credit remains problematic: loan conditions are often opaque, bureaucratic, and difficult to meet, particularly for farms without collateral or formal financial literacy. This combines with a chronic shortage of capital, preventing technological renewal, farm infrastructure development or diversification toward higher-value crops. Agriculture therefore struggles to provide a stable livelihood, reinforcing outward migration and discouraging long-term

investment. Input-cost inflation — especially fertilisers, fuel, and feed — intensifies vulnerability to global market swings, making land-use decisions more risk-averse and short-term oriented.

Instruments & Policies exert both enabling and restrictive effects, divided into three subcategories. Subsidies play a decisive role: afforestation schemes historically encouraged forest planting, while support for native species helps conserve biodiversity but involves strict compliance procedures. Land-based payments are influential because large farms secure substantial income purely through area size, which can reduce incentives for innovation or conversion. Technology development support is welcomed, yet only accessible for farmers with matching capital. The legislative environment is similarly double-edged. EU accession fundamentally reshaped market functioning and subsidy logic, increasing regulatory density. National Park and Natura 2000 designations protect ecological assets but restrict land conversion, building, and ownership, placing farmers on a constrained development path. Meanwhile, administrative burden has grown steadily; uniform rules treat small and large farms alike, and the volume of inspections fosters compliance fatigue.

The *Social Environment* further influences the trajectory of land-use change. Rural demographic ageing reduces generational renewal — many heirs leave agriculture, and only a small number of young farmers take over existing holdings. Labour shortages limit the management of livestock, orchards and labour-intensive crops. Cooperation remains weak, diminishing collective bargaining capacity, while recreational animal keeping introduces alternative land uses with low economic relevance. Local residents have limited influence over land-use decisions, and past oil exploratory drilling has raised concerns regarding groundwater impacts.

Finally, *Climate Change* introduces both adaptation pressures and heightened vulnerability. Warmer winters facilitate the survival of pathogens and invasive species, demanding new pest-management strategies. Extreme spring frosts increasingly damage orchards, while avian influenza destabilises livestock systems. The most systemic issue is atmospheric drought combined with declining groundwater and soil moisture, leading to rapid disappearance of precipitation and accelerating water deficits year-on-year. Biodiversity loss and reduced ecosystem stability feed back into productivity decline, reinforcing risk-sensitive land-use choices.

Collectively, these drivers shape land-use change not through single impacts but through interlocking constraints and opportunities, where economic uncertainty, regulation, social capacity and climatic exposure continually redefine what farming is possible, and for whom.

3 Factors influencing land-use decision making

Based on interviews, document analysis and insights from the earlier Policy Lab meetings, we also developed a visual summary that synthesises how land-users understand and respond to landscape change. In the following section, we present the perceived drivers of land-use decisions, emphasising that not all factors reflect direct biophysical or economic pressures, several are rooted in farmers' interpretations, values, memories and judgements, rather than external constraints themselves. These internal drivers therefore shape how structural forces are experienced and translated into action, revealing not only what influences farming decisions, but how farmers make sense of change in the Sand Ridge environment. The schematic figure of the factors influencing land use decision-making can be seen below (Figure 2), the full list of factors can be found in the Appendix.

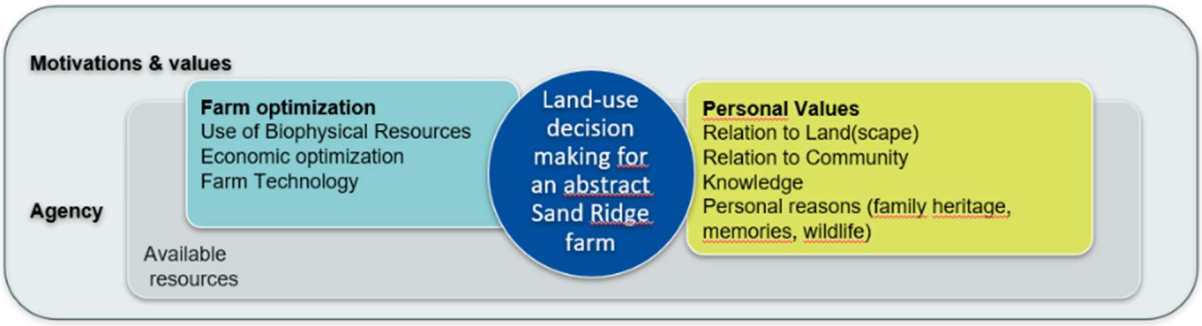


Figure 2: Mindmap for understanding land-use decision making in the case study area – motivations and values

The analysis of land-use decisions in the Sand Ridge region reveals a complex constellation of drivers that operate across personal, social, ecological, economic, and technological dimensions. Rather than acting in isolation, these drivers interact and reinforce one another, shaping how farmers perceive constraints, opportunities, and responsibilities in a landscape increasingly characterised by water scarcity and environmental stress. The categorisation of drivers highlights that land-use change is not only a response to biophysical pressures but also deeply embedded in values, memories, knowledge systems, and social relations.

Personal values emerge as a foundational layer influencing decision-making. Many farmers articulate a strong commitment to preserving family heritage, reflecting long-standing intergenerational ties to land and place. Land is not viewed merely as a productive asset but as a carrier of family history, identity, and moral obligation. This sense of stewardship is often reinforced by personal memories, particularly recollections of childhood experiences when water was more abundant and landscapes were perceived as healthier and more resilient. Such memories function as reference points against which current degradation is assessed, shaping both loss narratives and aspirations for restoration. In some cases, personal values also translate into concrete actions aimed at helping wildlife, such as the creation of wildlife ponds, motivated by emotional responses to visible ecological decline and suffering.

Closely linked to personal values is the farmers' relationship to land. Habitat protection appears as a significant driver, where land-use decisions are guided by the intention to conserve biodiversity and maintain ecological functions, even at the expense of short-term productivity. At the same time, respondents point to the disappearance of the traditional farmstead lifestyle as a major structural change. The erosion of this landscape-adapted way of life is associated with the spread of industrial agriculture, standardisation of practices, and the loss of locally embedded ecological knowledge. This shift is perceived not only as an economic transformation but also as a cultural and environmental rupture that constrains more adaptive and place-sensitive land-use strategies.

Relations to the local community further shape decision-making processes. Trust-based relationships within the community are repeatedly highlighted as enabling factors for certain land-use choices, particularly those involving cooperation, informal exchange, or shared risk-taking. Where trust and long-standing social ties exist, farmers are more likely to coordinate actions, share resources, and align practices. Community action also emerges as a distinct driver, illustrating how collective responses can be mobilised when environmental changes—such as declining water availability or wildlife loss—are perceived as shared threats. These collective initiatives demonstrate the latent potential of local social capital, even if such cooperation remains uneven and fragile.

Knowledge plays a central role in shaping adaptive behaviour. Learning from experience is frequently cited, with farmers emphasising that land-use decisions are informed by trial-and-error processes, observation of outcomes, and reflection on past mistakes. This experiential knowledge is complemented by learning from each other, where successful local examples and peer practices serve as important reference points. Rather than relying primarily on formal advisory systems, farmers often draw inspiration from neighbouring farms or trusted individuals, underscoring the importance of horizontal knowledge exchange in the region.

Personal constraints also exert a strong influence on land-use trajectories. Health reasons, including physical strain and age-related limitations, can directly lead to the abandonment or simplification of certain activities, such as livestock keeping. Overwork and lack of time further restrict the capacity to maintain diversified farming systems, pushing farmers towards fewer, less labour-intensive activities. These personal factors highlight that adaptation capacity is not solely determined by awareness or motivation, but also by embodied and temporal limits.

Farm optimisation strategies reflect attempts to align production with changing environmental conditions. Conscious breed selection and the preference for native animal species are cited as adaptive responses to climatic stress, based on the perception that locally adapted breeds are more resilient and require fewer external inputs. These choices indicate an effort to reduce vulnerability by working with, rather than against, ecological constraints.

Biophysical resource conditions form a critical structural layer of decision-making. Poor soil quality is identified as a fundamental constraint that limits viable land-use options, often making crop production economically unfeasible. Overuse of land exacerbates water management

problems, reinforcing the need for uncultivated or water-retaining areas. At a broader scale, the dryness of the Danube–Tisza floodplain is recognised as a key determinant of water availability in the Sand Ridge, linking local land-use decisions to regional hydrological management. In this context, afforestation is sometimes preferred over production, as water scarcity renders arable farming increasingly unviable. Water retention emerges as a unifying concern, reflecting widespread recognition that maintaining existing water resources is essential for any future land-use strategy.

Economic optimisation drivers reveal how farmers seek to remain viable under tightening constraints. Cost-cutting measures, such as reducing soil cultivation, are adopted to lower expenses without significantly reducing yields. Direct-from-farm sales and alternative supply chains are used to bypass intermediaries and mitigate price manipulation, while cost-effective procurement through global markets reflects continued integration into wider economic systems. These strategies illustrate the balancing act between local adaptation and global market dependence.

Finally, farm technology plays a supporting role in adaptation efforts. Investments in more efficient irrigation technologies aim to reduce water loss, while organic fertilisation is preferred to improve soil condition and reduce reliance on synthetic inputs. The adoption of new agricultural technologies, particularly regenerative and non-tillage practices, reflects growing interest in approaches that enhance water retention and humus formation. Together, these technological choices signal a gradual reorientation towards practices that align economic viability with ecological resilience.

4 Drivers and factors influencing land-use decision making

To validate and refine the results of the previous analytical phase, we invited participants of the Policy Lab alongside local farmers, municipal representatives and domain experts to a structured validation workshop. The objective was not only to verify whether the identified drivers accurately reflect local realities, but also to understand how different types of farming systems prioritise and interpret these drivers in practice. The workshop was designed to test the robustness of our abductively derived driver framework and to compare how land-use decisions are shaped across varied operational contexts. Validation was carried out for three farm types representing the spectrum of agricultural systems in the Sand Ridge region:

- a conventional medium-scale farm open to agroecological approaches,
- a traditional smallholder mixed farm,
- and a regenerative farm.

In the following section, we present the outcomes of the workshop in the context of these three farm profiles, highlighting where perceptions align with or diverge from the original driver analysis. We asked the participants of the three groups to think about their own experience and farm practice while answering the questions and contributing to the discussion. At the centre of the board, the guiding question: *"Which factors shape land-use decisions among farmers in the Sand-Ridge region?"*. This helped structure the discussion and anchor the subsequent mapping of interconnections. Most drivers were deemed as highly influential, suggesting that the set of drivers distilled from interviews, literature and media analysis adequately reflected the realities experienced by farmers.

The workshop lasted around 60 minutes and consisted of three main parts:

- *Part 1. Driver assessment and grading.*

  Participants first reviewed a set of drivers that possibly influence their current land-use generated through abductive analysis of interview material. Each driver was then collectively evaluated and scored on a 1–3 scale based on perceived impact (using a 1-to-3-star scale, and additional option of non-relevant). The drivers were colour-coded according to category (external (drivers), internal (factors)), although this categorisation was not disclosed during the exercise to avoid influencing prioritisation.

- *Part 2. Mindmap construction.*

  Participants collaboratively organised the drivers into clusters, forming a mindmap structure that represented perceived relationships, causal linkages and thematic proximities. This exercise made visible how farmers themselves conceptualise the complexity of land-use decision-making. The mindmaps created by the 3 groups were translated and digitalized by us, and are analyzed in chapters 5.1., 5.2. and 5.3. The set of drivers in the original mindmap framework for each case can be found in the Annex.

- *Part 3. Identifying drivers of change.*

  Finally, participants selected the drivers that most strongly motivate or compel land-use change within their farming context. These were graded on a 1–5 scale, allowing for a more fine-grained assessment of influence and enabling comparison between farm types.

4.1 Drivers and factors influencing land-use decision making: the case of a conventional medium-scale farm

This section summarises the validation workshop for a medium-scale conventional farm in Sand Ridge. The focal farm consists of 50 ha cereal–oilseed rotation combined with livestock. Although conventional in structure, input levels are lower than typical conventional farms, the farmer uses manure rather than much synthetic fertiliser, and he is open to agroecological techniques, including future product processing. The system provides income stability in good years, yet drought creates vulnerability, irrigation prospects are uncertain, and adaptation is increasingly necessary. Together with neighbours, s/he participates in a water-retention cooperation, signalling a slow transition within conventional production systems.

The importance of drivers

Drivers influencing land-use decision-making were evaluated through discussion and mapping. Compared to smallholders, influences here appear more structural than cultural. The impact of the global market economy places medium-scale farmers at a competitive disadvantage, as they cannot achieve the volume-based efficiency of large-scale producers. Shortage of capital and low payoff reduce investment capacity, while livelihood remains the threshold condition: the farm must be profitable to continue. The farmer's interest in processing suggests a shift toward value-added strategies.

Policy instruments were considered central. Administrative burdens were regarded as disproportionately heavy, leading the farmer to exit the Agri-Environment Scheme despite organic management. Land-based support and technology-development subsidies currently benefit large-scale farms, not medium-sized ones. While EU influence was recognised as strong, responsibility between EU and member-state implementation was debated. The group introduced the lack of flexible agricultural strategy as a new key driver, describing it as a systemic limitation that restricts adaptation to drought and market volatility.

Climate-related conditions were discussed without using the term climate change. Instead, farmers refer to water scarcity as the primary driver, with groundwater decline reinforcing long-term risk. Water retention was seen as the most important future-oriented strategy. Frost damage influences sowing decisions, biodiversity loss is acknowledged but less urgent, and invasive species were not considered impactful due to their manageability.

Social drivers reflect structural change in agrarian culture. The ageing farming society, labour shortages and the lack of successors pose significant risks. Cooperation is weak, despite recognition of its potential power. Learning from each other remains superficial rather than knowledge-based. The workshop added another new driver: lack of region-specific knowledge. Although such knowledge exists, uptake is limited, suggesting behavioural, not informational, barriers. Poor soil quality requires adaptation, species shifts are increasingly relevant, and no-till was rejected as unsustainable in the long term. No-till agricultural practices are emerging in the region as part of the adaptation pathway. This farmer is open to agroecological techniques, fighting biodiversity loss is one of his main endeavours. However he obtains certain scepticism towards the agenda of regenerative farming as a holistic approach, deemed unsustainable and monoculture-like by him on the long term. Across all domains, three overarching levers stand out:

- water scarcity
- lack of flexible agricultural strategy
- lack of cooperation and knowledge-exchange.

Links among the drivers, the mindmap

Instead of discussing each driver individually, participants grouped them into an interconnected structure. Figure 3 represents the mindmap created by the participants, indicating the titles they gave to each cluster and the connections they found between them.

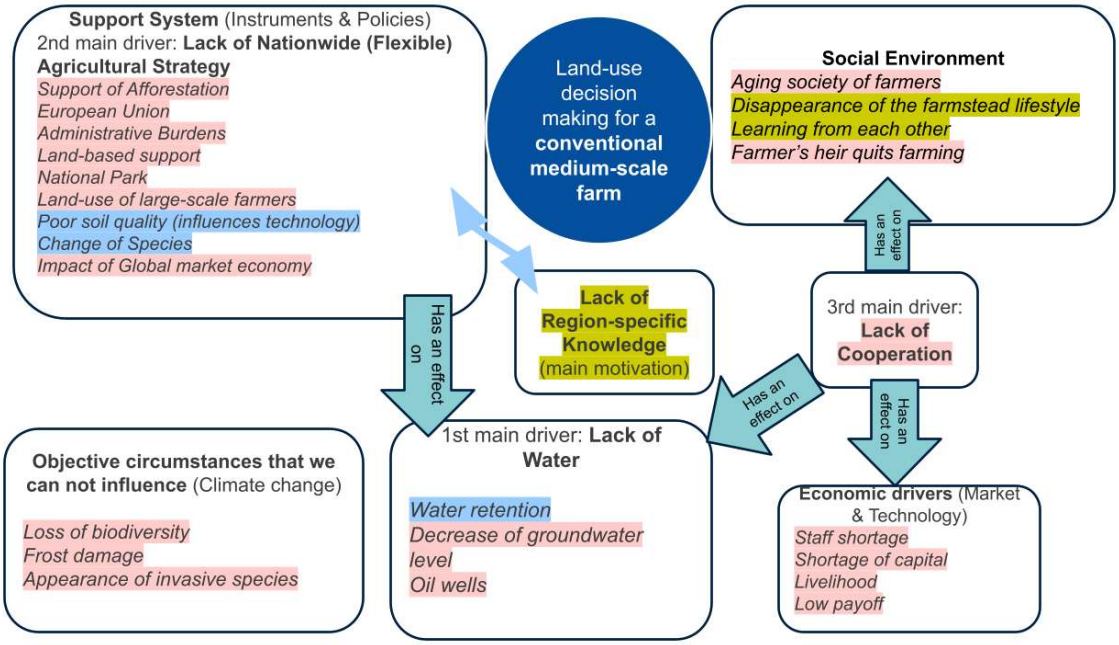


Figure 3: Mindmap for understanding land-use decision making of a conventional medium-scale farm on the Sand-ridge (created by participants)

Water scarcity formed the first and strongest cluster, linked to groundwater loss, oil wells, frost exposure and the need for retention measures. The group perceived groundwater loss, oil wells and water retention initiatives as subcategories of the main driver: *Lack of Water*. A second cluster grouped policy and institutional factors, subsidy distribution, administrative requirements, EU frameworks, discontinued afforestation support and the limited accessibility of technology development. These were perceived as powerful structural forces that shape what kinds of decisions are economically rational. A third cluster centred on cooperation and knowledge: ageing, succession gaps, labour shortages, lifestyle shifts, limited peer learning and the missing uptake of region-specific knowledge. Smaller drivers relating to biodiversity, species change, soil and invasive plants sit at the edges of this structure. The mind-map therefore visualises a decision space shaped not by isolated pressures, but by overlapping climate, policy and social systems.

Most impactful drivers

When asked which drivers genuinely induce change rather than merely influence planning, the group placed the subsidy system at the top. Farmers adapt to funding frameworks more than to ecological or technological reasoning. Because most support mechanisms reward scale, medium-sized farms adjust behaviour around eligibility rather than long-term resilience. Limited access to technology development intensifies this dependency on the subsidy system. In practice, subsidies function as behavioural signals; directing effort, investment and crop choice, rather than guidance toward development, sustainability and self-dependency in farming.

Water scarcity forms the second major change-driver. It accelerates crop abandonment and pushes production toward extensive or alternative forms. The group noted that maize and sunflower are already disappearing in some areas. Water-driven change is incremental yet cumulative: as availability declines, it erodes the viability of conventional rotations, forcing diversification, process innovation or scaled-back production. The cooperative approach to water retention indicates collective awareness of the need to change an approach to farming that dates back generations.

A third driver, knowledge, remains latent but potentially transformative. If region-specific knowledge were more actively shared and applied, adaptation could accelerate quickly. The workshop revealed that knowledge exists but is not accessed. This implies that institutional support, cooperation structures and advisory systems could unlock change more effectively than technical innovation alone. The role of media reinforces this dynamic: public narratives on inland water or drought management shape perceptions and may alter collective expectations. Communication therefore acts as an amplifier, capable of shifting land-use norms before economic pressure makes land use change unavoidable.

Together, these impact findings suggest that land-use change in medium-scale farms is shaped less by agronomic conditions themselves and more by the systems through which farmers navigate them: subsidy logic, market structure, knowledge access and the capacity to organise collectively.

4.2 Drivers and factors influencing land-use decision making the case of a traditional smallholder mixed farm

This traditional smallholder mixed farm (~5000 m^2 arable, goats, cows, poultry, orchard and grassland) represents a post-peasant household system combining livestock and crop production with strong reliance on local ecological knowledge. Operating with low capital and limited mechanisation, it focuses primarily on self-provisioning, selling surplus vegetables, fruit and dairy locally. Though economically vulnerable, the system remains culturally resilient and ecologically adaptive, contributing to agrobiodiversity and the social fabric of the community. The following section presents how drivers of land-use change were perceived within this farm type.

The importance of drivers

During the participatory mind-mapping exercise we first collected from the previously prepared list the drivers influencing the land use change and their relevance in the case of traditional smallholder mixed farms producing vegetables, fruits and dairy products for self-provisioning and sell in the Sand Ridge region. In the second step, we explored the interconnectedness of these drivers and finally we asked the participants to assess how much those impact land use change.

The most dominant drivers of land-use decisions in small mixed farms are the decrease of soil water level, atmospheric drought, and the resulting water shortage. These hydrological changes reinforce each other, leading to increasing aridity, reduced productivity, and heightened annual risk in cultivation. Climate change intensifies this system further by worsening water scarcity and increasing weather unpredictability.

Personal and cultural drivers are also highly influential. Personal memories: especially childhood experiences and knowledge inherited from parents and grandparents; strongly shape land-use choices. Closely related is the motivation of preserving family heritage, which reflects long-term emotional attachment to land and the wish to pass it on to the next generation.

At the same time, the disappearance of the farmstead lifestyle marks the erosion of traditional ecological knowledge, while urban consumers increasingly lose familiarity with the sensory quality of real, locally grown produce. A further key driver is the land use practices of large-scale farmers, perceived as having a strong (mostly negative) effect, connected to global market incentives and EU subsidy systems, and often resulting in inefficient or wasteful water use.

Among the relevant but less dominant influences are frost damage, water retention, and conscious breed selection, all of which affect annual planning and adaptation. Poor soil quality and the appearance of pathogens also directly shape production decisions. Learning plays an essential role — both learning from each other and learning from experience — through community events, field visits and conferences.

Trust and social ties appear as important enablers: trust-based relationship with the community and direct-from-farm sales/alternative supply chains support farm viability, particularly within short supply chains. Health reasons were also widely emphasised — farming ensures access to chemical-free food and supports physical or mental well-being, including family health and therapeutic values of working with land.

Economic context is significant. European Union opportunities and funding influence operational choices, while livelihood remains a crucial baseline condition — farmers continue only as long as the activity remains viable and meaningful. The impact of the global market economy stands out within this group: year-round supply expectations, fluctuating prices and unstable sales channels push producers toward informal exchanges, CSA-type box communities or individual market strategies.

The workshop also identified several drivers with minor influence on land-use decisions. These included support for irrigation, cutting costs by reducing soil cultivation, change of species, irrigation development, organic fertilisation, and the appearance of invasive species such as *Ailanthus* or *Wisteria*, which persist independently of water conditions.

Social and organisational factors, lack of cooperation, community action, and the influence of local residents, were acknowledged, but perceived as weak unless efforts are coordinated collectively. Source of information follows a similar pattern: limited in individual effect, but potentially powerful in awareness-raising and knowledge transfer.

Other low-impact drivers in this category included recreational animal husbandry, keeping native animals, aging, young farmer taking over the farm, the heir quitting farming, administrative burden, low payoff, support for technology development, land-based support, support for native species, overuse of the land/water resources, and measures of helping wildlife (e.g. wildlife ponds), sometimes generating unintended outcomes such as increased predation pressure.

Links among the drivers, the mindmap

Participants collaboratively organised the drivers into clusters, forming a mindmap structure that represented perceived relationships, causal linkages and thematic proximities. Figure 4 represents the mindmap created by the participants.

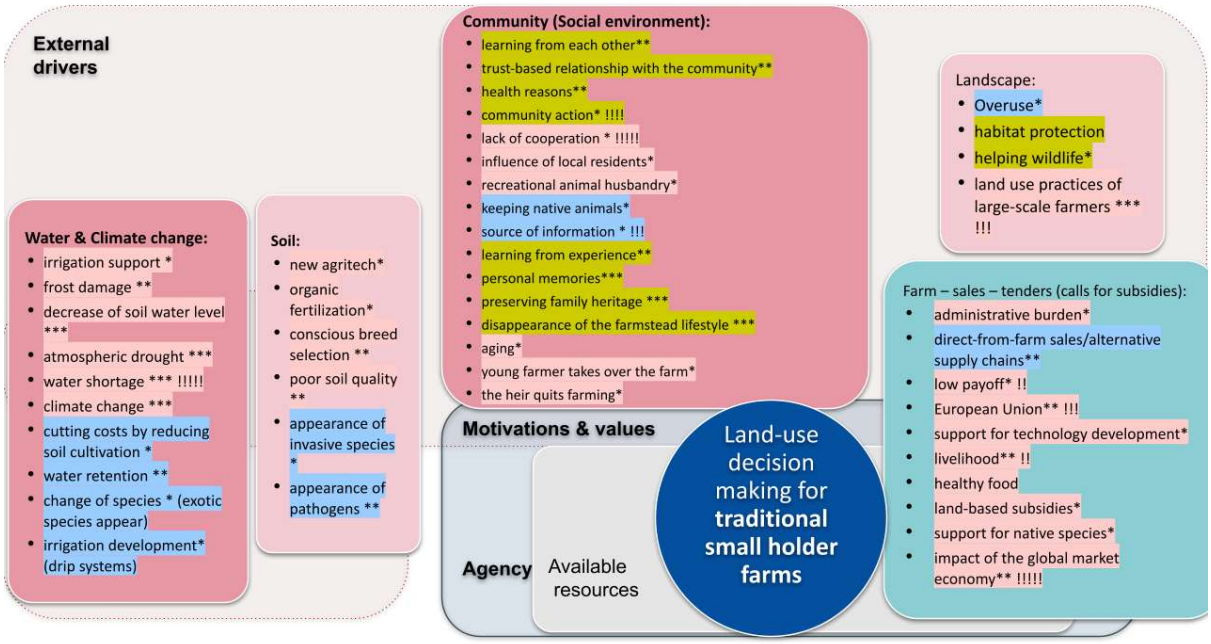


Figure 4: Mindmap for understanding land-use decision making of a traditional smallholder farm on the Sand-ridge (created by participants)

According to the small group of participants on traditional smallholder farms, these drivers were grouped together in a way that suggests they perceive connections between them, even if they did not explicitly articulate these links. They defined five main groups: water & climate change, soil, community, landscape and farm (sales & calls for subsidies). We kept the names for the categories given by the participants of the workshop. Having a closer look at the categories one might observe that sometimes the drivers are loosely or not linked to category names.

For example, new agricultural technology (e.g., regenerative agriculture, no-till), use of organic fertilisers, conscious breed selection, poor soil quality, the appearance of invasive species, and the appearance of pathogens were seen as related factors. While participants primarily referred to soil as a reference point, the grouping indicates an implicit recognition that these drivers are

connected to the broader natural environment and, to some extent, to climate change. The way these factors cluster together in their discussions suggests that farmers intuitively understand their interdependence, even if they did not formally reflect on it.

According to the group discussion water & climate change and community play a central role in land use decision-making, other drivers are less relevant. It is also worth noting that our original clustering of the drivers was overwritten during the group discussion.

Most impactful drivers

Finally, we asked the participants about the influence of the different drivers on land use change. Among the factors that most strongly motivate farmers to adapt or change their practices, water shortage emerged as the single most critical driver. Its effects are immediate and pervasive: without sufficient water, traditional cropping and livestock practices cannot be sustained, and farmers are forced to reconsider what, when, and how to cultivate or manage the land.

Closely linked are social and market dynamics that only achieve their full potential through coordination. Lack of cooperation and the impact of the global market economy have particularly strong influence. Individual farmers may feel limited effect from these drivers alone, but together they can push for significant adaptation; the cooperation among the farmers could counterbalance the negative effects of the global market economy. The global market's influence is multifaceted: it demands year-round supply, sets price pressures, and introduces uncertainty in sales channels. Farmers respond with individual strategies, such as bartering, local box communities, or short supply chains, to compensate for these pressures.

Community action also plays a crucial role in driving change, although it is slightly less influential. When local initiatives prioritise local products and foster conscious consumption, through cooperative marketing, CSA-style box schemes, or consumer engagement, they can strongly motivate farmers to adapt their land-use practices.

Another set of powerful motivators are linked to information, policy, and institutional frameworks. Information sources are critical in raising awareness among consumers and transmitting local knowledge, helping farmers make informed decisions about production, sourcing, and marketing. Similarly, the European Union serves as a strong driver through funding and programmatic support, encouraging adoption of new practices, innovation, and alignment with regulatory standards, while also shaping the market orientation between local consumption and export.

Large-scale farmers' land use practices exert strong indirect influence: their resource-intensive and globally oriented operations create pressures on smallholders, particularly regarding water use and local competition. This driver is amplified by the structure of global and EU-supported agricultural systems, often compelling smaller producers to innovate or change to remain viable.

Economic viability remains a central, although moderately influential driver. Livelihood and low payoff influence decisions in a direct, practical sense: farmers are more likely to change practices if their current methods are not profitable, or if they perceive that market prices and consumer demand do not justify continued effort. The consideration of what is "worth doing" often includes the dual lens of economic sustainability and the production of healthy, high-quality food.

4.3 Drivers and factors influencing land-use decision making: the case of Medium-scale farms transitioning to regenerative farming

This section summarises the validation workshop dedicated to medium-scale farms that are either transitioning toward regenerative practices or already experimenting with them in the Sand Ridge region. The discussion brought together five participants, four of them directly involved in farming. In contrast to other tables where experts and land-users were mixed, this group was more cohesive in terms of background. Yet beneath this apparent homogeneity lay substantial diversity in their production systems: some participants manage orchards, others operate livestock-based enterprises, while several focus on no-till or otherwise low-input arable farming on underutilised soils. Their farms share medium scale and an orientation toward ecological regeneration, but differ in resource availability, market exposure and strategic priorities. The following section outlines how they perceived the structural external drivers shaping land-use decisions within this emerging regenerative farming pathway.

The importance of drivers

Although drivers emerged in a non-linear order during the workshop, they are presented here according to their respective categories. Among the external drivers, several stood out as particularly influential. The most critical were shortage of capital, the impact of the global market economy, the role of the European Union as a regulatory power, the combined effects of atmospheric drought and the decrease of soil water level. These drivers were described as shaping both the economic viability and ecological limits of farming in the region. Social pressures such as the heir quitting farming and staff shortage were likewise highlighted as decisive, pointing to long-term structural challenges in generational renewal and labour availability. Biodiversity loss, avian flu, and the appearance of invasive species further underscored the growing ecological vulnerability faced by regenerative-oriented farmers.

Drivers receiving two or one star such as loans, administrative burden, aging, the National Park, or specific climatic stressors like frost damage were seen as relevant but less central. Their influence is uneven: important in certain farm types or years, yet not consistently decisive across the group.

Turning to the internal drivers, participants again emphasised a small number of highly influential factors. Preserving family heritage, the disappearance of the farmstead lifestyle, overwork, learning from experience and learning from each other were described as shaping everyday decision-making as much as external structural conditions. Ecological adaptation strategies

such as conscious breed selection, keeping native animals, change of species and water retention were similarly prioritised, even if the latter was accompanied by the note: *"it would be important, but there is no water."* New approaches, including regenerative agricultural technologies, reflected an openness to innovation within the constraints of local conditions.

Internal drivers marked with two or one star such as helping wildlife, afforestation instead of production, personal memories, or irrigation development were acknowledged as relevant but situational, either dependent on available resources, farm structure or the personal motivations of individual farmers.

Finally, few drivers were identified as not relevant for this group. These included technological development in the conventional sense, financial support for irrigation (due to insufficient water resources investment in such infrastructure is not meaningful), and cost-effective procurement through the global market, which did not align with the scale or production logic of the participating farms, even if the broader effects of the global market were discussed elsewhere and marked with special emphasis and high relevance.

Overall, the discussion revealed that external or structural and personal considerations, aligning in tone with insights from the other groups while reflecting the specific realities of medium-scale farmers shifting towards regenerative practices. One participant also introduced a new driver "human greed" highlighting that behavioural motives can influence land-use choices just as strongly as formal economic or ecological factors.

Links among the drivers, the mindmap

In the second task, participants were asked to organise the identified drivers into groups based on their own understanding of how these factors relate to one another. Unlike in our preparatory work where drivers were synthesised into predefined categories derived from interviews, literature and media analysis we did not provide any structural guidance during the exercise. Instead, the aim was to observe how farmers themselves conceptualise linkages and categories. This approach allowed us to capture their implicit logic of connections, revealing patterns of association that may diverge from expert-derived classifications and offering insight into how they perceive the dynamics shaping land-use decisions.

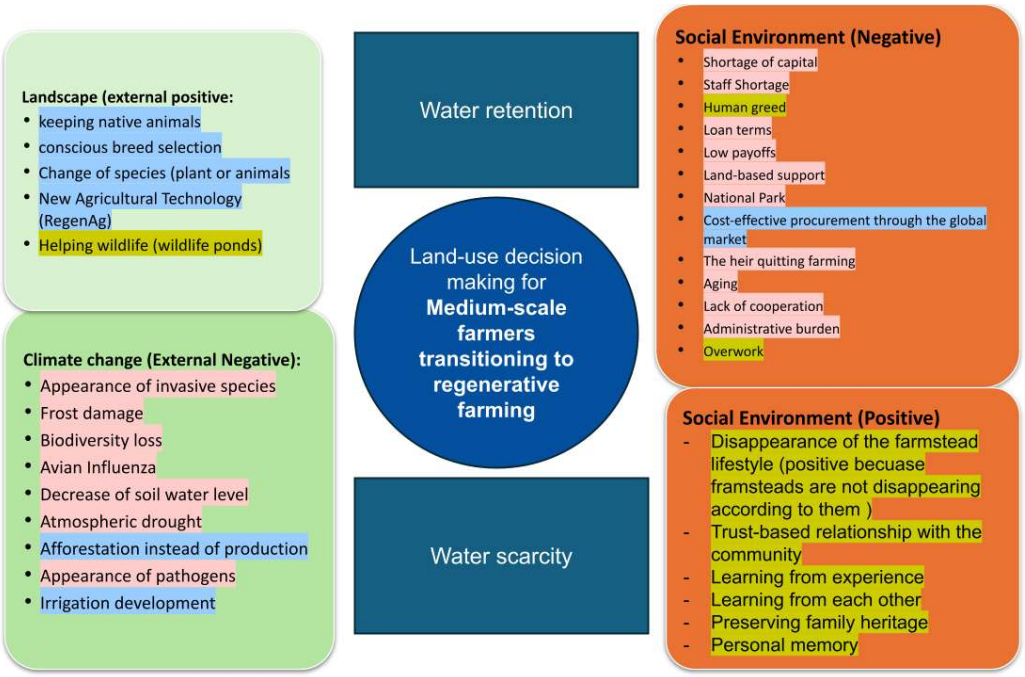


Figure 5: Mindmap for understanding land-use decision making of a medium-scale farm transitioning to regenerative farming on the Sand-ridge (created by participants)

During the grouping exercise, participants first emphasised the need to distinguish between a landscape's interests perspective and a human's considerations perspective, which led them to separate the drivers into two overarching domains: *Natural* and *Social*. A second organising principle emerged from their everyday farming experiences, namely the differentiation between *positive* and *negative* influences. This resulted in four operative categories: Landscape (external positive), Climate change (external negative), Social environment (positive), and social environment (negative). Notably, the two positive clusters closely reproduced the structure of our preparatory categorisation (as also reflected by the colours on the mind-map), whereas the negative clusters showed partial alignment with some meaningful deviations. For example, cost-effective procurement through the global market which we had preliminarily classified under "economic" drivers was placed by farmers within the negative social environment, indicating a different interpretive logic than expert frameworks typically apply. Two drivers were given special prominence and placed as standalone elements: water scarcity, identified as the single most decisive constraint, and water retention, repeatedly raised throughout the discussion despite its limited feasibility. The resulting mind map therefore reflects an ordering principle that is grounded in farmers lived experience.

Most impactful drivers

The last part of the validation workshop was marking the already categorised drivers according to their impact factor. When reflecting on which drivers most decisively shape their own farming practices, participants immediately identified water scarcity as the dominant force. They described it not as one issue among many, but as the condition that connects and amplifies all

others, determining what can be grown, how systems must be adapted, and ultimately whether farming remains viable at all. One participant illustrated this starkly by recounting how all three of his children chose to leave agriculture after witnessing the struggle to maintain the farm. They live in the city now and learned other professions, he and his wife are now considering selling their land and moving to the city as well, a decision he linked directly to the worsening situation connected to water. Although "climate change" had not appeared explicitly on the cards, it surfaced immediately in the discussion, with farmers emphasising the cumulative influence of climate-related pressures: drought, declining groundwater, extreme weather and biological stressors on their everyday decisions.

Technological factors were also regarded as influential, particularly the limits of access to new agrotechnologies. Participants stressed that promising innovations exist yet remain out of reach for medium-scale farms like them due to the high investment costs. As one farmer put it, *"A lot of things are not profitable for a farmer with 100 hectares. I can't buy a 40-million-forint tractor, it wouldn't pay off even for my grandson."* These constraints were further illustrated through anecdotes about invasive species, a topic that became more prominent as the discussion shifted toward personal experiences. In parallel, the role of the global market was repeatedly underlined: price volatility, input costs and market expectations all exert substantial pressure, shaping both what farmers attempt and what they abandon.

Toward the end of the conversation, attention turned to the personal motivational drivers in the social- personal and "positive" corner of the map. Participants acknowledged that this identity, attachment to land, and the satisfaction derived from meaningful work remain essential for sustaining their commitment. Yet they also pointed to the lack of trust and weak cooperation as major obstacles preventing collective action, even though cooperation was broadly recognised as one of the few viable pathways out of their current difficulties.

5 Discussion and Reflections

The Sand Ridge functions as a semi-arid socio-ecological system in which water scarcity is not a temporary disturbance but a structural condition. Its hydrological behaviour is characterised by low buffering capacity, meaning that historical land-use decisions, particularly afforestation and drainage, continue to influence groundwater decline today. This long ecological memory of the area underscores how past policy choices remain embedded in current environmental constraints.

The final Policy Lab meeting reinforced a core insight repeatedly seen in the wider research: water is not just an environmental variable but the principal organising logic shaping how farmers think about land, risk and the future. Participants did not use the vocabulary of climate change, yet their concerns, groundwater depletion, disappearing surface moisture, frost damage, soil desiccation, all point toward lived experience of climatic change. Water was consistently framed as the condition of possibility for farming: its absence dictates what can be grown, its potential

return motivates interest in water retention, and its unpredictability drove a shift away from input-dependent irrigation aspirations, particularly among small and medium scale farmers. While large-scale producers could benefit more from greater irrigation support, it cannot deliver high yields or stable incomes due to limited water availability. In this group, water became the central reference point for adaptation discourse, displacing technological modernisation or market diversification as strategic anchors. This points to high local awareness but limited systemic interpretation of climate dynamics.

Across stakeholders, also the subsidy regime emerged as the most influential behavioural driver, often outweighing agronomic reasoning or ecological pressures. Farmers respond primarily to compliance opportunities rather than to longer-term ecological adaptation, because existing policies favour large-scale production and offer limited incentives for mid-scale farm transformation.

Farming systems in the region are far from homogeneous. Regenerative pioneers exist but represent a small proportion of producers; conventional medium-scale farms dominate economically yet are increasingly vulnerable to drought; meanwhile, traditional mixed smallholders retain ecological flexibility and cultural continuity but operate under significant economic fragility. Traditional mixed smallholders approach land use through heritage, identity and ecological resilience but lack economic stability. Regenerative innovators experiment with systemic adaptation but remain socially marginal and institutionally unsupported. Medium-scale conventional farms hold the largest leverage potential, financially stable enough to innovate, yet structurally constrained by subsidy incentives, ageing demographics and low knowledge circulation. This triangulation reveals that each farm type possesses a different theory of change: smallholders rely on continuity and memory; regenerative farms on experimentation and networks; medium farms on stability and incrementalism. Yet all are equally exposed to water scarcity, and none feel institutionally empowered to initiate collective action; reinforcing water's primacy as a shared risk but not a shared coordination mechanism.

Social and knowledge conditions further constrain adaptive capacity. An ageing farming population, labour shortages, low cooperation and weak knowledge circulation all restrict collective action. Region-specific agronomic knowledge is available in the area, but farmers do not actively seek or exchange it, suggesting a failure of knowledge uptake rather than knowledge production.

5.1 Methodological Reflections

The workshop validation reinforced these insights: it did not contradict earlier classification of drivers, but it sharpened priority relationships, elevating subsidies, knowledge access and cooperation deficits while downgrading biodiversity concerns and invasive species.

Through the workshop, farmers blended the original categories into three intersecting influence fields: water – ecology, governance – subsidy, and cooperation – knowledge. Drivers such as biodiversity loss or invasive species, emphasised earlier in the theoretical framework, were downgraded when confronted with farmers' lived experiences. Conversely, drivers absent or weak in the original model, especially lack of flexible agricultural strategy and knowledge uptake failure, arose as dominant meanings. Rather than contradicting earlier theory, workshops reweighted and relationally reorganised the system, showing water and governance as systemic attractors around which other drivers orbit.

As workshop participants worked in three parallel groups at different tables, we wrote methodological reflections accordingly. The lessons learnt below therefore follow the logic of the three tables, reflecting the distinct dynamics, priorities and forms of knowledge that emerged in each discussion.

Lessons learnt - Conventional medium-scale farms

The workshop was highly dynamic and rich in knowledge exchange, though less linear than originally planned. Participants, including a farmer, advisor and decision-maker, brought deep practical and policy insight, making moderation challenging but productive. Debate often moved beyond validation toward co-construction of understanding, especially when subsidy allocation and legislative responsibility were discussed. For this reason, strict scoring proved unrealistic. Participants were much more interested in explaining drivers than in ranking them. They often rejected simple categorisation and instead elaborated on why a driver matters, how it intersects with others, and under what conditions it becomes impactful. As a result, strict scoring was rarely followed, but the qualitative depth we gained far exceeded what a numeric rating would have produced. Through this process, we were able to capture both high-importance drivers (such as water scarcity, lack of flexible agricultural strategy and poor cooperation) and drivers that were considered relevant but not decisive.

Moderation required flexibility. Rather than asking participants to evaluate each driver individually, we adapted by presenting groups of 6–10 drivers at once, allowing participants to choose what to prioritise, debate or discard. This method worked well, it preserved momentum, engaged participants' expertise, and revealed which drivers naturally drew attention. Where consensus was strong, drivers quickly proved to be both important and impactful; where views diverged, the discussion itself exposed structural tensions and knowledge gaps. The final mind-map therefore reflects not only which drivers matter, but how they became meaningful in conversation.

Lessons learnt – Traditional small holder mixed farms

In retrospect, the workshop did not deliver strict validation in a narrow methodological sense, but it produced something arguably more valuable: a knowledge-rich, co-interpreted framework that aligns well with participants' lived experiences.

An importance - impact analysis shows that only a small number of drivers are simultaneously highly important in everyday small-scale farming and strongly influence land-use

change. These core determinants are water shortage, climate-driven aridification, and the landscape impact of large-scale farmers, indicating that hydrological constraints and external market-structural pressures currently shape both daily practice and adaptation.

In contrast, personal memory, family heritage and health-related motivations are central to why farmers remain active in agriculture, yet they have limited power to trigger land-use transformation on their own. These values sustain continuity rather than push change.

Several drivers have low-importance in this type of farming but still have a high-influence; these could be hidden leverage points. Although less present in everyday thinking, global market forces, lack of cooperation, community action, and information flows can rapidly induce behavioural change when activated or coordinated.

Finally, a broad set of drivers have both low-importance and low-influence, including subsidies, invasive species, succession, and administrative burden. These form the background environment of farming but currently do not determine land use or innovation trajectories.

Lessons learnt - Medium-scale farms transitioning to regenerative farming

The medium-scale regenerative farming group developed a working rhythm that differed from the more linear discussions. Participants frequently moved between focused engagement with the task and moments of storytelling or anecdotes triggered by drivers. We created categories or compare drivers, then an example or memory emerged, which made others to share similar experiences, before the group naturally returned to the main thread of the workshop. This flow characterised the entire session. Rather than interrupting the process, it revealed how closely everyday practice, memory and interpretation are intertwined for the participants.

What became clear through this dynamic is that personal drivers carry substantial weight for these farmers. Their relation to the landscape is direct, emotional and grounded in daily experience, which shaped how they prioritised and explained the drivers. While other tables tended to stay closer to institutional reasoning, here experiential knowledge guided the conversation. Ultimately, this interplay of structured analysis and lived experience enriched the workshop outcome, with a layered understanding of how medium-scale regenerative farmers navigate and make sense of the forces influencing land-use decisions.

What we learned from the process

The final Policy Lab meeting continued a pattern seen earlier in the research: participants were exclusively middle-aged or elderly men. This demographic concentration limited the discussion of personal motivations and identity-related drivers — even though such aspects appeared prominently in media narratives and interviews with other actor groups. Instead of emphasising household-level values or wellbeing aspects, participants focused on landscape characteristics, technological constraints and structural barriers. This suggests that personal drivers are present in the wider system but not articulated by the medium-scale male farmers who dominate decision spaces.

Interestingly, one of the most productive sources of “best practice” came not from the group itself but from media examples: local actors forming a water association to deliberately flood multi-owned fields to increase infiltration and retention. This was recognised as promising, yet such initiatives did not spontaneously emerge within workshop discussions; again, hinting at low self-efficacy and an expectation that solutions must come from outside the farm unit. Participants acknowledged that collective action is valuable but repeatedly described cooperation as impossible, often attributing this to long-standing cultural and historical patterns of distrust.

The Policy Lab activities unfolded in a constructive and respectful atmosphere, but several methodological lessons emerged. Role distribution among facilitators could have been clearer, particularly when group dynamics required redirection. Time pressure occasionally curtailed deeper probing into latent motivations. Moreover, some tables required stronger moderation to keep discussions anchored and ensure all participants engaged, especially when dominant voices steered topics away from driver validation. Overall, the process worked well, but these insights suggest refinements for future sessions, particularly where demographic homogeneity magnifies interpretive blind spots.

5.2 Major Drivers influencing land-use decisions

Based on interviews, four Policy Lab workshops, and a targeted literature review, the analysis identifies a broad set of drivers shaping climate-related land-use change in the Sand Ridge region. These drivers operate across multiple scales and combine long-term structural forces with more immediate pressures that influence farmers’ decisions, production strategies, and adaptation pathways. Rather than acting in isolation, economic, regulatory, social, and climatic drivers interact to redefine what forms of land use are viable and for whom.

Structural external drivers operate largely outside the direct control of land users but fundamentally shape their decision-making environment. These drivers were grouped into four main categories: Market & Technology, Instruments & Policies, Social Environment, and Climate Change. Market and technology drivers are characterised by persistent economic uncertainty, volatile input and output prices, limited bargaining power, and restricted access to capital. These conditions discourage long-term investment, technological renewal, and diversification, reinforcing short-term, risk-averse land-use strategies.

Instruments and policies exert ambivalent effects. Subsidy schemes strongly influence land-use decisions, often favouring land-based payments and afforestation, while innovation-oriented support remains accessible mainly to farms with sufficient co-financing capacity. At the same time, regulatory frameworks linked to EU accession, protected areas, and Natura 2000 designations impose development constraints and increase administrative burdens, particularly for smaller producers. Uniform compliance requirements and frequent inspections contribute to compliance fatigue and disengagement.

The social environment further conditions land-use change through demographic ageing, weak generational renewal, labour shortages, and limited cooperation. Declining livestock keeping, recreational land uses, and concerns over groundwater impacts from past extractive activities also shape local perceptions of land-use risks and opportunities. Climate change intensifies these pressures through increasing atmospheric drought, declining groundwater and soil moisture, extreme weather events, biodiversity loss, and growing instability in crop and livestock systems.

Alongside these structural drivers, land-use decisions are strongly shaped by internal factors rooted in values, knowledge, and lived experience. Personal values such as preserving family heritage, memories of past landscape conditions, and concern for wildlife influence how farmers interpret environmental change and justify their choices. Relations to land, community trust, and collective action shape cooperation potential, while experiential learning and peer-to-peer knowledge exchange guide adaptive practices. Personal constraints—health, ageing, and overwork—limit adaptive capacity, while farm optimisation, resource conditions, economic strategies, and technological choices reflect ongoing efforts to align production with ecological constraints.

Together, the findings show that land-use change in the Sand Ridge emerges from the interaction of external structural pressures and internally mediated responses, highlighting both vulnerabilities and potential leverage points for future adaptation.

5.3 Reflections of the specific context of the decision making

Land-use decision-making in the Sand Ridge is shaped by a distinctive combination of structural constraints, socio-ecological conditions and historically embedded perceptions of agency. Farmers operate in a context where water scarcity functions as a constitutive condition rather than an external shock: declining groundwater, atmospheric drought and soil desiccation define the boundaries of what is considered feasible farming. Decisions are therefore made within a narrow horizon of perceived options, where adaptation is framed less as transformation and more as damage limitation.

A key contextual feature is the strong externalisation of responsibility. Although interviews and prior research highlight the importance of personal values, identity and attachment to land, these motivations rarely surface explicitly in collective settings. Instead, farmers predominantly interpret drivers as external—policy frameworks, subsidies, markets and ecological constraints—and expect solutions to emerge from institutional or technological interventions rather than from collective or individual agency. This orientation is closely linked to historically rooted mistrust and weak cooperation, which continues to limit confidence in joint action despite emerging examples of successful water-retention initiatives.

Scale plays a decisive role in shaping how land and risk are perceived. Farm size not only determines economic viability but also influences farmers' sense of relevance within policy

schemes and their engagement with support instruments. Medium-scale actors, in particular, often perceive existing subsidies as mismatched to their operational reality, reducing their motivational impact and shifting attention toward landscape conditions, soil quality and incremental technical adjustments.

5.4 Policy pathways and recommendations

The analysis confirms that water scarcity is not simply a stressor but a constitutive force shaping decision horizons, risk perceptions and adaptive thinking in the Sand Ridge. The lack of usable water is already altering cropping patterns, pushing producers toward extensive land use, cooperative infrastructure and soil-based retention approaches. Crucially, farmers perceive water as a boundary beyond which neither innovation nor production is possible, making hydrological conditions the most reliable predictor of future land-use change.

In parallel, the report highlights that the subsidy system is the single most behaviour-shaping mechanism, more influential than climate information, agronomy or technology availability. Farmers adjust their actions to align with subsidy logic rather than ecological forecasts, but perceived ineligibility among medium-scale actors also means that these farmers disengage rather than transform. Thus, subsidies act as both incentive and exclusion mechanism, determining who can participate in innovation and who internalises stagnation.

When considering the three farm types, the research suggests that their capacity for change is differentiated not by awareness but by structural positioning. Smallholders possess adaptive culture but lack capital; regenerative farms possess vision but lack institutional traction; medium-scale farms possess potential but lack enabling policy frameworks. Collectively, workshops showed that the initial deductive model of drivers underestimated this differentiation and overestimated climate-awareness discourse, while participant-led modelling elevated governance, cooperation deficits, and hydrological constraints as systemic levers.

Cooperation and knowledge circulation appear to be the most underused but potentially powerful drivers of change. The findings indicate that technological availability is not the primary barrier; rather, it is the lack of mechanisms that enable farmers to learn, organise and act collectively. To support transition, interventions should therefore prioritise four strategic entry points: strengthening water retention capacity; increasing flexibility and relevance within agricultural policy; enhancing cooperative structures and trust between actors; and activating region-specific knowledge exchange systems.

Overall, the results point toward a dual transformation agenda: hydrological stabilisation and governance redesign. Water retention, flexible and inclusive subsidy arrangements, cooperation platforms and knowledge circulation emerge as the actionable pathways. The reflection remains valid: solutions are not absent in the region, the conditions for mobilising them are. Future practice, research and policy must therefore focus not on generating more

drivers or technologies, but on enabling farmer agency, fostering cooperation, and redesigning subsidy mechanisms that unlock adaptation rather than merely reward scale.

The discussion revealed that farmers hold deep contextual knowledge but often externalise responsibility, expecting solutions to arrive through policy change rather than collective agency. This diversity illustrates that adaptation potential exists within the system, although it is unevenly distributed and conditioned by institutional and financial factors.

Appendix

In the appendix we provide the list of drivers, notes and photos from the validation workshop as well as the original mindmap filled out by us based on the interviews and workshop for each farm type.

Appendix 1: List of the drivers

List of structural external drivers

Categories	Drivers	One-sentence definitions
Market & technology	Low payoff	The return on agricultural activity is uncertain and low.
Market & technology	Loan terms	Credit terms are difficult to understand and difficult for farmers to meet.
Market & technology	Shortage of capital	Farmers do not have sufficient capital.
Market & technology	Livelihood	Agriculture does not provide adequate income.
Market & technology	Impact of the global market economy	Input materials are constantly becoming more expensive, while the prices of agricultural products fluctuate unpredictably.
Effects of subsidies	Support for afforestation	Support schemes directly influence the types of crops farmers plant, such as forests or vineyards.
Effects of subsidies	Support for native species	Subsidies linked to native species encourage their preservation, but strict controls make it difficult for farmers to operate.
Effects of subsidies	Land-based support	Land-based subsidies strongly influence farmers' decisions because they represent significant income for large areas, while limiting opportunities for change.
Effects of subsidies	Support for technology development	Farmers rely on technological development subsidies to replace their old machinery with modern, more efficient equipment.
Effect legislation	European Union	The introduction of EU regulations and subsidies has fundamentally transformed the functioning of the market
Effect legislation	National Park	National Park regulations severely restrict farmers' freedom of action, for example, they cannot buy land, only lease it, which puts them on a forced path.
Effect legislation	Natura 2000	The Natura 2000 regulations restrict the use of the land because farmers cannot build facilities and certain activities are prohibited due to landscape protection regulations.
Administrative burden	Administrative burden	Excessive administration and rigid rules place a significant burden on farmers, especially because small and large farms are

		treated equally and are subject to an increasing number of controls.
Social environment	Aging	Due to the aging of the farming community, fewer young people are entering agriculture because they are not attracted to a difficult and uncertain livelihood, so there is no one to take over family farms.
Social environment	Lack of cooperation	The lack of cooperation and solidarity among farmers weakens the representation of their interests and joint action.
Social environment	Recreational animal husbandry	Non-commercial animal husbandry.
Social environment	Land use practices of large-scale farmers	
Social environment	Oil wells	Previous test drillings may also have had a detrimental effect on groundwater.
Social environment	Influence of local residents	Local people have little influence over land use issues.
Social environment	Young farmer taking over the farm	
Social environment	Staff shortage	Unable to find workers for a range of activities.
Social environment	The heir quitting farming	
Climate change	Appearance of pathogens	Due to warmer winters, pathogens and pests are no longer destroyed, so they appear earlier and in greater numbers, directly influencing farming decisions.
Climate change	Appearance of invasive species	Climate change and lack of cultivation make it easier for invasive species to take over and displace native vegetation.
Climate change	Frost damage	Extreme spring frosts have become more frequent, regularly destroying blossoming orchards, thus fundamentally influencing cultivation decisions and species selection.
Climate change	Avian influenza	The regular recurrence of avian influenza has crippled livestock farming for a long time, making farming unpredictable.
Climate change	Atmospheric drought	Due to atmospheric drought, precipitation simply "disappears" over the region, so the landscape cannot absorb or retain moisture, which severely hinders farming.
Climate change	Biodiversity loss	The decline in species and habitat diversity weakens the ecosystem and makes farming more vulnerable.

Climate change	Inland water	The presence of groundwater used to cause problems in farming, but now it is its absence that causes problems.
Climate change	Decrease of soil water level	Due to the persistent decline in the groundwater level, the landscape is unable to retain water, so surface precipitation disappears quickly and farming activities start with a greater water shortage year by year.

List of personal drivers (motivations and values)

Categories	Drivers	One-sentence definitions
Personal values	Preserving family heritage	It expresses a connection to a place and land that spans generations, which is why land use decisions are often guided by family tradition and heritage preservation.
Personal values	Personal memories	Personal memories are a motivating factor, stemming from people's recollections of their childhood, when there was still water in the landscape.
Personal values	Helping wildlife (wildlife ponds)	Action in response to the suffering and destruction of wildlife, with the aim of changing the situation.
Relation to land	Habitat protection	It describes the intention to preserve ecological values and biodiversity when land use decisions are motivated by the protection of living organisms and the maintenance of habitats.
Relation to land	Disappearance of the farmstead lifestyle	It marks the decline of the traditional, landscape-adapted farmstead lifestyle, which is linked to the spread of industrial agriculture and the loss of local ecological knowledge in land use decisions.
Relation to community	Trust-based relationship with the community	It emphasizes the role of community trust and local relationships in land use decisions, where shared values and mutual cooperation are key.
Relation to community	Community action	It shows the power of community action and cooperation when locals respond together to changes that threaten the landscape and wildlife, and work together to find solutions to environmental problems.
Knowledge	Learning from experience	It refers to learning from practical experience, where land use decisions are shaped by knowledge gained from one's own mistakes and observations.
Knowledge	Learning from each other	It highlights the role of learning from and inspiring each other, where land use decisions are influenced by successful local examples and good practices of others.

Personal reasons	Health reasons	Physical strain and health limitations can directly influence land use decisions, for example, leading to the abandonment or conversion of certain activities such as livestock farming.
Personal reasons	Overwork	It refers to limitations arising from overload and lack of time, when land use decisions are influenced by the farmer's inability to maintain multiple activities simultaneously.
Farm optimization	Conscious breed selection	Switching to animal and plant species that are adapted to climatic changes.
Farm optimization	Keeping native animals	This means giving preference to native species, because, in the farmer's experience, they are more resistant and require less external intervention.
Farm optimization	Source of information	
Use of biophysical resources	Poor soil quality	Poor soil quality fundamentally determines land use options, as low crop yields make it almost impossible to make a living from crop production.
Use of biophysical resources	Overuse	Overused areas cause water management to deteriorate, so uncultivated, water-retaining areas are needed.
Use of biophysical resources	Dryness of the Danube-Tisza floodplain	The water conditions of the Danube-Tisza floodplain determine water retention in the Sand Ridge region, so land use decisions depend on the management of the floodplain.
Use of biophysical resources	Afforestation instead of production	Instead of production, it is better to reforest, as the arable land is not viable due to water shortages.
Use of biophysical resources	Water retention	This indicates the need to retain existing water resources.
Economic optimization	Cutting costs by reducing soil cultivation	Reducing soil tillage lowers costs without compromising crop yields.
Economic optimization	Direct-from-farm sales/alternative supply chains	The producer sells directly from home to avoid price manipulation by wholesalers.
Economic optimization	Cost-effective procurement through the global market	He sources the necessary raw materials from the global market and always buys at the most favorable price.
Farm technology	Irrigation development	The producer switches to more efficient irrigation technology in order to manage with less water loss.

Farm technology	Organic fertilization	The farmer prefers organic fertilization to improve soil condition and reduce fertilizer use.
Farm technology	New agricultural technology (RegenAg)	The farmer is using new, non-tillage technologies because they result in better water retention and humus formation in the soil.

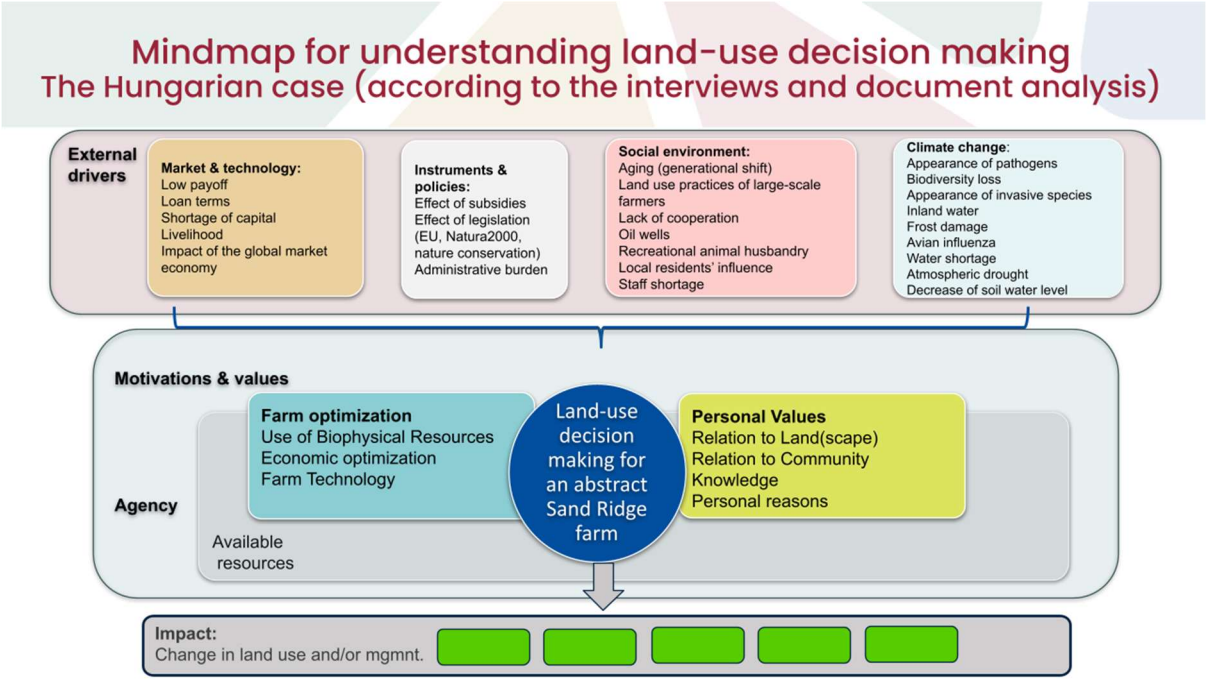


Figure 6: Mindmap for understanding land-use decision making: The Hungarian case (according to the interviews and document analysis)

Mindmaps of the 3 Farm types (based on the interviews & workshop, created by the research team):

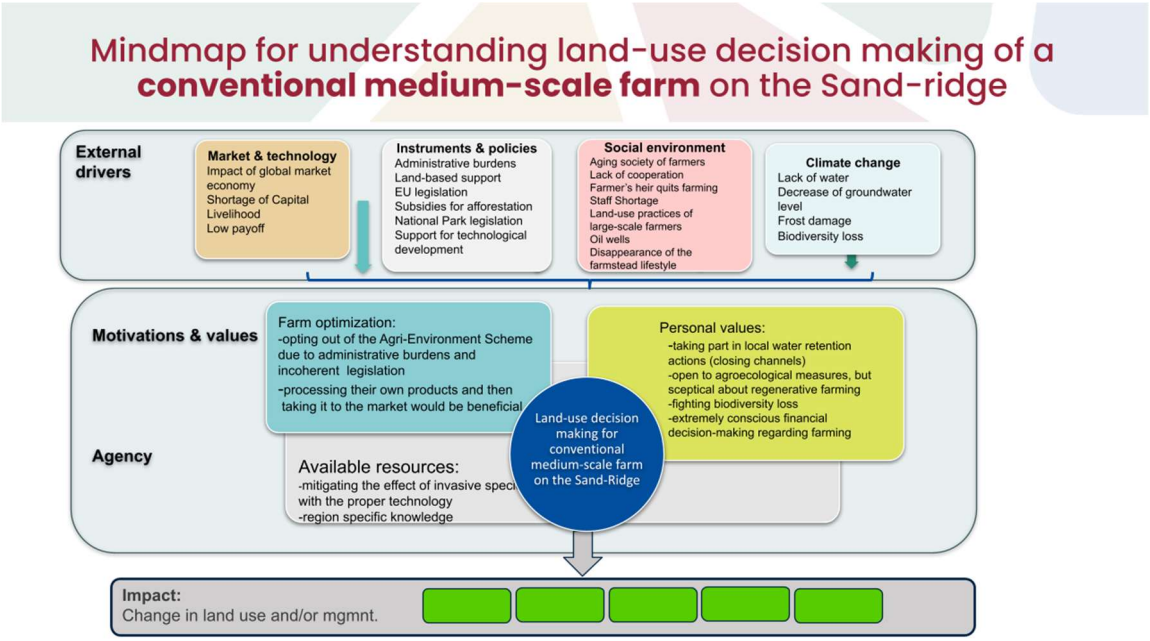


Figure 7: Mindmap for understanding land-use decision making of a conventional medium-scale farm on the Sand-ridge

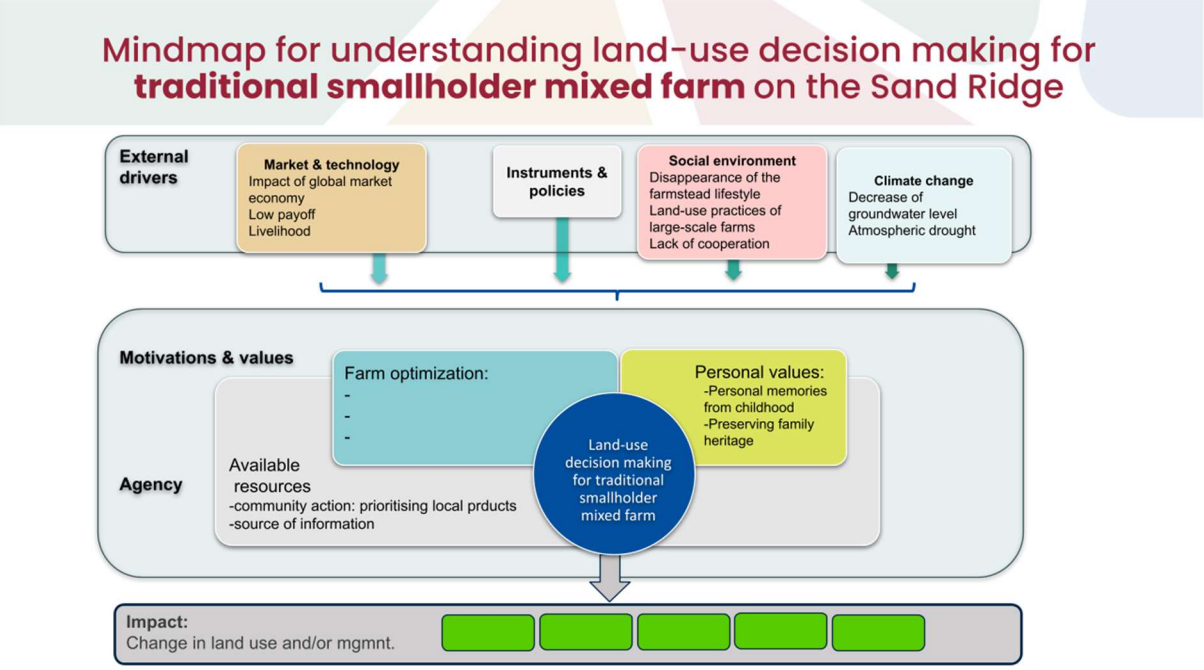


Figure 8: Mindmap for understanding land-use decision making of a traditional smallholder mixed farm on the Sand-ridge

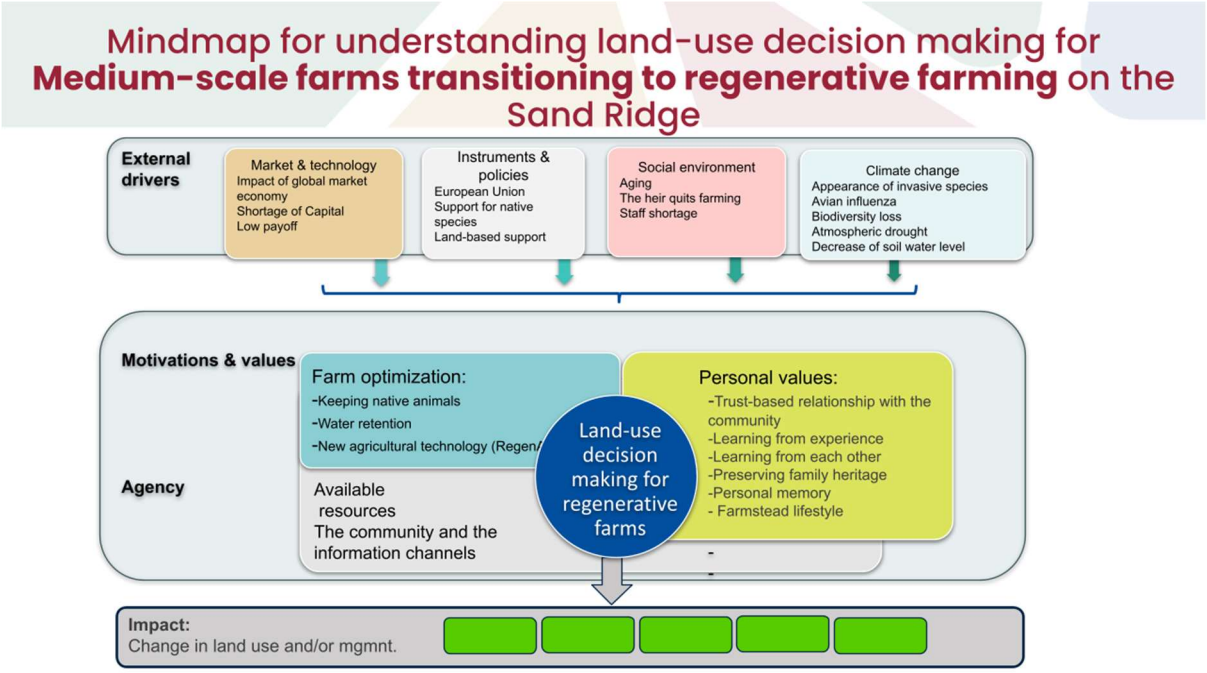


Figure 9: Mindmap for understanding land-use decision making of a medium-scale farms transitioning to regenerative farming on the Sand-ridge

Appendix 2. Notes from the validation workshop conducted as part of the 5th policy Lab meeting, on the 19th of November 2025.

1stValidation group: Medium-scale farms transitioning to regenerative farming

Members of the group

Farmer1: Is a regenerative, no-till farmer who cultivates a diverse range of legumes and continually experiments with new species to adapt to changing conditions. He applies advanced regenerative farming practices and is an active member of the regenerative farming association.

Farmer2: Kiskunok a Vízért Association founder and member, farmer who has recently given up agricultural activities because of the water scarcity and low payoff. Active member in organising the community.

Farmer3: Has a dynamic way of thinking, drawing on his background as a teacher and his experience in municipal politics. He primarily manages orchards he is familiar with a wide range of farming activities.

Farmer4: He also has a background as a teacher and plays an active role in community organisation. He is primarily a livestock farmer but maintains a broad and diverse set of agricultural interests. Interested in no-till and regenerative practices.

Expert1: He is a sociologist, social worker and recognised as an expert on traditional farmsteads. As an active member of the local community, he contributed thoughtfully to every discussed topic.

During the workshop the farmers connected their responses to their own farming experience and practices, such as the expert who is familiar with traditional farmstead practices.

Overall group dynamics

The group engaged with enthusiasm from the outset, creating a lively and open atmosphere that sustained the discussion throughout. Their exchanges frequently moved between focused discussion and anecdotal storytelling, reflecting a natural way of articulating challenges and making sense of complex issues. At times they drifted into extended narratives, yet they consistently returned to the guiding questions with clarity and intention. We, as organisers, allowed space for these stories, recognising that this oscillation between personal experience and structured reflection supported a deeper and more grounded understanding of the drivers under discussion.

2nd Validation group: experts & farmer – conventional medium-scale farming

Members of the group

Farmer: older farmer with political affiliation in the past and a degree in agricultural engineering. His farm is 50 hectares, he describes it as complex farming (livestock and crop farming), with an open attitude towards agroecological farming techniques.

Expert1: retired farmers' advisor of the Hungarian Chamber of Agriculture who worked in the Sand-ridge region

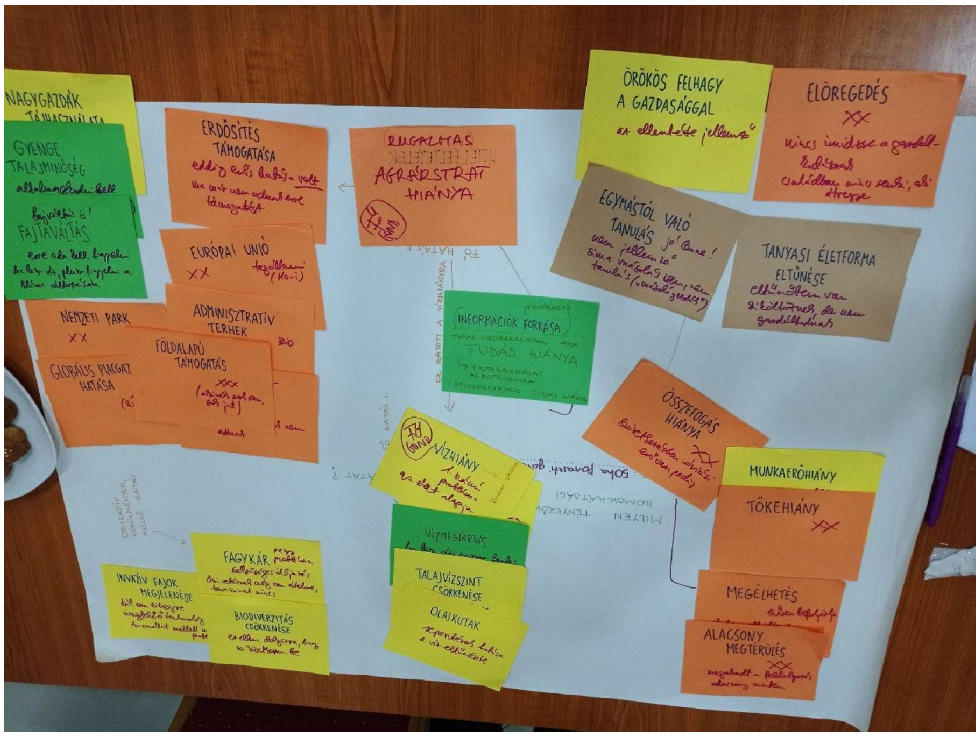
Expert2/Decision-maker: member of BirdLife Hungary, oversees and takes part in legislative processes (such as agricultural state subsidies)

Expert3: member of WWF Hungary

During the mindmap task the idea was that the group will focus on the perspective and experiences of the farmer in the group, discussing the drivers from a point of view of that farm type.

Overall group dynamics

Being grouped together provided a great opportunity for discussion between the farmer and experts that they were eager to exploit, therefore the focus often shifted from the land-use of the group's specific farm type towards discussing matters of wider agricultural issues. The farmer and Expert2 lead the group discussion, often disagreeing on the topics, Expert1 sharing personal experiences and stories from his past as an active farmers' advisor, and Expert3 taking an observatory stance.



3rd Validation group: small scale farmers

Members of the group

Participants: Farmer 1.: traditional smallholder mixed farm (less than 1 hectares), also an employee of the county council, as climate referent

Farmer 2. elderly vineyard owner (1 hectare, other 4-hectare former vineyard, now abandoned land)

Expert: member of WWF Hungary

Local cultural referent

Discussed farm type: small-scale mixed family farm (or traditional smallholder mixed farm), with ~5000m2 arable land, goats, cows, poultry, orchards and some grassland producing vegetables, fruits and dairy products for self-provisioning and sale.

Overall group dynamics

The group worked effectively despite meeting for the first time, quickly focusing on the selection of the farm type and completing the mind-mapping exercises with clarity and engagement. Participants were familiar with the smallholder mixed farms under discussion, which enabled a productive assessment of the drivers

influencing land-use decisions. the discussion was slightly dominated by one of the farmers, but still the other farmer, and the cultural referent of the settlement had some words. The expert defined this role, as an observatory role.

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