

Regional development in the context of major infrastructure projects: participatory processes, governance challenges, and patterns for success

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Abstract.

This article addresses questions of institutional anchoring, coordination and participatory approaches with a comparative, case-based examination of regional development practices in selected large-scale infrastructure projects. It draws on four case studies – the expansion of Frankfurt Airport, the decommissioning of the Asse II mine in Germany, the Swiss sectoral plan procedure for deep geological repositories, and the Swedish repository siting process – as it draws on four case studies constellations that serve as examples of how regional development is institutionally and procedurally designed in practice. The case studies are used to abstract typical instruments, actor constellations, and modes of interaction between formal planning, participation, and informal regional development approaches. Based on a cross-case synthesis, the article identifies recurring challenges and patterns of success.

1 Introduction

The integration of regional development perspectives into the planning processes of large-scale infrastructure has emerged as a critical requirement in cases of high societal controversy. The siting of deep geological repositories for highly radioactive waste is an especially complex and contested planning challenge. It combines demanding technical and safety requirements with profound societal questions about procedural justice, concerning how decisions are made and who is involved, as well as distributive justice, concerning how burdens and benefits are allocated. In Germany, the Site Selection Act (*Standortauswahlgesetz*, *StandAG*) reflects this dual character: alongside geological and safety criteria, it establishes a set of instruments explicitly designed to integrate the socio-economic concerns of affected regions into the siting process. These include socio-economic potential analyses, regional conferences, regional development concepts, and site agreements (StandAG (2017) §10 (4), instruments that together signal a recognition that the region hosting a repository carries a permanent burden on behalf of the entire country (Endlagerkommission, 2016).

Yet the question of how participatory regional development can be effectively designed and implemented in such contexts remains insufficiently understood. Two bodies of literature that are directly relevant to this challenge, research on participatory governance and research on regional development, have largely evolved in parallel, without systematic integration. Studies on

public participation in infrastructure planning have focused primarily on procedural conditions for acceptance and legitimacy, while regional development research has for a long time concentrated on economic potentials. The link between the two questions of how participatory processes can be designed to actively enable regional development, and how regional development in turn shapes the conditions for legitimate participation, has received comparatively little attention.

35 This article addresses this gap through a comparative, case-based examination of regional development practices in four large-scale infrastructure contexts: the expansion of Frankfurt Airport, the decommissioning of the Asse II mine in Germany, the Swiss sectoral plan procedure for deep geological repositories (*Sachplan geologische Tiefenlager*), and the Swedish repository siting process. These cases were selected as illustrative examples constellations that vary in national context, legal framework, societal contestation, and institutional design, while sharing the common challenge of governing regional development under
40 conditions of contested infrastructure. A comparative case study approach is particularly suitable, as it enables the identification of recurring patterns across diverse contexts without forcing generalization. While the empirical findings are derived from three case studies in the context of Radioactive Waste Management (RWM) and one airport expansion their insights are transferable to other contested infrastructure contexts.

The article is guided by two research questions. First, which institutional and procedural designs of participatory regional
45 development can be identified across these cases? Second, which recurring patterns – in terms of success factors, enabling conditions, and risks – can be derived from these experiences and translated into actionable insights for future processes?

2 Regional development in large infrastructure planning

2.1 Conceptual considerations regarding the delineation of a region and the identification of its endogenous potentials

Infrastructure development does not occur in an institutional vacuum. Instead, it unfolds in regions with pre-existing structures.
50 This raises the question of what constitutes a region and how it develops over time. The term region is inherently open, complex, and subject to change over time (Tretter, 2017; Ermann et al., 2022). A region generally is described as a geographically connected space (Maier et al., 2012; Pizzera, 2015; Chilla et al., 2015; Clair, 2023), without a universally valid approach to its definition. Regions are often regarded as historically evolved units shaped by cultural, economic and natural conditions. They may emerge independently of administrative borders and serve as an identity forming framework (Tretter,
55 2017; Scharff, 1993; Groth & Sutter, 2016; Pizzera, 2015). In terms of how regions are characterised, three different approaches can be distinguished: The *essentialist approach* seeks to identify a purported essence of a region through observable phenomena such as dialects or architecture. The *positivist approach* attempts to empirically measure a region via quantitative data. In contrast, the *constructivist approach* emphasizes that regions are socially produced and attempts to understand how natural, economic, socio-cultural and political conditions and processes shape regional formations (Chilla et al., 2016; Kühne,
60 2015). Correspondingly, regions can be delineated based on three principles: *homogeneity* (shared structural characteristics),



functionality (interactions and interdependencies) and *administrative* (boundaries of municipalities or districts) (Baier, 2012; Brensing et al., 2022).

In debates on spatial planning and site selection, the formation of regions may therefore present challenges. Geologically defined areas or administrative planning boundaries do not necessarily coincide with areas of perceived affectedness or socially constructed spaces such as urban or rural areas. Moreover, multilevel governance systems involve different administrative institutions with planning and approval responsibilities. The aim of this study is to identify the concepts of regions and their boundaries that have proved useful and applicable in practice.

2.2 Regional development as a planning and governance task

No universally accepted understanding of regional development exists: It is a socially constructed and dynamic concept, depending on the objectives, which evolve in response to changing societal priorities and visions (Chilla et al, 2016; Pike et al., 2007). From an analytical perspective, regional development seeks to engender socio-economic processes within spatial units, whereas in normative terms it aims to improve socio-economic and environmental conditions and qualities within these units (Chilla et al., 2016). Similarly, regional development can be understood as an attempt to address regional problems by mobilizing locally available potentials while taking regional particularities into account (Maier et al., 2012; Rodriguez-Pose & Wilkie, 2017).

Historically, regional development has mostly been framed in economic terms. Early approaches focused primarily on promoting economic growth, increasing income levels and creating employment, often with the aim of reducing disparities between prosperous and lagging regions (Pike et al., 2007). While the creation of equivalent living conditions remains a central objective, the scope of regional development has broadened considerably. Contemporary debates increasingly emphasize goals such as social inclusion and cohesion and have shifted the focus from regional weaknesses towards the activation of strengths and adaptive capacities (Hummelbrunner et al. 2013). This shift has been accompanied by a transformation from a more hierarchical and state centred steering of regional development toward cooperative planning approaches. These approaches aim to create enabling environments for bottom-up networks and to integrate regional development more effectively into the multilevel governance systems (Heintel, 2018).

Here, Clair (2023) conceptualizes sustainable regions as places where people can continue to live over the long term because employment opportunities exist, basic needs are met, environmental conditions remain healthy and inhabitants experience a sense of belonging. From this perspective, regional development aims to sustain regions over time, for example, by stabilizing population levels and fostering innovation. Achieving this requires collaborative and vision driven processes and capacity building for both human capital and institutions (Clair, 2023).

As a planning and governance task, regional development relies on a range of instruments, that can broadly be categorized as legal and planning related, financial and persuasive (Chilla et al., 2016). Legal and planning instruments are primarily embedded in systems of spatial planning and territorial governance, which establish regulatory frameworks for land use and coordinate spatial development across governance levels. Financial instruments include funding programs, subsidies and



targeted investments designed to stimulate economic development or support structural transformation. Persuasive instruments
95 focus on coordination, strategic vision building, promotion and participation (ibid). To better understand the institutional
setting in which large-scale infrastructure projects are planned, the following paragraphs will briefly outline the instruments
used at different levels of governance, with a particular focus on Germany, where two of the case studies examined in this
study are located.

2.3 Formal anchoring and informal networks and institutions of regional development in the planning system

100 While EU spatial planning lacks binding instruments¹, its influence is indirectly exerted through a range of overlapping legal
frameworks and sector policies with spatial implications, such as Natura 2000 (Chilla et al. 2016) or financial mechanisms like
the LEADER Programme (Brensing et al. 2022).

The main legal and statutory competences therefore lie at the level of the Member States, which pursue different approaches
to governance. According to Chilla et al. (2016) and Giacometti & Lange Scherbenske (2015) planning traditions in Europe
105 can be understood as a continuum characterised by different allocations of authority across governance levels. In Scandinavian
countries, for example, spatial planning is largely organized around strong municipal mandates, while the national level plays
a comparatively limited role. In contrast, the so called “Napoleonic” planning tradition, found in countries such as France,
Italy, Spain, and Portugal is characterised by a dominant role of the national state combined with comparatively strong
municipalities. The United Kingdom and Ireland are often associated with a lower degree of institutionalization and a stronger
110 role of nationally oriented planning approaches. Many Eastern European countries are similarly characterized by more
centralized governance structures, while their legal systems are still undergoing transitions. The “Germanic” planning cultures
found in federal systems such as Germany, Austria, and Switzerland are characterised by decentralized structures that assign
significant roles to all governance levels, including the regional level, thereby requiring coordination and horizontal
governance.

115 In Germany, the vertical coordination of spatial governance is structured by the counter-current principle (*Gegenstromprinzip*).
As outlined in the Federal Spatial Planning Act, planning processes at various governance levels are required to be mutually
responsive. Higher-level plans are providing a strategic framework, while regional concerns must be given consideration
within higher-level planning processes. Primary responsibility for planning lies with the federal states, as stipulated in the
Federal Spatial Planning Act, which establishes the framework for their planning systems. However, the federal level retains
120 limited sectoral competencies, for example in maritime spatial planning and large-scale infrastructure.²

¹ The European Spatial Development Perspective (ESDP), an informal document adopted in 1999, provides a comprehensive
overview of territorial trends and a differentiated set of common objectives (CEC, 1999). The following process leading to the
Territorial Agenda 2030 produced another strategic document aimed at promoting territorial cohesion by creating equivalent
living conditions (Territorial Agenda 2030, 2020).

² In addition, two joint tasks enshrined in the German Basic Law form the core of federal and state level cooperation in regional
development policy: the Joint task for the improvement of regional economic structures (GRW), which focuses on

At the state level, spatial development is formalized through state development programmes or plans. Federal states are subdivided into distinct planning regions, which are overseen by higher regional planning authorities. These authorities employ a range of instruments such as regional plans and, in certain instances, spatial impact assessments to evaluate the territorial compatibility of major projects (Chilla et al. 2016). At the municipal level, legally binding land-use planning (*Bauleitplanung*) is implemented in two stages. Preparatory land-use plans define general land use categories and bind public authorities. Subsequently, local development plans (*Bebauungspläne*) regulate land use and building rights at the parcel level. In addition to these formal instruments, numerous informal and persuasive processes exist at the regional and local levels. At the beginning of the 1990s, for example, local agenda processes were initiated, and similar processes continue to influence regional development to this day by linking regional quality of life with global sustainability concerns. Other initiatives support clusters or regional value chains and promote the concept of metropolitan regions and functional soft spaces³, for instance through connected/integrated transport systems (Chilla et al. 2016).

2.4 Objectives to be achieved by regional development in the site selection process for large infrastructure projects

When large infrastructure projects are implemented, whether transport routes, energy supply facilities or disposal sites, nearby locations often bear the burden for areas located further away. This is particularly evident in the case of the search for a site for a final repository for highly radioactive materials, where one region ultimately carries the long-term burden for the entire country (Brunnengräber, 2019). This raises questions of procedural justice, which calls for a fair decision-making process that allows affected regions to contribute their interests (Cotton, 2018), as well as distributive justice, which requires that disadvantages resulting from facilities be adequately compensated (Drögemüller, 2018). The objective for regional development therefore is to assess what characteristics and potentials constitute the region to get an idea which disadvantage might need to be compensated (Endlagerkommission, 2016). These potentials are understood as a broad set of factors, that include structural, economic, and natural characteristics as well as mental factors concerning the wellbeing of the population, identification and attractiveness for visitors (Sperfeld et al. 2025; OECD 2022). According to the literature on successful strategies for regional development it is essential to build on the regional specificities and endogenous resources to ensure long-term sustainability and self-sufficiency (Maier et al., 2012). To strengthen resilience and the employment opportunities, strategies aimed at economic diversification and targeted specialisation are recommended (ArL Leine-Weser, 2016; Otto & Werner, 2022). Regarding governance structures, the active involvement and stable cooperation structures of regional actors are considered crucial. Successful approaches combine long-term strategic visions with governance structures that enable the representation of key stakeholders and legitimize the allocation of resources, while avoiding excessive steering and preserving flexibility (SECO, 2014; ArL Leine-Weser, 2016; Knieling et al. 2001).

economically weaker regions, and the Joint task of the improvement of agricultural structures and coastal protection (GAK), which primarily supports rural and agricultural development and forms the basis for various funding schemes.

³ Soft spaces are temporary functional regions (Brensing et al., 2022), characterized by open, overlapping boundaries and governance structures (McClelland & Shaw, 2024).



150 **2.5 Hypothesis on enabling conditions**

Based on the literature on participatory regional development, we develop a set of hypotheses that operationalize the insights gained and examine them through the following case studies. These hypotheses serve as heuristic propositions for comparing the case studies and guiding the search for cross-case patterns rather than establishing universal causal relations.

- 155 1. *Regional definition*: Regional development processes are more legitimate and stable when stakeholders are involved in defining the delineation of the region affected and when existing governance structures are effectively integrated in the resulting spatial framework.
2. *Learning processes*: Because regional development processes rely heavily on human interaction and cooperation, they are more effective when they actively promote capacity building and incorporate adaptive learning processes as well as ongoing evaluation.
- 160 3. *More than compensation*: Regional development gains stronger acceptance when long-term structural investments are combined with flagship projects that generate visible short-term benefits, whereas purely financial compensation tends to have limited legitimacy.
4. *Transparency*: Regional cohesion and trust depend on a transparent governance framework that clarifies opportunities for participation and ensures a proportional and balanced distribution of development projects across the region.

165 **3 Analytical framework and methodological approach**

Case selection follows established principles of comparative case study methods (Gerring, 2008; Seawright & Gerring, 2008; Paparini et al., 2021; Bartlett & Vavrus, 2017), guided by four selection criteria: variance maximization across procedural status, societal contestation, and infrastructure types; comparability of spatially significant large-scale infrastructure processes within societal negotiation; coverage of all process phases, from planning and site search to completion; and consideration of case-specific governance and contextual dimensions.

170 The case studies are structured along an Input-Throughput-Output/Outcome-Impact (ITO/OI) framework, building on Easton's (1965) foundational systems model and subsequent adaptations (Kelly et al. 2024; Schwerdtner et al. 2015). This framework was chosen for its clearly structured analytical grid to decompose complex processes into operationalizable dimensions and to identify key relationships and effects without overburdening analysis with legal or institutional detail.

175 Desk research findings informed the design of semi-structured expert interviews. In each case study six to eight interviews were conducted with key actors involved in the development, implementation or accompaniment of the respective infrastructure project and its regional development processes. Interviewees represented diverse institutional roles and governance levels, including project operators, regional development bodies, municipalities, civil society organisations, and academic experts (App A).⁴ Interviews were conducted via digital platforms and were recorded with the participants' consent.

180 Transcripts were analysed using qualitative content analysis (Mayring 2010, Rädiker & Kuckartz 2019) in MAXQDA,

⁴ The table in Appendix A contains an anonymised list of interviewees, including their roles in the process and an ID.



185 applying a combined deductive-inductive coding procedure. Main categories and primary subcategories were derived deductively from the ITO/OI framework and the interview guide (App B); additional subcategories were developed inductively from the empirical material to capture case-specific characteristics. Intercoder reliability was ensured through a jointly developed coding scheme, iterative coding cycles, and regular editorial meetings. Qualitative findings were triangulated with available secondary data, like regional statistics, monitoring reports or regional development concepts and continuously cross-checked against documentary sources to identify convergences, contradictions and complementary perspectives. In the final synthesis step, case-level findings were compared and integrated with the theoretical groundwork established in the preceding literature review.

4 Case-based insights into regional development practices

190 4.1 Germany: Expansion of Frankfurt Airport

Case introduction & context

The expansion of Frankfurt Airport, particularly the construction of the *Startbahn West* in the 1980s, triggered fierce resistance and riots. After Fraport AG, the airport operator, announced a further expansion of the airport in 1997 – the construction of a new runway in the northwest, the *Landebahn Nordwest* – the Hessian state government initiated a mediation process (1998–
195 2000) which concluded in recommendations for an anti-noise pact, a ban on night flights, the capacity expansion of the airport, and the optimisation of the existing system as well as the establishment of a Regional Dialogue Forum (*Regionales Dialogforum, RDF*). It later evolved into the Airport and Region Forum (*Forum Flughafen und Region, FFR*), a non-statutory body designed to accompany formal approval procedures and facilitate dialogue among stakeholders (FFR 2026b).

Participation institutions and formats for regional development

200 The Aviation Act stipulates that an Aircraft Noise Commission (*Fluglärmkommission, FLK*) – a statutory body – has to be set up at any airport with scheduled flights and noise protection areas (*Lärmschutzbereiche*) (Fluglärm-Portal 2026). An FLK was therefore established at Frankfurt Airport in 1966. The FLK consists of representatives from communities affected, aircraft noise protection officers (*Fluglärmschutzbeauftragte*), airlines, and airport operators. The commission advises the authorities on measures to protect against aircraft noise and air pollution. This includes commenting on proposals for or changes of flight
205 routes and making recommendations. FLK members work closely together with FFR members as some members hold positions in both bodies (Administration_Frankfurt_ID2; Coordination_Frankfurt_ID3; Participant_Frankfurt_ID4; Coordination_Frankfurt_ID6).

The establishment of the FFR is unique nationally as there is no other airport region where a non-statutory body has been brought to life in addition to the statutory body. It has created an opportunity to examine the airport region, to work together
210 to develop measures, to monitor and discuss the negative impacts, and to strive for improvements together. The FFR therefore consists of five committees with different areas of responsibility, bringing together various stakeholders from administration



and politics, business and the aviation industry, and the public.⁵ For example, the ExpASS is responsible for developing and evaluating noise reduction measures and provides technical assessments regarding flight route changes to the FLK. The UNH, meanwhile, operates as an information and monitoring centre. As part of its in-house exhibition⁶ it informs the public about various topics related to Frankfurt Airport with a focus on presenting facts, but also including the opinions of individual stakeholders. However, the reach and reception of this offer is considered to be limited (Coordination_Frankfurt_ID3). Though, one powerful tool introduced by the RDF and maintained by the FFR is the Frankfurt Aircraft Noise Index, which provides a separate assessment method alongside the legally determined designation of the noise protection area. Over the past two decades, various studies on noise, the environment, and health, as well as a social monitoring, have been conducted to observe the different impacts of the airport operations. While the NORAH study (“Noise-Related Annoyance, Cognition, and Health”) focused on the effects of noise on the residents in the airport region (UNH 2015), the social monitoring examined the social, economic, and spatial effects of the airport in terms of positive and negative impacts (UNH 2026a), and the ultrafine particles (UFP) studies have been taking a close look at the pollution and effects of ultrafine particles on the residents in the airport region (UNH 2026b). This ongoing monitoring system enables a review of the impact of the airport operations. It is a reactive, sectoral monitoring system.

Results and impacts

To compensate for the negative effects of the airport, financial instruments are implemented. The Regional Fund Act (*Regionalfondsgesetz*) offered, between 2012 and 2017, promotion and financing of passive noise protection and sustainable municipal development of affected municipalities in the airport region. It was introduced as an “immediate follow-up to the expansion of the airport that went into operation in 2012” (Administration_Frankfurt_ID2) and the associated burdens. The fund was aimed at private individuals, schools/daycare centres and sustainable local development. However, it involved a “high level of bureaucracy” that was “labour-intensive” and could not be afforded by every local authority (Administration_Frankfurt_ID2). In 2017, the Regional Fund Act was replaced by the Regional Burden Equalization Act (*Regionallastenausgleichsgesetz*), whereby the 21 affected municipalities receive fixed funding budgets in accordance with their exposure to aircraft noise. These funds can be used more freely and independently (Administration_Frankfurt_ID2; Participant_Frankfurt_ID4; Coordination_Frankfurt_ID6), provided that these measures serve to mitigate the effects of aircraft noise or improve the quality of life in the local communities. The Regional Burden Equalization Act thus points to a “path to reducing bureaucracy” (Participant_Frankfurt_ID1; see also Administration_Frankfurt_ID2) in comparison to the Regional Fund Act, as only proof of the use of the budget is required.

⁵ These committees are the Executive Board (*Vorstand*), the Coordination Council (*Koordinierungsrat*), the Expert Committee on Active Noise Protection (*Expertengremium Aktiver Schallschutz, ExpASS*), the Convent (*Konvent*), and the Environment and Neighborhood House (*Umwelt- und Nachbarschaftshaus, UNH*).

⁶ “Protest. Mediation. Dialogue. Frankfurt Airport, the Region, and its People” (*Protest. Mediation. Dialog. Der Frankfurter Flughafen, die Region und ihre Menschen*)



- 240 Furthermore, Frankfurt Airport contributes to the economic development of the region (Participant_Frankfurt_ID1). The city of Frankfurt benefits in particular from its municipal stake in Fraport AG, which secures regular income for the city in the form of dividends and profit distributions. At the regional level, the airport acts as a central driver of development by promoting the establishment of supplier companies, logistics-related services and aviation-related businesses. These effects contribute to value creation in the region.
- 245 The close monitoring and support of the Frankfurt airport region – through the establishment of the FFR and the implementation of various studies – over such a long period of time is a unique feature and has generated enthusiasm among stakeholders in other large-scale infrastructure projects, especially in the context of airport expansion (Administration_Frankfurt_ID2; Participant_Frankfurt_ID4). The region benefits from positive economic effects generated by the airport. However, this strong concentration on airport-related infrastructure and the region’s growing dependence on
- 250 Frankfurt Airport are viewed critically. In addition, despite compensatory measures, there continues to be an uneven distribution of the burdens caused by the airport in the airport region, which are concentrated primarily in the immediate vicinity of the airport.

4.2 Germany: Decommissioning of Asse II

Case introduction & context

- 255 The Asse II facility is a former salt mine in the district of Wolfenbüttel, Lower Saxony, Germany. Originally operated as a rock salt and potassium mine until 1964, it was subsequently used as a research site and, between 1967 and 1978, as a disposal facility for approximately 126,000 drums of low- and medium-level radioactive waste (Domasch & Zschiesche 2017). The site became a symbol of past intransparent, technology driven and top-down governance of German nuclear policy, an example of the “decide-announce-defend” strategy that produced significant public conflict and loss of institutional trust (Di Nucci &
- 260 Brunnengräber 2023, Mez & Häfner 2021, Themann 2021, Brunnengräber 2015).
- The region is predominantly rural, approximately two thirds of the area is being used as agricultural land (Statistisches Bundesamt 2022, 2024), regional identity is fragmented: while local pride exists around specific cultural and natural landmarks, the controversy surrounding the mine has had a negative effect on the image of surrounding communities (Schiller & Carlsson 2015; Bolze et al. 2015).
- 265 The primary trigger for regional development intervention was the formal recognition, that the facility posed long-term geological and radiological risks. This led to the decommissioning decision enshrined in the so-called Lex Asse (amendment to Atomgesetz § 57b), which mandated the immediate decommissioning of the facility following retrieval of the radioactive waste. The establishment of the foundation *Stiftung Zukunftsfonds Asse* represents the institutionalized response to compensate the affected region. As of the time of writing, the facility is in the planning stage of waste retrieval – a spatial compatibility
- 270 assessment (*Raumverträglichkeitsprüfung*) was completed in 2025 (ArL Braunschweig, 2025).

Participation institutions and formats for regional development



Established in January 2008 as a non-statutory participatory body, the Asse-2-Begleitgruppe (A2B) served as the representation of regional interest in the planning process around the decommissioning of Asse II (A2B, n.d). It brought together municipal representatives, civil society actors (from various sectors and interest groups), and – without voting rights – the operator and federal and state ministries (Kallenbach-Herbert, 2017). Its central achievements include consensus for and legislative anchoring of waste retrieval, as well as the application of nuclear rather than mining law to the facility. The process is described as a pioneer of a new cooperative participation culture, though its structural fragility was equally acknowledged (Domasch & Zschiesche 2017). Between 2008 and 2020, the group was engaged in a constant working process, before suspending work due to a conflict over the interim storage of the waste, which is yet to be retrieved, and ultimately dissolving in 2022. The internal tensions were significant, the process lacked sufficient agreement on rules of procedure, mandates and roles (Participant_Asse_ID3, Coordination_Asse_ID4). Topics of regional development such as negative impacts on tourism, property values and regional image, while discussed in the A2B, were not its primary mandate (Participant_Asse_ID3).

Established with the Asse-Stiftungsgesetz (AsseStG) by the Lower Saxony state legislator in November 2015, the foundation “Stiftung Zukunftsfonds Asse” is financed through an annual federal payment of EUR 3 million (BMUB 2014). It operates as a public-law foundation based in Wolfenbüttel and is institutionally anchored in the administration of the county Wolfenbüttel. Its statutory mandate is to promote regional development with particular attention to communities closest to the facility. The foundation’s governance ensures intersectoral and multi-level-representation through a council (*Stiftungsrat*) (15 members, local /district political representatives, federal /state delegates with veto rights on larger grants) and a three-member-board (*Stiftungsvorstand*) chaired by the County Executive (*Landrätin/Landrat*). The foundation’s funding priorities (civil society, culture, volunteering, environmental projects and community centres) were pragmatically derived from the statutory text, rather than stemming from a potential analysis or participatory process, but are further developed and evaluated by the foundation bodies. The foundation operates both as a grant giving body and as a regional development actor that leverages additional federal programme funding.

Two LEADER Local Action Groups (LAG) overlap with the affected area. Both developed Regional Development Concepts through Strengths, Weaknesses, Opportunities, Threats (SWOT) analyses and participatory processes including citizen surveys and workshops (Schladen-Werla 2024; LAG „Elm-Schunter” 2022).⁷

Results and impacts

By November 2025, the Stiftung Zukunftsfonds had approved funding with a total volume exceeding EUR 21.5 million (Stiftung Zukunftsfonds Asse 2025). The municipalities closest to the facility received close to one third of total funding, consistent with the statutory priority. The amounts depend on local needs and can start from under thousand EUR. The

⁷ The development concepts mention challenges and risks posed by the Asse II facility, on the other hand it is seen as an advantage of these processes not to be too closely associated with the facility. Coordination between LEADER instruments, other persuasive instruments and concepts in the region and the Zukunftsfonds occurs informally by foundation staff or in personal union of people forming the foundation bodies (Participant_Asse_ID1).



foundation implements an impact-oriented funding management, requiring applicants to define outputs and intended impacts in their applications (Stiftung Zukunftsfonds Asse 2016). The foundation documents funding transparently on their website, but its statutory mandate does not include a more extensive monitoring obligation. The A2B, which served as the only multi-stakeholder oversight forum, has dissolved. Thus, no institutionalized monitoring process for regional development in connection with the decommissioning of the Asse II facility exists, which is identified as a structural gap as well as a challenge for constrained staff capacities (Administration_Asse_ID2, Participant_Asse_ID1). The foundation's activities are widely described as strengthening voluntary association and civic engagement (Administration_Asse_ID2; Participant_Asse_ID3, Participant_Asse_ID1), which can play a distinctive role in socially stabilizing a community in a rural context. However, critical voices point to the absence of a coherent strategic logic or vision connecting individual projects to broader regional development goals (Coordination_Asse_ID6, Administration_Asse_ID2). Initially, the foundation was perceived as a consolation prize, and for some actors, the association of its funding with the controversial mine makes engagement impossible; they have labelled the funds as “blood money” (Participant_Asse_ID1; Operator_Asse_ID5). Interviewees' views on whether the foundation supports regional agency and a sense of self-efficacy differ: some are happy about additional resources that other communities cannot rely on, while others were hoping for more visible flagship projects (Administration_Asse_ID2; Participant_Asse_ID1).

The Asse II case illustrates tension in compensatory regional development: Stiftung Zukunftsfonds has demonstrated that an instrument for low threshold grants can activate local civic engagement and generate substantial project output within a relatively short timeframe. However, the absence of participatory and conceptual anchoring of the funding priorities and the limited monitoring capacities constrain the foundation's ability to demonstrate lasting development impact and the connection between the projects and the reason for the compensation. The participation format of the A2B illustrates a dilemma of many siting situations: participatory processes might work well on the basis of shared principles and objectives but encounter serious stress when abstract consensus is translated into spatially concrete decisions, like the siting for an interim storage facility. The dissolution of the A2B removed the only multi-perspective forum capable of integrating regional development concerns into the broader governance of the decommissioning process, leaving a structural gap. The spatial compatibility assessment (*Raumverträglichkeitsprüfung*, completed 2025) confirmed that the retrieval process will affect regional development potential including recreational and agricultural land and protected areas (ArL Braunschweig 2025). The institutional landscape is currently not configured to translate these findings into proactive regional development strategies. While current discourse in the municipality focuses on preventing the siting decision close to Asse, it remains uncertain whether the formal decisions on the siting that follow the spatial impact assessment and geological processes in the mine will allow for a new policy window, for a participatory regional development planning.

4.3 Switzerland: Swiss sectoral plan procedure for deep geological repositories

Case introduction & context



The Swiss search for a deep geological repository (DGR) is governed by the Sectoral Plan for Deep Geological Repositories (Sachplan geologische Tiefenlager, SGT), a national-level, multi-stage procedure initiated in 2008 (SFOE 2008). Under
335 coordination of the Swiss Federal Office of Energy (SFOE), the process has evolved through three stages, transitioning from broad geological evaluation to a site-specific regional development focus (SFOE 2024a). In September 2022, the National Cooperative for the Disposal of Radioactive Waste (Nagra) proposed the region of Nördlich Lägern as the preferred site, with formal general licence applications submitted in November 2024 (Nagra 2025).

The institutional context is characterised by highly formalised, well-resourced participation structures designed to integrate
340 technical safety considerations with regional development concerns. Central are the Regional Conferences (RCs) – formalised bodies with legal mandates, permanent offices, dedicated secretariats, and independent budgets – which act as primary platforms for institutionalised participation (SFOE 2024b). A distinctive characteristic is the systematic integration of existing cantonal planning authorities in the regional participation process of the SGT, ensuring regional development measures remain coherent with broader spatial planning while avoiding parallel structures (Administration_Switzerland_ID4).

Nördlich Lägern itself constitutes an administratively artificial region created specifically for the SGT procedure, spanning
345 parts of three cantons without corresponding to historically grown social boundaries (Participant_Switzerland_ID6). The region-building process required intensive identity and image work to foster regional cohesion. To address this, the procedure utilises the Target Vision Nördlich Lägern 2050 (*Zielbild Nördlich Lägern 2050*): a shared long-term regional development vision developed through backcasting methodology, working backward from a collectively defined 2050 „North Star“ to
350 identify necessary short- and mid-term measures (Expert Group Regional Development 2024). This participatory co-creation approach reflects a procedural logic treating the repository not merely as technical infrastructure requiring mitigation, but as a potential catalyst for regional transformation (Participant_Switzerland_ID3). The site’s proximity to the German border necessitated cross-border stakeholder consultation. Nevertheless, the border situation gives rise to asymmetries between German and Swiss communities in the process. Furthermore, the SGT process faces challenges due to the absence of pre-
355 negotiated agreements on budget allocation funds management (e.g. foundation vs. fund), and funding providers. Additionally, no provisions are in place for the period after the formal sectoral planning procedure concludes in late 2027, leaving the implementation of the vision unclear.

Participation institutions and formats for regional development

Building on the governance structures described above, the RCs are organised as associations comprising governing boards
360 and specialized technical groups. Particularly relevant is the Expert Group Regional Development, which functions as an early detection unit for emerging risks and opportunities (SFOE 2024b). The Target Vision Nördlich Lägern 2050 serves as the primary instrument for integrating regional aspects in the process, enabling actors to derive concrete short- and mid-term measures from the collective long-term vision.

To broaden public involvement beyond the RC structures, the procedure employed citizen dialogue formats via digital
365 platforms, which generated over 150 community project proposals. Further, a social study (*Gesellschaftsstudie*) was carried out, accompanied by representative population surveys. Subsequently, soft factors were incorporated into the Economic and



Social Monitoring programme. This monitoring programme acts as an early warning system and a “radar” for socio-economic shifts (Participant_Switzerland_ID3) tracking indicators related to population development, economic structure, employment, real estate markets, and social cohesion (SFOE 2015). A specific procedural focus is placed on empowerment and capacity building of local economic actors, with targeted initiatives preparing small and medium-sized enterprises (SMEs) for future procurement opportunities (Advisory_Switzerland_ID2). Given the border location, pragmatic participation formats facilitate rapprochement between Swiss and German stakeholders with differing risk perceptions (Coordination_Switzerland_ID1). Within these networks, committed „local heroes“ play catalytic roles, though their importance also represents a potential vulnerability (Coordination_Switzerland_ID5).

375 **Results and impacts**

The Sectoral Plan procedure has evolved from a purely technical siting process into a catalyst for institutional capacity building and regional transformation. While physical implementation remains prospective, the process has produced significant outcomes: the establishment of capable governance structures, strategic visions, and institutionalized monitoring systems (SFOE 2024b). Federal monitoring indicates stable to slightly positive trends in population and employment, suggesting that the anticipated repository has not triggered negative effects such as population decline (Bieri & Jans 2025: 49).

In socio-spatial terms, the procedure has constructed a new functional space through identity- and image-building initiatives, including the *Kulturgast* cultural programme and the development of a regional branding (Participant_Switzerland_ID3). SMEs are being systematically prepared for future procurement opportunities as part of the broader empowerment strategy (Scherer & Zwicker-Schwarm 2020). On a governance level, a key impact has been the development of the Regional Conferences into capable actors operating on equal footing with federal authorities (SFOE 2024a).

Despite these achievements, limitations persist. Although quality-of-life indicators remain stable, 43% of respondents in the core area reported perceived negative effects on communal life, indicating increasing polarization (SFOE 2025a: 133; de Sombre & Rütter-Fischbacher 2018: 109). Cross-border tensions remain unresolved despite participation efforts (Coordination_Switzerland_ID1), and ongoing negotiations on indemnification and benefit distribution pose risks to inter-municipal solidarity (Participant_Switzerland_ID6).

The Swiss DGR search unfolds within a longitudinal, three-stage temporal structure. From its initiation in 2008 to the submission of general license applications in November 2024, the process has transitioned progressively from geoscientific evaluation to site-specific regional development (Nagra 2025; SFOE 2024a). The anticipated conclusion of the SGT in 2029 marks only the beginning of a centennial timeframe, including construction, operation, closure, and long-term monitoring (SFOE 2014: 103).

The dynamics reveal a distinction between immediate procedural outcomes and delayed structural effects. In the short term, the process has generated intensive identity work and institutionalized participation. However, broader socio-economic transformation remains largely prospective: monitoring data suggests stable to slightly positive trends, indicating that the repository project may function as a catalyst for regional attention that offsets negative perception effects during planning (SFOE 2025b). Institutional learning is further evident in the expansion of study approaches to include a social study



(*Gesellschaftsstudie*) focusing on social cohesion, risk perception, and community identity (de Sombre & Rütter-Fischbacher 2018: 106, 126; Administration_Switzerland_ID4).

The 2022 siting proposal created a critical juncture that concentrated attention, resources, and conflict within a single region. Cross-border tensions represent a persistent source of contestation: German municipalities' exclusion in decision-making
405 creates grievances that cannot be fully resolved through participation improvements. The reliance on „local heroes“ remains a potential source of instability, though the structural stabilization of the RCs provides institutional buffering (Participant_Switzerland_ID3).

Taken together, the Swiss case demonstrates that procedural characteristics function as key enabling conditions for sustained regional development capacity. The integration of cantonal planning authorities prevents parallel structures; the combination
410 of monitoring systems, state-funded capacity building, and the Target Vision instrument positions the region as an active functional space capable of capturing development opportunities (Advisory_Switzerland_ID2). However, persistent cross-border tensions and social polarisation show that even highly developed procedural designs cannot fully resolve underlying conflicts.

4.4 Sweden: Repository siting process

415 Case introduction & context

The Swedish site selection process was initiated in the 1970s and discontinued in 1985 due to strong public opposition (Litmanen et al. 2017). After unsuccessful investigations in several regions, it was resumed in 1992 (NEA 2011). That same year, the Swedish Nuclear Fuel and Waste Management Company (*Svensk Kärnbränslehantering AB, SKB*) invited all municipalities in Sweden to participate in feasibility studies (Kari et al. 2021). Since 1989, SKB has emphasized that, alongside
420 geological criteria, additional factors – such as municipalities' willingness to host a repository – should be considered (Kari et al. 2021; Litmanen et al. 2017). Voluntariness became a key principle of the Swedish site selection process (NEA 2011). After several municipalities withdrew, the process from 2002 till 2008 focused on Östhammar and Oskarshamn, both of which hosted nuclear facilities. In 2009, Östhammar was selected as the final repository site due to more favorable geological conditions (Litmanen et al. 2017, Kim 2015). Oskarshamn will host the future encapsulation plant, making both municipalities
425 integral to Sweden's nuclear waste management system (Litmanen et al. 2017, Bergmans 2010). In January 2025, construction of the high-level radioactive waste repository in Forsmark began (Dahlström 2025).

Sweden has a long tradition of local self-government (Berggren & Lindfors 2013). The site selection process therefore placed significant emphasis on municipalities as key actors. They are politically engaged stakeholders, actively shaping the process (Daoud & Elam 2012). Their importance and planning and permitting authority is also reflected in the conceptualization of the region, which is defined along administrative boundaries (Operator_Sweden_ID1, Participant_Sweden_ID2, Coordination_Sweden_ID5). Local social acceptance as an informal factor was an additional decisive criterion in defining the
430 region (Daoud & Elam 2012). Annual surveys show that the support for the repository and the encapsulation plant in the respective municipalities is very high and continues to increase (SKB 2018, SKB 2024).



Participation institutions and formats for regional development

435 In 1995, the municipality of Östhammar established a final disposal group to ensure continuous municipal involvement during the site selection process. The organization's composition has evolved in response to changing requirements over the years. In early 2023, the previous working groups were replaced by two new bodies – the Repository Group and the Condition Council. They aim to review documents, advise the municipal board, and promote public information and dialogue. The groups include politicians from all parties as well as civil servants- (Östhammars Kommun 2026).

440 The added value programme was adopted in 2009 through negotiations between SKB and the municipalities. It is a central component of the site selection process and local regional development, aiming to contribute positively to the development of the society and region around the repository (NEA 2022, Bergmans 2010). Starting in 2010 and extending until the completion of the repository an added value of SEK 2 billion, approximately EUR 200 million, is expected to be generated in the region according to estimations of SKB (Setzman 2014). Notably the agreement was reached before a decision on the siting was

445 made. Following the agreement the hosting municipality of Östhammar receives 25 per cent of the fund, while Oskarshamn is allocated the remaining 75 per cent (Lehtonen et al. 2020, NEA 2022). Both municipalities acknowledged that the host municipality already benefits economically from the repository, through increased revenue and job creation (Bergmans 2010, Kärnavfallsradet 2016). The programme is structured in two phases, with 20 percent generated before (2010 – 2022) and 80 percent after the licence has been granted for construction (2022 – est. 2037) (Kim 2015, Kärnavfallsradet 2016, Steuer 2024).

450 Funding decisions on submitted initiatives and proposals are made by a steering committee, consisting of five members – the chairman of SKB, the vice chairman of SKB, the president of SKB and the mayors of the two municipalities (NEA 2011, Setzmann 2014, Kärnavfallsradet 2016, NEA 2022, Operator_Sweden_ID1). The committee meets four times a year and serves as a forum for exchange between the project developer and the affected municipalities (NEA 2022, Coordination_Sweden_ID5). The municipalities primarily determine which proposals are submitted and retain the authority

455 to define the type of project (Operator_Sweden_ID1).

The Repository Group and added value programme are funded by the Nuclear Waste Fund (Östhammar Kommun 2026). Established in 1978 and managed by the Swedish National Debt Office (*Riksgälden*), the state fund is a central instrument, financed through fees from nuclear power plant operators (Riksgälden 2025). It has also been used to support critical voices during the site selection process, enabling them to actively participate in the process (Participant_Sweden_ID3).

460 Results and impacts

In Phase 1 of the programme, an added value of over SEK 400 million was generated, corresponding to approximately EUR 34.4 million invested in the region during that period (Östhammar Kommun et al. 2020). Key measures implemented include e.g. the establishment of a technical university, and initiatives promoting entrepreneurship among students. Ongoing projects in Phase 2 include, among others, the *Alunda* Programme for local development, *Föreningslyftet* to engage associations and enhance municipal attractiveness and *Lyftet Storbrunna* supporting cultural centre activities (Kihlberg 2021). Phase 2 is based

465 on a strategic framework developed by the municipalities and SKB in 2020 (Östhammar Kommun et al. 2020).



There is currently no independent, data-driven monitoring of regional development measures. To monitor progress, data from government sources, i.e. Statistics Sweden, are utilized (Operator_Sweden_ID1). Projects are evaluated through reports prepared by the project managers, municipalities, and SKB (Operator_Sweden_ID1, Coordination_Sweden_ID4). For smaller-
470 scale projects, evaluations are often limited to confirming implementation. The results of these evaluations are mostly publicly available (Operator_Sweden_ID1).

The added value programme is widely regarded as positive and particularly effective (Operator_Sweden_ID1, Participant_Sweden_ID2, Coordination_Sweden_ID5). It focuses on measures that benefit the community as a whole rather than individual residents. Ideas and plans, previously stalled due to limited funding, have now become feasible
475 (Coordination_Sweden_ID5). The added value programme was designed to provide stimuli in various areas, i.e. new housing, infrastructure and industrial development (Operator_Sweden_ID1, Participant_Sweden_ID2, Participant_Sweden_ID3, Coordination_Sweden_ID4, Coordination_Schweden_ID5). By creating what are expected several hundred jobs over the next years Östhammar hopes to attract new residents and help reduce the municipal tax burden, since, in the absence of property tax arrangements in Sweden, neither industry nor tourism contribute significantly to the local revenue (Operator_Sweden_ID1,
480 Participant_Sweden_ID2, Coordination_Sweden_ID5). Further improvements to the local infrastructure are planned, with particular focus on the Road 288 (*Riksväg 288*), and the development of an industrial cluster, aiming to establish and reinforce the region as an independent economic hub (Participant_Sweden_ID2, Coordination_Sweden_ID5). Due to a recent shift in regional political leadership, it is unclear whether the first measures will be implemented as planned (Participant_Sweden_ID2). The programme also addresses education, culture, and sport initiatives, which are more
485 immediately visible to the public, by e.g. financially supporting music festivals or local associations (Coordination_Sweden_ID5).

Despite the wide range of stimuli, the programme faces structural limitations in monitoring, evaluation, and political dependencies potentially constraining its long-term effectiveness.

5 Cross-case patterns of regional development

490 The four case studies illustrate the heterogeneity of regional development processes in the context of large-scale infrastructure projects with a significant spatial impact. Despite the marked differences in national, legal, cultural, and socio-economic conditions, typical patterns, mechanisms for success, challenges, and areas of tension can be identified.

5.1 Success factors and conditions for effective regional development

The utilization of endogenous potentials is a central prerequisite for effective participatory regional development. The
495 Frankfurt case illustrates how the autonomous and flexible allocation of financial resources enables the targeted promotion of place-specific potentials and quality of life for the inhabitants. This includes capacity building initiatives directed not only at civil society but also at local economic actors, with a particular focus on structural development and the improvement of

underlying framework conditions. The Swiss case further illustrates this orientation: here, capacity building extends to supporting local economic actors in participating in procurement processes related to the repository project itself, thereby enabling the region to capture economic opportunities arising directly from the infrastructure investment. Beyond project funding, the operational activities of the Zukunftsfonds Asse Foundation demonstrate how regional development bodies can take on a more strategic role, for instance, by facilitating the development of regional strategies for the management of natural resources and the promotion of a bioeconomy, thereby contributing to long-term structural resilience. Soft factors must be systematically considered alongside material incentives. Across all case studies examined, intangible factors, including regional image, collective identity, and social cohesion, gained relative importance compared to material ones. This is particularly evident in the three regions of Asse, Switzerland, and Frankfurt, where the absence of pre-existing territorial identities directly affects the perceived legitimacy of governance arrangements and actors' willingness to engage. Potential responses to this challenge include institutional anchorage within existing administrative jurisdictions or deliberate image work grounded in a constructivist understanding of regions, for instance, through the co-development of shared visions or target images.

The establishment of specialized dialogue and governance structures is another critical success factor. The systematic inclusion of relevant actors through dedicated dialogue institutions ensures transparency and comprehensibility, while simultaneously securing coordination and building up steering capacity. Such structures facilitate the integration of diverse perspectives and interests. Empirical examples include the FFR and FLK in Frankfurt, the regional conferences in Switzerland, and the steering committee in Sweden. The absence of such dedicated dialogue and governance structures, as observed in the Asse case, following the dissolution of the A2B, constitutes a significant impediment to effectively addressing questions of regional development in ongoing siting processes. A cross-sectoral integration approach, bringing together actors from different societal sectors, strengthens both institutional learning and collaborative problem-solving capacity. Ensuring that participatory formats are sufficiently tailored to diverse target groups is equally important. Capacity building at the individual and organizational level constitutes a key enabling condition for both participatory processes and the realization of regional development projects. This entails training and developing people who take sustained responsibility for regional processes, beginning with smaller projects and progressively expanding in scope.

Financial arrangements must go beyond simple monetary compensation. Transparency, fairness, and unambiguous decision-making structures in the distribution of funds are identified as key success factors for securing acceptance and regional cohesion. Crucially, where funding is administered through an independently managed fund rather than distributed directly from operators to municipalities, the independence and credibility of the process is better safeguarded, and the risk of compensation payments being perceived as attempts to purchase acceptance is reduced. Ensuring financial independence and equitable, proportional distribution among affected communities is essential in this regard. Switzerland draws an analytically useful distinction between indemnification (*Abgeltungen*), unconditional payments recognizing the assumption of a national burden, and compensations (*Kompensationen*) for specific damages, though the allocation between these categories remains contested and tends to dominate regional development discussions. Sweden offers the most instructive counter-model: by

negotiating the distribution of funds between host municipalities before a siting decision was reached and before winners and losers were known, a solidarity-based arrangement was achieved that pre-empted competitive dynamics and positioned financial resources as development enablers from the outset. The central implication across cases is that the perceived legitimacy of financial arrangements depends critically on regional autonomy over fund deployment, additionality relative to existing fiscal transfers, impact-oriented support for structurally significant projects, transparent allocation criteria, and the strict separation of project operator and funding roles.

535

Long-term orientation, monitoring, and a learning-focused approach are indispensable for adaptive regional governance. The sustained, decades-long participatory process in Frankfurt, spanning approximately 30 years, demonstrates how continuity enables adaptation to evolving needs and challenges. The Swiss case employs systematic economic and societal monitoring as an early-warning mechanism to identify emerging risks. The development of shared target images provides a long-term vision from which planning can work backwards. In Sweden, the steering committee comprises individuals holding relevant institutional roles by virtue of their office, ensuring structural continuity. The Asse case provides an instructive example of how impact-oriented funding can be implemented in a low-threshold manner, simultaneously supporting the capacity building of those implementing projects and fostering an outcome-focused orientation in project delivery.

540

545

Trust forms a foundational enabling condition for participatory processes. The active engagement of key figures (so-called local heroes) is strongly emphasized across the Asse, Swiss, and Frankfurt cases; in Sweden, the role of mayors is of particular significance. Empowering these key figures by equipping them with the necessary competencies and clearly defining their spheres of influence and decision-making discretion is therefore identified as a central governance task. Conversely, where communication becomes dominated by potential burdens and disadvantages rather than developmental perspectives, or where the political handling of scientific findings lacks transparency, trust erodes and disillusionment sets in – as illustrated by the Asse case, where this dynamic generated considerable disappointment and lasting mistrust among affected communities. Clarity of roles and a forward-looking communicative orientation are thus not merely organizational details, but prerequisites for sustaining the legitimacy and collaborative capacity of regional governance processes.

550

555 **5.2 Risks and tensions in participatory regional development**

Despite the numerous promising approaches identified across the case studies, the findings also reveal that participatory regional development processes associated with large-scale infrastructure projects carry substantial risks and structural pitfalls. These risks are less attributable to individual misjudgements than to systemic deficits in governance, participation, communication, and institutional design.

560

The delineation of the region constitutes a foundational tension in participatory regional development. Regional boundaries are rarely self-evident; rather, they emerge from the intersection of geological-functional criteria, political-administrative logics, and subjective territorial identities. These three dimensions not only shape perceptions of belonging and affectedness, but also inform competing claims regarding compensation, participation, and planning rights, and are in turn shaped by them. Where boundaries remain unclear, the question of who belongs to the host region and who does not, becomes a source of



565 conflict. Fuzzy boundaries may equally give rise to new actor constellations, a dynamic that can both enrich and further
complicate regional governance.

The case studies illustrate how differently this tension is navigated across contexts. In Frankfurt, the regional boundary is
defined primarily through an impact-based approach, tracing the spatial reach of aircraft noise, a definition that shifts
dynamically as conditions evolve. The Asse case illustrates tensions in region delineation, where overlapping spatial units
570 create parallel governance structures that require coordination. The Swiss case of Nördlich Lägern represents a deliberately
constructed artificial region transcending existing administrative and historically grown boundaries, spanning parts of three
cantons, and extending across the German border, a configuration that proves particularly challenging where differing national
risk perceptions produce divergent claims regarding the legitimate scope of participation and compensation. In Sweden, by
contrast, the municipality serves as the primary and largely uncontested reference unit. Its substantial statutory competencies
575 in planning and land use provide a clear institutional anchor that pre-empts many of the boundary conflicts observed elsewhere,
suggesting that strong, legitimate administrative units at the regional scale can itself be a structural precondition for more stable
governance arrangements. These findings underscore the relevance of the constructivist approach to regional delineation, as
regions emerged as socially produced spaces. Consequently, this means that efforts to foster a regional identity must be factored
into the planning.

580 Loss of institutional knowledge and lack of continuity poses a significant structural risk in long-running infrastructure
processes. As key actors leave over time, accumulated knowledge, prior agreements, and established working relationships
risk being lost. This was described as a central problem by multiple interview partners in the Asse case. Those who had
originally set the direction of the process were no longer present, and what had once been agreed upon had not been successfully
carried forward, with prior commitments ceasing to be of interest to those subsequently involved. This challenge is
585 compounded by a related structural tension: the underrepresentation of younger generations in participatory processes. Large-
scale infrastructure projects unfold across timeframes spanning multiple generations, while individual engagement and career
horizons are considerably shorter, creating a persistent temporal mismatch. In Switzerland, participation in the Nördlich
Lägern regional conference is characterized by demographic imbalances. Attempts to involve younger participants face the
structural difficulty that complex topics such as regional development feel remote from everyday concerns.

590 **5.3 Policy implications for enabling conditions**

The findings across the four case studies converge on several interconnected policy implications for the design of participatory
regional development processes associated with large-scale infrastructure projects. A foundational first step is the thorough
assessment of endogenous regional potentials, encompassing not only economic assets but also soft factors such as identity,
image, and social cohesion and the participatory development of a shared long-term vision that can orient planning backwards
595 from a collectively defined target image. This vision-building process should itself be used to participatively delineate the
region, as boundary-setting has direct consequences for legitimacy, compensation claims, and the scope of participation.

Effective governance requires the design of specialized, independent dialogue, and governance structures with clearly defined roles, explicit conflict resolution mechanisms, and formats that are attractive and accessible to diverse target groups including younger generations. Capacity building, at both individual and organizational levels, must be an integral component, and an independent institution should be established to manage project-related funds, ensuring regional autonomy over resource deployment and a transparent, pre-negotiated distribution of benefits among affected communities.

Long-term orientation must be institutionally anchored through monitoring systems and a shared target image, while project-level funding should be impact-oriented rather than output-focused. Across all dimensions, transparency and consistent follow-through by decision-makers are essential: expectations must be clearly set and reliably met, and communication should remain forward-looking rather than problem-focused. Finally, combating the loss of institutional knowledge and ensuring continuity requires deliberate mechanisms including clear mandate, role, and process documentation; structural incentives such as financial support, hybrid participation formats; and targeted outreach strategies that connect the long-term stakes of regional development to the everyday realities of younger populations.

6 Conclusion and research outlook

6.1 Summary of results

This article explored institutional designs and formats to identify patterns of success and challenges in participatory regional development processes within the context of large-scale infrastructure projects. The four case studies reveal a set of enabling conditions, as well as some tensions that must be recognised and carefully managed.

Regional development is best approached on the basis of endogenous potential, taking soft factors such as regional identity and social cohesion into account. Dedicated governance and dialogue structures are indispensable. Without them, the probability of the discourse shifting from opposition to the project to constructively shaping development paths for the region is lower, as the capacity to address regional development issues in formal procedures and cross-sectoral integration is lacking. Capacity building at organisational and individual levels, as well as the deliberate empowerment of key figures, is equally critical. Financial arrangements must go beyond compensation, ensure regional autonomy, proportional distribution and a strict separation between project operators and funding structures. Processes and institutions should be long-term oriented, i.e. through joint vision building, systematic monitoring, and impact-oriented funding schemes, but they should also allow for short-term visible effects through flagship projects. Trust is a critical resource for the process; it cannot be declared but emerges from the consistent and transparent behaviour of public actors over time.

The case studies also reveal a set of recurring structural tensions that no single governance design fully resolves. The delineation of the region might remain inherently contested, as geological, administrative, and identity-based logics produce competing boundary claims with direct consequences for participation rights and compensation. The complexity of multi-actor governance landscapes generates risks of role confusion, parallel structures, and the overburdening of voluntary participants. These risks might be managed through clear mandates, transparency about institutional designs, and partial professionalization.



630 The mismatch between a multi-generational project timeline and individual engagement horizon creates challenges through discontinuities in generational transitions what requires knowledge management and outreach strategies. Further, some tensions exist between the logic of financial compensation and a strategic development focus. While compensation may be viewed as a mere consolation or even “blood money”, establishing a shared vision and an accepted decision-making process for strategic investments is challenging and may also be criticised.

635 Participatory regional development in the context of contested infrastructure projects serves a dual purpose: fostering structural resilience in affected regions while simultaneously contributing to procedural legitimacy that large-scale, long-term projects require in order to remain socially viable. Because regional development is inherently place- and context-specific, no universal blueprint exists, neither for process design nor for the portfolio of projects that will prove effective in any given setting. The availability of financial resources and formal participation rights, while necessary, are insufficient conditions for success. As the cross-case analysis demonstrates, the factors that most consistently distinguish effective from ineffective processes are not
640 material but institutional and communicative: the continuity of engagement over time, transparency in decision-making, clarity of roles and mandates, and the independence of the institutions that govern the process. Investing in these conditions from the outset, rather than introducing them remedially once trust has eroded may therefore be the most needed design decision available to those responsible for shaping participatory regional development in the context of comparable processes.

6.2 Limitations

645 This article adopts an exploratory, comparative case study design, which is well suited to generating context-sensitive insights and identifying cross-case patterns, but careful consideration of generalizations and causal relations is still warranted. The selection of four cases was guided by theoretical relevance and variation in institutional context rather than representativeness, and the findings are best understood as heuristic propositions that can guide further investigation in additional settings, especially in radioactive waste management. Isolating the specific effects of individual infrastructure projects from broader
650 macroeconomic trends and parallel policy processes remains methodologically challenging within a case study design. Data availability, interviewee expertise, and willingness to participate varied across cases, particularly at the municipal level, which unevenly affects the depth of the retrospective analysis. Thus, the results should rather be read as context-sensitive insights into place specific dynamics, than as a generalizable blueprint.

6.3 Future research

655 With regard to future research, the question of how to measure the success of participatory regional development processes beyond hard economic indicators remains methodologically unresolved: where key outcomes such as trust, identity, image, and social cohesion are qualitatively anchored, robust yet context-sensitive assessment frameworks are needed. Closely related is the challenge of institutional continuity and capacity retention in long-running processes, future research should examine which financial and organizational arrangements, including remuneration models, dedicated secretariats, and knowledge
660 management systems, most effectively sustain participation quality and prevent the loss of institutional memory across

665 personnel transitions. The governance of financial arrangements, particularly the timing, architecture, and legitimacy of fund distribution models, warrants comparative investigation across a broader range of cases. Under which conditions do early institutional frameworks provide useful orientation, and when do they constrain the very regional agency they are intended to support? Finally, the particular temporal dimension of repository siting spanning generations, raises largely unaddressed questions about intergenerational knowledge and legitimacy preservation.



2 Appendices

APPENDIX A

Case study_ID	Role of the organisation/ interviewee
Participant_Frankfurt_ID0	Economic actors & businesses (Participant IV)
Participant_Frankfurt_ID1	Representatives of local authorities (Participant I)
Administration_Frankfurt_ID2	Technical and regulatory authorities (Administration III)
Coordination_Frankfurt_ID3	Organiser/coordinator of an advisory panel (Coordination/Advisory I)
Participant_Frankfurt_ID4	Representatives of local authorities (Participant I)
Administration_Frankfurt_ID5	Regional Development Officer (Administration II)
Coordination_Frankfurt_ID6	Organiser/coordinator of a support/advisory panel (Coordination/Advisory I)
Participant_Asse_ID1	Regional development agency/organiser/coordinator of an advisory body (Participant I)
Administration_Asse_ID2	Administration: Officer responsible for regional development in the region (Administration II)
Participant_Asse_ID3	Civil society organisation (Participant II)
Coordination_Asse_ID4	Expert and researcher with a specific focus on regional development in the region (Coordination/Advisory III)
Operator_Asse_ID5	Infrastructure project developer (Operator I)
Coordination_Asse_ID6	Representatives of overlapping informal cooperation (Coordination/Advisory II)
Coordination_Switzerland_ID1	Officer responsible for regional development in the region (Administration II) and representative of foreign interests (Coordination/Advisory IV)
Advisory_Switzerland_ID2	Expert and researcher with a specific focus on regional development in the region (Advisory II/Coordination)
Participant_Switzerland_ID3	Regional development agency (Participant III)
Administration_Switzerland_ID4	Authority responsible for the proceedings (Administration I)
Coordination_Switzerland_ID5	Expert and researcher with a specific focus on regional development in the region (Coordination/Advisory III)



Participant_Switzerland_ID6	Representatives of local authorities (Participant I)
Participant_Switzerland_ID7	Regional development agency (Participant III) and representatives of local authorities (Participant IV)
Participant_Switzerland_ID8	Regional development agency (Participant III) and representatives of local authorities (Participant I)
Operator_Sweden_ID1	Infrastructure project developer (Operator I)
Participant_Sweden_ID2	Representatives of local authorities (Participant I)
Participant_Sweden_ID3	Civil society organisation (Participant II)
Coordination_Sweden_ID4	Regional expert and researcher (Coordination/Advisory III)
Coordination_Sweden_ID5	Representatives of overlapping informal cooperation (Coordination/Advisory II)
Administration_Sweden_ID6	Regional Development Officer (Administration II)

670 **APPENDIX B**

Interview-Guidelines

1. Introduction

- Welcome and introduction
- Brief introduction to the research project and the aims of the interview
- 675 • Information on confidentiality and obtaining consent for recording
- Outline of the procedure and duration of the interview
- Enquiry whether the interviewee has any further questions

2. Introductory question [open, associative]

- 680 • What are the special features of the [here: region]?
- What comes to mind when you think of the development of the [here: region]?
- (What do you personally associate with the region?)

[Interviewer's note: Address the concept of region. If people are not connected to the region of the case study, ask more generally about the understanding of regions and development.]

685 **3. Thematic block I: Concept of region & definition of regional potential** [INPUT]

Question 1: What criteria or characteristics are used to define the [here: region]?

[Interviewer's note: Depending on the person's prior knowledge, specify, if necessary: Which methodological and/or conceptual criteria were used to define or delimit the region].

- 690 **In-depth 1a:** Which regional authorities were included? What spatial radius was applied when selecting organizations and institutions for participation?



In-depth 1b: Which formal (e.g. administrative boundaries) and informal (e.g. functional interdependence, cultural-historical) factors played a role in defining the region or the specific radius?

Question 2:

695 Was an assessment of the region's development potential carried out methodically (using economic, environmental, or social indicators)? (*audio track: reference to strengths and weaknesses, status quo in the region*)?

[Interviewer's note: The aim here is to find out whether and how a potential analysis/impact study (cf. SÖPA in DE or SÖW in CH) was carried out as a basis for regional development and monitoring].

In-depth 2a: To what extent was the regional development process able to build on the potential analysis/impact study of [here: refer to the instrument mentioned for assessing the socio-economic status quo in the case study]?

700 **In-depth 2b:** How are [here: refer to the instrument mentioned for assessing the socio-economic status quo in the case study] and the regional development processes monitored? Is monitoring in place and if so, how is it implemented? (*optional explanation: How were the analyses and their findings followed up in the process*)?

Question 3: How (based on which data or indicators) is the regional potential and its development recorded, evaluated, developed and monitored? Did the process include procedures for verification and validating the data and indicators?

705 *[Interviewer's note: overarching question on data & methodology of potential analysis, regional development and monitoring. Depending on the case example and the expertise of the interviewee, individual instruments should be addressed here via the in-depth questions]*

In-depth 3a: How and by whom was the data collected? Were there any particular challenges to overcome (e.g. data availability, measurability, data protection)?

710 **Follow-up:** Who determined the scope and area of [here: refer to the instrument mentioned for assessing the socio-economic status quo in the case study], regional development and monitoring? Was the required data publicly available or was it based on specific surveys and analyses?

In-depth 3b: What methods were used for the survey? How are the outcomes of the concepts measured and evaluated?

715 **Follow-up:** Which short- or medium-term indicators (*on demand: e.g. employment figures, regional economic performance, transport modelling*) are used for this purpose?

In-depth 3c: Have 'soft' factors (*only on request: e.g. concerns and fears about possible future environmental impacts or about a negative change in the image or identity of the region*) or only 'hard' measurable criteria been considered?

4. Thematic block II: Formats, methods and processes of regional development [PROCESS]

720 **Question 4:** Was a systematic approach to regional development applied, what did it look like? *More specifically: Which methods, instruments or approaches are/were used in the process of developing regional development concepts?*

Question 5: Was the public involved in defining the scope of [here: make a reference to the case study e.g. mention the SÖW and the social survey for Switzerland, or cite SÖPA as an example of the StandAV], or were they able to comment on it?

725 **Follow-up:** Did the process include formats that allowed participants to contribute their local expertise? How were different perspectives incorporated in the process?



Question 6: To what extent are/were participatory processes such as citizen participation, stakeholder events or direct consultations included in the regional development process? How were these different formats of participation in the context of regional development evaluated by those involved?

730 **Follow-up:** What measures and processes were implemented to enable participants to actively and effectively participate in regional development in advance (*on request: e.g. via further training programs, accompanying experts, expert opinions, etc.*)?

Question 7: [*Interviewer's note: if comparative studies have taken place*] How are/were regional potentials and suitable development approaches compared between different regions in the underlying studies [*establish reference to the case study here: e.g. mention SÖW & Gesellschaftsstudie for Switzerland or SÖPA as an example for the StandAV*]?

735 **In-depth 7a:** What challenges or hurdles arise in terms of comparability and transferability to other regions? (*audio track: How much supra-regional comparability and regional specificity is needed for successful regional development?*)

Question 8: How do you rate the result? Are the proposed strategies appropriate for the region and realistically implementable in terms of efficiency and effectiveness [*reason for developing a concept*]? How do you perceive the public discussion on the process and result of the concept development?

740 5. Thematic block III: Success factors and monitoring of regional development [OUTPUT]

Question 9: In your opinion, what are (additional) central components of a 'good' regional development strategy (*on request: financial compensation measures, appreciative communication, local agency and benefits*)?

745 **In-depth 9a:** Which proven approaches or innovative practices have been particularly well received by the public and/or professionals (in terms of efficiency, effectiveness, acceptance and feasibility)?

6. Thematic block VI: Long-term effects and benefits [OUTCOME/IMPACT]

Question 10: What long-term effects have emerged or are anticipated as a result of the regional development measures (e.g. change in identity, infrastructure)?

750 **In-depth 10a:** How are/were these effects identified and measured (through monitoring), and to what extent do the results align with the expectations of those affected?

In-depth 10b: Are there specific advantages or benefits that have arisen or are expected to arise for people directly affected or involved on site?

Question 11: In your opinion, which aspects should have been given greater consideration when developing or implementing the regional concepts?

755 **Question 12:** Are there specific challenges that have remained unresolved so far? [*if necessary: give specific examples from API/research!*]

7. Conclusion

- Summary: *Summarize the most important findings from the discussion.*

Question 13: What should be avoided at all costs when it comes to regional development?

760 **Question 14:** Are you familiar with the German site selection procedure (StandAV) for the search for a final storage site for highly radioactive waste? What do you think the German StandAV can learn from [here: region] for the regional development process?

- Open question: *Give the opportunity to express further comments or thoughts.*
- Thanks, and farewell.

765



Code, data, or code and data availability

N/A

Supplement link

N/A

770 Team list

N/A

Author contributions

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