

DER ÖFFENTLICHE SEKTOR THE PUBLIC SECTOR

Foundational Livability in Austria:
Insights from the Re:sl:Ze Project
and a Research Agenda on Income,
Infrastructure and Time

Öffentliche Dateninfrastrukturen im
Mobilitätssektor: Mobilithek und
Mobility Data Space als Plattformen für
datenbasierte Innovationsökosysteme

Von lokalen Erfahrungen zu
gemeinsamen Erkenntnissen:
Entwicklung einer Wirkungsanalyse
für transformative Anpassung in
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Power Relations in Groundwater
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Evaluating Biodiversity Enhancement
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Who is entitled to speak for nature? A
qualitative analysis of representation
and guardianship in Rights of Nature
initiatives

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1 | 2026

52. Jahrgang

“Der öffentliche Sektor - The Public Sector”, als Printzeitschrift im Jahr 1975 gegründet, erscheint seit 2015 als elektronisches Open-Access-Journal des Forschungsbereichs Finanzwissenschaft und Infrastrukturpolitik im Institut für Raumplanung der Technischen Universität Wien. Seit 2017 ist “Der öffentliche Sektor” Mitglied des Directory of Open Access Journals (DOAJ), gemeinsam mit 10.000 anderen Open-access-Zeitschriften aus der ganzen Welt.

Das zweisprachige Journal lädt zum Diskurs über die Bedeutung und Herausforderungen staatlicher Aufgabenerfüllung, mit besonderem Augenmerk auf die Wechselwirkung zwischen gesellschaftlichem und wirtschaftlichem Wandel, politischer Steuerung und räumlicher Entwicklung auf unterschiedlichen Ebenen. Gleichzeitig sollen verschiedene Rollenmodelle in der Aufgabenverteilung zwischen öffentlichem, privatem und zivilgesellschaftlichem Sektor hinterfragt und diskutiert werden.

In einem multidisziplinären Ansatz werden Fachleute verschiedener Disziplinen angesprochen: Finanzwissenschaft und Fiskalpolitik, Raumplanung, Infrastrukturplanung und -politik, Bodenmanagement und -politik, Ressourcenökonomie, Planungsrecht, Immobilienwirtschaft und Wohnungswesen, Politikwissenschaft, Volkswirtschaftslehre, Stadtsoziologie sowie andere verwandte Gebiete.

“Der öffentliche Sektor - The Public Sector” versteht sich als Wissensspeicher und Kommunikationsplattform zwischen Wissenschaft und Praxis einerseits und zwischen Jungakademiker*innen und erfahrenen Expert*innen andererseits.

Immer wieder widmen wir uns einem Schwerpunktthema, zu dem dann ein spezifischer “Call for Papers” auf der Webseite eingerichtet wird. Ansonsten werden andere geeignete Beiträge aus den oben genannten Themenkreisen veröffentlicht. Die Herausgeber ermutigen insbesondere junge Wissenschaftler*innen, Artikel zur Veröffentlichung einzureichen. Nach Prüfung und Akzeptanz des Abstracts werden alle eingereichten Artikel einer Review durch ein oder mehrere Mitglieder des Editorial Board unterzogen, fallweise werden auch externe Reviewer*innen beigezogen. Es werden keine Autorengebühren eingehoben. Publikationssprachen sind Deutsch oder Englisch.

“Der öffentliche Sektor - The Public Sector” was founded in 1975 as a print journal and is published by the Department of Public Finance and Infrastructure Policy at the Institute of Spatial Planning at TU Wien since 2015 as an open-access journal provided. Since 2017 “The Public Sector” is member of the Directory of Open Access Journals (DOAJ), along with 10,000 open-access publications from all around the world.

The aim of the bilingual journal is to advance the discussion on public intervention in a socio-economic and spatial context, studying the interrelations between economic and social change, policy design and policy impacts on different spatial levels. At the same time, it encourages the discussion on roles of and co-operation between the public, private and the different non-profit sectors.

It follows a multi-disciplinary approach, addressing experts from various disciplines and fields such as public economics, urban and regional planning, infrastructure policy, fiscal policy, environmental economics, land use policy and planning, planning law, real estate management and housing economics, political science, urban sociology and other related fields.

“Der öffentliche Sektor - The Public Sector” considers itself as a platform for exchange between science and practice, as well as between young academics and senior experts.

The journal adopts a focused thematic format with specific calls for papers. Each issue is devoted to a particular theme selected by the editorial board. However, papers that fall into the broad research fields mentioned above will also be published. The journal especially encourages young researchers to submit papers. After acceptance of the abstract, all papers will be reviewed by one or more members of the advisory board and eventually also by external reviewers. No open-access or paper submission fees will be charged. Publication languages are English and German.

See all issues of “The Public Sector” at

» oes.tuwien.ac.at

Impressum

Eigentümer, Herausgeber und Verleger

Forschungsbereich Finanzwissenschaft und Infrastrukturpolitik, Institut für Raumplanung der Technischen Universität Wien; vertreten durch Univ.-Prof. Dr. Michael Getzner; Karlsplatz 13, 1040 Wien, Tel. +43/1/58801-280321
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Web: <https://www.tuwien.at/ar/ifip>

Redaktion und inhaltliche Verantwortung dieser Ausgabe

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Umsetzung im reposiTUM

Universitätsbibliothek der TU Wien
Web: repositum.tuwien.ac.at

52. Jahrgang

Heft 1 | 2026 – Juli 2026

ISSN 1563-4604 (Print)
ISSN 2412-3862 (Online)

Der Öffentliche Sektor - The Public Sector erscheint zweimal pro Jahr als Open-Access-Zeitschrift unter der Creative Commons-Lizenz CC-BY-NC (non-commercial). Printausgaben können zum Selbstkostenpreis bestellt werden bei:

Ilse Bednar

c/o Forschungsbereich Finanzwissenschaft und Infrastrukturpolitik (E280-03) im Institut für Raumplanung der Technischen Universität Wien, Karlsplatz 13, 1040 Wien
E-Mail: [oes\(at\)ifip.tuwien.ac.at](mailto:oes(at)ifip.tuwien.ac.at)

Open Access Online

Web: oes.tuwien.ac.at

Druck

druck.at Druck- und Handelsgesellschaft mbH, Aredstraße 7
A-2544 Leobersdorf, Tel. +43/2256/64131

Bankverbindung

Technische Universität Wien, Institut für Raumplanung
IBAN: AT72 1200 0514 2900 0401 | BIC: BKAUATWW
UID: ATU37675002 | DVR: 0005886 | Handelsgericht Wien



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Editorial

Anna-Theresa Renner

Liebe Leser*innen,

ich freue mich Ihnen hier die Ausgabe 1/2026 unserer Zeitschrift „Der Öffentliche Sektor – The Public Sector“ präsentieren zu dürfen. Die Ausgabe gibt einen Einblick in aktuelle Arbeiten am Forschungsbereich Finanzwissenschaft und Infrastrukturpolitik der TU Wien und darüber hinaus. Im Sinne der gelebten Zweisprachigkeit der Zeitschrift gibt es, neben zwei deutschsprachigen, auch vier englischsprachige Beiträge.

Die vorliegende Ausgabe beginnt mit einem Beitrag der Residualeinkommen, Soziale Infrastruktur und Zeitverwendung gemeinsam denkt und analytisch verschränkt. Tatjana Neuhuber und Antonia Schneider zeigen anhand österreichischer Daten aus der Konsum- und Zeitverwendungserhebung sowie räumlicher Infrastrukturdaten wie diese drei Bereiche zusammenspielen, und nur gemeinsam Rückschlüsse auf Unterschiede in der regionalen Lebensqualität und der Daseinsvorsorge zulassen. Die Ergebnisse beruhen auf einem kooperativen Forschungsprojekt der TU Wien mit der Arbeiterkammer Wien, dessen Ergebnisse auch auf der Projektwebseite einsehbar sind (<https://resize.project.tuwien.ac.at/>). Wie wichtig Daten nicht nur für die Wissenschaft, sondern auch für die Verkehrsplanung sind, zeigt der Beitrag von Norbert Földi auf. Er plädiert für die Involvierung der öffentlichen Hand in der Bereitstellung von Dateninfrastrukturen im Mobilitätsbereich um einen sicheren Datenaustausch unter transparenten Nutzungsbedingungen sicherzustellen, und so langfristig Innovation und Digitalisierung zu fördern.

Die folgenden Beiträge werfen einen Blick auf den menschlichen Umgang mit natürlichen Ressourcen und der Umwelt. Zunächst geben Tommaso Gimelli, Anna Kalhorn und Michael Getzner einen Einblick in die Konzeptionierung und erste Ergebnisse eines internationalen Forschungsprojekts, das in sechs verschiedenen europäischen Ländern zur transformativen Klimawandelanpassung in Bergregionen durchgeführt wird (<https://mountresilience.eu/de/>). Auf partizipativen und transdisziplinären Ansätzen beruhend, zeigen sie Gestaltungsprinzipien für einen regionsübergreifenden Bewertungsansatz von Adaptierungsmaßnahmen auf. Im nächsten Beitrag diskutiert Rebecca Hauschild die teils konträren Interessen verschiedener Stakeholder und die damit einhergehenden Konflikte um die Wasserentnahme aus der Lüneburger Haide in Deutschland. Einem weiteren Fallbeispiel widmet sich der Beitrag von Elham Eslampanah Sendi: dem Windpark Pretul in der Steiermark. Der Autor analysiert, ob die Bestrebungen zur Erhaltung der Biodiversität – insbesondere die Renaturierung des Schwarziengelmoos – die Prinzipien der International Union for Conservation of Nature erfüllt. Im letzten Beitrag dieser Ausgabe widmen sich schließlich Jonas Gurman und Yanic Kieser auf theoretischer Ebene den Rechten der Natur und zeigen Möglichkeiten auf, wie diese in der Praxis vertreten werden können.

Ich wünsche viel Spaß beim Lesen!

Foundational Livability in Austria: Insights from the Re:sl:Ze Project and a Research Agenda on Income, Infrastructure and Time

Tatjana Neuhuber, Antonia E. Schneider

Foundational economy scholarship has developed a rich conceptual account of the goods, services and infrastructures required to sustain everyday life. Yet the empirical measurement of foundational livability remains comparatively underdeveloped, particularly where monetary resources, spatial accessibility and time use intersect. This paper addresses that gap through the Austrian Re:sl:Ze project, which combines three complementary dimensions: residual income, social infrastructure and time use. Drawing on the Austrian Household Budget Survey 2019/20, a municipality-level social infrastructure dataset and the Austrian Time Use Survey 2021/22, the project examines what existing data can reveal about foundational livability and where important research gaps remain. The descriptive findings show that necessary expenditure substantially reduces the effective financial resources of low-income, tenant, single-person and single-parent households. They also reveal marked territorial differences in access to childcare, education, health, care and social services, with particularly weak provision in smaller municipalities and when accessibility by public transport is considered. Time-use patterns further demonstrate persistent gender inequalities in unpaid work, which are especially pronounced in households with children and in municipalities with poorer infrastructure provision. Taken together, the three pillars show that foundational livability cannot be captured through income or regional averages alone. The available datasets, however, do not permit direct causal analysis of how changes in provision affect household expenditure, time burdens or ecological pressures. The paper, therefore, presents Re:sl:Ze as both an empirical proof of concept and a research agenda for developing more integrated, longitudinal and spatially sensitive measures of foundational livability.

1 Introduction

Everyday wellbeing is generated through systems of provision rather than through private income alone. Still, inequality is generally measured through income and wealth. These indicators remain fundamental, but they provide an incomplete picture of households' material conditions and their capacity to participate in everyday social life. Households with similar disposable incomes may face very different living conditions depending on their housing and energy costs, access to healthcare, education, childcare, eldercare and public transport,

and the amount of time required to organize everyday needs. As the Re:sl:Ze project argues, income does not tell the whole story. Households' livability is also shaped by necessary expenditure, the availability and accessibility of social infrastructure, and the unequal distribution of time between paid work, unpaid care and other responsibilities.

These dimensions are closely connected. The concept of foundational livability thereby highlights also the spatial component by focusing on the capacity of an area to provide households with the essential services they require to satisfy their needs (Calafati et al., 2023). High rents or energy costs reduce the income available for other purposes. Poorly accessible services require longer journeys and may limit the time available for paid work, education, rest or social participation. Where childcare, care services,

transport or other basic infrastructures are unavailable, unaffordable or difficult to access, households must find alternative ways to meet the underlying needs. They may purchase private services, rely on private cars, reorganize paid employment, reduce consumption elsewhere or provide services themselves through unpaid labor. The withdrawal, inadequacy or marketisation of collective provision therefore does not necessarily eliminate costs. Rather, costs may be transferred from public budgets and collectively organized systems to households. This transfer may take several forms: higher monetary expenditure, additional travel and organizational time, intensified unpaid work, or greater dependence on environmentally intensive private alternatives. The consequences may also differ within households. In particular, additional care and organizational responsibilities may be absorbed disproportionately by women.

Against this background, the paper is guided by the following question:

How can foundational livability be empirically assessed through residual income, social infrastructure and time use, and what limitations and research needs emerge from the Austrian case?

The starting point is the Re:sl:Ze project¹. The project was designed to broaden the analysis of livability in Austria by examining three dimensions of inequality jointly: the income remaining after necessary expenditure (i.e., residual income), the availability and accessibility of social infrastructure, and the distribution of time within households. It thus represents an initial attempt to make the relationships between monetary resources, collectively provided services and household labor empirically visible. The purpose is not to provide a definitive empirical answer to this question. The available datasets do not permit a comprehensive causal analysis of how changes in particular services are translated into household expenditure, time use and socio-ecological impacts. Instead, the paper develops a research agenda for studying these relations and takes stock of what can already be observed with existing Austrian data.

The significance of Re:sl:Ze lies in bringing an empirically grounded perspective to a field that has so far developed primarily through conceptual, theoretical and policy-oriented work. Foundational economy research has produced a rich vocabulary for rethinking economic development around everyday needs, collective provision, social citizenship and livability rather than productivity and competitiveness alone (Barbera & Jones, 2020; Foundational Economy Collective, 2018; Russell et al., 2022). More recent contributions have extended this

perspective to social reproduction, ecological limits, spatial accessibility, political discontent and the unequal distribution of time (Bärnthaler et al., 2021; Bassens et al., 2025; Hansen, 2022). Yet the empirical operationalization of these ideas remains less advanced. In particular, there are still relatively few attempts to examine monetary resources, infrastructure provision and time use within a common analytical framework.

This matters because the central claims of foundational economy scholarship concern relationships that cannot be observed through conventional income or regional-growth indicators alone. The quality of everyday life depends not only on how much households earn, but also on the costs they cannot avoid, the services they can access, the distances they must travel and the unpaid labor required to meet needs that are not collectively provided. Bassens et al. (2025), for example, argue that foundational livability emerges at the intersection of household characteristics, income and the spatial organization of systems of provision. They call for a more fine-grained analysis of inter- and intra-household differences generated through the interaction of income, time and space. Bärnthaler et al. (2021) similarly argue that residual-income measures must be complemented by time-use data because household-level monetary indicators can conceal the unequal distribution of unpaid work.

The approach and findings of Re:sl:Ze make this debate empirically tangible in the Austrian context. Rather than beginning with sectors or employment classifications, the project starts from households and asks how three dimensions of everyday life, residual income, social infrastructure and time use, shape the experience of inequality. This shift in perspective is important. It moves the analysis from the question of how much income a household receives to the question of what resources remain after essential needs have been met, from the formal existence of public services to their spatial availability and accessibility, and from the household as a seemingly unified economic unit to the distribution of paid and unpaid work among its members. The project thus translates key propositions of foundational economy theory into observable dimensions of household livability.

Its contribution lies less in producing a single headline indicator than in making visible the relationships that conventional statistics tend to separate. By reading household budgets, infrastructure provision and time-use data alongside one another, the analysis reveals forms of inequality that disappear when income, place and everyday labor are treated as independent domains. The value of this perspective becomes especially clear in the residual-income findings. Nominal household income offers only a partial account of financial security because households must first meet largely unavoidable costs for housing and other essentials. Single-person and single-parent households face comparatively high necessary

¹ The full name of the project is: Perspectives on Inequality in Austria: Residual Income, Social Infrastructure and Time Use (<https://resize.project.tuwien.ac.at/>)

expenditure and correspondingly narrow financial margins, while tenant households lose a substantial share of their disposable resources to housing costs. What appears as an income difference is therefore also a difference in the cost of securing everyday life. This gives empirical substance to a central claim of foundational economy scholarship: access to essential goods and services depends not only on how much income households receive, but on how provision is organized, priced and distributed across space.

Re:sl:Ze, therefore, contributes more than a descriptive account of Austrian inequality. It shows how foundational economy theory can be translated into an empirical research strategy centered on the distribution of resources, access and responsibility. It also broadens the meaning of provision. Provision is not confined to services delivered by the state or purchased in markets. It also includes the work households perform when institutional systems do not meet everyday needs. This makes it possible to analyze privatization not only as a change in ownership, but as a redistribution of costs and responsibilities across the state, markets and households.

The project should consequently be understood as a proof of concept for a broader national and international research agenda. It demonstrates that foundational livability can be approached empirically by placing household budgets, infrastructure and time in relation to one another. It also establishes a baseline from which more integrated research can proceed. The value of this contribution lies not in claiming that all dimensions have already been unified in a single dataset, but in showing that their combination changes what becomes visible. This shift is important for both research and policy. Policies that appear redistributive when evaluated through income may have different consequences once housing costs, mobility requirements or care burdens are considered. Reductions in public provision may appear as fiscal savings while generating additional private expenditure and unpaid work. Conversely, investment in accessible social infrastructure may produce benefits that are not fully reflected in conventional economic indicators. It may increase residual income, reduce time poverty, support paid employment, redistribute care and lessen dependence on individualized private solutions. Re:sl:Ze provides a first empirical basis for making such effects discussable in Austria.

This paper is structured as follows. Section 2 situates the Re:sl:Ze project within the foundational economy literature, focusing on residual income, social reproduction, spatial accessibility and the transfer of costs and responsibilities to households. Section 3 presents the exploratory research design, the three empirical pillars (residual income, social infrastructure and time use) and the Austrian data sources used to operationalize them. Section 4 reports the descriptive findings for each pillar and examines how financial resources, infrastructure

provision and paid and unpaid work intersect across household types, social groups and territories. Section 5 discusses these findings in relation to the privatization of foundational costs, the role of social infrastructure and the intra-household distribution of unpaid work. Section 6 concludes by outlining a research agenda on cumulative foundational advantage and precarity, subjective livability and political discontent, and the ecological distributional effects of different systems of provision.

2 Foundational provision, households and the privatization of costs

2.1 From economic growth to the foundations of everyday life

The foundational economy approach emerged as a critique of economic and regional policies centered on competitiveness, innovation, export-oriented industries and productivity. The original Manifesto for the Foundational Economy called for a “gestalt flip” in industrial policy. Rather than giving priority to a relatively narrow group of technologically advanced and internationally traded sectors, policy should focus on the systems that provide the goods and services required in everyday life (Bentham et al., 2013).

The foundational economy is commonly defined as the part of the economy that produces and distributes goods and services “consumed by all citizens regardless of income or status because they support everyday life” (Bentham et al., 2013). It includes material systems of provision such as energy, water, food, housing, waste and transport, as well as providential services including healthcare, education and care (Foundational Economy Collective, 2018). Hansen (2022) describes these as “mundane services” that are nevertheless essential to human wellbeing.

This perspective challenges the treatment of the economy as a unitary space in which all activities can be assessed using the same metrics. Foundational thinking instead distinguishes between economic zones with different purposes, business models, temporalities and forms of consumption. Foundational sectors are often based on territorially embedded infrastructures, networks and branches, involve long-term investment horizons and facilitate collective rather than exclusively individual consumption (Bärnthaler, 2025). The central normative shift concerns the objective of economic policy. Rather than assuming that economic growth or productivity gains will eventually improve living conditions, foundational economy scholarship argues that policy should directly secure access to welfare-critical goods and services. As

Hansen (2022) puts it, foundational goods and services should take center stage because “the absence of such services restricts possibilities for citizens to live decent lives” (p. 1034).

The foundational perspective also questions the dominance of productivity as a measure of economic success. Froud et al. (2020) distinguish between a technical understanding of the everyday economy as a collection of low-productivity sectors and a social understanding in which the defining characteristic is contribution to wellbeing. From the latter perspective, productivity has limited relevance as a universal target because many foundational activities, including care, education and health, cannot be assessed meaningfully by maximizing output per worker hour. Their social value depends on quality, continuity, accessibility and the relational character of provision.

2.2 Public, private and hybrid provision

The foundational economy literature does not reduce provision to a binary opposition between state and market. Essential goods and services may be provided by central government, municipalities, public enterprises, non-profit organizations, cooperatives, community organizations or private firms². The relevant question is whether institutional arrangements secure affordability, accessibility, quality, continuity and democratic accountability.

Bärnthaler et al. (2021) argue that affordable and high-quality foundational provision is a public responsibility, but not necessarily one that requires direct delivery by the central state. Housing associations, cooperatives and coalitions of local and regional actors may play important roles, particularly where they are responsive to territorial circumstances. Similarly, Plank (2020) emphasize the diversity of possible ownership and governance arrangements, including public, cooperative and non-profit forms. For private providers, foundational economy scholarship has proposed the principle of the social license. Providers operating in protected, regulated or territorially anchored markets should accept social

obligations in exchange for the right to operate. These may include commitments concerning service quality, wages, employee training, local procurement, reinvestment, taxation, debt and environmental practices (Foundational Economy Collective, 2018).

Hansen (2022) therefore notes that the foundational approach does not necessarily require “ownership changes from private to public” (p. 1035). Instead, private providers may be governed through social licenses that require social returns and responsible financial practices. This distinction is important for the present research agenda. The transfer of costs to households cannot be inferred from ownership alone. A publicly owned service may still be inaccessible or underfunded, while a private or cooperative provider may be strongly regulated and universally accessible. The analysis must therefore consider ownership, financing, regulation, spatial accessibility and household outcomes jointly.

Yet the literature is highly critical of the financialization of foundational sectors. Foundational services generally require stable investment, moderate returns and long time horizons. Financialized business models instead privilege short-term returns, debt-financed extraction and shareholder value. This tension has contributed to pressure on wages and working conditions, the squeezing of suppliers and declining service quality (Bayliss et al., 2023).

González and Taylor (2026) extend this argument by conceptualizing foundational sectors as sites of value struggles. In their analysis of marketplaces, foundational roles such as everyday provisioning, social interaction and local attachment conflict with commercial and real-estate valuations. Foundational assets are therefore not inherently or permanently foundational. Their role is politically contested and depends on the value regimes through which they are governed.

2.3 Residual income and the household effects of provision

A key contribution of foundational economy research is the concept of residual income. Rather than treating post-tax income as an adequate indicator of living standards, residual income subtracts unavoidable expenditure on essential goods and services, such as housing, utilities and transport. It therefore measures the resources households retain after meeting basic needs. This distinction matters because households with comparable incomes can face substantially different necessary expenditures. Housing tenure, energy efficiency, household composition, regional prices and access to collective services all affect the portion of income that remains available. Bärnthaler et al. (2021) describe residual income as an alternative to GDP- and market-income-based measures because it places private income in relation to

² We use “privatization” throughout to cover two related but distinct mechanisms by which the cost of an unmet need is shifted onto households, rather than in the narrow sense of asset sale or contracted-out delivery alone. The first is market privatization (or marketization): households pay directly for a service that was previously free or subsidized, or that a well-functioning collective system would have provided. This mechanism is captured primarily through residual income. The second is household privatization (or familialization): the need is met through unpaid labor inside the household rather than through any monetary transaction at all. This mechanism is captured primarily through time use. Social infrastructure functions as the shared driver of both: weak or inaccessible provision can push households toward either track, or both simultaneously. This two-track distinction follows the logic already present in Bärnthaler et al. (2021), who describe the “privatization” of unpaid reproductive work as continuous with, but distinct from, market privatization.

infrastructure-based collective consumption. Residual income also alters the interpretation of successful and unsuccessful regions. A region with high wages or gross value added may still offer poor foundational livability if housing, mobility and/or utility costs absorb a large share of household income. Conversely, collectively provided services may improve living standards without directly increasing private monetary income. The concept is particularly relevant to the question of cost privatization. When collective services are withdrawn or become more expensive, the effect may appear as an increase in household expenditure rather than a reduction in nominal income. The resulting decline in residual income can therefore be interpreted as one possible household-level effect of changes in systems of provision (Bayliss et al., 2021).

However, residual income has important limitations. As Bärnthaler et al. (2021) note, measuring resources at household level may obscure the unpaid work through which household members meet needs. Although income may be pooled, time and responsibility are not necessarily shared equally. Residual income can therefore conceal “the uneven distribution of unpaid work within the household” (p. 6., italics in original) which is central to gender inequality.

2.4 Time use, social reproduction and intra-household inequality

Feminist economics provides a necessary extension to foundational economy analysis by emphasizing social reproduction and unpaid work. Everyday life depends not only on goods and services purchased in markets or provided by the state, but also on cooking, cleaning, childcare, eldercare, household administration and emotional support. Much of this work is performed without pay and is distributed unequally by gender (Sayer, 2016).

Bärnthaler et al. (2021) argue that foundational thinking has historically concentrated too heavily on paid employment and monetized provision. They therefore call for the “revaluing [of] unpaid work” (p.1) and for time-use surveys to become an integral component of foundational measures of livability. They further argue that adequate time-use metrics are required “to make unpaid work visible” (p. 6) and to identify activities that sustain everyday life and human flourishing. The relationship between infrastructure and unpaid work is particularly important. If childcare, schools, healthcare or shops are distant, poorly coordinated or unavailable at relevant times, households must spend more time travelling, organizing and providing care themselves. These time costs may affect employment possibilities, leisure, rest and social participation.

Bassens et al. (2025) conceptualize these relations through the interaction of money, space and time. Foundational practices involve the daily movements households make between the home, workplace, school, shops, healthcare and other services. They emphasize that these practices differ among household members and note that women, because of their continuing role as primary caregivers, are often disproportionately involved in time-consuming care and trip-chaining activities. Higher-income households may be able to respond to these constraints by purchasing private services, outsourcing domestic tasks or using private mobility. The authors describe this as the capacity to “buy time” (p. 10). Lower-income households, by contrast, may depend more heavily on self-provision through cooking, cleaning and care. The substitution of public or collective provision by household labor is therefore likely to be both classed and gendered.

This perspective changes how privatization is understood. Privatization is not limited to the sale of state-owned assets or the outsourcing of services. It may also involve the less visible transfer of responsibility into households. Bärnthaler et al. (2021) refer to the continued subordination of unpaid to paid labor as reinforcing the “privatization” of socially necessary reproductive work.

2.5 Space, accessibility and foundational livability

Foundational goods and services are spatially organized. Their value depends not only on whether they formally exist, but on whether households can reach and use them. Accessibility is shaped by distance, transport options, opening hours, service capacity, cost and household time constraints. Bassens et al. (2025) argue that current debates about regional inequality focus too strongly on aggregate measures such as productivity, output and employment. Such measures may conceal major differences in everyday living conditions within the same region. They therefore propose the concept of foundational livability, which examines how household characteristics interact with income and the spatial organization of foundational systems.

From this perspective, proximity to affordable, high-quality services can free both time and money. Conversely, poor accessibility may generate transport poverty, constrain employment choices and intensify unpaid work. Bassens et al. (2025) distinguish between foundational privilege and foundational precarity. Privileged households may have high residual income, short travel times, high-quality services and the ability to outsource domestic work. Precarious households may face low residual income, longer journeys, poor-quality provision and a greater reliance on gendered unpaid labor.

Spatial inequalities can consequently become intra-household inequalities. For example, where a household has only one car, access to full-time employment may be concentrated in the person who uses it, while other household members remain restricted to local employment and care activities. Poor public transport and low-density development can therefore influence both the household's monetary budget and the division of labor within it.

3 Data and Methods

3.1 Research Design

Re:sl:Ze adopts an exploratory, descriptive, multidimensional research design to examine inequality in Austria through three interrelated dimensions: residual income, social infrastructure and time use. The methodological starting point is that no single dataset or indicator can adequately capture the conditions under which households organize everyday life. Income records monetary resources, but not how much of those resources must be spent on unavoidable needs. Infrastructure data describe the territorial organization of services, but not how households compensate when these services are absent or difficult to reach. Time-use data reveal the work performed inside households, but not the financial and spatial conditions under which this work takes place.

The analysis therefore brings together different forms of evidence that are usually considered separately. Household expenditure data are used to examine the resources available after necessary costs. Spatial data are used to represent the availability and accessibility of essential services. Time-use data are used to investigate the distribution of paid and unpaid work between women and men and across different household and territorial contexts. This combination reflects the central premise of foundational economy research: Everyday wellbeing is generated through systems of provision rather than through private income alone. Household income, infrastructure and time are therefore treated not as independent dimensions, but as different elements of the same provisioning process.

The empirical analyses presented in Re:sl:Ze are primarily descriptive. They compare median or average outcomes across income groups, household types, housing tenures, educational groups, employment arrangements, municipality-size categories and levels of infrastructure provision. The purpose is not to estimate causal effects or to construct a single model of inequality. Instead, the analyses identify systematic patterns that become visible when monetary, spatial and temporal dimensions are examined alongside one another.

This descriptive orientation is an important first step in the empirical development of foundational economy research. The literature offers a substantial theoretical account of foundational provision, social reproduction and livability, but rarely operationalizes these concepts through multiple forms of household and spatial data. Re:sl:Ze demonstrates how existing official and geospatial datasets can already be used to translate theoretical propositions into observable relationships in Austria. The approach can therefore be understood as both an empirical status assessment and a methodological proof of concept. It documents current inequalities while establishing a framework that can support more advanced analyses in the future. The descriptive findings identify relevant associations, clarify which dimensions should be analyzed jointly and provide a basis for subsequent multivariate, longitudinal, spatial and causal research.

3.2 Household income, necessary expenditure and residual income

The financial component of the analysis is based primarily on the Austrian Household Budget Survey 2019/2020 conducted by Statistics Austria. The survey provides information on household income and consumption expenditure and allows the project to distinguish between total resources and the portion of income absorbed by necessary expenditure.

Residual income is defined as household income after the deduction of expenditure required to meet basic needs. The Re:sl:Ze analysis includes necessary expenditure in the areas of housing, food, health, mobility and education. These categories are broadly relevant across households, although the amount spent varies substantially by income, household composition, tenure and place. The purpose of the residual-income measure is to distinguish nominal income from the financial resources households can actually use after essential needs have been met. Two households with similar incomes may have very different residual incomes where one faces higher rent, mobility or health costs. Residual income is therefore better suited than income alone to identifying the financial consequences of different systems of provision.

The descriptive analyses compare income, necessary expenditure and residual income across income quintiles, household types, federal states, municipality-size categories and tenure groups. Particular attention is given to tenant households because housing costs and tenure structures substantially affect comparisons between regions. For comparisons, the values are equalized using an OECD-based scale in order to account for household size and composition. In the project presentation, a single-person household receives a weight of 1, two adults a weight of 1.5, and a couple with one child under the age of 14 a weight of 1.8. Both absolute expenditure

and expenditure relative to income are considered. This distinction is important because necessary expenditure may appear relatively similar in absolute monetary terms across income groups while placing very different pressures on household budgets.

3.3 Social infrastructure as the empirical core

As foundational livability highlights the spatial component of provisioning systems, the social-infrastructure dataset forms the empirical core of the Re:sl:Ze framework. Residual income and time use measure important household outcomes, but infrastructure provides the connecting layer between household conditions and the broader organization of foundational provision. It captures the territorial context within which households must satisfy essential needs.

Social infrastructure is understood here as the network of facilities and services that support everyday life, including provision in areas such as childcare, education, healthcare and other essential services. Its relevance extends beyond the simple presence of a facility. What matters is whether households have meaningful access to the services on which everyday life depends. A well-developed infrastructure can reduce travel, save money and time, support labor-market participation and reduce the amount of care and organizational work that must be performed privately. The project accordingly describes social infrastructure as indispensable provision that can create security and save households distances, time and money.

The infrastructure analysis combines information from a range of administrative and geospatial sources. These include the Austrian childcare statistics, medical-provider directories, information from the Austrian health and social-affairs administration, OpenStreetMap, data.gv.at, education-related administrative sources and supplementary online location information. Bringing these sources together makes it possible to move beyond isolated sectoral indicators and towards a more comprehensive representation of the local foundational environment. The resulting infrastructure indicator classifies municipalities according to their overall level of provision. The importance of this dataset is analytical as well as empirical. Social infrastructure represents the institutional and spatial conditions that mediate between household needs and household resources. Where services are accessible, needs can be met partly through collective provision. Where provision is weak, households may have to compensate through market purchases, travel or unpaid labor. Infrastructure therefore makes it possible to investigate how the organization of provision influences the location and form of everyday costs.

This is particularly important because infrastructure inequalities are not reducible to a simple urban-rural distinction. Municipality size provides a useful territorial classification, but settlements of similar size may differ in the quantity, diversity and accessibility of their services. A dedicated infrastructure indicator offers a more direct measure of the foundational environment than population size alone. It enables comparisons between areas that may be similar demographically but differ substantially in the resources available to residents. The social infrastructure data also provide the basis for connecting the three main dimensions of Re:sl:Ze. Infrastructure provision can be compared with financial burden to investigate whether poorly served areas are associated with higher necessary expenditure or reduced household flexibility. It can also be related to time use to examine whether service scarcity corresponds with increased unpaid work.

3.4 Time-use data and intra-household inequality

The time-use component is based on the Austrian Time Use Survey 2021/2022 conducted by Statistics Austria. Time use is analyzed because monetary household indicators do not reveal how necessary work is distributed between individual household members. Whereas income is generally pooled and measured at household level, time remains an individual and finite resource. The analysis distinguishes particularly between paid employment and unpaid work, including household labor, childcare and care for other household members. It examines variation by gender, education, employment status, household composition, municipality size and infrastructure provision.

This individual-level perspective is essential for identifying intra-household inequality. A household may have a moderate or high income while its members experience very different combinations of paid work, unpaid work and discretionary time. Time-use data therefore make visible forms of inequality that disappear when the household is treated as a single unit. The analyses focus on adults of working age and compare average daily time allocations across groups. The project notes that persons aged 15 and above living in the household are counted as adults in the relevant household classifications. This affects the interpretation of categories that may include older children or care-dependent adult relatives.

3.5 Austria as a case

Austria provides a particularly instructive case for examining foundational provision and multidimensional livability and inequality. It combines a comparatively extensive welfare state with substantial territorial, institutional and household-level variation. Essential services are shaped

by a federal governance structure involving the national government, nine federal states and municipalities, while provision also includes social-insurance bodies, non-profit organizations and private providers. This institutional diversity makes Austria analytically valuable. National averages can suggest relatively comprehensive provision, yet the conditions under which households access services differ significantly across federal states, municipalities and settlement types. Responsibilities for services such as childcare, education, healthcare, care and transport are distributed across levels of government and organizational forms. As a result, households may encounter very different local configurations of foundational provision within the same national welfare system.

Austria's settlement structure also creates a useful context for spatial analysis. Vienna constitutes a large metropolitan center with a distinct housing market, public-transport system and infrastructure density. The remaining federal states contain combinations of medium-sized cities, suburban areas, small towns, rural municipalities and alpine or peripheral settlements. Municipality size and remoteness influence the distances households must travel, the range of services available locally and the feasibility of providing specialized facilities.

Austria is also relevant because of the continuing importance of gendered employment and care arrangements. The time-use evidence shows substantial differences between women and men in unpaid work, particularly in couple households with children and among part-time workers. These patterns interact with local infrastructure: women in smaller and more poorly provided municipalities perform more unpaid work, while men's contribution varies less across space.

The Austrian case therefore makes it possible to examine foundational inequality within a relatively affluent welfare state. The central issue is not simply whether services exist nationally, but how their organization produces different household outcomes across places and social groups. This is theoretically important because foundational precarity should not be understood only as the complete absence of welfare institutions. It can also arise through uneven accessibility, affordability, capacity and the private work required to compensate for gaps in otherwise extensive systems. However, Austria is not an exceptional or isolated case. The dimensions and relationships examined by Re:sl:Ze between essential expenditure, infrastructure access, and unpaid work are relevant to other European welfare states characterized by decentralized provision, urban-rural differences and gendered care regimes. The Austrian analysis can therefore contribute to broader comparative research on how welfare institutions and spatial structures distribute the costs of everyday provision.

4 Results

The results are organized around the three pillars of the Re:sl:Ze framework: residual income, social infrastructure and time use. Each pillar captures a different dimension of inequality. Residual income shows the financial resources that remain after households have met essential needs. Social infrastructure describes the spatial conditions under which those needs can be met through collectively organized services. Time use reveals how the work of maintaining everyday life is distributed within households.

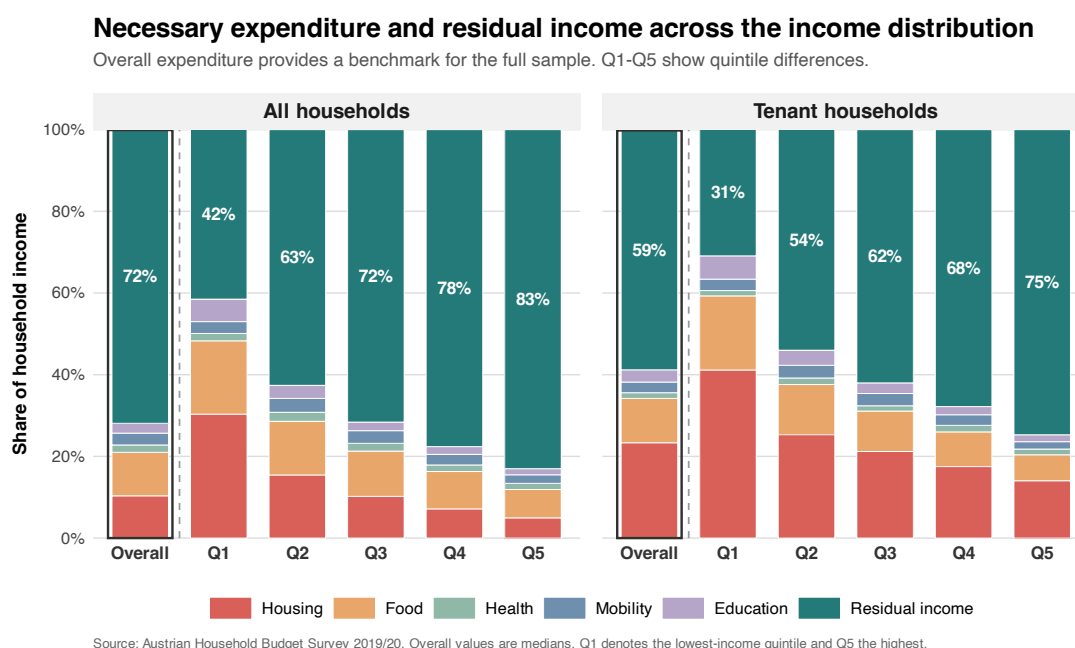


Figure 1: Necessary expenditure and residual income across income quintiles for all versus tenant households.

Taken together, the findings reveal a multi-dimensionality of inequality that becomes visible only when income, infrastructure and time are considered in combination. Household income by itself says little about the resources that remain once essential needs have been met. Necessary expenditure reshapes the distribution of effective financial security, access to childcare, health care, education and other foundational services varies considerably between municipalities, and the unpaid work required to sustain everyday life remains distributed unequally. These dimensions, however, are not isolated from each other. They interact in ways that can reinforce advantages and disadvantages. Lower living costs may be offset by weak infrastructure, while inadequate provision can reappear as longer journeys, higher private expenditure or additional unpaid work within the household.

4.1 Residual income: Necessary expenditure amplifies financial inequality

The residual-income analysis begins with the distinction between household income and the resources that remain after essential expenditure. Necessary expenditure includes housing, food, health, mobility and education. Figure 1 shows necessary expenditure and residual income for all households as well as only tenant households across the income distribution. Across all Austrian households, approximately 72 per cent of household income remains after these categories have been deducted. Among tenant households, however, the corresponding share falls to approximately 59 per cent. The difference is driven particularly by housing: whereas all households spend, on average, around 10 per cent of their income on housing, the share exceeds 23 per cent among tenants. This first

result demonstrates that housing tenure is central to households' effective financial position. Analyses based only on income conceal the very different costs faced by owners and tenants. Tenant households have less financial room for savings, unexpected expenditure, leisure or investment even where their nominal income resembles that of other households.

The distributional consequences become particularly visible when households are compared across income quintiles in Figure 1. In absolute terms, expenditure on necessities does not vary as dramatically as income itself. All households require housing, food, mobility, health and education. Relative to income, however, the differences are substantial. The lowest-income quintile spends almost 60 per cent of its income on necessary expenditure. By contrast, the highest-income quintile spends only around 20 per cent on the same broad categories. Middle-income households retain more than 70 per cent of their income after necessary costs, while the lowest-income households have much less capacity to absorb unexpected expenditure. The disparity is even greater among tenants. After necessary expenditure, tenant households in the lowest income quintile retain only around 30 per cent of their income. The relative burden of housing declines steadily with income and accounts for approximately 14 per cent of income among tenants in the highest quintile.

Necessary expenditure therefore has a regressive effect. Although essential needs are broadly shared, their costs absorb a much larger proportion of the resources of low-income households. Higher-income households are not only able to spend more in absolute terms, but they also retain a disproportionately larger share of income once necessities have been met.

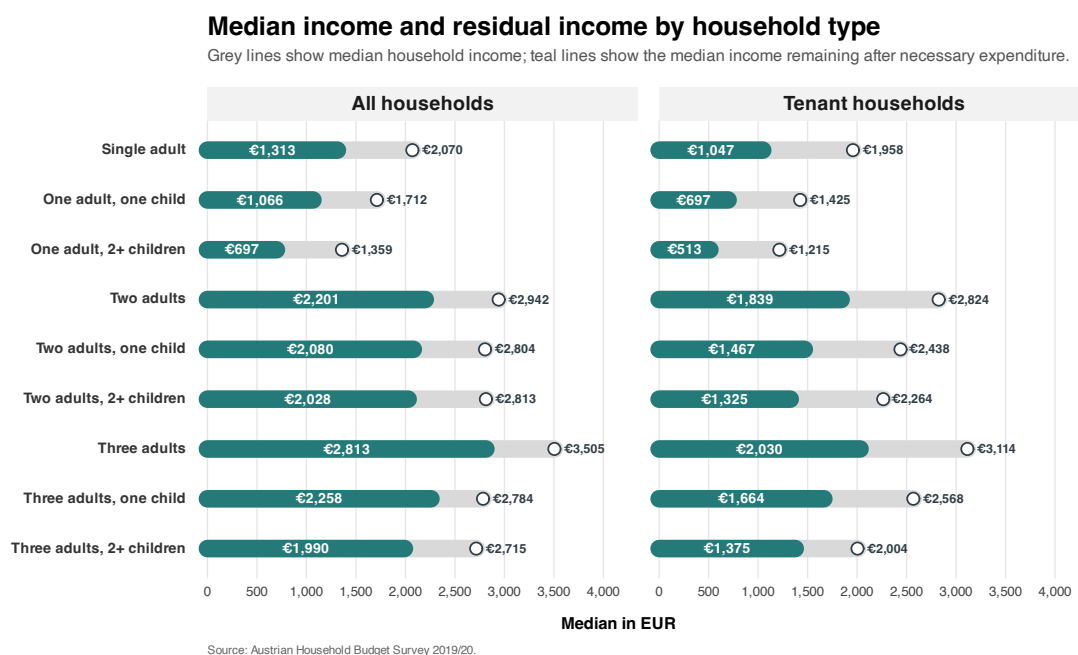


Figure 2: Median income and residual income by household type.

Household composition structures financial vulnerability

Residual income also differs markedly by household type (Figure 2). Single-person and single-parent households have lower incomes and carry relatively high necessary costs because they cannot share fixed expenditures across several income earners. They consequently have lower residual incomes and face greater difficulty covering living costs than many couple households. The pattern reflects both economies of scale and labor-market participation. Additional household members increase expenditure, but additional earners may increase income more strongly. A household combining full-time and part-time employment may therefore retain more income than a household dependent on one full-time earner, even after equivalence weighting.

Education and employment differences are magnified after essential costs

Figure 3 shows that education is strongly associated with residual income because necessary expenditure must be met by households across educational groups, whereas access to well-paid employment differs considerably. Among households in which all working-age members are employed full time, those whose highest educational qualification is compulsory schooling have a median residual income of approximately €1,100. Where at least one household member has completed post-secondary or tertiary education, the corresponding figure is approximately €2,800. Differences also persist among households involving part-time employment. Households with post-secondary or tertiary education retain around €400 more in median residual income than households whose highest qualification is compulsory schooling.

These results show that full-time employment alone does not guarantee comparable financial security. Wage levels and employment quality matter because necessary costs create a floor below which expenditure cannot easily be reduced. Educational inequalities in labor-market returns are therefore reproduced, and in some cases intensified, at the level of residual income. The comparatively low residual incomes of part-time households are particularly concerning in the Austrian context, where part-time employment is highly gendered and closely associated with care responsibilities. Educational differences within part-time households may therefore overlap with gendered divisions of paid and unpaid work, especially among mothers, and contribute to longer-term inequalities in earnings, social-security entitlements and financial resilience

Regional outcomes depend on housing tenure and local costs

Substantial differences are also evident between federal states and municipality-size categories, as shown in Figure 4. When all households are considered together, Vienna has comparatively high expenditure and, together with Carinthia, among the lowest household and residual incomes. Upper Austria and Lower Austria show the highest residual incomes. The interpretation changes once the analysis is restricted to tenant households. Vienna no longer records the highest housing expenditure and instead has the highest residual income among tenants. Rents are highest in Vorarlberg, followed by Salzburg, while tenant households in Burgenland and Carinthia face the lowest rental costs.

Residual income rises with educational attainment

The education gradient is particularly strong in households where all working-age members are employed full-time.

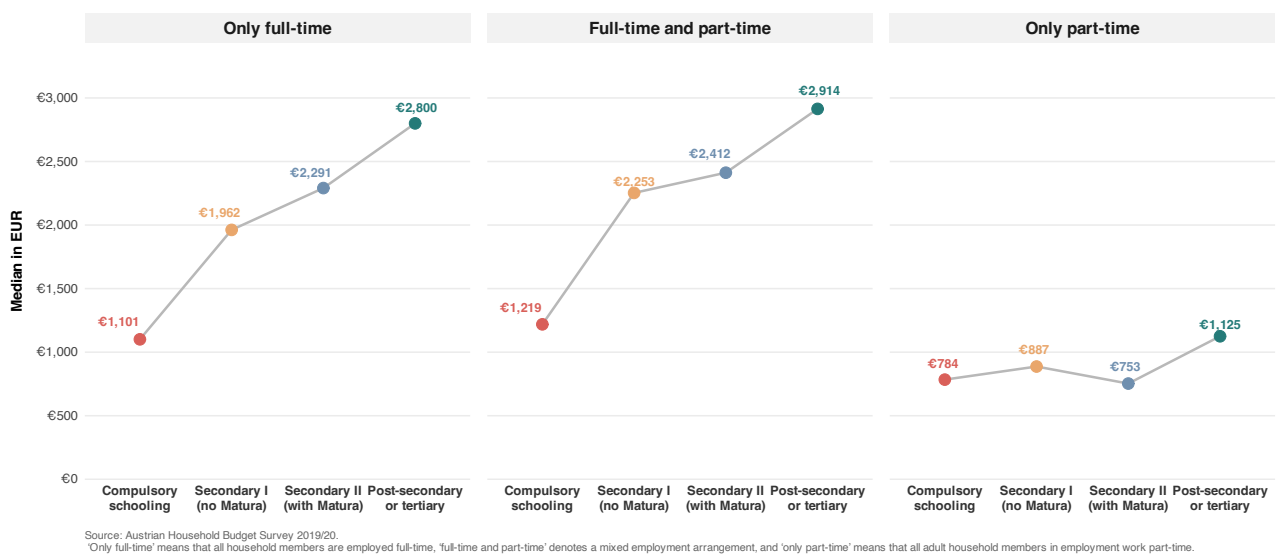
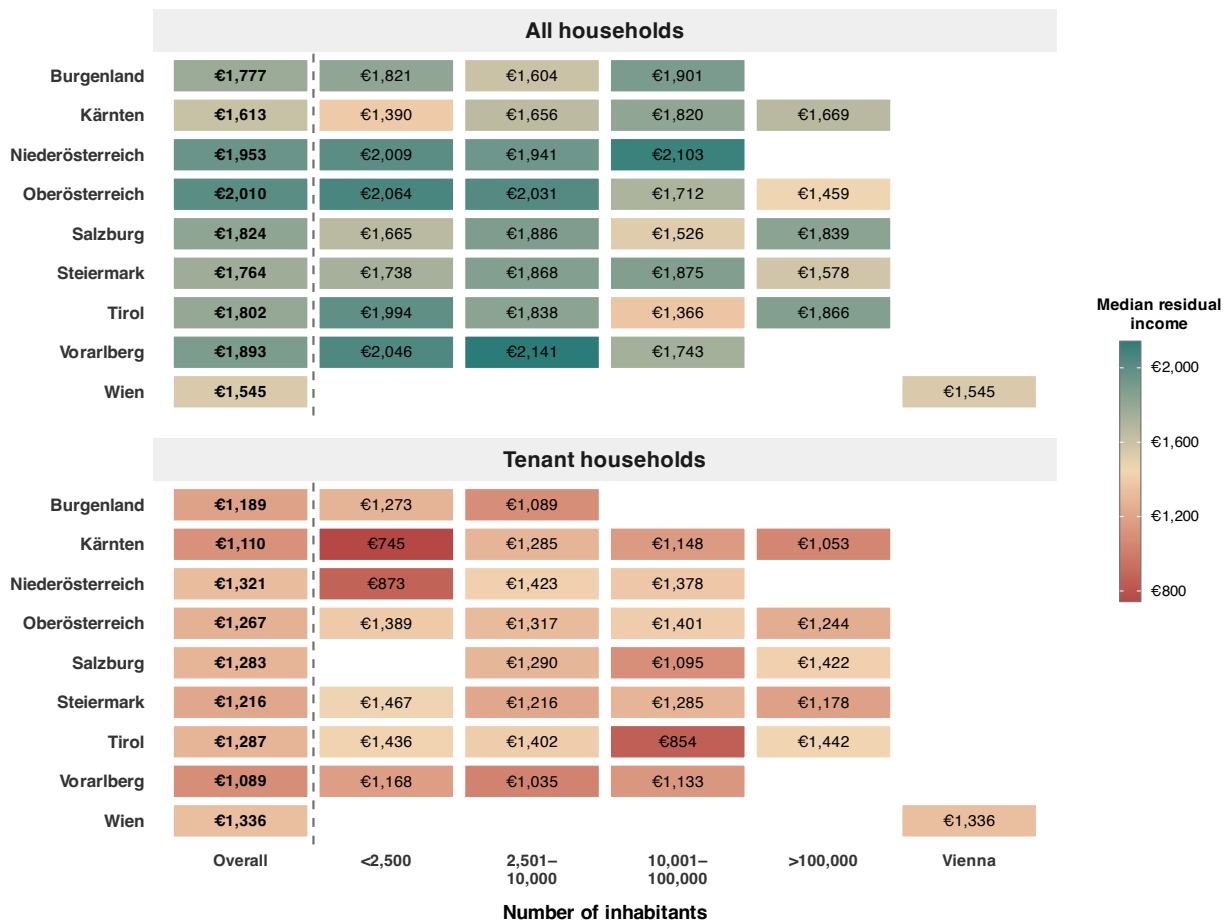


Figure 3: Median residual income by educational attainment and household employment composition.

Residual income varies across federal states and municipality sizes

The Overall column provides the federal-state benchmark; the remaining cells show variation across municipality-size classes.



Source: Austrian Household Budget Survey 2019/20.
Values are median residual income in EUR. Blank cells indicate municipality-size combinations that are not represented in the data.

Figure 4: Median residual income by federal state and municipality size.

The contrast reflects Austria's spatially uneven tenure structure. Vienna contains a much larger proportion of tenants, meaning that housing expenditure is captured more directly for a larger share of households. In smaller and more rural municipalities, higher rates of owner occupation can produce apparently higher residual incomes, especially where mortgage repayments are not included in the expenditure measure. Vienna records a residual income of around €1,545 when all households are considered, while smaller municipalities in several federal states show higher values.

These findings caution against interpreting higher residual income automatically as higher livability. In rural areas, low recorded housing expenditure may coexist with weaker public transport, fewer nearby services and greater dependence on private mobility or unpaid household provision. The financial advantage associated with lower costs can therefore be offset by infrastructural and temporal disadvantages.

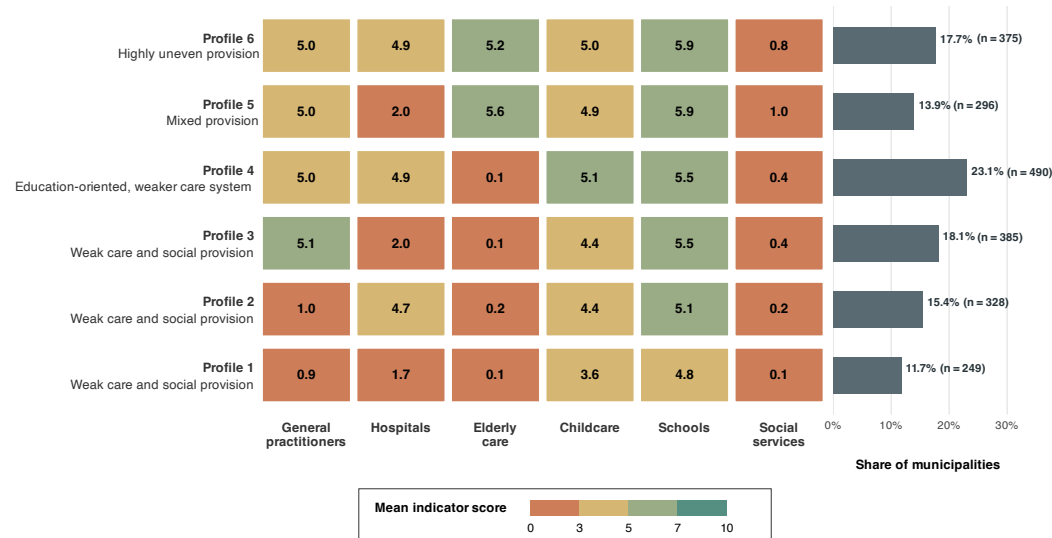
4.2 Social infrastructure: Uneven access to the foundations of everyday life

The second pillar examines the availability and accessibility of six areas of social infrastructure. The indicator relates services to local need, for example, general practitioners to the population, kindergarten groups to children aged three to six, and elderly-care places to the population aged over 70. Provision in neighboring municipalities is also included at a lower weight where it can be reached within 30 minutes by car or public transport. The indicator ranges from 0 to 10. A value of 0 signifies that a service is neither locally available nor accessible, while a value of 10 represents very good provision and accessibility, taking into account proximity, capacity and appropriate opening arrangements.

The results show that the Austrian infrastructure provision cannot be reduced to a simple division between adequately and inadequately served regions. A cluster analysis of the six indicators identifies six recurring municipal infrastructure profiles, each combining different

Austria’s municipalities follow distinct infrastructure profiles

The profiles are derived from all six service indicators. Each cell shows the profile’s mean score, while the bars show how common each profile is.



Source: Self-collected data from Statistics Austria’s childcare statistics, Docfinder, the Austrian Medical Professions Handbook, the Federal Ministry of Social Affairs and Health, OpenStreetMap, data.gv.at, the Federal Ministry of Education, and Google

Figure 5: Social-infrastructure profiles across Austrian municipalities.

strengths and weaknesses (Figure 5). The weakest profile, accounting for 11.7 per cent of municipalities, combines very limited access to general practitioners, hospitals, elderly care and social services with only moderate childcare and school provision. A further 15.4 per cent of municipalities have comparatively good access to hospitals, childcare and schools, but weak general-practitioner, elderly-care and social-service provision. Another 18.1 per cent display the opposite healthcare pattern: access to general practitioners and schools is relatively strong, while hospital access, elderly care and social services remain weak. These profiles demonstrate that even municipalities with some well-developed services can lack essential parts of the wider infrastructure system.

The largest profile, comprising 23.1 per cent of municipalities, performs relatively well in relation to general practitioners, hospitals, childcare and schools, but records almost no elderly-care or social-service provision. This is particularly important because it shows how a municipality may appear broadly well served when attention is limited to education and general healthcare, while still offering a highly incomplete system of care and social support. Strong provision in one field therefore cannot be assumed to compensate for the near absence of another. Only the two strongest profiles, together covering 31.6 per cent of municipalities, achieve medium or good elderly-care provision. One of these combines relatively strong elderly care, schools, childcare and general-practitioner access with weak hospital access. The strongest profile performs comparatively well across five of the six dimensions yet still records a very low social-services score. Social services are therefore not merely weak in the most disadvantaged municipalities; they constitute a structural gap across the entire profile distribution. Even municipalities with

otherwise broad provision often lack an adequate social-service infrastructure.

Taken together, Figure 5 shows that foundational livability depends on the completeness of the local service system rather than on strength in a single dimension. Schools are the most consistently well-provided service across the profiles, while elderly care and social services generate the largest gaps. Because the overall indicator gives equal weight to all six dimensions, a major deficit in one field can substantially reduce a municipality’s overall score.

At the same time, regional accessibility frequently depends on private transport, as shown in Figure 6. The deterioration of the infrastructure rating when public rather than private transport is considered indicates that some apparent provision is conditional upon household car access. This matters economically, temporally and ecologically. Private mobility requires expenditure, consumes time and reinforces car-dependent spatial structures.

The distribution of the individual indicators shows particularly weak provision in care and social services. Social service institutions are the least widely available category, partly because their absolute number is comparatively small. Elderly care is also highly uneven: only about 10 per cent of municipalities achieve medium, good or very good provision in this area. Schools and childcare facilities display a more favorable pattern when accessibility by car is considered. No municipality is classified as poorly served in relation to schools, and the same applies to childcare under the car-accessibility measure. The assessment deteriorates, however, when accessibility by public transport is used. Many municipalities then move

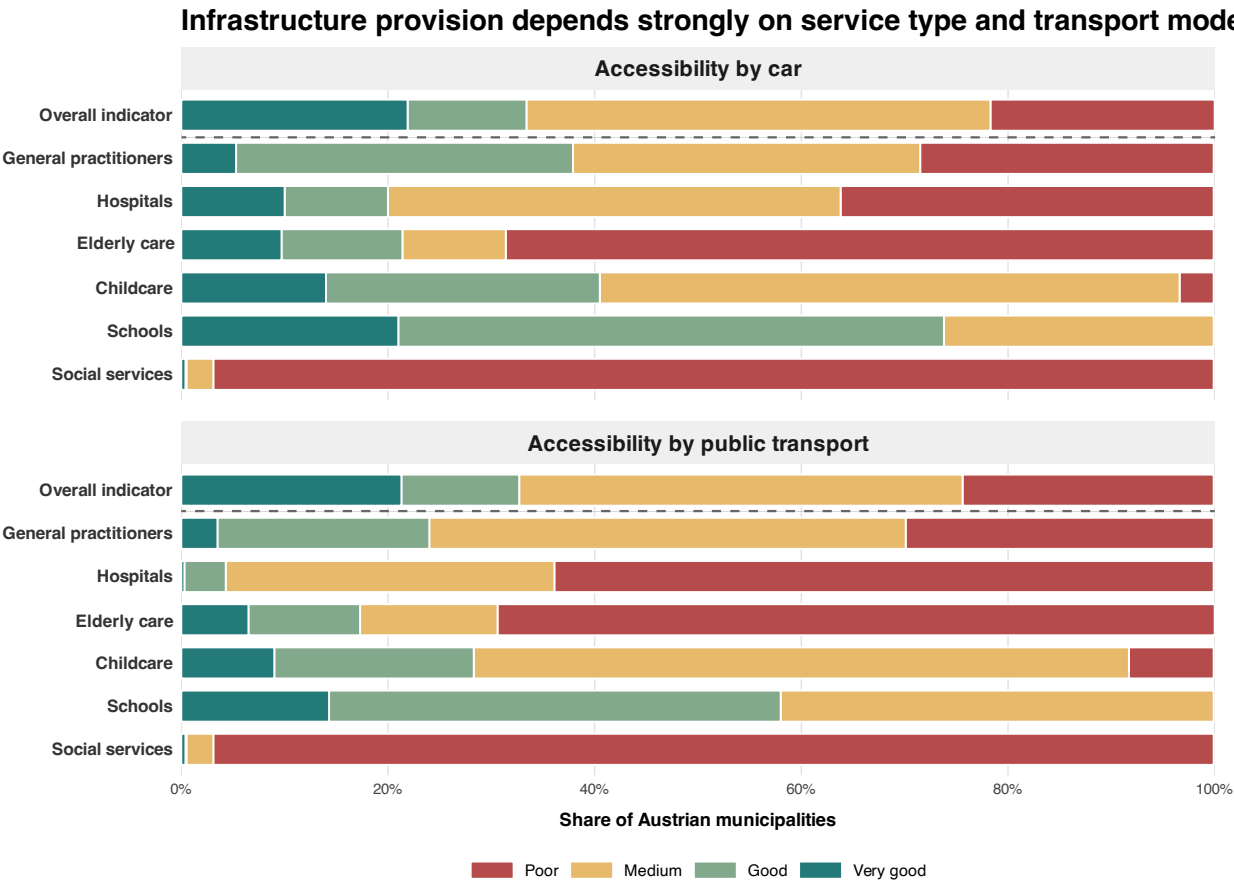


Figure 6: Infrastructure provision by accessibility by car and public transport.

into lower categories, and only a small number achieve very good provision across several infrastructural fields.

The difference between car and public-transport accessibility exposes an important form of hidden inequality. Formal access may appear adequate where households are assumed to possess and use a car. For those without access to private mobility or where one vehicle is shared within the household the same infrastructure landscape may be substantially less accessible.

Differences within federal states exceed many differences between them

At the level of federal-state averages, social-infrastructure provision appears relatively similar across much of Austria, with Vienna standing out as the clearest exception. The mean scores of the other federal states are clustered within a comparatively narrow range. Taken alone, these averages could suggest that regional differences are modest.

The municipality-level distributions in Figure 7 tell a more complex story. In several federal states, the spread of scores is wide, and the middle 50 per cent of municipalities already covers a substantial range of provision. The tails extend further still, showing that some municipalities within the same federal state achieve comparatively strong infrastructure scores while others remain much more weakly served. The overlap between the state distributions is considerable: a relatively well-served municipality in a lower-scoring federal state may outperform a weakly served municipality in a state with a higher average. Vienna differs not only because its average is higher, but also because its municipal districts are embedded in a dense metropolitan infrastructure system. Services are more numerous, spatially concentrated and often reachable across district boundaries. In the other federal states, provision is more dispersed and municipal scores are shaped more strongly by local availability and access to neighboring municipalities.

This within-state variation is substantively important because federal-state means describe administrative territories rather than the service environments households encounter in everyday life. Two households

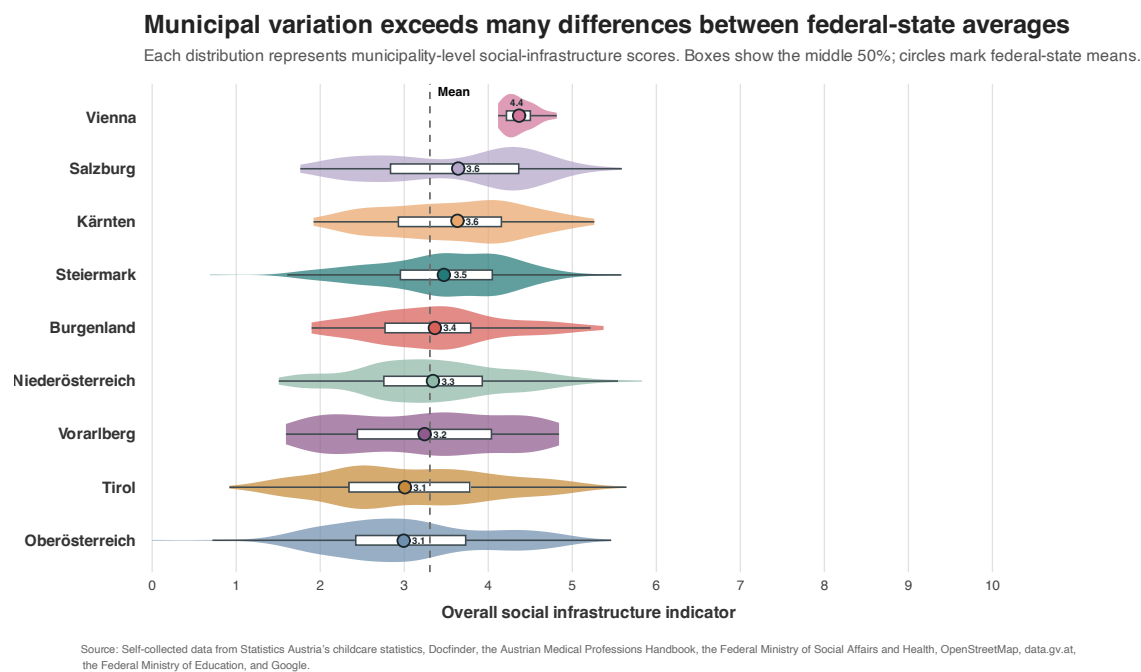


Figure 7: Municipal variation in social infrastructure provision within Austrian federal states.

located in the same federal state may face very different combinations of access to general practitioners, hospitals, childcare, schools, elderly care and social services. One municipality may provide a relatively complete local system, while another may depend heavily on facilities located elsewhere or may lack particular services altogether.

The findings therefore caution against treating national or federal-state averages as sufficient indicators of foundational livability. Such averages smooth over the local mismatches that matter most to households: adequate schooling but weak elderly care, accessible primary healthcare but limited hospital access, or relatively strong childcare alongside an absence of social-

The geography of residual income differs from the geography of infrastructure

Federal-state averages compare median residual income with mean municipality-level social-infrastructure provision.

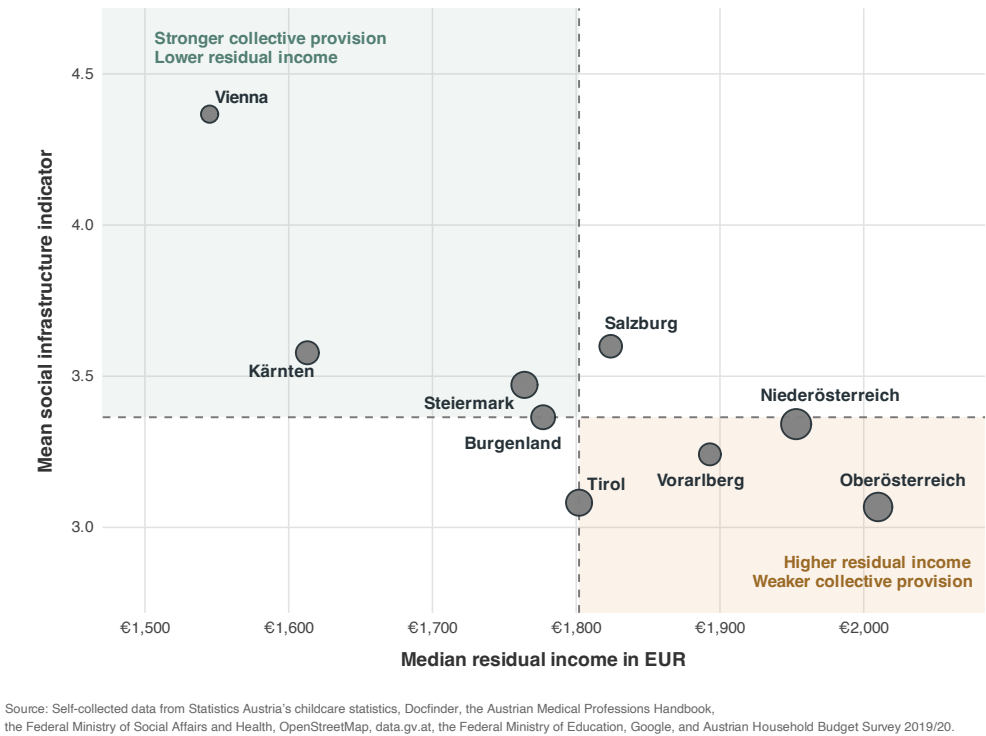


Figure 8: Federal-state averages of residual income and social-infrastructure provision in Austria.

service institutions. The municipality and its accessible surroundings are consequently the more meaningful spatial scale for assessing everyday infrastructure provision.

Infrastructure and financial burden do not follow the same geography

The comparison between residual income and infrastructure in Figure 8 shows that financial and infrastructural advantage do not necessarily coincide. Some smaller municipalities have relatively high residual incomes because of lower housing costs and higher owner-occupation rates yet offer weaker social infrastructure. Vienna, by contrast, records relatively low residual income when all households are considered but has the best infrastructure provision.

This divergence illustrates why neither dimension can serve as a complete proxy for livability. Low living costs may produce financial room but may require households to travel further, own a car or organize care privately.

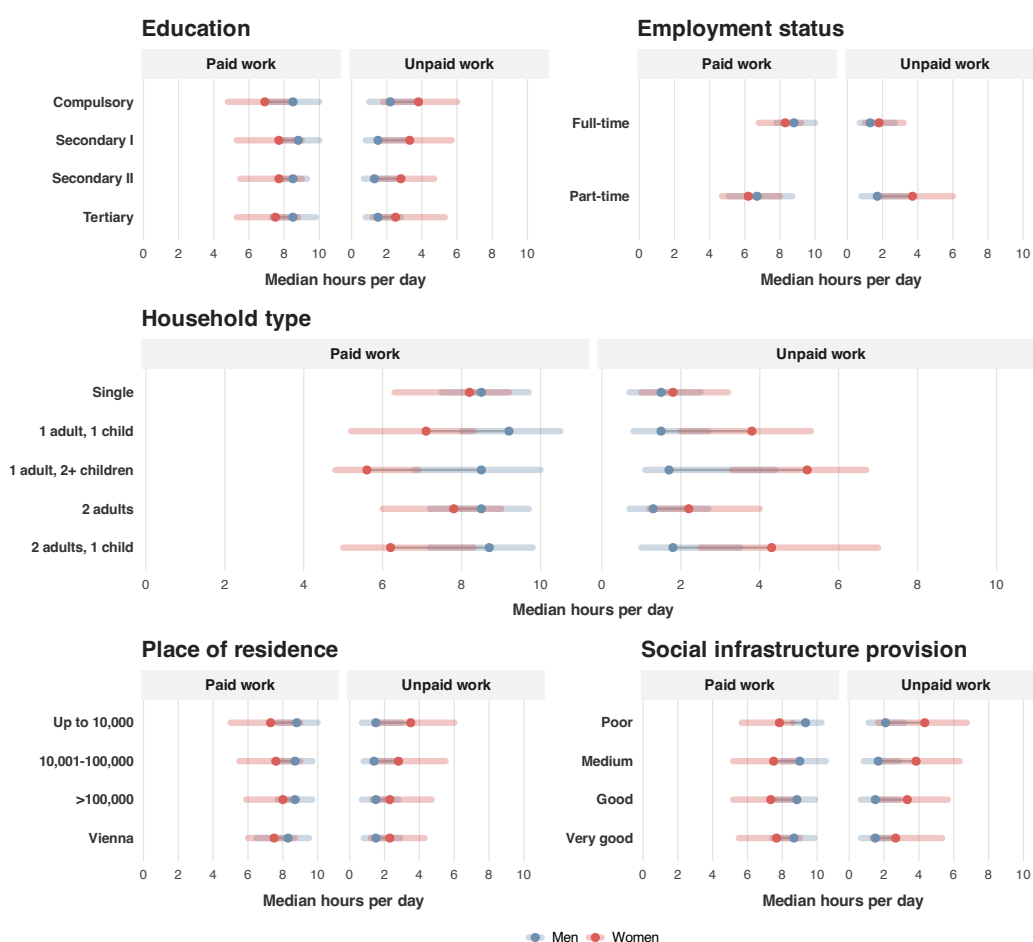
Strong urban infrastructure may save time and reduce the need for household self-provision but coexist with high housing expenditure. The social-infrastructure results consequently reveal a form of inequality that income statistics do not capture. The key question is not only how much money households retain, but what that income must purchase because services are unavailable collectively.

4.3 Time use: Gendered inequalities in paid and unpaid work

The third pillar examines how adults aged 21 to 64 allocate time between paid employment and unpaid care and household work. Unlike income measures, which generally treat the household as a combined unit, time-use data reveal differences between individual household members. Across the results in Figure 9, the most consistent finding is a pronounced gender gap in unpaid work. Women spend more time than men on household labor, childcare and the care of relatives. The

Gender gaps in paid and unpaid work

Each point shows the median number of hours per day. Thick horizontal segments indicate the interquartile range (Q1–Q3).



Source: Self-collected data from Statistics Austria's childcare statistics, Docfinder, the Austrian Medical Professions Handbook, the Federal Ministry of Social Affairs and Health, OpenStreetMap, data.gv.at, the Federal Ministry of Education, Google, and Austrian Time Use Survey 2021/2022.

Figure 9: Gender differences in paid and unpaid work across socioeconomic, household and spatial characteristics.

size of this difference varies with education, employment status, household composition and place, but it does not disappear in any of the groups examined.

Education changes the size, but not the direction, of the gender gap

Women perform more unpaid work than men at every educational level. Among men, the allocation of time between paid and unpaid work changes relatively little across educational groups. Among women, higher education is associated with somewhat more paid work and somewhat less unpaid work. The gender difference nevertheless persists among university-educated adults. Higher education may improve women's labor-market opportunities and increase the financial capacity of households to purchase childcare or domestic services, but it does not eliminate gendered responsibility for unpaid work. The result points to the limits of explanations based exclusively on human capital. Education affects the resources available to negotiate or outsource work, but the division of labor remains shaped by broader gender norms and institutional arrangements.

Part-time work has different implications for women and men

Employment status reveals an especially sharp contrast. Women working part time perform almost twice as much care work as women employed full time. Part-time employment among women therefore does not generally translate into a corresponding increase in leisure. Rather, the reduction in paid hours is largely absorbed by household and care responsibilities. Among part-time workers, women perform more than twice as much unpaid work as men. The findings indicate that men's reduced paid working time is more likely to translate into personal or leisure time, whereas women's reduced hours are more likely to be used for unpaid work.

This pattern has consequences beyond the daily time budget. Part-time employment lowers current earnings, career opportunities and future pension entitlements. When part-time work is combined with greater responsibility for unpaid care, it can increase women's long-term financial dependence and exposure to poverty. Time inequality and income inequality are therefore mutually reinforcing. The unequal division of care contributes to unequal employment trajectories, while unequal earnings affect households' ability to purchase substitutes for unpaid work.

Household formation intensifies gender specialization

Among single adults, women and men show comparatively small differences in the division between paid and unpaid work. The pattern changes once adults live in couple households. Women in couples perform, on average,

approximately 50 minutes more unpaid work per day than their male partners. The gap widens considerably with children. In couple households with one child under the age of 15, women spend more than four hours per day on care and household work, compared with less than two hours among men. At the same time, men perform almost two hours more paid work per day than women. With additional children, these differences become more pronounced. Women further reduce paid employment and increase unpaid work, while men extend their paid working time. A gender difference is also visible among single parents: single fathers spend more time in employment, while single mothers perform more care work.

Household composition is therefore not simply an additional demographic characteristic. The transition from single living to partnership and parenthood reorganizes the division of labor in a systematically gendered way. The presence of children increases the total volume of necessary work, but the additional workload is allocated differently to women and men.

Place of residence shapes women's unpaid work more strongly than men's

The territorial analysis shows that women in the smallest and most rural municipalities perform more than one additional hour of care work per day compared with women in Vienna. As municipality size increases, women's unpaid workload declines. Men's unpaid work, by contrast, remains comparatively stable across municipality-size categories. This result indicates that spatial context does not affect all household members in the same way. Rurality is associated with a more traditional and unequal division of unpaid work.

Several mechanisms may contribute to this pattern. Rural labor markets may provide fewer full-time employment opportunities for women, services may be further away or less compatible with working hours, and care may be more strongly organized through family networks. The descriptive analysis cannot isolate these mechanisms, but it demonstrates that time-use inequality has a clear spatial dimension.

Poor infrastructure is associated with substantially higher unpaid work among women

The strongest connection between the three pillars appears when time use is compared directly with infrastructure provision. Men's unpaid work remains relatively constant across infrastructure categories. Among women, however, the relationship is substantial: women in municipalities with poor infrastructure provision perform, on average, more than 1.5 additional hours of unpaid work per day compared with women in well-provided areas. This result provides empirical support for the central

proposition of the Re:sl:Ze framework. When public or collectively organized services are missing or difficult to reach, necessary care and provisioning activities do not disappear. They are more likely to be performed privately within households, and women absorb a disproportionate share of that additional work.

5 Discussion: From foundational provision to the privatization of everyday costs

This paper has been guided by the question:

How can foundational livability be empirically assessed through residual income, social infrastructure and time use, and what limitations and research needs emerge from the Austrian case?

By placing residual income, social infrastructure and time use within a common analytical framework, Re:sl:Ze makes visible the principal channels through which the costs of foundational provision can be redistributed. It thereby turns a broad theoretical proposition into an empirically grounded research agenda.

The findings suggest that the privatization of foundational provision should not be understood only as a formal change in ownership. It also involves shifts in the practical responsibility for satisfying essential needs. When collective provision is absent, difficult to reach, unaffordable or insufficiently compatible with everyday schedules, households must compensate. They may pay more for housing, mobility, childcare or other substitutes; spend additional time travelling and coordinating services, or perform more care and household work themselves. The effects can therefore appear in monetary budgets, time budgets and the organization of social reproduction.

This broader understanding is consistent with foundational economy scholarship, which distinguishes between market provision, public provision and the unpaid “core economy” of family and community. Bärnthaler et al. (2021) note that austerity and marketization can shift socially necessary work towards households, often without making that transfer visible as an economic cost. The Re:sl:Ze findings add an Austrian empirical perspective to this argument: the household is not simply the final consumer of foundational goods and services, but frequently also the provider.

5.1 Privatization as a redistribution of costs rather than their disappearance

The first answer suggested by the findings is that reductions or deficiencies in collective provision do not remove the costs of satisfying essential needs. They alter where those costs appear and who bears them. Residual income provides the clearest monetary expression of this process. The results show that necessary expenditure absorbs a much larger proportion of the income of low-income households than of high-income households. Among the lowest-income households, close to 60 per cent of income is devoted to housing, food, health, mobility and education, compared with around 20 per cent in the highest quintile. Among low-income tenants, only around 30 per cent remains after necessary expenditure.

These results are consistent with the wider foundational livability literature. Bassens et al. (2025) show that, across several Western European countries, low-income groups devote between half and three-fifths of total expenditure to a limited set of foundational essentials. They argue that residual-income differences do not correspond in any simple way to regional GDP or productivity and may extend well into middle-income groups during cost-of-living crises. The Austrian findings therefore should not be read as an isolated national pattern. They reflect a more general distinction between nominal income and the margin of comfort that remains after households have secured the necessities of everyday life.

Expenditure on housing, energy, transport, health or care is not merely the outcome of individual consumer choice. It depends on systems of provision: housing tenure structures, public-transport availability, energy infrastructures, service fees, spatial planning and the degree to which needs are satisfied collectively rather than through private purchasing power. Barbera and Jones (2020) describe the foundational economy as the economic infrastructure of social citizenship, combining private and collective forms of consumption. They emphasize that material and providential sectors have increasingly been exposed to privatization, outsourcing, marketisation and financialization, processes through which welfare responsibilities are reframed as matters for individual planning, assets and debt. From this perspective, higher private expenditure is not simply an unfortunate side effect. It may be the direct household-level expression of a political shift from collective entitlement towards market entitlement.

Similarly, it is argued that the historical movement from public ownership, public operation and regulation towards privatization, outsourcing and financialization has made private income more decisive for access to foundational goods and services (Bayliss et al., 2021). Market entitlement privileges private consumption and leaves low-income households more exposed when basic prices rise. Re:sl:Ze

helps identify the Austrian distributional structure through which such exposure would operate. Tenants, single parents, pensioner households and households with weak labor-market resources have comparatively little residual income with which to absorb additional costs.

5.2 Social infrastructure as the missing link between income and household self-provision

The second contribution concerns the central role of social infrastructure. The Re:sl:Ze findings demonstrate that income and expenditure cannot be interpreted independently of place. Municipalities differ not only in housing costs and wages, but in the availability and accessibility of healthcare, education, childcare, care and social services. This is important because the consequences of weak provision are not exhausted by service non-use. Where services are unavailable locally, households may travel to neighboring municipalities, depend on private vehicles, reorganize employment around opening hours, use informal networks or perform the work themselves.

The social infrastructure indicator shows that provision is particularly weak in elderly care and social services and that assessments deteriorate markedly when accessibility by public transport rather than by car is considered. Small municipalities have lower average provision, although substantial variation exists among municipalities of similar size. These patterns support Bassens et al.'s (2025) call to analyze foundational livability through the interaction of household resources, accessibility and time rather than through territorial averages alone. They argue that households in the same locality may experience radically different conditions depending on income, access to services and their ability to manage spatial constraints. Their distinction between foundational privilege and precarity is especially useful here. Privileged households can convert income into shorter travel times, private mobility and outsourced domestic labor, while precarious households are more likely to face long journeys, poor services and unpaid self-provision.

The Austrian findings also complicate simple urban-rural or prosperous-disadvantaged classifications. Higher residual income in a small municipality does not necessarily imply higher foundational livability. It may partly reflect owner occupation or low recorded housing expenditure while concealing additional mobility requirements and limited access to care. Conversely, lower residual income in an urban area may coexist with more extensive public transport, childcare and health provision.

This finding is directly relevant to the concept of privatization. When access to public or publicly regulated services is conditional on private mobility, the service may remain formally collective while part of its practical cost

has been privatized. Households provide the vehicle, fuel, travel time and coordination. Similarly, a childcare facility may exist, but limited hours may require parents to reduce paid employment or arrange additional informal care. The boundary between public and private provision is therefore shaped not only by ownership but by the actual conditions of use.

5.3 Time use reveals the intra-household distribution of privatized costs

The third and perhaps most distinctive answer to the research question concerns time. Residual income can show what a household retains financially, but it cannot show who performs the work required to sustain that household. The time-use findings demonstrate that the costs of insufficient provision are not only transferred between institutions and households. Rather, they are also distributed unequally among household members.

Across educational groups, employment arrangements and household types, Austrian women perform more unpaid care and household work than men. The difference becomes substantially larger in couple households and especially after the arrival of children. Women in part-time employment devote much of the time released from paid work to unpaid labor, whereas men's reduced working hours are more likely to generate additional discretionary time. Women in small municipalities perform more unpaid work than women in Vienna, and the difference between poorly and well-provided municipalities exceeds 1.5 hours per day.

These results strongly support the feminist critique of household-level foundational metrics. Bärnthaler et al. (2021) argue that residual income can obscure the "core economy" of self-organized care because it treats the household as a pooled monetary unit. They therefore call for time-use data to make visible the unequal distribution of reproductive work. Re:sl:Ze operationalizes precisely this argument by showing that household livability cannot be evaluated without examining the allocation of paid and unpaid work. The results are also consistent with Bassens et al.'s (2025) account of "buying time." Higher-income households can use money to outsource cleaning, childcare or care, while lower-income households depend more heavily on self-provision. These differences generate gendered inequalities in paid and unpaid labor.

The association between poor infrastructure and women's unpaid work is particularly important. It suggests that the privatization of provision is not gender-neutral. Where collective services are weak, household compensation appears to be disproportionately organized through women's time. The public cost may be reduced or displaced, but the necessary work is still performed. This also reveals a feedback loop between time and monetary inequality.

Greater unpaid care responsibility can lead women to reduce paid working hours. Part-time employment then lowers current earnings, career progression and future pension entitlements. Lower individual income can in turn weaken bargaining power within households and reduce the capacity to purchase services that would save time. The privatization of time burdens therefore produces longer-term financial consequences.

5.4 Public versus private provision: Ownership matters, but governance and access matter more

The results should not be interpreted as evidence that every private provider worsens household livability or that direct state provision is always sufficient. Foundational economy scholarship is more institutionally pluralist than a simple state-market binary suggests. Hansen (2022) notes that foundational provision may be delivered by public, non-profit, cooperative or private organizations. The central requirement is that providers follow certain social obligations, such as affordability and service quality. This is the rationale behind social licensing. The question is therefore not ownership alone, but whether governance arrangements protect use value and universal access (Bayliss et al., 2023).

Nevertheless, ownership and financing remain consequential because they shape institutional incentives. Foundational services generally require long-term investment, stable returns and continuity. Financialized business models prioritizing short-term extraction may conflict with these characteristics and can reduce service quality, worsen working conditions and increase debt. Bärnthaler et al. (2021) similarly trace the foundational economy approach to a critique of privatization, austerity and financialization, which underestimate long-term and spatially distant social costs. The Re:sl:Ze framework adds an important criterion for evaluating any system of provision: its consequences must be traced beyond provider-level performance and into households. A service may be financially efficient for a municipality or profitable for a private operator while generating travel time, user fees or unpaid care work elsewhere. Conversely, a public investment may appear costly in budgetary terms but increase household residual income, reduce time poverty and support employment.

The relevant evaluation question is therefore not simply whether provision is public or private, but:

- Who finances the service?
- Who can access it in practice?
- How much household expenditure does it replace or create?

- How much travel and coordination does it require?
- Does it reduce or increase unpaid work?
- How are these effects distributed by income, gender, household type and place?

This broader accounting would make visible costs that are otherwise externalized to households.

6 From descriptive patterns to a research agenda on foundational livability

The Re:sl:Ze findings should not be read as a direct empirical test of whether the withdrawal, marketization or reorganization of public provision has caused particular monetary or temporal burdens in Austrian households. The analyses are descriptive, the three pillars draw on different datasets, and changes in provision are not followed longitudinally for the same households. The project therefore cannot determine whether a specific infrastructure gap caused higher expenditure, whether a service closure increased women's unpaid work or whether stronger collective provision reduced household emissions.

Its contribution is instead to establish the empirical and conceptual foundations for such research. The results identify dimensions that foundational economy theory suggests should be connected, but which are rarely observed together: the income remaining after essential expenditure, the availability and accessibility of foundational services, and the distribution of paid and unpaid work. Re:sl:Ze thus provides a first analysis of the Austrian conditions under which the privatization of foundational responsibility could occur and formulates a research program for examining these processes more directly.

This agenda is timely because foundational economy scholarship has developed a substantial theoretical account of how everyday wellbeing depends on collective systems of provision, while empirical evidence on the interactions between household money, accessibility and time remains comparatively fragmented. Bassens et al. (2025) explicitly identify the organization of official statistics as an obstacle to studying foundational privilege and precarity across time and space. They call for data capable of analyzing how inter- and intra-household inequalities arise through the "dialectics of income, time and space" (p. 18). Re:sl:Ze advances this agenda by showing that these dimensions can already be operationalized in Austria, even though their direct relationships require further investigation.

6.1 Studying cumulative configurations of foundational advantage and precarity

A first research priority is to move beyond separate measures of income poverty, infrastructure deprivation and time poverty towards an analysis of their cumulative configurations. The present findings show that these dimensions do not necessarily follow the same geography. Some households face high housing costs but benefit from dense infrastructure. Others retain more income because of lower housing expenditure but depend on private vehicles or household self-provision. Still others may experience high essential costs, weak services and substantial unpaid workloads simultaneously.

These combinations resemble what Bassens et al. (2025) conceptualize as the relational ideal types of foundational privilege and foundational precarity. Foundational privilege combines high residual income, good services, short travel times, mobility choice and the capacity to outsource household tasks. Precarity combines low residual income, poor or distant services, transport disadvantage and the performance of invisible reproductive labor within households. The concept is relational because the ability of more affluent households to purchase mobility, care and convenience can coexist with, and sometimes depend upon, the poorly paid or unpaid labor of others.

Future research should identify how such configurations are distributed across Austrian household types and territories. Foundational livability is situated at the intersection of household resources and spatial systems rather than being a simple characteristic of a region. The relevant unit of analysis is therefore neither the household nor the territory alone, but their interaction. Such an approach would avoid assuming that all rural, urban, low-income or tenant households experience the same conditions. Longitudinal data would be particularly valuable. The stronger claim that costs are being transferred requires observing change. For example, what happens to expenditure, employment and unpaid work after a childcare facility closes, public-transport frequency declines, fees increase or a new service becomes available. Quasi-experimental designs could compare affected and unaffected municipalities before and after such changes.

6.2 Connecting material conditions with subjective livability and political discontent

A second research direction concerns the relationship between foundational conditions and political attitudes and subjective wellbeing. Re:sl:Ze does not include indicators of trust, satisfaction, voting or political participation. It therefore cannot establish whether households facing low residual income, inaccessible services or time pressure

are more politically dissatisfied. The findings nevertheless identify material conditions that the emerging literature suggests may shape how citizens evaluate institutions and places. Bassens et al. (2025) argue that political discontent may arise not only from absolute deprivation, but from the experience of “falling below” socially expected standards of livability. In this account, deteriorating provision and the sense that everyday systems no longer function can generate resentment, disengagement or progressive mobilization. Their research agenda therefore connects foundational practices with place-based cultures and politics, including the emotional and embodied experience of deteriorating collective provision.

For Austria, future studies could link the Re:sl:Ze indicators with survey data on institutional trust, satisfaction with public services, perceptions of regional neglect, electoral participation and party preference. The analysis should distinguish objective provision from subjective experience. A household may have a service within a technically acceptable distance but experience it as inaccessible because of waiting lists, opening hours, cost or a lack of public transport. Conversely, residents may evaluate provision positively despite relatively low facility density where informal networks function effectively.

Qualitative research is needed alongside statistical analysis. Interviews and household case studies could examine when service gaps are interpreted as individual inconvenience, local disadvantage or institutional failure. They could also reveal why similar material conditions generate different political responses. This line of inquiry would broaden the study of regional polarization. Rather than explaining discontent mainly through employment loss, productivity or aggregate economic decline, it would investigate whether the everyday experience of housing pressure, inaccessible care, weak mobility and time scarcity contributes to the perception that collective institutions no longer provide security.

6.3 Integrating ecological impacts and eco-social distribution

A third major extension concerns ecological pressures. Re:sl:Ze does not measure household emissions, energy use, land consumption or the environmental footprint of different service arrangements. The present results nevertheless identify relevant mechanisms, especially where access to infrastructure depends on private cars. Transport research shows that car-dependent land-use patterns produce both environmental impacts and forms of social exclusion (Mattioli et al., 2017). Households may experience either car deprivation or forced car ownership, with the latter imposing significant financial costs on those who cannot realistically reach essential activities without a vehicle (Mattioli, 2014). The ecological and social effects are therefore interconnected: the same spatial structure

that increases emissions may also reduce residual income and constrain households without cars. Future research should estimate the emissions and resource implications of different foundational configurations. Relevant comparisons include collective and individual transport, centralized and decentralized service locations, institutional and household care, and efficient housing versus poorly insulated private rental housing. Such analysis should use life-cycle and consumption-based measures where possible, since environmental burdens may be shifted geographically as well as institutionally.

At the same time, collective provision cannot automatically be assumed to be environmentally superior. Hansen (2022) argues that ecological sustainability remains insufficiently developed within foundational economy thinking. Transforming foundational systems requires coordinated changes in technologies, organizational structures, institutions and user practices; environmental clauses attached to providers are unlikely to be sufficient by themselves. Eco-social policy research offers a complementary perspective by examining whether environmental interventions distribute costs and benefits fairly. Climate policies can have markedly different distributional effects and environmental effectiveness, efficiency and equity depend on the design of policy packages and compensation mechanisms (Vona, 2023). A Re:sl:Ze-based ecological agenda should therefore ask not only whether an intervention reduces emissions, but also whether it raises necessary expenditure or excludes

households that lack the resources required to adapt. This is particularly important for measures that rely on private investment. Policies promoting electric vehicles, home insulation or household energy technologies may disproportionately benefit owner-occupiers with savings and access to credit, while tenants and low-income households remain exposed to high energy or mobility costs.

Taken together, these research directions point toward a broader understanding of foundational livability as the capacity of households to meet everyday needs without being exposed to excessive financial costs, inaccessible services, unequal time burdens or environmentally unsustainable forms of private provision. The central contribution of Re:sl:Ze is to show that these pressures must be examined jointly rather than as separate questions of income, infrastructure provision, and gender. A more complete empirical agenda would therefore combine household-level and spatial data, track changes over time, and assess both objective conditions and lived experience. Such research could provide a stronger basis for policies that do not merely compensate households for individual disadvantage but reshape the collective systems through which essential needs are met. In this sense, Re:sl:Ze is not an endpoint, but a framework for investigating how public provision, household resources, time and environmental constraints interact in the production of everyday security and inequality.

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Öffentliche Dateninfrastrukturen im Mobilitätssektor: Mobilithek und Mobility Data Space als Plattformen für datenbasierte Innovationsökosysteme

Norbert Földi

Die Digitalisierung des Mobilitätssektors erhöht die Bedeutung von Daten als Grundlage für innovative Mobilitätsdienste und digitale Verkehrssteuerung. Vor diesem Hintergrund gewinnen staatlich initiierte Datenplattformen und Datenräume als Infrastrukturen datenbasierter Innovationsprozesse an Bedeutung. Der Beitrag untersucht diese Entwicklung am Beispiel von Mobilithek und Mobility Data Space. Auf Grundlage einer qualitativen Dokumentenanalyse zentraler Strategie-, Programm- und Plattformdokumente zeigt der Beitrag, dass beide Initiativen unterschiedliche, jedoch komplementäre Ansätze staatlicher Dateninfrastrukturpolitik darstellen. Während die Mobilithek offene Mobilitätsdaten bündelt, ermöglicht der Mobility Data Space kontrollierten Datenaustausch unter definierten Nutzungsbedingungen. Die Fallstudien deuten darauf hin, dass staatliche Institutionen als Infrastrukturgeber und Koordinatoren datenbasierter Innovationsökosysteme auftreten.

1 Einleitung

Die fortschreitende Digitalisierung verändert grundlegende Strukturen wirtschaftlicher und gesellschaftlicher Prozesse. Insbesondere im Mobilitätssektor gewinnt die Nutzung und Verfügbarkeit von Daten an Bedeutung. Digitale Technologien ermöglichen es, große Mengen an Mobilitätsdaten zu erfassen, zu verarbeiten und in vielfältigen Anwendungen nutzbar zu machen. Diese Daten bilden die Grundlage für neue Geschäftsmodelle, innovative Mobilitätsdienste sowie datenbasierte Verkehrssteuerungssysteme (Kitchin 2014).

Im Kontext dieser Entwicklung rückt die Bereitstellung geeigneter Dateninfrastrukturen zunehmend in den Fokus der öffentlichen Hand. Während Daten lange Zeit primär innerhalb einzelner Organisationen genutzt wurden, entstehen gegenwärtig datenbasierte Ökosysteme, in denen öffentliche und private Akteure Daten austauschen und gemeinsam nutzen. Digitale Plattformen spielen hierbei eine zentrale Rolle, da sie als Vermittlungsstrukturen

fungieren, über die Daten bereitgestellt, kombiniert und weiterverarbeitet werden können (Kenney/Zysman 2016; Gawer 2014).

In der Plattformliteratur wird hervorgehoben, dass Plattformen nicht nur technische Infrastrukturen, sondern auch organisatorische Arrangements digitaler Wertschöpfung darstellen. Sie koordinieren Interaktionen zwischen unterschiedlichen Nutzergruppen, erzeugen Netzwerkeffekte und können dadurch neue Formen wirtschaftlicher und organisatorischer Wertschöpfung ermöglichen (Parker/Van Alstyne/Choudary 2016; Srnicek 2017). Gleichzeitig gewinnen Plattformen auch im öffentlichen Sektor an Bedeutung, wenn staatliche Institutionen digitale Infrastrukturen bereitstellen, die Datenaustausch, Interoperabilität und Innovation unterstützen (Margetts/Naumann 2017; Bonina/Eaton 2020).

Gerade im Mobilitätssektor entstehen neue Formen datenbasierter Innovationsökosysteme.

Verkehrsdaten stammen aus unterschiedlichen Quellen, darunter öffentliche Verkehrsunternehmen, private Mobilitätsanbieter, Infrastrukturbetreiber, Automobilhersteller, Navigationsdienste oder Kommunen. Um das Innovationspotenzial dieser Daten zu erschließen, verfolgen viele Staaten und supranationale Institutionen Strategien zur Förderung offener Daten, interoperabler Datenräume und gemeinsamer Governance-Strukturen (European Commission 2020; OECD 2019).

Auch in Deutschland wurden in den vergangenen Jahren verschiedene Initiativen aufgebaut, um Mobilitätsdaten besser verfügbar zu machen und datenbasierte Innovationen zu fördern. Zwei zentrale Beispiele sind die Mobilithek, die als nationale Plattform für offene Mobilitätsdaten und als nationaler Zugangspunkt fungiert, sowie der Mobility Data Space, der einen kontrollierten und souveränen Datenaustausch zwischen Akteuren des Mobilitätssektors ermöglichen soll (Mobilithek o. J.; Mobility Data Space o. J.a). Beide Initiativen verfolgen das Ziel, Daten als Grundlage für neue Mobilitätsdienste, digitale Geschäftsmodelle und eine effizientere Verkehrsorganisation nutzbar zu machen.

Vor diesem Hintergrund stellt sich die Frage, welche Rolle solche staatlich initiierten Plattformen und Datenräume für die Entwicklung datenbasierter Innovationsökosysteme im Mobilitätssektor spielen und wie sie institutionell organisiert sind. Während privatwirtschaftliche Plattformen bereits intensiv untersucht wurden, besteht weiterhin Forschungsbedarf zur Rolle öffentlicher Institutionen bei der Gestaltung von Datenplattformen, Datenräumen und kooperativen Datenökosystemen. Die zentrale Forschungsfrage des Beitrags lautet daher: Welche Rolle spielen staatlich initiierte Datenplattformen wie Mobilithek und Mobility Data Space für die Entwicklung datenbasierter Innovationsökosysteme im Mobilitätssektor?

Zur Beantwortung dieser Frage wird zunächst die Bedeutung von Dateninfrastrukturen und Plattformen im Kontext digitaler Innovationsökosysteme diskutiert. Anschließend werden die beiden Fallbeispiele Mobilithek und Mobility Data Space anhand zentraler Dokumente analysiert und hinsichtlich ihrer Zielsetzung, Governance-Struktur, Akteurskonstellation, Datennutzungsregeln und innovationspolitischen Funktion untersucht. Abschließend werden die Ergebnisse mit Blick auf die Rolle staatlicher Institutionen bei der Gestaltung datenbasierter Innovationsökosysteme diskutiert.

Der Beitrag leistet damit einen Beitrag zur Forschung über digitale Infrastrukturpolitik im öffentlichen Sektor, indem er zeigt, wie staatlich initiierte Datenplattformen und Datenräume als Instrumente zur Entwicklung datenbasierter Innovationsökosysteme im Mobilitätssektor fungieren können.

2 Methodisches Vorgehen

Der Beitrag verfolgt einen qualitativ-analytischen Ansatz zur Untersuchung staatlich initiierten Datenplattformen im Mobilitätssektor. Im Mittelpunkt steht die Frage, welche Rolle öffentliche Dateninfrastrukturen für die Entwicklung datenbasierter Innovationsökosysteme spielen und wie sie institutionell sowie governance-bezogen ausgestaltet sind.

Methodisch basiert der Beitrag auf einer qualitativen Dokumentenanalyse. Diese stellt in der Verwaltungs- und Policyforschung ein etabliertes Verfahren dar, um politische Strategien, institutionelle Arrangements sowie programmatische Zielsetzungen systematisch zu rekonstruieren. Dokumente werden dabei nicht lediglich als ergänzendes Material verstanden, sondern als eigenständige Quellen zur Analyse politischer Steuerungslogiken und institutioneller Strukturen (Bowen 2009).

Der Dokumentenkörper wurde gezielt zusammengestellt, um sowohl den politischen und regulatorischen Kontext als auch die konkrete Ausgestaltung der beiden Plattforminitiativen abzubilden. Einbezogen wurden europäische und nationale Strategiedokumente, rechtliche und programmatische Grundlagen, technische Plattformbeschreibungen, Informationen zu Betreibermodellen sowie öffentlich zugängliche Projekt- und Plattformmaterialien. Tabelle 1 fasst die zentralen Dokumentengruppen und ihre analytische Funktion zusammen.

Dokumentengruppe	Beispiele	Analytische Funktion
Europäische Daten-politik	Europäische Datenstrategie, Data Governance Act, ITS-Richtlinie 2010/40/EU, Delegierte Verordnungen (EU) 2017/1926 und 2022/670, Common European Mobility Data Space	Einordnung des Data-Space-Ansatzes, der europäischen Governance-Anforderungen und der rechtlichen Vorgaben für nationale Zugangspunkte
Nationale Daten- und Open-Data-Politik	Open-Data-Strategie der Bundesregierung, mFUND-Dokumente	Rekonstruktion staatlicher Zielsetzungen und Förderlogiken
Mobilithek-Dokumente	Plattformbeschreibung, technisches Schnittstellendokument, mFUND-Leitfaden	Analyse von Zugangsmodell, Datenformaten, Standardisierung und Rolle als nationaler Zugangspunkt
Mobility-Data-Space-Dokumente	Plattformbeschreibung, Informationen zu DRM Datenraum Mobilität GmbH, Membership-Modell, Whitepaper	Analyse von Entstehung, Betreiberstruktur, Datennutzungsregeln und Governance-Modell

Aktuelle Governance-Literatur	Arbeiten zu Plattform-Governance, Open-Government-Data-Plattformen, Data Spaces und Datenökosystemen	Theoretische Einordnung der Fallstudien und Ableitung von Vergleichsdimensionen
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Tabelle 1: Dokumentengrundlage der Analyse
Quelle: Eigene Darstellung.

Die Auswertung orientierte sich an sechs Analyse kategorien: (1) Zielsetzung der Plattform, (2) Rolle staatlicher Institutionen bei Initiierung, Finanzierung und Rahmensetzung, (3) Akteurs- und Betreiberstruktur, (4) Regeln des Datenzugangs und der Datennutzung, (5) Standardisierung und technische Interoperabilität sowie (6) innovationspolitische Funktion und europäische Einbettung. Diese Kategorien wurden aus der Plattform- und Data-Space-Governance-Literatur abgeleitet und im Verlauf der Analyse auf die beiden Fallbeispiele angewendet (Tiwana 2014; Bonina/Eaton 2020; Otto/Jarke 2019; Möller et al. 2024).

Die Kategorien wurden in zwei Schritten angewandt. Zunächst wurden Mobilithek und Mobility Data Space jeweils fallbezogen analysiert, um Zielsetzung, institutionelle Einbettung, Betreiberstruktur, Datennutzungsregeln und technische Standardisierungsmechanismen getrennt herauszuarbeiten. Anschließend wurden die Ergebnisse vergleichend verdichtet, um Unterschiede zwischen einem Open-Data-basierten Plattformmodell und einem stärker kontrollierten Data-Space-Modell sichtbar zu machen. Im Mittelpunkt stand damit nicht eine quantitative Wirkungsmessung, sondern die Rekonstruktion dokumentierter Governance-Arrangements und ihrer innovationspolitischen Funktion.

Die Fallauswahl erfolgt bewusst. Mobilithek und Mobility Data Space stehen exemplarisch für zwei unterschiedliche Ansätze staatlicher Dateninfrastrukturpolitik im Mobilitätssektor. Während die Mobilithek vor allem auf die Bereitstellung offener Mobilitätsdaten ausgerichtet ist, verfolgt der Mobility Data Space einen stärker koordinierten Ansatz des kontrollierten Datenaustauschs. Die vergleichende Betrachtung ermöglicht es, unterschiedliche Governance-Modelle öffentlicher Datenplattformen herauszuarbeiten und deren Bedeutung für datenbasierte Innovationsökosysteme zu diskutieren.

Die Analyse erhebt nicht den Anspruch, sämtliche Formen öffentlicher Datenplattformen empirisch abzubilden. Vielmehr handelt es sich um eine konzeptionell informierte Fallanalyse, die zwei zentrale deutsche Initiativen in ihren europäischen und governance-bezogenen Kontext einordnet. Entsprechend werden die Ergebnisse in der Diskussion vorsichtig formuliert und als Hinweise auf mögliche Rollen staatlicher Institutionen in datenbasierten Innovationsökosystemen verstanden.

3 Daten als Infrastruktur im Mobilitätssektor

Mit der zunehmenden Digitalisierung wirtschaftlicher und gesellschaftlicher Prozesse gewinnen Daten eine immer größere Bedeutung als strategische Ressource. In zahlreichen Branchen werden Daten heute als zentrale Grundlage für Innovationen, neue Geschäftsmodelle sowie effizientere Organisationsformen betrachtet. Insbesondere im Mobilitätssektor entstehen durch digitale Technologien große Mengen an Daten, die beispielsweise aus Fahrzeugen, Verkehrsinfrastrukturen, Navigationssystemen oder mobilen Endgeräten generiert werden (Kitchin 2014).

In diesem Zusammenhang wird in der wirtschafts- und innovationspolitischen Literatur zunehmend von einer Datenökonomie gesprochen. Daten gelten dabei als zentraler Produktionsfaktor digitaler Wertschöpfungsprozesse, der sowohl für Unternehmen als auch für staatliche Institutionen an Bedeutung gewinnt. Während traditionelle Industrien primär auf physische Produktionsfaktoren angewiesen sind, basieren viele digitale Geschäftsmodelle maßgeblich auf der Sammlung, Verarbeitung und Analyse großer Datenmengen (OECD 2019).

Die wachsende Bedeutung von Daten führt zugleich zu neuen Anforderungen an institutionelle und technische Infrastrukturen, die den Zugang zu Daten ermöglichen und deren Nutzung erleichtern. Daten können daher als eine Form öffentlicher oder quasi-öffentlicher Infrastruktur verstanden werden. Dazu zählen digitale Plattformen oder Datenräume, die zwar von öffentlichen Institutionen initiiert oder unterstützt werden, deren Nutzung jedoch durch eine Vielzahl öffentlicher und privater Akteure erfolgt. Ähnlich wie Verkehrs- oder Energieinfrastrukturen schaffen Dateninfrastrukturen grundlegende Voraussetzungen für wirtschaftliche Aktivitäten, Innovationen sowie neue digitale Dienstleistungen (Kitchin 2014; Plantin et al. 2018).

Im Mobilitätssektor wird diese Entwicklung besonders deutlich. Digitale Mobilitätsdienste, intelligente Verkehrssysteme sowie datenbasierte Verkehrssteuerung basieren auf der Verfügbarkeit heterogener Daten. Diese stammen aus unterschiedlichen Quellen, darunter Fahrzeuge, Sensoren in Verkehrsinfrastrukturen, Navigationssysteme, mobile Endgeräte, Verkehrsunternehmen, Infrastrukturbetreiber und öffentliche Verwaltungen. Die Integration solcher Daten stellt eine zentrale Voraussetzung für neue Mobilitätsangebote sowie für eine effizientere Organisation von Verkehrssystemen dar (Kitchin 2014). Dateninfrastrukturen erfüllen in diesem Kontext eine Vermittlungsfunktion. Sie ermöglichen es, Daten zu sammeln, zu speichern, zu beschreiben, auffindbar

zu machen und zwischen verschiedenen Akteuren auszutauschen. Damit schaffen sie die technischen und organisatorischen Voraussetzungen für datenbasierte Innovationen. Zugleich sind sie nicht nur technische Systeme, sondern auch institutionelle Arrangements, da Fragen des Zugangs, der Datenqualität, der Verantwortlichkeiten und der Nutzungsrechte geregelt werden müssen (Plantin et al. 2018; Möller et al. 2024). Die Forschung zu öffentlichen Datenökosystemen betont zudem, dass solche Ökosysteme schrittweise entstehen und sich über mehrere Reifestufen hinweg entwickeln, in denen technische, organisatorische und institutionelle Voraussetzungen zusammenwirken (Lnenicka et al. 2024).

Vor diesem Hintergrund gewinnen offene Daten im Mobilitätsbereich an Bedeutung. Open Data bezeichnet Daten, die frei zugänglich gemacht und ohne größere Einschränkungen genutzt, weiterverarbeitet und verbreitet werden können. Ziel von Open-Data-Strategien ist es häufig, Transparenz zu erhöhen sowie Innovationen im privaten und öffentlichen Sektor zu fördern. Durch die Bereitstellung offener Daten können Unternehmen, Forschungseinrichtungen und zivilgesellschaftliche Akteure neue Anwendungen auf Basis öffentlicher Daten entwickeln (Janssen/Charalabidis/Zuiderwijk 2012; Bonina/Eaton 2020).

Neben offenen Daten gewinnen kontrollierte Modelle des Datenteilens an Bedeutung. Die Europäische Datenstrategie betont die Entwicklung gemeinsamer europäischer Datenräume, in denen öffentliche und private Akteure Daten unter gemeinsamen technischen, organisatorischen und rechtlichen Rahmenbedingungen teilen können (European Commission 2020). Der Data Governance Act konkretisiert diese Entwicklung, indem er unter anderem Datenintermediationsdienste, vertrauensbasierte Datennutzung und sektorspezifische Datenräume als Elemente einer europäischen Datenökonomie adressiert (European Commission 2022a).

Im Mobilitätsbereich ist diese Entwicklung eng mit intelligenten Verkehrssystemen und nationalen Zugangspunkten für Verkehrsdaten verbunden. Die europäische ITS-Politik verpflichtet die Mitgliedstaaten dazu, bestimmte Verkehrs- und Mobilitätsdaten über nationale Zugangspunkte zugänglich zu machen. Besonders relevant sind die Delegierte Verordnung (EU) 2017/1926 zu EU-weiten multimodalen Reiseinformationsdiensten sowie die Delegierte Verordnung (EU) 2022/670 zu EU-weiten Echtzeit-Verkehrsinformationsdiensten, die jeweils auf der ITS-Richtlinie 2010/40/EU aufbauen (European Commission 2017; European Commission 2022b). Beispiele für diese Entwicklung sind nationale Zugangspunkte für Verkehrsdaten sowie standardisierte Datenaustauschsysteme wie DATEX II, die den Austausch von Verkehrsdaten zwischen öffentlichen und privaten Akteuren erleichtern sollen (European Commission o. J.a; Mobilithek 2025).

Vor diesem Hintergrund lassen sich Datenplattformen im Mobilitätssektor als Bestandteil öffentlicher Infrastrukturpolitik verstehen. Staatliche Institutionen schaffen rechtliche Rahmenbedingungen, stellen teilweise selbst digitale Infrastrukturen bereit oder fördern deren Aufbau. Der Aufbau solcher Plattformen ist daher nicht nur ein technisches, sondern auch ein institutionelles und governancebezogenes Projekt. Wie sich solche Plattformstrukturen konkret ausgestalten, wird im Folgenden anhand von Mobilithek und Mobility Data Space untersucht.

4 Governance digitaler Plattformen und Datenräume im öffentlichen Sektor

Digitale Plattformen haben sich in den vergangenen Jahren zu einer zentralen Organisationsform der digitalen Ökonomie entwickelt. Plattformen fungieren als Vermittlungsstrukturen, die Interaktionen zwischen verschiedenen Nutzergruppen ermöglichen und koordinieren. Sie schaffen damit digitale Marktplätze oder Infrastrukturen, auf denen Daten, Dienstleistungen oder Informationen ausgetauscht werden können (Parker/Van Alstyne/Choudary 2016).

In der Plattformforschung wird hervorgehoben, dass Plattformen nicht nur technische Vermittlungsinfrastrukturen sind, sondern auch institutionelle Arrangements, die Interaktionen zwischen verschiedenen Nutzergruppen strukturieren. Durch ihre Vermittlungsfunktion können Plattformen Anbieter und Nachfrager miteinander verbinden, Transaktionskosten reduzieren und neue Formen digitaler Wertschöpfung ermöglichen (Gawer 2014; Srnicek 2017). Ein zentrales Merkmal digitaler Plattformen besteht zudem in Netzwerkeffekten: Der Nutzen einer Plattform steigt typischerweise mit der Anzahl ihrer Nutzerinnen und Nutzer, da mit wachsender Teilnehmerzahl auch die potenziellen Interaktionen innerhalb der Plattform zunehmen (Kenney/Zysman 2016).

Für den öffentlichen Sektor stellt sich dabei die Frage, welche Rolle staatliche Institutionen bei der Entwicklung solcher Plattformen einnehmen. Während private Plattformen häufig von Unternehmen betrieben werden, können auch öffentliche Institutionen Plattformen aufbauen oder unterstützen, um den Austausch von Daten zu erleichtern oder innovationsfördernde Rahmenbedingungen zu schaffen. In diesem Zusammenhang wird von Government Platforms oder Government-as-a-Platform gesprochen (Margetts/Naumann 2017; Bender/Heine 2021).

Öffentliche Plattformen unterscheiden sich jedoch von privatwirtschaftlichen Plattformmodellen. Während private Plattformen häufig wirtschaftliche Ziele verfolgen, stehen bei staatlich initiierten Plattformen Ziele wie Transparenz, Interoperabilität, Innovationsförderung, faire Zugangsbedingungen oder die Verbesserung öffentlicher Dienstleistungen im Vordergrund. Staatliche Plattformen können daher als Teil einer umfassenderen Infrastrukturpolitik verstanden werden, die grundlegende digitale Infrastrukturen für verschiedene Akteure bereitstellt (Plantin et al. 2018; Bonina/Eaton 2020).

Ein zentraler Aspekt solcher Plattformen ist ihre Governance. Plattform-Governance beschreibt die institutionellen und organisatorischen Regeln, die Betrieb und Nutzung einer Plattform strukturieren. Dazu gehören technische Standards, Zugangsregeln, Datenschutzbestimmungen, Datennutzungsregeln, Rollenverteilungen sowie Mechanismen zur Qualitätssicherung (Tiwana 2014). Gerade bei öffentlichen Datenplattformen treffen unterschiedliche Interessen und institutionelle Logiken aufeinander: öffentliche Ziele wie Transparenz und Daseinsvorsorge, private Interessen an Datensouveränität und Wettbewerb sowie technische Anforderungen an Interoperabilität.

Neuere Arbeiten zu Open-Government-Data-Plattformen zeigen, dass Governance nicht nur den technischen Zugang zu Daten betrifft, sondern auch die Entwicklung eines Plattformökosystems. Plattformbetreiber müssen eine installierte Basis von Datenanbietern und Datennutzern aufbauen, Regeln für Teilnahme und Nutzung definieren sowie die kontinuierliche Pflege und Weiterentwicklung des Ökosystems organisieren (Bonina/Eaton 2020). Dadurch verschiebt sich der Fokus von der bloßen Veröffentlichung einzelner Datensätze hin zur aktiven Gestaltung von Datenökosystemen.

Datenräume erweitern diese Perspektive. Während Open-Data-Plattformen vor allem auf freien Zugang zu Daten abzielen, sollen Datenräume einen souveränen und kontrollierten Datenaustausch zwischen verschiedenen Organisationen ermöglichen. In Data Spaces verbleiben Daten typischerweise bei den jeweiligen Datenanbietern; geteilt werden sie unter definierten Zugangs- und Nutzungsbedingungen. Die Literatur zu Industrial Data Ecosystems und Data Spaces betont daher die Kombination aus digitaler Infrastruktur, Governance-Rahmen, Datensouveränität und kooperativer Wertschöpfung (Otto/Jarke 2019; Möller et al. 2024).

Für Datenräume ist Governance besonders wichtig, weil sie häufig föderiert organisiert sind. Governance muss hier festlegen, wer teilnehmen darf, welche Rollen verschiedene Akteure übernehmen, wie Nutzungsbedingungen definiert werden, wie technische Standards umgesetzt werden und wie Vertrauen zwischen den Teilnehmenden entsteht. Der Data Spaces Support

Centre Blueprint beschreibt Governance entsprechend als Baustein, der transparente Entscheidungsprozesse, Datennutzungsvereinbarungen und vertrauenswürdige Interaktionen zwischen Teilnehmern sichern soll (Data Spaces Support Centre 2024). Ähnlich betont die aktuelle Data-Space-Governance-Debatte, dass Datenräume sowohl technische als auch institutionelle Koordination benötigen (Gaia-X Hub Germany 2025).

Für die Analyse von Datenräumen ist dabei besonders relevant, dass Datensouveränität nicht allein als Eigentum an Daten zu verstehen ist. In der Data-Space-Literatur bezeichnet sie vielmehr die Fähigkeit von Datenanbietern, Bedingungen der Datennutzung festzulegen, Zugriffe zu kontrollieren und Nutzungsrechte entlang des Datenlebenszyklus institutionell und technisch abzusichern (Jarke/Otto/Ram 2019; von Scherenberg/Hellmeier/Otto 2024). Datenräume verbinden daher technische Komponenten wie Connectoren, Kataloge und Identitätsdienste mit vertraglichen und organisatorischen Regeln. Governance umfasst in diesem Verständnis nicht nur Plattformbetrieb, sondern auch Mitgliedschaftsregeln, Rollenmodelle, Nutzungsbedingungen, Konfliktregelung und Mechanismen zur Vertrauensbildung.

Aktuelle Forschung zu Data-Space-Designoptionen zeigt zudem, dass Datenräume unterschiedlich stark zentralisiert oder föderiert organisiert sein können. Sie unterscheiden sich etwa hinsichtlich Betreiberstruktur, technischer Architektur, Zugangsregeln, Wertschöpfungsmodell und Art der bereitgestellten Datenprodukte (Gieß/Schoormann/Möller/Gür 2025). Für öffentliche Dateninfrastrukturen ist diese Unterscheidung wichtig, weil staatliche Institutionen nicht zwangsläufig selbst alle Plattformfunktionen übernehmen müssen. Sie können auch Standards setzen, Anschubfinanzierung leisten, institutionelle Regeln etablieren oder interoperable Strukturen zwischen verschiedenen Datenökosystemen fördern.

Im Mobilitätssektor ist diese Governance-Frage besonders relevant. Mobilitätsdaten stammen aus einer Vielzahl unterschiedlicher Quellen und werden von öffentlichen Verkehrsunternehmen, Infrastrukturbetreibern, privaten Mobilitätsanbietern, Automobilherstellern, Logistikunternehmen, Kommunen und Technologieunternehmen generiert. Der Austausch solcher Daten setzt daher nicht nur technische Schnittstellen voraus, sondern auch institutionelle Rahmenbedingungen, die Vertrauen schaffen, Zuständigkeiten klären und Anreize für die Bereitstellung und Nutzung von Daten schaffen (OECD 2019; Möller et al. 2024).

In der innovationspolitischen Diskussion wird der Staat in solchen Konstellationen häufig als Orchestrator von Innovationsökosystemen beschrieben. Als Orchestrator schafft der Staat Rahmenbedingungen, die Kooperationen

zwischen verschiedenen Akteuren ermöglichen und koordinieren. Dabei muss er nicht zwangsläufig selbst zentraler Plattformbetreiber sein, sondern kann Infrastrukturen bereitstellen, Standards fördern, Akteure vernetzen und institutionelle Vertrauensmechanismen unterstützen (Mazzucato 2018).

Gerade im Mobilitätssektor lassen sich unterschiedliche Initiativen beobachten, die den Aufbau solcher Plattformstrukturen verfolgen. Beispiele sind nationale Zugangspunkte für Verkehrsdaten im Rahmen der europäischen ITS-Politik, Initiativen zum Aufbau sektoraler Datenräume im Kontext der europäischen Datenstrategie sowie der Common European Mobility Data Space, der bestehende und neue Mobilitätsdatenökosysteme interoperabel verknüpfen soll (European Commission o. J.a; European Commission o. J.b; deployEMDS o. J.). Vor diesem theoretischen Hintergrund werden im folgenden Abschnitt die Mobilithek und der Mobility Data Space als zwei unterschiedliche deutsche Ausprägungen staatlicher Dateninfrastrukturpolitik untersucht.

5 Fallstudien staatlicher Datenplattformen im Mobilitätssektor

Zur Analyse dieser Fragestellung werden im Folgenden zwei Initiativen aus dem deutschen Mobilitätssektor untersucht: die Mobilithek sowie der Mobility Data Space. Beide Initiativen verfolgen das Ziel, Mobilitätsdaten zugänglich zu machen und deren Nutzung für Innovationen zu unterstützen, unterscheiden sich jedoch in ihrer Governance-Logik, ihrem Zugangsmodell und ihrer institutionellen Ausgestaltung.

5.1 Die Plattform Mobilithek

Die Mobilithek stellt eine zentrale Datenplattform für Mobilitätsdaten in Deutschland dar. Sie bietet Zugang zu offenen Mobilitätsdaten, fungiert als nationaler Zugangspunkt und dient zugleich als Marktplatz für Mobilitätsdaten (Mobilithek o. J.). Damit ist sie nicht nur ein Datenportal, sondern ein infrastruktureller Knotenpunkt, über den Datenangebote verschiedener Akteure auffindbar, abrufbar und weiterverwendbar gemacht werden sollen.

Die Plattform wurde im Kontext der deutschen Open-Data-Strategie und der europäischen Anforderungen an nationale Zugangspunkte für Verkehrsdaten entwickelt (Bundesministerium des Innern, für Bau und Heimat 2021). Das Bundesministerium für Verkehr beschreibt die Mobilithek als zentralen, einheitlichen und benutzerfreundlichen Zugang zu Mobilitätsdaten,

der Verkehrsplanung, Verkehrssteuerung und digitale Mobilitätsdienste unterstützen soll (Bundesministerium für Verkehr o. J.a). 2023 ging der frühere Mobilitäts Daten Marktplatz in die Mobilithek über; damit wurden bestehende Dateninfrastrukturen in einer neuen Plattformarchitektur zusammengeführt (Bundesanstalt für Straßenwesen o. J.).

Staatliche Rahmensetzung wird bei der Mobilithek auf mehreren Ebenen sichtbar. Erstens stellt der Bund die Plattform als nationale digitale Infrastruktur bereit. Zweitens ist sie in europäische Vorgaben zu intelligenten Verkehrssystemen und nationalen Zugangspunkten eingebettet. Die ITS-Richtlinie 2010/40/EU bildet hierfür den übergeordneten Rechtsrahmen; die Delegierte Verordnung (EU) 2017/1926 konkretisiert Anforderungen an multimodale Reiseinformationsdienste, während die Delegierte Verordnung (EU) 2022/670 Vorgaben für Echtzeit-Verkehrsinformationsdienste und entsprechende Datenbereitstellung über nationale Zugangspunkte enthält (European Commission 2017; European Commission 2022b). Drittens werden im Rahmen von Förderprogrammen wie dem mFUND Anreize zur Bereitstellung offener Mobilitätsdaten gesetzt. Der mFUND-Leitfaden zur Datenbereitstellung betont, dass möglichst viele Daten aus geförderten Projekten über die Mobilithek als Open Data verfügbar gemacht werden sollen (Bundesministerium für Verkehr 2022).

Die Mobilithek adressiert damit ein zentrales Problem offener Mobilitätsdaten: Daten entstehen dezentral bei vielen verschiedenen Akteuren, sind aber ohne gemeinsame Plattformen, Metadaten, Schnittstellen und Standards nur begrenzt auffindbar und nutzbar. Die Plattform schafft einen zentralen Zugangspunkt, über den Datenanbieter ihre Datensätze bereitstellen und Datennutzer diese Daten finden, abonnieren oder weiterverarbeiten können. Die eigentliche Datenproduktion verbleibt jedoch bei den jeweiligen Datengebern.

Technisch basiert die Mobilithek auf standardisierten Schnittstellen und Austauschformaten. Die technische Schnittstellenbeschreibung sieht unter anderem DATEX II als zentrales Format für den Austausch von Mobilitätsdaten vor und unterstützt daneben weitere Übertragungs- und Containerformate (Mobilithek 2025). Damit übernimmt die Plattform eine wichtige Rolle bei der technischen Interoperabilität. Zugleich bedeutet dies nicht, dass alle Daten zentral harmonisiert oder qualitativ vereinheitlicht werden. Vielmehr hängt die Qualität und Standardkonformität der Daten weiterhin wesentlich von den Datenanbietern sowie von fachlichen Vorgaben und Datenprofilen ab.

Gerade bei der Harmonisierung von Datenformaten zeigt sich die verteilte Governance der Mobilithek. Die Plattform schafft technische Anschlussfähigkeit und stellt Spezifikationen sowie Schnittstellen bereit, übernimmt

jedoch nicht allein die fachliche Verantwortung für sämtliche Dateninhalte. Datenanbieter müssen ihre Datensätze so bereitstellen, dass sie maschinenlesbar, strukturiert und möglichst standardisiert nutzbar sind. Fachliche Vorgaben entstehen aus mehreren Quellen: aus europäischen ITS-Anforderungen, aus nationalen Mobilitätsdatenvorgaben, aus technischen Standards wie DATEX II sowie aus Förderbedingungen, etwa im Rahmen des mFUND. Die konkrete Zuständigkeit für Datenqualität und Aktualität verbleibt damit häufig bei den jeweiligen Datenhaltern, während die Mobilithek als Plattform die Auffindbarkeit, technische Bereitstellung und standardisierte Anbindung unterstützt. Damit beruht die Mobilithek auf einem Zusammenspiel von öffentlicher Plattformbereitstellung, regulatorischer Rahmensetzung und dezentraler Verantwortung der Datenlieferanten.

Aus governance-theoretischer Perspektive lässt sich die Mobilithek als staatlich initiierte Open-Data-Infrastruktur verstehen. Der Staat übernimmt hier vor allem die Rolle eines Infrastrukturgebers und Regelsetzers. Er stellt eine Plattform bereit, schafft Anreize zur Datenbereitstellung und verknüpft nationale Datenpolitik mit europäischen Vorgaben. Die Nutzung der Daten bleibt hingegen weitgehend den Akteuren des Ökosystems überlassen, etwa Unternehmen, Forschungseinrichtungen, Kommunen oder zivilgesellschaftlichen Organisationen.

Gleichzeitig bleiben Governance-Herausforderungen bestehen. Dazu gehören die Sicherstellung ausreichender Datenqualität, die Pflege von Metadaten, die Standardisierung heterogener Datenformate und die Gewinnung einer kritischen Masse an Datenanbietern und Datennutzern. Die Verantwortung hierfür ist verteilt: Der Bund stellt die Plattform und den institutionellen Rahmen bereit, Plattformbetreiber und technische Dienstleister gewährleisten den Betrieb, während Datenanbieter für Inhalt, Aktualität und Qualität ihrer Datenangebote verantwortlich bleiben. Diese verteilte Zuständigkeit ist typisch für öffentliche Datenökosysteme und erfordert kontinuierliche Koordination.

Die Mobilithek zeigt damit, wie staatliche Institutionen offene Daten nicht nur veröffentlichen, sondern infrastrukturell organisieren können. Ihre innovationspolitische Funktion liegt vor allem darin, den Zugang zu Mobilitätsdaten zu erleichtern, Such- und Transaktionskosten zu senken und neue datenbasierte Anwendungen zu ermöglichen. Sie steht somit für einen Open-Data-basierten Ansatz staatlicher Dateninfrastrukturpolitik.

5.2 Mobility Data Space

Der Mobility Data Space verfolgt einen anderen Ansatz. Während die Mobilithek primär offene Mobilitätsdaten bündelt, dient der Mobility Data Space als Datenraum für den kontrollierten und souveränen Austausch von

Mobilitätsdaten zwischen unterschiedlichen Akteuren. Die Initiative versteht sich als Datenmarktplatz, auf dem Partner aus dem Mobilitätssektor Daten gleichberechtigt und selbstbestimmt austauschen können (Mobility Data Space o. J.a).

Die Entstehung des Mobility Data Space ist eng mit der deutschen Datenstrategie, der europäischen Gaia-X-Initiative und der Debatte um Datensouveränität verbunden. Der Aufbau geht auf politische und innovationspolitische Impulse zurück, unter anderem auf die Konzertierte Aktion Mobilität und die Förderung durch das Bundesministerium für Verkehr (acatech o. J.; acatech 2021; Bundesministerium für Verkehr o. J.b). Der Staat trat hier weniger als unmittelbarer Betreiber einer Open-Data-Plattform auf, sondern als Initiator, Förderer und Ermöglicher eines kooperativen Datenökosystems.

Institutionell ist der Mobility Data Space inzwischen über die DRM Datenraum Mobilität GmbH organisiert. Nach Angaben des Mobility Data Space ist diese Trägergesellschaft als Non-Profit-Organisation strukturiert und aus einem Projekt der acatech Stiftung hervorgegangen. Sie hat die Aufgabe, den Datenraum weiter aufzubauen und ihn technisch sowie kommerziell zu orchestrieren (Mobility Data Space o. J.b). Damit ist die Betreiber- und Betreuungsstruktur stärker ausdifferenziert als bei einer klassischen Open-Data-Plattform.

Die Governance des Mobility Data Space basiert auf der Idee, dass Datenanbieter die Kontrolle über ihre Daten behalten. Nach der Selbstdarstellung des MDS bleibt der Datenprovider Eigentümer der Daten und entscheidet selbst, ob und mit welchem Mitglied ein Datenaustausch erfolgt (Mobility Data Space o. J.a). Der Datenraum stellt somit nicht primär ein zentrales Datenlager dar, sondern bietet organisatorische und technische Mechanismen, über die Daten unter definierten Bedingungen geteilt werden können. Dieses Modell entspricht zentralen Prinzipien von Datenräumen, wie sie im MDS-Whitepaper und in der Data-Space-Literatur diskutiert werden (Mobility Data Space 2022; Otto/Jarke 2019; Möller et al. 2024).

Regeln zur Datennutzung entstehen in solchen Datenräumen auf mehreren Ebenen. Erstens akzeptieren Teilnehmende die institutionellen Rahmenbedingungen des Datenraums, etwa Mitgliedschafts- und Nutzungsbedingungen. Zweitens können Datenanbieter konkrete Bedingungen für einzelne Datenangebote festlegen, etwa hinsichtlich Zugang, Zweckbindung, Nutzung oder Entgelt. Drittens sichern technische Komponenten wie Connectoren und Katalogdienste die Auffindbarkeit und den kontrollierten Austausch von Daten. Diese Kombination aus institutionellen Regeln und technischen Mechanismen ist typisch für Datenräume (Data Spaces Support Centre 2024).

Ein praktisches Beispiel verdeutlicht diese Funktionslogik. Auf der Use-Case-Seite des Mobility Data Space werden Anwendungen beschrieben, die auf der Kombination unterschiedlicher Mobilitätsdaten beruhen; dazu zählen etwa Fahrzeugdatenprodukte von Bridgestone Mobility Solutions wie Floating-Car-Daten, Origin-Destination-Daten, Informationen zu gefährlichen Fahrereignissen, Standstill-Daten oder EV-Charging-Events (Mobility Data Space o. J.e). Solche Daten sind für Verkehrsmanagement, Flottenanalysen oder Prognosemodelle potenziell wertvoll, können aber wirtschaftlich sensibel sein. Im Data-Space-Modell werden sie deshalb nicht einfach als offene Daten veröffentlicht, sondern als Datenangebote mit definierten Zugangs-, Nutzungs- und gegebenenfalls Entgeltbedingungen bereitgestellt. Das Beispiel zeigt, wie der MDS Datennutzung praktisch zwischen Offenheit und Kontrolle organisiert.

Darüber hinaus zeigt die Verbindung zwischen Mobilithek und Mobility Data Space, wie Datenräume bestehende Plattformen ergänzen können. Der MDS weist darauf hin, dass Mobilithek-Datenangebote über den Datenraum auffindbar und nutzbar gemacht werden können, während die Inhalte weiterhin bei der Mobilithek gehostet oder gebrokkert werden. Der MDS übernimmt dabei Funktionen wie Authentifizierung, Veröffentlichung und Auffindbarkeit von Metadaten; die eigentliche Datenübertragung erfolgt zwischen den beteiligten Systemen bzw. Vertragspartnern (Mobility Data Space o. J.d). Das verdeutlicht, dass Datenräume bestehende Datenplattformen nicht notwendigerweise ersetzen. Sie können vielmehr als förderierende Infrastrukturen wirken, die vorhandene Plattformen, Datenanbieter und Datennutzer unter gemeinsamen Nutzungs- und Vertrauensmechanismen verbinden.

Für die Governance des Mobility Data Space bedeutet dies, dass Regeln nicht nur auf der Ebene einzelner Datenangebote relevant sind, sondern auch auf Ebene des gesamten Ökosystems. Neben technischen Fragen wie Connector-Nutzung, Identitätsmanagement und Metadatenkatalogen geht es um die Frage, welche Akteure Mitglied werden können, welche Pflichten mit der Mitgliedschaft verbunden sind, wie Datenangebote beschrieben werden und wie Vertrauen zwischen bislang getrennt agierenden Organisationen aufgebaut wird. Damit verschiebt sich die zentrale Governance-Frage von der bloßen Datenveröffentlichung hin zur kooperativen Gestaltung eines dauerhaften Datenökosystems.

Auch die wirtschaftliche Ausgestaltung unterscheidet sich von klassischen Open-Data-Plattformen. Der Mobility Data Space ist international ausgerichtet und adressiert Unternehmen, Mobilitätsanbieter, öffentliche Institutionen, Kommunen und weitere Organisationen. Der Zugang erfolgt über ein Mitgliedschaftsmodell. Nach Angaben der Plattform werden Mitgliedsbeiträge zur Mitfinanzierung von MDS-Services genutzt, etwa für den

Betrieb der technischen Plattform, Community-Angebote, Workshops, Arbeitsgruppen, Matchmaking und Use-Case-Koordination; zugleich erhält der MDS weiterhin öffentliche und private Finanzierung (Mobility Data Space o. J.c).

Die europäische Einbettung ist für den Mobility Data Space besonders wichtig. Der MDS wird als Teil der europäischen Cloud-Initiative Gaia-X dargestellt und ist mit der Mobilithek verknüpft (Bundesministerium für Verkehr o. J.b; Mobility Data Space o. J.b). Zudem steht er in einem breiteren europäischen Kontext, in dem der Common European Mobility Data Space bestehende und entstehende Mobilitätsdatenökosysteme fördern und interoperabel verbinden soll (European Commission o. J.b).

Aus governance-theoretischer Perspektive lässt sich der Mobility Data Space daher als kooperative Datenraum-Infrastruktur interpretieren. Der Staat schafft hier nicht nur einen offenen Zugang zu Daten, sondern unterstützt den Aufbau eines institutionellen Rahmens, in dem auch wirtschaftlich sensible oder wettbewerbsrelevante Daten unter kontrollierten Bedingungen geteilt werden können. Seine innovationspolitische Funktion liegt darin, Vertrauen, Datensouveränität und kooperative Wertschöpfung im Mobilitätssektor zu ermöglichen.

6 Diskussion: Staatliche Plattformen als Infrastruktur für datenbasierte Innovationsökosysteme

Die Analyse der beiden Fallbeispiele zeigt, dass staatlich initiierte Datenplattformen im Mobilitätssektor unterschiedliche Formen öffentlicher Dateninfrastrukturpolitik verkörpern. Allerdings erlaubt die Untersuchung von zwei Fallbeispielen keine allgemeine Aussage darüber, dass staatliche Institutionen in allen Bereichen der Datenökonomie zunehmend aktiver werden. Präziser lässt sich sagen: Die beiden Fälle deuten darauf hin, dass der Staat im Mobilitätssektor ausgewählte digitale Infrastrukturen bereitstellt, fördert oder institutionell rahmt, um datenbasierte Innovationsökosysteme zu unterstützen. Die zentralen Unterschiede der beiden Plattformen lassen sich in Tabelle 2 zusammenfassend darstellen.

Dimension	Mobilithek	Mobility Data Space
Grundidee	Zentrale Plattform und nationaler Zugangspunkt für Mobilitätsdaten	Datenraum für kontrollierten und souveränen Austausch von Mobilitätsdaten
Datentyp	Vor allem offene Daten und Daten mit öffentlichem Zugang	Geteilte Daten unter definierten Nutzungs- und Zugangsbedingungen
Governance-Modell	Open-Data-Plattform mit zentralem Zugang und technischen Schnittstellen	Koordinierter Datenraum mit Mitgliedschaft, Datensouveränität und Nutzungsregeln
Rolle des Staates	Bereitstellung und Finanzierung einer offenen Dateninfrastruktur; Einbettung in NAP- und Open-Data-Politik	Initiierung, Förderung und politische Rahmensetzung eines kooperativen Datenökosystems
Betreiber-/Akteursstruktur	Bundesplattform mit vielen dezentralen Datenanbietern und Datennutzern	DRM Datenraum Mobilität GmbH als Non-Profit-Trägerschaft; Mitglieder aus öffentlichen und privaten Organisationen
Innovationslogik	Innovation durch freien Zugang, Auffindbarkeit und Wiederverwendung von Mobilitätsdaten	Innovation durch vertrauensbasierten Austausch auch sensibler oder wirtschaftlich relevanter Daten

Tabelle 2: Vergleich zentraler Merkmale der Plattformen Mobilithek und Mobility Data Space
Quelle: Eigene Darstellung.

Die Mobilithek repräsentiert einen Open-Data-basierten Ansatz. Ihre zentrale Funktion besteht darin, Daten auffindbar, zugänglich und über Standards nutzbar zu machen. Die Plattform reduziert Such- und Transaktionskosten, schafft einen institutionellen Zugangspunkt und erleichtert die Wiederverwendung von Mobilitätsdaten. Damit unterstützt sie insbesondere solche Innovationsprozesse, die auf offenen Daten und breiter Nachnutzung beruhen.

Der Mobility Data Space steht dagegen für einen Data-Space-basierten Ansatz. Seine Funktion besteht nicht primär darin, Daten vollständig öffentlich zugänglich zu machen, sondern Datenaustausch unter definierten Bedingungen zu ermöglichen. Dies ist insbesondere für Daten relevant, die wirtschaftlich sensibel, wettbewerbsrelevant oder nicht ohne Weiteres als Open Data verfügbar sind. Der MDS adressiert damit ein Problem, das reine Open-Data-Strategien nur begrenzt lösen können: die Schaffung vertrauenswürdiger Rahmenbedingungen für kooperativen Datenaustausch zwischen eigenständigen Organisationen.

Beide Ansätze sind daher nicht als Gegensätze, sondern als komplementäre Formen staatlicher Dateninfrastrukturpolitik zu verstehen. Die Mobilithek

fördert Innovation durch offenen Zugang und Wiederverwendung; der Mobility Data Space fördert Innovation durch kontrollierten, vertrauensbasierten Austausch. Zusammen verweisen beide Initiativen auf eine Verschiebung staatlicher Digitalpolitik: Staatliche Institutionen treten nicht nur als Regulierer oder Datenproduzenten auf, sondern auch als Infrastrukturgeber, Förderer und Koordinatoren von Datenökosystemen.

Diese Rolle lässt sich mit dem Konzept des Staates als Orchestrator von Innovationsökosystemen verbinden (Mazzucato 2018). Im untersuchten Kontext bedeutet Orchestrierung jedoch nicht, dass der Staat alle Aktivitäten zentral steuert. Vielmehr schafft er technische und institutionelle Voraussetzungen, setzt Förderimpulse, definiert rechtliche Rahmenbedingungen und unterstützt die Vernetzung unterschiedlicher Akteure. Gleichzeitig bleiben Datenbereitstellung, Datenqualität, Nutzung und Geschäftsmodelle in hohem Maße dezentral organisiert.

Die Analyse zeigt zugleich Grenzen staatlicher Plattformpolitik. Datenplattformen erzeugen nicht automatisch lebendige Datenökosysteme. Sie müssen ausreichend Datenanbieter und Datennutzer gewinnen, Vertrauen aufbauen, technische Standards etablieren und klare Verantwortlichkeiten schaffen. Gerade im Mobilitätssektor ist dies anspruchsvoll, weil Akteure mit sehr unterschiedlichen Interessen beteiligt sind: öffentliche Verwaltungen, Verkehrsunternehmen, Automobilindustrie, digitale Plattformanbieter, Kommunen, Forschungseinrichtungen und Start-ups.

Die internationale Perspektive macht deutlich, dass Deutschland mit Mobilithek und Mobility Data Space nicht isoliert agiert. Der Common European Mobility Data Space soll eine gemeinsame technische und Governance-Struktur schaffen, um bestehende und entstehende Mobilitätsdatenökosysteme interoperabel zu verbinden (European Commission o. J. b). Das EU-Projekt deployEMDS erprobt hierzu konkrete Anwendungsfälle in mehreren europäischen Ländern und zielt darauf, gemeinsame Bausteine, Governance-Ansätze und Use Cases praktisch umzusetzen (deployEMDS o. J.). Vor diesem Hintergrund erscheinen Mobilithek und MDS als nationale Bausteine einer breiteren europäischen Entwicklung.

Für die deutsche Fallanalyse ist diese europäische Entwicklung aus zwei Gründen relevant. Erstens entsteht mit dem Common European Mobility Data Space ein Referenzrahmen, der nationale Dateninfrastrukturen nicht ersetzt, sondern miteinander verbinden soll. Zweitens zeigen Projekte wie deployEMDS, dass europäische Mobilitätsdatenräume nicht allein aus zentralen Plattformen bestehen, sondern aus der Kombination lokaler Anwendungsfälle, gemeinsamer technischer Bausteine und abgestimmter Governance-Strukturen. In dieser Perspektive kann die Mobilithek als

nationaler Zugangspunkt und der Mobility Data Space als kooperativer Datenraum als Teil einer mehrstufigen europäischen Infrastrukturarchitektur verstanden werden.

Gleichzeitig unterscheiden sich nationale Dateninfrastrukturen in Europa je nach Verwaltungsstruktur, Datenpolitik, Marktorganisation und bestehender Plattformslandschaft. Frankreich betreibt mit transport.data.gouv.fr einen nationalen Zugangspunkt, der Mobilitätsdaten aus Frankreich bündelt und Produzenten bei Qualität, Konformität und Veröffentlichung unterstützt (République Française o. J.). Die Niederlande verfügen mit dem National Data Warehouse (NDW) über eine etablierte Verkehrsdateninfrastruktur, die unter anderem mit nationalen DATEX-II-Profilen arbeitet und damit Standardisierung besonders stark technisch operationalisiert (NDW o. J.). Diese Beispiele zeigen, dass nationale Zugangspunkte und Mobilitätsdatenplattformen zwar einem europäischen Rahmen folgen, aber organisatorisch und technisch unterschiedlich ausgestaltet sein können. Ein systematischer Ländervergleich bleibt daher ein wichtiger Ansatzpunkt für weitere Forschung.

Insgesamt deuten die Fallstudien darauf hin, dass öffentliche Dateninfrastrukturen im Mobilitätssektor eine doppelte Funktion erfüllen: Sie sind technische Infrastruktur für den Datenaustausch und zugleich institutionelle Infrastruktur für Kooperation. Ihre langfristige Wirkung hängt davon ab, ob es gelingt, technische Interoperabilität, Datenqualität, vertrauenswürdige Governance und geeignete Anreize für die Beteiligung verschiedener Akteure miteinander zu verbinden.

7 Fazit

Die fortschreitende Digitalisierung verändert zunehmend auch den Mobilitätssektor. Daten bilden die Grundlage für digitale Anwendungen, neue Mobilitätsdienste und innovative Formen der Verkehrssteuerung. Vor diesem Hintergrund hat der Beitrag untersucht, welche Rolle staatlich initiierte Datenplattformen für datenbasierte Innovationsökosysteme im Mobilitätssektor spielen.

Die Analyse zeigt, dass Mobilithek und Mobility Data Space zwei unterschiedliche, aber komplementäre Modelle staatlicher Dateninfrastrukturpolitik darstellen. Die Mobilithek bündelt offene Mobilitätsdaten und fungiert als nationaler Zugangspunkt; der Mobility Data Space ermöglicht kontrollierten Datenaustausch unter definierten Nutzungsbedingungen. Damit adressieren beide Initiativen unterschiedliche Datenarten und Nutzungskontexte: offene Fahrplan-, Infrastruktur- und Verkehrsdaten einerseits sowie wirtschaftlich sensiblere Betriebs-, Fahrzeug- oder Nachfragedaten andererseits.

Der zentrale Befund lautet, dass staatlich initiierte Datenplattformen nicht nur technische Systeme sind, sondern auch institutionelle Koordinationsstrukturen. Der Staat tritt dabei nicht primär als alleiniger Plattformbetreiber oder zentraler Datenkontrolleur auf, sondern als Infrastrukturgeber, Förderer, Regelsetzer und Koordinator. Diese Rolle ist jedoch differenziert zu verstehen: Aus zwei Fallbeispielen lässt sich keine allgemeine Aussage über alle Bereiche der Datenökonomie ableiten, wohl aber ein Hinweis darauf, wie öffentliche Institutionen im Mobilitätssektor Datenökosysteme gezielt rahmen können.

Der Beitrag leistet damit einen konzeptionellen Beitrag zur Forschung über digitale Infrastrukturpolitik im öffentlichen Sektor. Er zeigt, dass Datenplattformen und Datenräume als Instrumente staatlicher Innovations- und Infrastrukturpolitik verstanden werden können. Ihre Bedeutung liegt nicht allein in der Bereitstellung von Daten, sondern in der Gestaltung von Governance-Strukturen, die Zugänglichkeit, Datensouveränität, Standardisierung, Vertrauen und kooperative Wertschöpfung miteinander verbinden.

Gleichzeitig macht die Analyse deutlich, dass der Aufbau funktionierender Datenökosysteme ein langfristiger institutioneller Prozess ist. Plattformen müssen ausreichend attraktiv für Datenanbieter und Datennutzer sein, Datenqualität und technische Interoperabilität sichern, Zuständigkeiten klären und Anreize für die Beteiligung verschiedener Akteure schaffen. Ohne solche Rahmenbedingungen besteht die Gefahr, dass Dateninfrastrukturen zwar technisch existieren, aber nur begrenzt genutzt werden.

Die Ergebnisse sind vor dem Hintergrund der methodischen Anlage des Beitrags zu interpretieren. Die Untersuchung basiert auf einer qualitativen Dokumentenanalyse ausgewählter Fallbeispiele und erhebt keinen Anspruch auf eine umfassende empirische Wirkungsmessung. Zukünftige Forschung könnte daher Interviews mit beteiligten Akteuren, Nutzungsdaten der Plattformen oder vergleichende Analysen anderer europäischer Dateninfrastrukturen einbeziehen. Besonders fruchtbar erscheint ein internationaler Vergleich, um zu untersuchen, wie sich nationale Zugangspunkte, Datenräume und öffentliche Plattformmodelle in unterschiedlichen institutionellen Kontexten entwickeln.

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Von lokalen Erfahrungen zu gemeinsamen Erkenntnissen: Entwicklung einer Wirkungsanalyse für transformative Anpassung in Bergregionen

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Transformative Klimawandelanpassung in Bergregionen erfordert einen Bewertungsrahmen, der Vergleiche über verschiedene Skalen, geografische Gebiete und sozioökonomische Kontexte hinweg ermöglicht und gleichzeitig die Sensibilität für lokale Gegebenheiten bewahrt. Während neuere Bewertungsrahmen zunehmend bereichsübergreifende und partizipative Ansätze berücksichtigen, wird ihre praktische Anwendung in Anpassungsprojekten oft durch kurze Projektzyklen, ungleiche Monitoringkapazitäten und die Tendenz eingeschränkt, direkt messbare und zuordenbare Ergebnisse zu bevorzugen. Aufbauend auf methodischen Entwicklungen im Rahmen des Horizon-Europe-Projekts „[MountResilience](#)“ in sechs heterogenen europäischen Bergregionen, schlägt dieser Beitrag erste Gestaltungsprinzipien für einen gemeinsamen Bewertungsansatz vor. Zu den Schlüsselementen gehören eine begrenzte Anzahl gemeinsamer Bewertungskategorien, gemeinsam mit lokalen Akteuren erarbeitete Datenerfassungspläne, realistische Monitoringmaßnahmen, externe Validierung durch repräsentative Haushaltsbefragungen sowie eine narrative Interpretation, um komplexe und zeitlich verzögerte Auswirkungen zu erfassen. Dieser mixed-methods Ansatz erkennt Rahmenbedingungen wie Governance-Kapazitäten, Bürger:innenbeteiligung, Dateninfrastrukturen und institutionelle Routinen als integralen Bestandteil des Anpassungsfortschritts an. Er betont einen verantwortungsvollen Vergleich, indem er sich auf Fortschrittskategorien statt auf direkte Ranglisten konzentriert, auf eine selektive Quantifizierung, die mit Kausalaussagen im Einklang steht, sowie auf ein Monitoring, das auf langfristiges Lernen über Projektzyklen hinaus ausgelegt ist. Dieser Beitrag schlägt eine Weiterentwicklung transdisziplinärer, bereichsübergreifender Wirkungsanalyse vor, die regionsübergreifendes Lernen, Legitimität und eine effektive Steuerung von Anpassungserkenntnissen im Bergkontext unterstützt.

1 Einleitung

Angesichts des fortschreitenden sozial-ökologischen Zusammenbruchs gehören Bergregionen zu den sozial-technisch-ökologischen Systemen (vgl. McPhearson et al., 2022), die die dringende Entwicklung glaubwürdiger Maßnahmen zur Anpassung an den Klimawandel und deren großflächige Umsetzung erfordern. Deshalb

ist es von grundlegender Bedeutung, gemeinsame Rahmenwerke zur Bewertung von Wirkungs- und Folgenanalysen einzuführen, die eine transdisziplinäre Bewertung multidimensionaler Ergebnisse und Auswirkungen umfassen. Während die Notwendigkeit der Klimaanpassung für jedes Gebiet und jede Bevölkerung weltweit außer Frage steht, sind Bergregionen den Auswirkungen des Klimawandels besonders ausgesetzt,

wie zahlreiche Quellen, darunter zwei einflussreiche IPCC-Berichte (Adler et al., 2022; Hock et al., 2022), hervorheben. Ihre Vulnerabilität gegenüber den Auswirkungen des Klimawandels umfasst verändernde Niederschlagsmuster und Temperaturen, Verschiebungen bei der Gletscher- und Schneebedeckung, erhöhte Risiken von Regen- und Flusshochwasser, geologische Gefahren und Dürren, erheblichen Druck auf artenreiche Biome sowie sich verändernde touristische Bedingungen und daraus resultierende sozioökonomische Anfälligkeiten und Landnutzungskonflikte. Diese Belastungen betreffen nicht nur Hochgebirgsregionen und ihre Bewohner:innen, sondern auch die flussabwärts gelegenen Gebiete und weiterreichende territoriale Systeme, die von Bergökosystemen für eine Vielzahl von Ökosystemleistungen abhängig sind, darunter unter anderem Wasserregulierung, Schutz vor Gefahren, Erholungslandschaften sowie wichtige Inputs für Landwirtschafts- und Ernährungssysteme (vgl. Bernués et al., 2014; Grêt-Regamey et al., 2008, 2012). Daher ist die Anpassung in diesen Gebieten nicht nur ein lokales Umweltproblem, sondern vielmehr eine Herausforderung für den öffentlichen Sektor, das Infrastrukturmanagement, die multidimensionale Planung, wirtschaftliche Entwicklung, gesellschaftliche Akzeptanz und Unterstützung sowie institutionelle Koordination.

Unter den zahlreichen Herausforderungen, die dieses Unterfangen mit sich bringt, ist die Bewertung von Anpassungsprojekten von zentraler Bedeutung. Behörden, Förderstellen, regionale Akteure und letztlich auch die Bürger:innen und die Zivilgesellschaft benötigen fundierte Erkenntnisse, um beurteilen zu können, ob Anpassungsmaßnahmen funktionieren. Dazu gehört auch herauszufinden wer Kosten und Nutzen trägt, wer einbezogen wird und wessen Weltanschauungen somit berücksichtigt werden (vgl. Raymond et al., 2023), welche Praktiken übertragbar sind und wo und in welche Ressourcen investiert werden sollte. Eine transformative Anpassung nach der Definition des IPCC „verändert jedoch die grundlegenden Eigenschaften eines sozial-ökologischen Systems in Erwartung des Klimawandels und seiner Auswirkungen“ (Calvin et al., 2023, S. 120), sodass sie aufgrund komplexer Systemdynamiken selten einfache, unmittelbare oder leicht zuzuordnende Ergebnisse hervorbringt. Viele Maßnahmen sind nur im Rahmen einer längeren Abfolge von Ereignissen oder einer „Theorie des Wandels“ (engl. Theory of Change) nachvollziehbar und somit bewertbar (vgl. Stein & Valters, 2012). Diese beginnen in der Regel nicht mit sichtbaren biophysikalischen Veränderungen, die vielmehr das Endergebnis eines Zyklus sind. Sie beginnen mit institutionellen Regelungen, die Routinen zum Datenaustausch, partizipative Formate, Beratungsdienste, Finanzierungsmechanismen, Monitoringsysteme oder Entscheidungshilfetools ermöglichen und fördern. Diese Aktivitäten mögen im Vergleich zu konkreten Investitionen in physische blau-grüne, graue oder hybride Infrastrukturen oder

naturbasierte Lösungen (NbS) wie Flussrenaturierung, Kühlinfrastruktur oder Wiesenrenaturierung indirekt erscheinen. Wie wir zeigen werden, entscheiden eben diese „ermöglichenden“ Maßnahmen oft darüber, ob spätere Anpassungsmaßnahmen überhaupt möglich, legitim und nachhaltig werden.

Das Verstehen von Maßnahmen innerhalb ihres jeweiligen Kontexts schafft eine zentrale Spannung bei der Planung und Durchführung von Bewertungen. Während die Notwendigkeit eines Vergleichs zwischen Regionen und Maßnahmen kaum bestreitbar ist und gemeinsame Kategorien und Rahmenbedingungen erfordert, birgt ein starrer Vergleich die Gefahr, lokale Unterschiede zu nivellieren und das, was am einfachsten zu messen ist, übermäßig zu belohnen – was nicht unbedingt oder sogar kaum jemals das ist, was für den Wandel am wichtigsten ist. Ein einzelner Index oder eine Handvoll Indikatoren mag Bürokraten und Fachpersonal gefallen oder für einen eng definierten Output nützlich sein, ist aber irreführend, wenn Kausalketten lang oder komplex sind, relevante Veränderungen eher qualitativer Natur sind, sich Ergebnisse über verschiedene geografische Räume und Zeitskalen erstrecken und Systemgrenzen umstritten sind.

Dieser Beitrag beleuchtet dieses Dilemma anhand der Erfahrungen, die im Rahmen der laufenden methodischen Weiterentwicklung des „MountResilience Impact Assessment Framework“ (Gimelli et al., under review) gesammelt wurden. Das zugrundeliegende Projekt erstreckt sich über sechs europäische Bergregionen: Tirol (AT), Gabrovo (BG), Wallis (CH), Piemont (IT), Lappland (FI) und den Kreis Sibiu (RO). Die regionalen Demonstrationsprojekte (RDs) unterscheiden sich erheblich hinsichtlich Geografie, institutionellen Rahmenbedingungen, Wirtschaftsstrukturen, Klimarisiken und Anpassungsprioritäten. Ihre Aktivitäten reichen von Beratungsdiensten und kommunaler Anpassungsplanung bis hin zu Plattformen für Wassermanagement, Entscheidungshilfetools, Warnsystemen, Strategien für den Tourismuswandel sowie naturbasierten oder ökosystemorientierten Maßnahmen (vgl. Pezzotti et al., 2024; Suitner et al., 2024; Abbildung 1).

Zum Zeitpunkt der Abfassung dieses Artikels befindet sich die entsprechende methodische Arbeit noch in der internen Projektüberarbeitung, sodass eine detaillierte Darstellung unseres methodischen Ansatzes noch verfrüht ist. Das Ziel dieses Beitrags beschränkt sich darauf, Gestaltungsprinzipien für den Aufbau gemeinsamer Anpassungserkenntnisse in heterogenen Bergregionen zu identifizieren, basierend auf unseren Erfahrungen mit lokalen Akteuren und transdisziplinärer Zusammenarbeit. Die übergeordnete These lautet, dass der Aufbau von Erkenntnissen selbst eine Governance-Aufgabe und zutiefst politisch ist. Aufbauend auf der vorhandenen Literatur zur Wirkungsanalyse und aktuellen Debatten unter Praktiker:innen reflektieren

wir über die Schwierigkeit, eine bereichsübergreifende, gemischtmethodische Bewertung in Anpassungsprojekten zu operationalisieren, die oft noch von ergebnisorientierten Berichtspflichten bestimmt werden. Zunächst stellen wir MountResilience als praxisorientiertes Beispiel für die Gestaltung transdisziplinärer Bewertungskonzepte vor. Nach einer Skizzierung der Makrostruktur unseres Wirkungsanalyse-Rahmens leiten wir in der Diskussion vier Gestaltungsprinzipien für einen verantwortungsvollen Vergleich ab.

2 Warum transformative Anpassung nach wie vor schwer zu bewerten ist

2.1 Sechs Regionen, ein gemeinsames Bewertungsproblem

MountResilience ist ein laufendes Projekt und dient daher lediglich als praxisorientierter Bezugspunkt. Auch wenn die folgenden sechs Demonstrationsregionen ihre bergige Lage gemeinsam haben, werden sie als deutlich heterogene Anpassungskontexte mit unterschiedlichen Risiken und Herausforderungen vorgestellt (Pezzotti et al., 2024; Suitner et al., 2024):

Die Regionen Tirol, Lappland, Râu Sadului, Gabrovo, Piemont und Wallis sind alle mit erheblichen klimabedingten Gefahren und Risiken konfrontiert, wobei sich die konkreten Auswirkungen und Anpassungsprioritäten je nach ihrem ökologischen, wirtschaftlichen und sozialen Kontext unterscheiden. In allen Regionen gehören steigende Temperaturen und sich verändernde Niederschlagsmuster zu den häufigsten Klimabedrohungen. Mehrere Regionen, insbesondere Tirol, Lappland und das Wallis, sind zusätzlich von Schnee, Gletschern, Permafrost oder Eisschmelze und damit stark von Berg- und nördlichen Ökosystemen abhängig. Extreme Wetterereignisse wie Dürren, Überschwemmungen, Stürme, Hitzewellen und Erdbeben treten besonders häufig in Gabrovo, Piemont, Râu Sadului und im Wallis auf.

Eine wesentliche Gemeinsamkeit, auf die alle Partner in den verschiedenen Regionen hinweisen, ist jedoch der allgemeine Mangel an Bewusstsein, Wissen, Zusammenarbeit und Maßnahmen in Bezug auf Anpassung an den Klimawandel sowie Naturgefahren. Tirol, Lappland, Râu Sadului und Gabrovo versuchen diese Lücken durch Kommunikationskampagnen, öffentliche Informationsveranstaltungen, die Einbindung von Interessengruppen und Netzwerkaktivitäten zu schließen. Ähnlich konzentrieren sich das Wallis und Piemont darauf, die Zusammenarbeit und Governance durch die Mobilisierung von Interessengruppen, Bildung,

Schulungen und Co-Creation-Prozesse zu verbessern. Das zeigt, dass der Aufbau sozialer und institutioneller Kapazitäten als genauso wichtig angesehen wird wie technische Anpassungsmaßnahmen.

Trotz dieser Gemeinsamkeiten unterscheiden sich die Regionen erheblich in ihren wichtigsten Schwachstellen und Anpassungsprioritäten. Tirol und Lappland sehen sich beide mit Unsicherheiten im Wintertourismus konfrontiert, die auf kürzere Winter und geringere Schneesicherheit zurückzuführen sind. Ihre Reaktionen unterscheiden sich jedoch. Tirol konzentriert sich auf Anpassungskonzepte für Skigebiete und ganzjährige Tourismusstrategien, während Lappland den Schwerpunkt auf Klimaanpassungscoaching und -planung speziell für Tourismusunternehmen in der frühen Wintersaison legt. Lappland zeichnet sich zusätzlich durch die Risiken für indigene Gemeinschaften und traditionelle Lebensgrundlagen aus, was zu gezielter Anpassungsunterstützung für Rentierzüchter:innen führt.

Râu Sadului unterscheidet sich von den anderen Regionen durch seinen starken Fokus auf traditionelle Landwirtschaft und Bergweidewirtschaft. Hitzewellen, Dürren und extreme Wetterereignisse tragen zur Bodenerosion bei und bedrohen dabei die auf Viehzucht basierenden Lebensgrundlagen. Folglich legt die Region den Schwerpunkt auf Techniken zur Wiederherstellung von Wiesen sowie politische Empfehlungen in Kombination mit dem Zugang zu Kreditprogrammen, um die wirtschaftliche Tragfähigkeit traditioneller Lebensgrundlagen zu verbessern.

Wasserbezogene Herausforderungen sind in Piemont und im Wallis besonders ausgeprägt. Beide Regionen sind mit steigenden Temperaturen, sich verändernden Niederschlagsmustern und zunehmender Wasserknappheit konfrontiert. Als Reaktion darauf konzentrieren sich beide auf die Verbesserung der Wasserbewirtschaftung und der Entscheidungsfindungssysteme. Piemont legt den Schwerpunkt auf Entscheidungshilfetools für Bewässerungskonsortien, Wassersysteme und landwirtschaftliche Betriebe, um die Bewässerungseffizienz zu verbessern und alternative Anbaukulturen sowie Bewässerungstechniken zu fördern. Das Wallis hingegen konzentriert sich auf die Schaffung einer inklusiven digitalen Plattform, um transparente und zugängliche Informationen über Wassermenge und -qualität zu verbessern und so fundierte Entscheidungen im Zusammenhang mit Wasserknappheit zu ermöglichen.

Gabrovo weist eines der breitesten Spektren an Klimarisiken auf, darunter Dürren, Stürme, Waldbrände, Überschwemmungen, Hitze- und Kältewellen. Im Vergleich zu den anderen Regionen legt Gabrovo einen stärkeren Schwerpunkt auf Notfallvorsorge und Herausforderungen der städtischen Infrastruktur. Zu seinen Anpassungsmaßnahmen gehören ein Frühwarn- und Monitoringsystem, eine Strategie für

grüne Infrastruktur zur Bekämpfung von städtischer Hitzebelastung und Überschwemmungen sowie Regenwassernutzungssysteme, um Wasserdruck und veraltete Infrastruktur zu bewältigen.

Insgesamt teilen zwar alle Regionen gemeinsame Anliegen, doch spiegeln ihre Anpassungsmaßnahmen ihre unterschiedlichen geografischen Bedingungen, wirtschaftlichen Strukturen und sozialen Schwachstellen wider. Berg- und nördliche Regionen wie Tirol, Lapland und das Wallis konzentrieren sich stark auf Auswirkungen im Zusammenhang mit Schnee, Gletschern und Tourismus, während Piemont und Gabrovo der Wasserwirtschaft und der Widerstandsfähigkeit der Infrastruktur Vorrang einräumen. Râu Sadului konzentriert sich unterdessen auf den Schutz traditioneller landwirtschaftlicher Lebensgrundlagen und die Verringerung der Bodendegradation. (Pezzotti et al., 2024; Suitner et al., 2024)

Abbildung 1 bietet einen Überblick über die Klimarisiken, mit denen sich die regionalen Demoprojekte befassen, sowie über ihre vorgeschlagenen Demoaktivitäten. Diese Aktivitäten könnten mehr als eine Risikokategorie abdecken (z. B. Anpassungscoaching für Rentierzüchter:innen).

Insgesamt verdeutlichen die in Abbildung 1 zusammengefassten Fälle, warum kein einzelner Satz an Indikatoren für „(transformative) Anpassung“ mechanisch vorgeschrieben werden kann. Eine Messung der wiederhergestellten Wiesenbiomasse in Rumänien lässt

sich nicht direkt mit der Entwicklung oder Zugänglichkeit einer digitalen Wasserplattform in der Schweiz oder der Inanspruchnahme von Beratungsdienstleistungen in Österreich vergleichen. Dennoch können all diese Maßnahmen zur transformativen Anpassung beitragen, wenn sie Kapazitäten, die Entscheidungsfindung verschiedener Akteure oder zukünftige Optionen verändern. Dies erfordert Bewertungsrahmen, die auf einer mittleren Abstraktionsebene funktionieren: umfassend genug, um regionsübergreifend zu gelten, aber spezifisch genug, um für lokale Akteure aussagekräftig zu sein. Zu weit gefasste Kategorien bleiben wahrscheinlich bedeutungslos, während zu detaillierte Indikatoren einen Vergleich unmöglich machen. Diese Spannung ist keine technische Herausforderung, sondern vielmehr ein zentrales methodisches Problem bei der Bewertung transformativer Anpassung in heterogenen Regionen und bei unterschiedlichen Arten von Maßnahmen. Schließlich stellen sie alle die Herausforderung dar, wie man fördernde Prozesse erkennen und bewerten kann, bevor die endgültigen Ergebnisse sichtbar sind.

2.2 Die Grenzen der ergebnisorientierten Bewertung

Viele Evaluierungs- und Berichterstattungsverfahren sind auf Maßnahmen ausgerichtet, die klare Inputs, kurze und einigermaßen vorhersehbare Kausalketten sowie messbare Outputs oder Ergebnisse aufweisen. Diese Logik ist im öffentlichen Sektor nützlich, da sie es

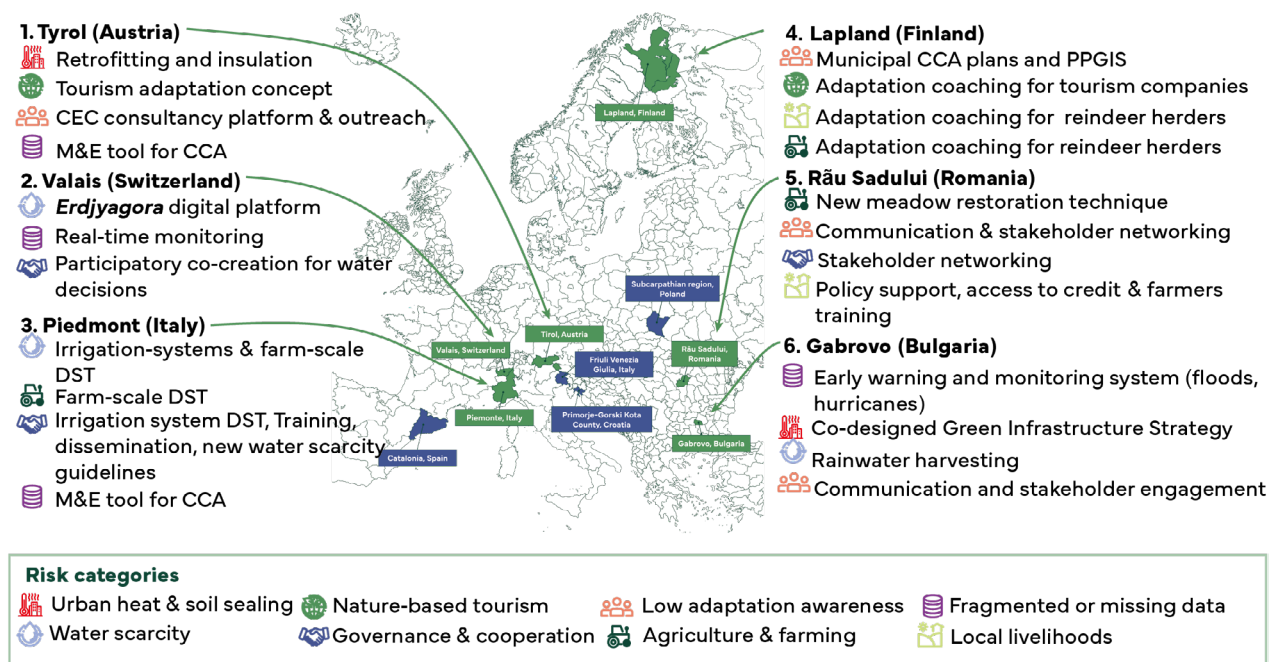


Abbildung 1: Überblick über die regionalen Demoprojekte (grün), die zentralen Herausforderungen im Rahmen von MountResilience und die durchgeführten Demonstrationsaktivitäten. Die in blau dargestellten Regionen sind als Replikatoren angedacht die auf Basis der Erfahrungen aus den Demoprojekten ihre Adaptionsmaßnahmen erstellen.
Quelle: Eigene Darstellung basierend auf Suitner et al. 2024 und Pezzotti et al., 2024.

Programmanager:innen und Geldgebern ermöglicht, zu überprüfen, ob geplante Aktivitäten umgesetzt, Outputs erbracht und vordefinierte Ziele erreicht wurden. Bei der Klimaanpassung, insbesondere wenn das erklärte Ziel eine Transformation ist, ist diese Logik zwar notwendig, aber nicht ausreichend.

Transformative Anpassung bezieht sich speziell auf Veränderungen, die die zugrunde liegenden Ursachen der Vulnerabilität angehen, anstatt bestehende Systeme nur am Rande zu flicken (Fedele et al., 2019; O'Brien, 2012; Pelling, 2010; Pelling et al., 2015). Oftmals erfordert ein transformativer Wandel auf Systemebene institutionelle, verhaltensbezogene und relationale Veränderungen, bevor sich diese im physischen Raum niederschlagen. Beispielsweise kann eine digitale Plattform zum Monitoring der Wasserverfügbarkeit und ihrer – möglicherweise konkurrierenden – Nutzungsarten nur dann zu einem transformativen Wandel beitragen, wenn eine Vielzahl von Wassernutzer:innen und anderen Interessengruppen den Daten vertraut, die Benutzeroberfläche versteht, die regelmäßige Nutzung der Plattform in ihren täglichen Abläufen etabliert und über das Mandat und die Befugnis verfügt, auf das Wassersystem einzuwirken. Ähnlich verhält es sich mit einem kommunalen Klimaanpassungsplan: Er kann seine vorgegebenen Ziele tatsächlich nur dann beeinflussen, wenn sich Änderungen in der Haushaltsplanung, der Landnutzungspolitik, den Verwaltungsabläufen und den Erwartungen der Interessengruppen ergeben. Bewertungskonzepte, die kurzfristige, direkt messbare Ergebnisse in den Vordergrund stellen, laufen Gefahr, diese Bedingungen zu vernachlässigen, selbst wenn sie theoretisch als wichtig anerkannt werden. Darauf wird in Abschnitt 2.3 näher eingegangen.

Angeichts der im Rahmen von MountResilience vorgeschlagenen Maßnahmen haben wir unsere Überprüfung bestehender Wirkungsbewertungsmethoden auf bestehende Rahmenwerke für naturbasierte Lösungen (z. B. Dumitru, 2021; Europäische Kommission. Generaldirektion Forschung und Innovation, 2021), soziale Innovation (z. B. Castro Spila et al., 2016) sowie die Bewertung durch Bürger:innenwissenschaft (z. B. Passani et al., 2022; Wehn et al., 2021) beschränkt. Diese Ansätze haben Teile dieser Herausforderung bereits ausdrücklich erkannt und setzen auf multikriteriale, partizipative und bereichsübergreifende Ansätze. Unser Beitrag versucht zu untersuchen, wie solche Erkenntnisse in heterogenen Bergregionen mit ungleicher Datenverfügbarkeit, institutioneller Kapazität und Interventionslogik umgesetzt werden können. Drei Punkte bleiben dabei besonders für die Anpassung in Bergregionen von Bedeutung:

Erstens sind bestehende Rahmenwerke stark von städtischen oder projektspezifischen Anwendungen geprägt. Bergregionen weisen im Vergleich zu bestehenden Anwendungen unterschiedliche

institutionelle Kapazitäten, Landnutzungskonflikte, ökologische Dynamiken und Expositionsmuster auf. Zweitens zielen viele Anpassungsmaßnahmen, wie bereits dargelegt, eher darauf ab, direkte biophysikalische Veränderungen zu ermöglichen, als diese selbst herbeizuführen. Sie bereiten die Anpassung mittel- bis langfristig vor oder unterstützen sie, anstatt die endgültige materielle Maßnahme darzustellen. Drittens verursachen heterogene Maßnahmen ein Vergleichbarkeitsproblem. Beratungsdienste, kommunale Anpassungsplanung, Entscheidungshilfen für die Bewässerung und Frühwarnsysteme lassen sich nicht sinnvoll vergleichen, als wären sie die gleiche Art von Maßnahme. Die Frage ist nicht, ob sie auf eine oder wenige Kennzahlen reduziert werden können, sondern wie ihr Beitrag zur Anpassung verständlich gemacht werden kann, ohne ihre Unterschiede zu verwischen.

2.3 Rahmenbedingungen als Fortschritt der Anpassung

Das zentrale Argument dieses Beitrags lautet, dass Rahmenbedingungen als Teil des Anpassungsprozesses betrachtet werden sollten, ähnlich wie bei der Diskussion um den Kapazitätsaufbau (engl. adaptive capacity) (z.B. Pahl-Wostl, 2009; Smit & Wandel, 2006). Sie sollten nicht lediglich als Hintergrundvariablen oder Umsetzungsdetails betrachtet werden, da sie entscheidend dafür sind, ob Regionen Risiken erkennen, Akteure koordinieren, Ressourcen mobilisieren, Daten auswerten, Bürger:innen einbinden und die Nachhaltigkeit der Maßnahmen langfristig gewährleisten können.

Wir schlagen daher vier Rahmenbedingungen als besonders relevant vor: Die erste ist „Governance-Kapazität“, also die Fähigkeit von Behörden und anderen Akteuren, gemeinsame Verantwortlichkeiten zu definieren und zu vereinbaren, sektorübergreifend Aktivitäten zu koordinieren und auf der Grundlage gemeinsamer und glaubwürdiger Erkenntnisse zu handeln. Die zweite ist „institutionelles Vertrauen und Partizipation“, also die Schaffung oder Stärkung glaubwürdiger Mechanismen, durch die sich alle relevanten Akteure und Bürger:innen informiert und aktiv einbezogen fühlen, sodass sie Einfluss auf die Prioritäten der Anpassung nehmen, Abwägungen treffen und letztlich staatliche Legitimität aufbauen können. Zunehmend wichtig wird die „Dateninfrastruktur“, also die Verfügbarkeit zuverlässiger, zugänglicher und interpretierbarer Datenströme, die Entscheidungen und das Monitoring über den Projektzyklus hinaus unterstützen können. Schließlich erfasst der Begriff „institutionelle Routine“ die Verankerung und Einbindung der Anpassung in die üblichen Planungs-, Budgetierungs-, Instandhaltungs- und Monitoringpraktiken.

Diese Bedingungen sind oft teilweise qualitativ, kontextabhängig und verlaufen langsam, was ihre Messung erschwert. Deshalb erfordert eine transformative Anpassungsbewertung einen gemischten Methodenansatz. Quantitative Indikatoren bleiben unverzichtbar, wo Ziele, Ausgangswerte und zuverlässige Daten vorliegen. Sie machen Fortschritte sichtbar und unterstützen die Rechenschaftspflicht. Letztlich sind qualitative und narrative Interpretationen jedoch notwendig, um Mechanismen, Einschränkungen, Machtverhältnisse, institutionelle Kulturen und verzögerte Auswirkungen zu verstehen.

3 MountResilience als praxisorientiertes Beispiel für den gemeinsamen Aufbau von Evidenz

3.1 Gemeinsam erarbeitete Datenerfassungspläne als Evidenz-Infrastrukturen

Um diese Herausforderungen anzugehen, konzentriert sich unsere Arbeit im Rahmen von MountResilience auf einen gemeinsamen Prozess zur Erstellung von Datenerfassungsplänen (DCPs – Data Collection Plans) für jede Demoregion, da diese am besten wissen, welche Datenströme existieren, welche Indikatoren aussagekräftig sind und welche Monitoringaufgaben realistisch sind (Abbildung 2). Dies ist wichtig, da ein theoretisch ambitionierter Indikator, der von lokalen Akteuren nicht erfasst, gepflegt oder gar verstanden werden kann, wahrscheinlich kein langfristiges Lernen unterstützt.

Umgekehrt können Daten, die bereits von Verwaltungen, Forschungseinrichtungen, Versorgungsunternehmen, Monitoringnetzwerken oder Projektpartnern produziert werden, nachhaltigere Datenerfassungsströme bieten als neue projektspezifische Messbemühungen. Das Prinzip besteht daher nicht darin, so viele Daten wie möglich zu sammeln, sondern die nützlichsten Daten zu erfassen, die plausiblerweise auch über die Projektlaufzeit hinaus verfügbar bleiben.

Darüber hinaus kann die gemeinsame Erstellung von DCPs als Verhandlungsinstrument verstanden werden. Im Rahmen des Prozesses haben wir regionale Partner gebeten, darzulegen, was sie als relevante Anpassungsfortschritte betrachten, welche kausalen Annahmen ihre Aktivitäten mit den erwarteten Ergebnissen verknüpfen und wo Monitoringkapazitäten bereits vorhanden sind oder noch fehlen. Anstatt eine bereits bestehende „Theorie des Wandels“ zu dokumentieren, half der Prozess dabei, potenziell konkurrierende Theorien zu gestalten, zu testen und aufeinander abzustimmen. Indem wir die Partner gebeten haben, Indikatoren, Ziele, Datenquellen und Zuständigkeiten zu identifizieren, zeigt der Prozess auf, welche Anpassungsambitionen bestehen und ob diese durch plausible Evidenzpfade gestützt werden.

Dies ist von zentraler Bedeutung für transformative Anpassung, bei der Veränderungen oft über verschiedene Zeithorizonte oder räumliche Skalen hinweg erwartet werden. Während Ergebnisse wie die Einrichtung einer Datenplattform, die Erbringung von Beratungsleistungen oder die Organisation von Stakeholder-Workshops bereits während der Projektlaufzeit beobachtet werden können, werden andere Effekte wie veränderte Landnutzungspraktiken, geänderte Wassermanagementpraktiken, verbesserte institutionelle Koordination, gesteigertes öffentliches Bewusstsein oder Akzeptanz möglicherweise erst später sichtbar. Die

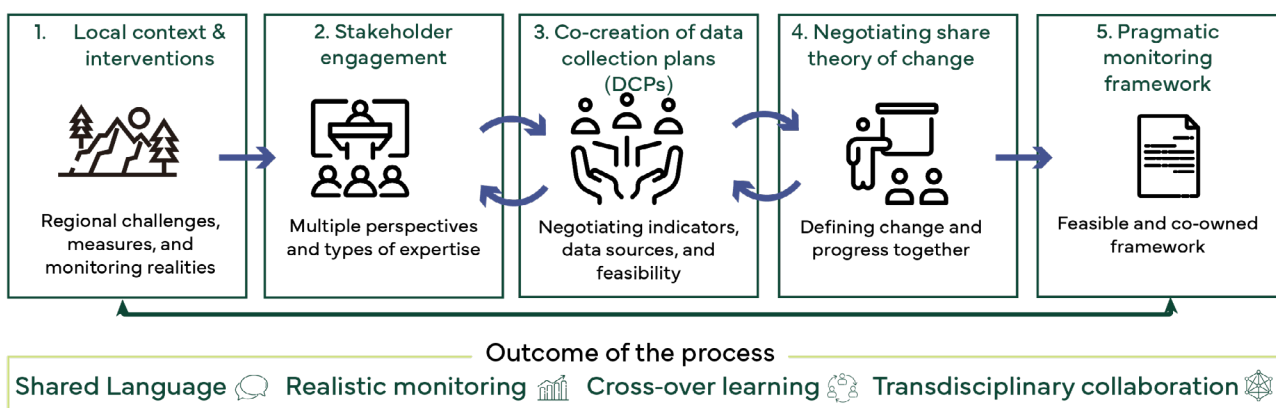


Abbildung 2: Von den Autor:innen geleiteter Co-Creation-Prozess unter Einbeziehung regionaler Demopartner bei der Entwicklung der Datenerhebungspläne. Dies umfasste verschiedene Feedback-Runden von März 2025 bis Oktober 2025.

DCPs helfen daher dabei, zu unterscheiden, was sofort überwacht werden kann, was plausibel zu erwarten ist und was eine längerfristige Beobachtung erfordert.

Gemeinsam erarbeitete DCPs bringen jedoch auch inhärente Herausforderungen mit sich, die ausdrücklich anerkannt und adressiert werden sollten. Die Pläne werden in erster Linie von den Projektpartnern selbst geprägt. Das macht die Datenerhebung zwar praxisnah und durchführbar, bedeutet aber auch, dass die daraus resultierenden DCPs institutionelle, politische, technische oder von Expert:innen definierte Anpassungsprioritäten möglicherweise anders widerspiegeln als die Wahrnehmung in der breiten Öffentlichkeit. Da in den DCPs die Weltanschauungen der Projektpartner widerspiegelt werden, könnte es durchaus sein, dass nur die Perspektiven derjenigen zum Ausdruck kommen, die bereits Machtpositionen im Governance-Ökosystem der Region innehaben. Aus diesem Grund ist eine zusätzliche Evidenzebene erforderlich, um zu überprüfen, ob die im Monitor-Design verankerten Prioritäten und die impliziten „Theorien des Wandels“ über das Projekt und den Kreis der konsultierten Stakeholder hinaus Resonanz finden.

3.2 Repräsentative Haushaltsbefragungen als externe Validierung der Anpassungsprioritäten

Zur Ergänzung der gemeinsam erarbeiteten Datenerfassungspläne (DCPs) umfasst unser Bewertungsansatz zwei repräsentative Haushaltsbefragungen in den sechs Demoregionen. Diese Umfragen sollen die lokal gemeinsam erarbeiteten Indikatoren nicht ersetzen, sondern vielmehr eine Validierungsebene auf Bevölkerungsebene bieten. Die Umfrage umfasste Fragen zu wahrgenommenen Klimarisiken, zum Bewusstsein für Anpassungsmaßnahmen, zum Vertrauen in Institutionen, zur Bereitschaft, sich an Anpassungsprozessen zu beteiligen und Anpassungsmaßnahmen zu unterstützen oder dafür zu zahlen, sowie zum Wohlbefinden und zur relativen Bedeutung, die verschiedenen Anpassungszielen beigemessen wird. Während die Datenerfassungspläne Projektaktivitäten und Prioritäten der Interessengruppen in messbare Indikatoren umsetzen, erfassen die Umfragen, wie die Bürger:innen Klimarisiken, Anpassungsbedürfnisse und politische Prioritäten in ihren Regionen wahrnehmen. Die Umfrage erfüllt drei Funktionen: Erstens helfen sie dabei zu überprüfen, ob die durch die gemeinsam erarbeiteten DCPs priorisierten Bereiche und Themen den breiteren Anliegen der Öffentlichkeit entsprechen. Zweitens liefern sie vergleichbare, regionsübergreifende Erkenntnisse zu Anpassungsprioritäten, selbst dort, wo sich konkrete Maßnahmen erheblich unterscheiden. Drittens unterstützen sie die Interpretation der Ergebnisse, indem sie aufzeigen, wie institutionelle oder technische Maßnahmen in breitere Muster von

öffentlichem Vertrauen, sozioökonomischem Hintergrund, Bevölkerungszusammensetzung, Risikowahrnehmung und gesellschaftlicher Akzeptanz eingebettet sind.

Die Validierungsfunktion ist wichtig, da Anpassungsmaßnahmen zwar technisch fundiert und institutionell kohärent sein können, aber dennoch an Legitimität mangeln, wenn sie nicht den Anliegen, Erwartungen oder der Bereitschaft der Bürger:innen zur Mitwirkung entsprechen. Umgekehrt können öffentliche Prioritäten Themen hervorheben, die in technischen Monitoringrahmen unterrepräsentiert sind, wie Vertrauen in Institutionen, wahrgenommene Fairness, Bereitschaft zur Teilnahme, Wohlbefinden, Risikowahrnehmung und die gesellschaftliche Akzeptanz von Anpassungsmaßnahmen. Die Haushaltsbefragungen dienen daher als externe Überprüfung des Bewertungsdesigns und tragen zur Gewichtung verschiedener Bereiche bei, indem sie repräsentative Bürger:innenperspektiven einbringen, die über das Konsortium und die am DCP-Prozess beteiligten Interessengruppen hinausgehen.

Die erste Erhebungswelle wurde 2024 vor der Umsetzung der regionalen Demoaktivitäten durchgeführt und schuf so eine Ausgangsbasis für spätere Vergleiche. Dabei wurden mithilfe einer zufälligen Quotenauswahl Antworten von 3.227 Personen aus den sechs regionalen Demogebieten gesammelt. Eine zweite Welle ist Ende 2026 geplant, um festzustellen, ob sich die öffentlichen Wahrnehmungen, Prioritäten und die Akzeptanz im Laufe der Zeit verändert haben.

3.3 Vorläufige Bewertungsbereiche und Arten von Fortschritten

Um einen Vergleich zu ermöglichen, ohne einen einzigen starren Satz an Indikatoren vorzuschreiben, arbeitet die sich entwickelnde Bewertungslogik mit einer begrenzten Anzahl breiter Kategorien. Zum Zeitpunkt der Erstellung dieses Dokuments sollten diese Kategorien als Teil eines laufenden methodischen Gestaltungsprozesses verstanden werden und nicht als genehmigter Projektrahmen. Ihre Funktion besteht darin, eine gemeinsame Sprache bereitzustellen, durch die heterogene Maßnahmen diskutiert werden können, und nicht darin, identische Indikatoren für alle Regionen vorzuschreiben.

Die erste Ebene besteht aus vier Bewertungsbereichen, die das Teilsystem identifizieren, in dem Veränderungen erwartet werden. Der Umweltbereich umfasst Veränderungen in Bezug auf Ökosysteme, Biodiversität, Klimaregulierung, Wasser, Boden, Bodenbedeckung und andere ökologische Bedingungen oder Ökosystemleistungen. Der gesellschaftliche Bereich erfasst Partizipation, Gerechtigkeit, soziales Lernen, Engagement der Gemeinschaft, Exposition gegenüber Klimarisiken, Gesundheit, Wohlbefinden und die

wahrgenommene Lebensqualität. Der wirtschaftliche Bereich erfasst Auswirkungen auf Aktivitäten wie Beschäftigung, Investitionen, sektorale Resilienz oder das Ökosystem privater Anpassungsfinanzierung. Der Bereich Governance und Politik erfasst institutionelle Arrangements, Planungskapazitäten, öffentliche Finanzierungsinstrumente, Koordinationsmechanismen, die Umsetzung von Politik sowie die Fähigkeit öffentlicher und kollektiver Akteure, auf Anpassungserkenntnisse zu reagieren.

Die zweite Ebene unterscheidet zwischen verschiedenen Arten von Fortschritten innerhalb eines Anpassungsprozesses und ordnet Indikatoren somit in eine implizite „Theorie des Wandels“ ein. Einige Indikatoren beschreiben Ausgangsbedingungen wie Gefährdung, demografische Trends, Landnutzung oder bestehende institutionelle Regelungen. Andere erfassen Strukturen, d. h. die Kapazitäten, Instrumente, Pläne, Datensysteme oder Governance-Regelungen, die die Voraussetzungen für die Anpassung schaffen. All diese Indikatoren dienen nicht dazu, Projektauswirkungen zu erfassen, sondern die Entwicklung jener kontextuellen Bedingungen zu beobachten, die zum Verständnis der Relevanz der Lösungen beitragen, und anzuerkennen, dass sich die behandelten „Probleme“ parallel zu den „Lösungen“ weiterentwickeln. Daher sollten die „Lösung“ und ihre Relevanz für den lokalen Kontext unter den aktualisierten Bedingungen bewertet werden. So entwickelt Piemont beispielsweise eine Reihe evidenzbasierter Entscheidungshilfetools, um die Wasserverfügbarkeit zu überwachen und die Koordination zwischen den Akteuren in Zeiten von Wasserknappheit und Dürren zu verbessern. Da die Entscheidungshilfetools innerhalb der Projektlaufzeit lediglich entwickelt und getestet werden, ist es unrealistisch, zu erwarten, dass sich in den Wasserstatistiken nennenswerte Veränderungen zeigen. Dennoch könnte die Einbeziehung von Statistiken zur Wasserverfügbarkeit und -nutzung in die DCPs relevant sein, um das Ausmaß des Problems (d. h. das Ungleichgewicht) zu erfassen, was wiederum dazu beiträgt, die potenzielle Relevanz der entwickelten Lösung zu verstehen (d. h. den künftigen Wasserverbrauch durch eine rationellere Verteilung und Nutzung dieser Ressource zu senken).

Eine dritte Gruppe erfasst Prozesse wie die Einbindung von Interessengruppen, die Bereitstellung von Beratungsdiensten, Schulungen, Workshops, Konsultationen oder partizipative Planung. Schließlich erfassen einige Indikatoren Ergebnisse, d. h. Veränderungen bei Praktiken, Kapazitäten, Umweltbedingungen, institutioneller Akzeptanz oder risikobezogenen Bedingungen, die plausibel mit der Maßnahme in Verbindung gebracht werden können. Diese Architektur ist ausdrücklich von den Empfehlungen der von der Europäischen Kommission eingesetzten NbS-Bewertungs-Taskforce inspiriert (European Commission.

Directorate-General for Research and Innovation, 2021). Der Wert dieser vorläufigen Architektur liegt in ihrer mittleren Abstraktionsebene. Die Domänen geben an, welche Art von Wert oder Systemdimension betroffen ist, während die Typen angeben, an welcher Stelle im Veränderungsprozess ein Indikator angesiedelt ist. Dadurch werden die Rahmenbedingungen sichtbar gemacht, ohne sie mit Endergebnissen zu verwechseln, und es hilft, voreilige Urteile zu vermeiden: Eine Region kann erhebliche Fortschritte beim Aufbau von Strukturen und Prozessen erzielen, auch wenn ökologische oder verhaltensbezogene Ergebnisse noch nicht sichtbar sind. Umgekehrt kann eine Maßnahme kurzfristige Ergebnisse liefern, ohne die für eine langfristige Transformation notwendigen institutionellen Routinen zu schaffen. Die Domänen-Typ-Struktur ermöglicht somit, Fortschrittmuster zwischen Regionen zu vergleichen, ohne dass alle Demoprojekte dieselben Indikatoren verwenden müssen.

3.4 Narrative Interpretation für komplexe und verzögerte Effekte

Ein weiteres Element, das zur Vervollständigung der Evidenzbasis benötigt wird, ist die narrative Interpretation. Manche Indikatoren lassen sich sinnvoll anhand von Zielen, Ausgangswerten oder Referenzwerten bewerten, Andere nicht. In vielen Fällen mag die Richtung der Veränderung klar sein, doch die genaue Schwelle für den Erfolg kann umstritten oder ungenau sein. Dies gilt besonders für Rahmenbedingungen wie institutionelle Koordination, Governance-Kapazitäten, das Vertrauen der Stakeholder, Routinen zum Datenaustausch und die Einführung neuer Entscheidungshilfetools.

Die narrative Interpretation sollte daher nicht als schwächerer Ersatz für eine quantitative Bewertung betrachtet werden. Sie ist notwendig, wenn Kausalzusammenhänge komplex sind, Effekte verzögert eintreten und Systemgrenzen schwer zu definieren sind. Eine narrative Darstellung kann erklären, warum sich ein Indikator verändert hat, welche Kontextfaktoren das Ergebnis geprägt haben, welche Akteure beteiligt waren und welche Annahmen die beobachteten Ergebnisse mit den erwarteten längerfristigen Outcomes verbinden. Sie kann auch Hindernisse, Zielkonflikte und unbeabsichtigte Effekte aufzeigen, die sich nur schwer in einer einzigen Punktzahl erfassen lassen.

Im Rahmen von MountResilience ist die narrative Interpretation besonders nützlich, da die Demoregionen unterschiedliche Maßnahmen umsetzen. Einige Aktivitäten konzentrieren sich auf direkte ökologische oder biophysikalische Veränderungen, wie Wiesenrenaturierung oder grüne Infrastruktur. Andere konzentrieren sich auf die Schaffung von Kapazitäten, wie Beratungsdienste, Datenplattformen, Governance-

Instrumente und kommunale Anpassungsplanung. Ein rein quantitativer Vergleich würde diese als gleichwertige Ergebnisse behandeln und damit ihre unterschiedlichen Rollen im Anpassungsprozess verschleiern. Eine rein qualitative Beschreibung würde jedoch das regionsübergreifende Lernen erschweren. Der sich abzeichnende Bewertungsansatz erfordert daher sowohl gemeinsame Kategorien zur Strukturierung von Vergleichen als auch Erzählungen, um den kontextuellen Sinn zu bewahren.

Zusammengenommen verdeutlichen die sechs regionalen Fallstudien, die gemeinsam erarbeiteten DCPs, die repräsentativen Haushaltsbefragungen und die Verwendung narrativer Interpretationen das pragmatische Verständnis der Anpassungsbewertung. Das Ziel ist nicht, einen einzigen, universellen Satz an Indikatoren vorzuschreiben oder Vergleiche gänzlich aufzugeben. Vielmehr geht es darum, eine gemeinsame Evidenzbasis zu schaffen, in der die verschiedenen Arten von Anpassungsfortschritten sichtbar gemacht, diskutiert und interpretiert werden können. Deshalb ist MountResilience ein nützlicher, praxisorientierter Bezugspunkt für transdisziplinäre, bereichsübergreifende Wirkungsanalysen. Es zeigt, dass die größte Herausforderung nicht nur in der technischen Messung liegt, sondern auch in der Steuerung der Evidenz selbst: zu bestimmen, was Fortschritt ausmacht, wer ihn definiert, wie er überwacht werden kann und inwieweit Vergleiche verantwortungsvoll durchgeführt werden können.

4 Gestaltungsprinzipien für transformative Anpassungsbewertung

Wie im vorigen Abschnitt gezeigt, kann sich die transformative Anpassungsbewertung in MountResilience aufgrund der sehr unterschiedlichen Beschaffenheit der sechs Demoregionen nicht auf einen einzigen, einheitlichen Satz an Indikatoren stützen. Das bedeutet nicht, dass ein Vergleich unmöglich ist, sondern vielmehr, dass er sorgfältig konzipiert werden muss. Das Ziel ist nicht, Regionen nach einem einzigen Maßstab für „Erfolg“ zu ordnen, sondern einen gemeinsamen Rahmen zu schaffen, durch den verschiedene Arten von Anpassungsfortschritten visualisiert und diskutiert werden können. Vier Gestaltungsprinzipien haben sich in der laufenden methodischen Arbeit als besonders relevant herausgestellt und werden im Folgenden beschrieben. Zusammengefasst helfen diese Prinzipien dabei, das zu operationalisieren, was wir als „verantwortungsvollen Vergleich“ bezeichnen: eine Form der Bewertung, die regionsübergreifendes Lernen unterstützt, ohne die Anpassung auf die am einfachsten messbaren Aspekte zu reduzieren.

4.1 Prinzip I: Kategorien statt Regionen vergleichen

Das erste Prinzip besteht darin, Kategorien von Fortschritten zu vergleichen und nicht ganze Regionen oder Maßnahmen. Ein Wiesenrenaturierungsprozess in Râu Sadului, eine digitale Wasserplattform im Wallis, ein Entscheidungshilfetooll für die Bewässerung in Piemont und Beratungsdienste für KMU in Tirol lassen sich nicht als gleichwertige Maßnahmen vergleichen. Ihre Ziele, Mechanismen und erwarteten Ergebnisse unterscheiden sich zu stark. Ein direkter Vergleich würde die Gefahr irreführender Schlussfolgerungen bergen, insbesondere wenn er Maßnahmen mit kürzeren Kausalketten oder leichter messbaren Ergebnissen als von Natur aus erfolgreicher einstufen würde.

Diese Maßnahmen lassen sich jedoch auf einer etwas abstrakteren Ebene vergleichen. Sie können alle im Hinblick auf die Art des Anpassungsfortschritts, den sie bewirken sollen, untersucht werden. Dies wurde in Abschnitt 3.3 erörtert.

Dieser Ansatz vermeidet die trügerische Präzision einer Rangliste unterschiedlicher Maßnahmen. Er vermeidet auch das gegenteilige Problem, jeden Fall als völlig einzigartig und damit unvergleichbar zu behandeln. Gemeinsame Kategorien löschen lokale Besonderheiten nicht aus, sondern ermöglichen regionsübergreifendes Lernen, indem sie Gemeinsamkeiten in der Logik des Wandels aufzeigen. Gleichzeitig erkennen sie an, dass die konkreten Indikatoren, Ziele und Datenquellen kontextsensitiv bleiben müssen. Ein verantwortungsvoller Vergleich sollte daher Fragen stellen wie:

- Welche Art von Fortschritt wird angestrebt?
- Schafft die Maßnahme in erster Linie günstige Rahmenbedingungen, führt sie Aktivitäten durch oder erzielt sie beobachtbare Ergebnisse?
- Welcher Bereich der Anpassung ist am unmittelbarsten betroffen?
- Welche Annahmen verbinden aktuelle Ergebnisse mit zukünftigen Ergebnissen?
- Welche Veränderungen sind bereits messbar, und welche erfordern eine längerfristige Beobachtung?

4.2 Prinzip II: Quantifizierung selektiv einsetzen

Die Quantifizierung kausaler Zusammenhänge zwischen Maßnahmen, ihrer Umsetzung und ihren Auswirkungen sollte wann immer möglich erfolgen, jedoch nur dort, wo sie eine stichhaltige Aussage stützen kann. Eine Quantifizierung

ist am besten geeignet, wenn klare Ziele definiert sind oder durch den Prozess der gemeinsamen Gestaltung festgelegt werden können; wenn Datenerhebung und -monitoring zuverlässig und vertrauenswürdig sind; wenn die Richtung der gewünschten Veränderung bekannt ist; wenn ein plausibler Kausalzusammenhang zwischen der Maßnahme und dem Gemessenen behauptet werden kann; und wenn ein aussagekräftiger Bezugspunkt oder eine Basiswert zur Verfügung steht, um die Messung nach Durchführung der Maßnahme abzugleichen.

Quantifizierung wird problematisch, wenn Schwellenwerte willkürlich sind, die Zuordnung schwach ist, Kausalketten zu lang oder zu komplex sind, um Kausalbehauptungen zu stützen, Veränderungen qualitativer Natur sind und durch quantitative Messungen falsch dargestellt werden oder die Datenqualität regional stark variiert. Dies gilt insbesondere für Aspekte wie die kulturelle Bedeutung einer Maßnahme, institutionelle Verankerung, Governance-Kulturen, politische Prozesse, Vertrauen, Legitimität oder Konfliktmediation. Umfragen können helfen, einige dieser Aspekte zu quantifizieren, müssen aber dennoch durch fundierte qualitative Belege ergänzt werden.

Gleichzeitig eignen sich Umfrageergebnisse nicht unbedingt zur Wirkungsmessung, da es zu einer Diskrepanz zwischen dem Umfang der Intervention und dem Umfang der Messung kommen kann. Die MountResilience-Fälle sind zum Beispiel kleine Anpassungs-Pilotprojekte, von denen einige möglicherweise erst gegen Ende der Projektlaufzeit voll funktionsfähig werden. Im Gegensatz dazu messen die Umfragen Wahrnehmungen auf regionaler Ebene. Es ist daher unwahrscheinlich, dass allein durch die Umfragen ein klarer „Effekt“ direkt beobachtbar oder zuordenbar ist.

Dies spiegelt das übergeordnete Prinzip der sorgfältigen Quantifizierung wider. Indikatoren sollten nur dann quantifiziert und gegebenenfalls aggregiert werden, wenn die daraus resultierenden Zahlen aussagekräftig bleiben. Ist dies nicht der Fall, sollten Indikatoren zwar weiterhin dokumentiert, aber durch strukturierte Beschreibungen interpretiert werden, anstatt sie in eine numerische Bewertung zu pressen. Das Ziel ist nicht, Quantifizierung zu vermeiden, sondern sie nur dort einzusetzen, wo sie das Bekannte verdeutlicht, anstatt es überzubewerten.

4.3 Prinzip III: Langfristige Monitoringmöglichkeiten erschaffen

Das dritte Prinzip lautet, das Monitoring auf langfristiges Lernen auszurichten und nicht nur auf die Projektberichterstattung. Dies ist besonders wichtig für Klimawandelanpassung, da viele relevante Ergebnisse nur langsam sichtbar werden. Das Monitoring sollte daher auf Datenströmen und Zuständigkeiten aufbauen, die plausibel über den Projektzeitraum hinaus fortgeführt

werden können. Dies erfordert einen pragmatischen Ansatz. Vorhandene institutionelle Daten sollten wo immer möglich genutzt werden. Neue Datenerhebungen sollten nur dann eingeführt werden, wenn sie einen klaren Mehrwert bieten und wenn die zuständigen Akteure die Kapazitäten haben, sie aufrechtzuerhalten. Indikatoren sollten für diejenigen verständlich sein, die sie erheben und nutzen sollen. Die Datenhoheit, die Häufigkeit der Erhebung und die Zuständigkeiten für die Interpretation sollten frühzeitig geklärt werden.

Das bedeutet nicht, die Ambitionen zu senken. Vielmehr geht es darum, die Ambitionen mit der Nachhaltigkeit in Einklang zu bringen. Ein ausgefeilter Indikator, der nach einem Berichtszyklus verschwindet, trägt kaum zum langfristigen Lernen im Bereich der Anpassung bei. Ein einfacher Indikator, der in eine bestehende Verwaltungs-, Technik- oder Monitoringroutine eingebettet ist, kann nützlicher sein. In diesem Sinne ist die Monitoringkapazität selbst Teil der Anpassungsfähigkeit. Regionen, die relevante Erkenntnisse beobachten, interpretieren und darauf reagieren können, sind besser in der Lage, ihre Strategien im Laufe der Zeit anzupassen und rechtzeitig auf sich entwickelnde Klimarisiken und -anfälligkeiten zu reagieren – sowohl wenn diese Bedrohungen akut sind (z. B. eine Sturzflut) als auch wenn sie chronischer Natur sind (z. B. abnehmende Schneedecke oder Anstieg der Durchschnittstemperaturen).

Die Unterscheidung zwischen den in Abschnitt 3.3 vorgestellten Bereichen und Arten von Indikatoren ist unerlässlich, da sie voreilige Schlussfolgerungen verhindert. Eine Region kann erhebliche Fortschritte beim Aufbau von Strukturen und Prozessen erzielen, auch wenn die endgültigen Ergebnisse noch nicht sichtbar sind. Eine andere Region mag messbare Ergebnisse vorweisen, verfügt aber nicht über die institutionellen Routinen, die zu deren Aufrechterhaltung erforderlich sind. Eine verantwortungsvolle Bewertung sollte diese Unterschiede deutlich machen, anstatt sie hinter einem einzigen Gesamturteil zu verbergen.

Die beiden repräsentativen Haushaltsbefragungen tragen zu dieser zeitlichen Logik bei. Die erste Erhebungswelle liefert eine Ausgangsbasis für die Wahrnehmung, Prioritäten und Akzeptanz der Bürger:innen, bevor die Haupteffekte der regionalen Demoaktivitäten vernünftigerweise erwartet werden können. Die zweite Erhebungswelle kann später dabei helfen zu beurteilen, ob sich diese Dimensionen während der Projektlaufzeit verschieben. Das löst zwar nicht das Problem der langfristigen Zuordnung, schafft aber eine strukturierte Grundlage für die Interpretation. So können Veränderungen in der öffentlichen Einstellung neben institutionellen und technischen Belegen berücksichtigt werden, was die soziale Legitimität der Anpassungsbewertung stärkt.

4.4 Prinzip IV: Co-Creation als Kapazitätsaufbau und Verhandlung der Theorie des Wandels

Das vierte Prinzip betont, dass es bei der Co-Creation nicht nur darum geht, Interessengruppen zu konsultieren, sondern auch darum, Kapazitäten aufzubauen und die Theorie des Wandels auszuhandeln. In Anpassungsprojekten wird Co-Creation oft als unerlässlich angesehen, um betroffene Akteure einzubeziehen, lokales Wissen anzuerkennen und zu vermeiden, dass Lösungen von außen aufgezwungen werden. Das ist zwar nach wie vor wichtig, doch spielt Co-Creation auch eine spezifische methodische Rolle bei der Wirkungsbewertung. Sie hilft zu klären, was Anpassungsfortschritt in der Praxis bedeutet, welche Veränderungen von Bedeutung sind, welche Belege diese zuverlässig abbilden können und wer dafür verantwortlich ist, diese Belege im Laufe der Zeit zu sammeln und zu nutzen.

Dies ist besonders wichtig bei transdisziplinären Projekten, bei denen die Partner unterschiedliche implizite Theorien des Wandels und Formen von Fachwissen vertreten. Technische Expert:innen konzentrieren sich vielleicht auf Instrumente und Infrastruktur, lokale Behörden auf Mandate und politische Machbarkeit, Forscher:innen auf theoretische Fundiertheit und die Zivilgesellschaft auf Legitimität und gelebte Erfahrung. Diese Perspektiven sind nicht nur unterschiedliche Sichtweisen auf dieselbe Maßnahme, sondern spiegeln unterschiedliche Annahmen darüber wider, wie Anpassung stattfindet und wie Erfolg aussieht. Es hilft daher, disziplinäre und institutionelle Silos aufzubrechen, da die Partner eine gemeinsame Sprache zur Beschreibung des Fortschritts aushandeln müssen, während sie ihre jeweiligen Kontexte respektieren. Wenn regionale Partner Indikatoren, Datenquellen, Ziele und Verantwortlichkeiten definieren, verdeutlichen sie den Weg, über den eine Maßnahme die Anpassung vorantreiben soll. Die gemeinsame Entwicklung von Datenerfassungsplänen ist ein praktischer Weg, um zu prüfen, ob der angenommene Zusammenhang zwischen Aktivitäten, Akzeptanz und längerfristiger Anpassung besteht und von den verschiedenen Akteuren, die vor Ort zusammenarbeiten, geteilt wird. Tatsächlich könnte dieser Prozess auch Lücken aufdecken. Es könnte sich herausstellen, dass für einige gewünschte Ergebnisse keine realistischen Datenquellen vorhanden sind, dass bestimmte Indikatoren für Forscher:innen wichtig sind, für Praktiker:innen jedoch nicht, oder dass sich die Partner nicht darüber einig sind, wie eine Aktivität und ihre Funktion als Output, „Ermöglicher“ (Enabler) oder Outcome einzustufen ist. Solche Meinungsverschiedenheiten sind nicht nur Hindernisse; sie liefern wertvolle Erkenntnisse, indem sie Schwachstellen oder Unstimmigkeiten in der Change-Theorie aufdecken. Sie zeigen auch auf, wo die Monitoringkapazitäten begrenzt sind, Zuständigkeiten unklar sind oder die institutionelle Unterstützung nicht ausreicht, um die Anpassung nach Projektende aufrechtzuerhalten.

Auf diese Weise unterstützt die gemeinsame Gestaltung direkt den Kapazitätsaufbau. Dies geschieht nicht nur durch die Einbeziehung der Stakeholder in den Dialog, sondern auch durch die Klärung der Verantwortlichkeiten für die Evidenz. Die Partner bewerten, was sie bereits überwachen, was sie realistisch aufrechterhalten können, welche Datenströme zuverlässig sind und welche Evidenz tatsächlich in die Entscheidungsfindung einfließen würde. Dadurch wird die Bewertung von einer externen Berichterstattungs Aufgabe zu einem gemeinsamen Lernprozess.

Es ist jedoch auch wichtig, Co-Creation nicht zu idealisieren. Sie ist in der Regel zeit- und ressourcenintensiv, komplex und manchmal frustrierend. Sie kann bestehende Machtungleichgewichte reproduzieren, wenn sich manche Akteure stärker einbringen als andere. Diese Herausforderungen sind der Grund, warum Co-Creation als strukturierte Bewertungsaufgabe und nicht als vages partizipatives Ideal angegangen werden muss. Ihr Wert liegt darin, Meinungsverschiedenheiten, Unsicherheiten und praktische Einschränkungen sichtbar zu machen, damit sie angegangen werden können, bevor es zu spät ist.

Für einen verantwortungsvollen Vergleich zwischen Regionen hat dies eine entscheidende Bedeutung: Gemeinsame Bewertungskategorien werden nur dann relevant, wenn sie in lokal aussagekräftige Protokolle übersetzt werden. Co-Creation ist der Prozess, der diese Übersetzung ermöglicht. Er sorgt dafür, dass gemeinsame Bereiche und Fortschrittsarten vergleichbar bleiben, während Indikatoren, Datenquellen und Narrative in der lokalen Realität verankert sind. Dadurch wird die Wirkungsbewertung zu einem Raum des gegenseitigen Lernens: Die Partner berichten nicht nur über Anpassungsfortschritte, sondern definieren gemeinsam, wie valide Evidenz aussieht.

5 Fazit

In diesem Beitrag wurde dargelegt, dass eine transformative Anpassung in Bergregionen Bewertungsansätze erfordert, die vergleichbar sind, ohne reduktiv zu wirken. Die Herausforderung besteht nicht darin, die bestehende Literatur zur Bewertung Komplexität, Partizipation oder bereichsübergreifende Effekte zu ignorieren. Vielmehr geht es darum, diese Erkenntnisse in der Praxis umzusetzen, insbesondere in heterogenen Anpassungsprojekten, bei denen sich die Regionen hinsichtlich Klimarisiken, institutioneller Kapazitäten, Datenverfügbarkeit und Interventionsarten unterscheiden.

Aufbauend auf der methodischen Entwicklung des MountResilience Impact Assessment Framework, wird in diesem Beitrag der Begriff des verantwortungsvollen

Vergleichs vorgeschlagen. Ein verantwortungsvoller Vergleich zielt nicht darauf ab, ganze Regionen zu bewerten oder Anpassung auf einen einzigen Erfolgsmaßstab zu reduzieren. Stattdessen strukturiert er die Evidenz anhand gemeinsamer Fortschrittskategorien, während Indikatoren, Datenquellen und Narrative lokal relevant bleiben. Dieser Ansatz hat praktische Auswirkungen auf die Anpassungssteuerung im öffentlichen Sektor. Die Entscheidung, was überwacht werden soll, ist kein neutraler technischer Schritt; sie bestimmt, was als Fortschritt gilt, wessen Prioritäten vertreten werden und welche Formen der Anpassungsarbeit sichtbar werden. Gemeinsam erarbeitete Datenerhebungspläne, repräsentative Haushaltsbefragungen und strukturierte narrative Interpretationen können daher quantitative Indikatoren ergänzen, indem sie technische Erkenntnisse, öffentliche Legitimität und kontextuelle Erklärungen miteinander verknüpfen.

Allerdings muss man die derzeitigen Grenzen dieses Ansatzes berücksichtigen. MountResilience ist ein laufendes Projekt, und das hier vorgestellte Rahmenwerk wird eher als praxisorientierter methodischer Beitrag, denn als abschließende Wirkungsbewertung präsentiert. Zukünftige Arbeiten sollten prüfen, wie sich die vorgeschlagene Architektur bewährt, sobald Umsetzungsdaten vorliegen, und ob das Gleichgewicht zwischen gemeinsamen Kategorien, lokaler Spezifität, Quantifizierung und narrativer Interpretation stabil bleibt. Dennoch deuten die ersten Erfahrungen darauf hin, dass Wirkungsanalysen selbst Teil einer transformativen Anpassung werden können, wenn sie den Akteuren helfen, Annahmen zu klären, Monitoringkapazitäten aufzubauen und gemeinsame Erkenntnisse für langfristige Klimaresilienz auszuhandeln.

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Power Relations in Groundwater Extraction Conflicts in Germany – Insights from the Lueneburg Heath

Rebecca Hauschild

This paper analyses the interests and power relations that manifest in groundwater conflicts in formerly water-rich regions from a political ecology perspective. Utilising a historical-materialist policy analysis and qualitative expert interviews, this study systematically examines the explicit and implicit interests and micro-struggles in the case of the Lueneburg Heath, Germany. The findings indicate that the conflict is predominantly characterised by a dynamic interplay between nature, public water supply, and economy. Yet, the conflict encompasses various micro-struggles on data collection, democratisation of decision-making processes as well as the regulation of water demands, too. Thereby, this paper sheds a light on the capitalist ruling system that shaped the water management in Germany.

1 Introduction

The redistribution of water from urban and rural areas is a long-standing global practice. Unlike other materials that can easily circulate in a globalised economy, water is distinctive, as it is volatile, finite and vital (Savenije 2002). Groundwater, often of superior quality yet historically invisible in public debate, is gaining prominence as climate change intensifies droughts and heightens cross-sectoral demand. This tendency is becoming increasingly evident not only in regions traditionally characterised by water scarcity, but also in countries perceived to be water-rich, such as Germany. Here, a conflict between Hamburg's public water supply utility and local actors of the Lueneburg Heath developed over the past decades. Hamburg started groundwater abstraction from Northern areas of the Lueneburg Heath (North Heath) in 1982. In 2024, these withdrawals accounted for approximately 12% of the city's tap water consumption. Hamburg's public water supplier seeks to increase its permanent abstraction permit to secure urban supply. Local actors (environmental groups, landowners, public bodies) oppose higher - and in some cases current - abstraction levels, referring to groundwater levels, ecosystems, agriculture and local supply security being at risk. The conflict is mainly carried out in administrative and legal disputes.

A substantial corpus of social science literature addresses (social-ecological) water conflicts associated with risks in quantity and quality. Several case studies focus on infrastructure projects (Gottgens, et al. 2001; Molle 2007; Sneddon 2012), water pollution (Bebbington/Williams 2008; Meijaard et al. 2020; Omofonmwan/Odia 2009; Özkaynak et al. 2012; Pastén-Zapata et al. 2014) or conflicts over corporate extractions (e.g. for bottled water) (Gauriat 2023; Jaffee/Newman 2013; Rosemann 2015). While these contributions usually focus on traditionally arid and semi-arid regions, little attention has been paid to conflicts in water abundant regions. Despite growing relevance due to shifting climatic and socio-economic conditions, research on groundwater conflicts over public water supply in water-rich regions is largely absent. As ecological conflicts can be conceptualised as social phenomena that are intrinsically linked to material transformations and power relations (Dietz/ Engels 2020; Peluso/Watts 2001), a power-critical examination of emerging conflicts over groundwater is needed. The present case study aims to address this gap by analysing a water conflict over water abstractions for public supply purposes in conditions that appear to be characterised by abundant water resources.

Building on a “modern” understanding of groundwater as a resource (Linton 2010), it is highly regulated, yet contested. This paper analyses the ecological distribution conflict in the Lueneburg Heath and the underlying societal nature relations. As an ecological distribution conflict, the struggle for groundwater is assumed a social phenomenon with close ties to material transformations and power relations (Dietz/Engels 2020; Peluso/Watts 2001). Water harbours a special significance within society’s metabolism. Due to its special characteristics of finiteness, vitality and fugacity (Savenije 2002), it can be considered one of society’s most essential substances. Its embeddedness in societal nature relations demands a thorough look at the political, economic, and social power structures producing it. Therefore, it needs to be asked what actors control, act and hold power to assert their interests within contested policy formulations (Karpouzoglou et al. 2023; Winterfeld 2022).

This paper aims to address this gap with the following research question: Which interests manifest in the groundwater conflict in the Lueneburg Heath? It is guided by three sub-questions: (1) Which actor groups are involved? (2) What interests and strategies do they pursue? (3) How do power relations shape proposed solutions?

Theoretically, the study draws on political ecology concepts to holistically examine how water and social relations co-constitute each other and employs a historical materialist policy analysis to situate the conflict within state-mediated power struggles. This paper contributes to current research by uncovering explicit and implicit interests and narratives, and in analysing how power and rule are reproduced through groundwater governance in a “water-rich” context under climate stress. The following sections will briefly introduce the political ecology concepts (2), describe the methodology (3), the historical background of the case (4) and present results of the context (5.1) and actor analysis (5.2). The results are discussed (6) and conclusions drawn in the final section (7).

2 The Political Ecology of Water

According to political ecology literature, water conflicts can be understood as ecological distribution conflicts (Martinez-Alier/O’Connor 1996) that negotiate the distribution of material nature, environmental costs and benefits as well as epistemologies and ontologies on nature (Dietz/Engels 2014; Escobar 2006; Peluso/Watts 2001). Consequently, conflicts are subject to questions of power and affect society’s relations with nature (Brand/Görg 2022). The concept of societal nature relations refers to the concept of social metabolism (Marx 1890). Societal nature relations understand society and nature as

two separated units of a dynamic relation (Jahn/Wehling 1998) that affect each other. Nature affects society as it constitutes the foundation for any societal activity (ibid.); it provides and represents the material basis of societies, for example through biomass and minerals. Vice versa, nature is affected by human activities and societal developments (ibid.). Societal nature relations extend the concept of social metabolisms by analysing the underlying mechanisms and structures that regulate these metabolic societal processes. These societal nature relations manifest along three dimensions, each of them being related to questions of power and rule (Brand/Görg 2022). The material-substantial dimension addresses the supply of human societies, which is accompanied by fundamental modifications of nature. Here, natural relations refer to the biophysical conditions of society (e.g. the installation of water pipelines to provide a city with water). The cultural-symbolic dimension refers to different understandings and epistemologies that are constructed around nature, reaching from romantic to instrumental-exploitative ideas of nature (e.g. water as an economic resource vs. water as a human right). Finally, the regulative dimension (Görg 2003) addresses the changeability of natural conditions over time and space (e.g. the designation of water protection areas).

The relationship between society and water can be further conceptualised as a hydrosocial cycle, which challenges the traditional dichotomy between water and society (Linton/Budds 2014; Swyngedouw 1997; 1999; 2004; 2007). Instead, water and social relations represent hybrids (Latour 1994) that mutually reconstitute each other as inherent parts of a closely intertwined cycle that constantly recreates itself. These co-constituted hydrosocial relations reflect social (power) relations and influence them in material, epistemological, ontological, cultural, political and social ways. Therefore, “[w]ater is what we make of it” (Linton 2010: 3). Consequently, this study aims to address the societal nature relations behind highly contested groundwater policies in supposedly water rich Lueneburg Heath.

The power relations at stake manifest in disadvantages for certain social groups and unequal appropriation of water. Thereby, power as well as active and passive hegemonies reflect larger ruling structures (Weber, 1976 [1921]) that are historically embedded. Furthermore, the prevailing understanding of water has a significant influence on how conflicts about water are understood and discussed. Given numerous existing epistemologies and ontologies of water, analyses must always reveal what understandings of water are at work, since it is the only way to visualise the “relationality of societal natural relations” (Schmitt 2022: 295, own translation). As ecological distributions conflicts involve more than control and access, they usually involve various micro-struggles - the subtle differences in which actors may differ (Brand et al. 2021). Such struggles can range from epistemological over cultural to political

framings of nature and beyond. Consequently, the present study seeks to analyse the explicit and implicit (micro) power struggles inherent in the groundwater conflict in the Lüneburg Heath, and to explore how these struggles are reflected in the formulation of proposed solutions.

3 Methodology

This study uses a case study design, combining a historical-materialist policy analysis (HMPA), qualitative expert interviews and document analysis to examine power relations. The HMPA (Brand 2013; Brand et al. 2021; Buckel et al. 2014), is an approach to analyse state policies and their interactions with hegemonial power relations. As a methodological framework it assumes that policies crystallise amid competing social forces, interests, power resources and hegemonic projects within a relational, contradictory state. As a materialistic approach, HMPA focuses on societal-material structures and interests (e.g. around water) that are embedded in various contradictory and conflictual social relations such as class, nature, and the North-South divide. Such social relations are historically grown and affect the implementation of policies. The study focuses on policy formulation processes and their contribution to the reproduction of existing social structures, as well as their effects on broader societal contradictions and crisis tendencies (Brand et al. 2021). The approach goes along with three major societal considerations (ibid.). Contextualities, such as political, socio-economic and cultural conditions shape the environment, in which policies arise (1). Capitalist conditions are considered conflictual, internally contradictory and crisis-prone. As policies emerge within capitalist systems, they shift a crisis to another policy area and function as symptomatic treatment (2). Finally, it draws from relational state theory (Jessop 1990; Poulantzas 2002[1978]), considering the state as a strategic, asymmetric field, where political actors and social forces contest and advance interests through policy formation, implementation, and obstruction. As a heterogeneous, contradictory entity, the state materialises and reproduces social power relations and inequalities. These societal struggles are most visibly articulated in and through policy processes (3).

Although Buckel et al. (2014) have proposed a division of the HMPA into three analyses, this study conducts a context and actor analysis and abstains from a process analysis, as the legal processes were ongoing during the data collection. Utilising grey literature, the study maps discursive and legal shifts in water and environmental governance. The actor analysis identifies key actors, their positions, motivations and interests, the alliances they form, their strategies, the power resources they mobilise and micro-struggles. Six qualitative expert interviews (Meuser/Nagel 2020) were conducted in

January and February 2024, with actors from the public water supply (Interview (I) 3), environmental NGOs (I1, I4), administrations (I5, I6), and independent experts (I2). The guideline-based, open interviews (ibid.) were tailored to respondents' roles, conducted in German via Zoom and lasted 45 to 60 minutes. Transcripts were generated using Microsoft Word's transcription tool and manually verified. An interpretative interview analysis (ibid.; 1991) was employed to surface explicit and implicit, institutionally situated knowledge. The procedure comprised paraphrasing, combined deductive–inductive coding, thematic comparison, conceptualisation and theoretical generalisation, supported by MAXQDA 22.0.

4 Case Study

Hamburg's historic transition from Elbe surface water to groundwater in the late 20th century externalised abstractions to the North Heath as urban demand grew and river water quality deteriorated (WorldTimes-Online, n.d.). In 1974, an initial authorisation by Lower Saxony authorities of up to 25 million m³ of water per year for abstractions by Hamburg prompted ecological research and local civic mobilisation (Adam 1989; HW 2013). Hamburg started its actual withdrawals in 1982 with voluntary self-restrictions of 15 million m³ (HW 2023c). After interim special permits from 2004 (15.7 million m³), Hamburg's utility applied in 2015 for 18.4 million m³ annually, including a 2.3 million m³ dry-weather buffer not intended for regular use; the core volume was 16.1 million m³ (HW 2015; Senat Hamburg 2016). In 2019, the Administrative District of Harburg, who is responsible for the water right procedure, granted a revocable superior permit for the demanded amounts (BUND Elbe-Heath, n.d.). This resulted in legal proceedings initiated by Hamburg to secure a higher and more secure entitlement as well as counterclaims by local actors citing ecological risks and participation deficits (HW 2023b). The Administrative Court of Lüneburg dismissed all suits in 2021, upholding existing protections without increasing allocations, after which Hamburg appealed (ibid., Administrative Court Lüneburg 2021). As of 2023, roughly 12 per cent of Hamburg's water derives from the North Heath via 38 wells, many in or near FFH sites, with further activations proposed and dense monitoring in place (HW 2023c).

5 Results

5.1 Context Analysis

The context analysis shows that the Lüneburg Heath groundwater conflict is embedded within evolving governance frameworks, shifting material conditions

and intensifying competition over a common resource. Since 2000, the EU Water Framework Directive (WFD) and the Flora-Fauna-Habitat (FFH) Directive have reoriented German water policy towards integrated, sustainability-led management and biodiversity protection, a shift consolidated in the Water Management Act (“Wasserhaushaltsgesetz”, WHG), whose 2009 revision articulated for the first time the law’s purpose of safeguarding water bodies as part of the natural balance and as the basis of human life through sustainable water management (WHG §1; UBA/BMU 2017). While the WHG gives the public water supply formal precedence as a service of general interest (WHG §50), federal states retain wide discretion in implementation, generating heterogeneous fee regimes, benefiting certain economic sectors as well as limited earmarking (NWG 2024; Römer 2019; VKU 2022). These discretionary regimes, together with revocable and short term authorisations, create administrative and legal uncertainty and can weaken the WFD’s polluter pays principle (Directive 2000/60/EC, art. 9). Groundwater is considered common property, thus necessitating the acquisition of licences for its utilisation. Despite formal sustainability goals (WHG §§6, 12), the long-term allocation process gives rise to administrative discretion and engenders both legal and planning uncertainties; thus, potentially undermining protection and supply. Material-environmental dynamics have markedly sharpened these tensions. The exceptional droughts and heat of 2018–2020 exposed vulnerabilities in groundwater-dependent ecosystems and public supply, elevated scarcity on the political agenda and catalysed strategic planning, including Germany’s National Water Strategy adopted in 2023 (Hari et al. 2020; Zdrzalek 2023; BMUKN 2023). At the same time, projected population growth is expected to raise Hamburg’s medium-term demand, while short-term drought peaks strain system capacity, prompting water-saving campaigns and calls for a state-level strategy aligned with national objectives (Statistik Nord 2021a; b; Bürgerschaft der Freien und Hansestadt Hamburg 2023). Agriculture’s expanding reliance on irrigation, especially in Lower Saxony, intensifies competition for groundwater even as nitrate contamination leaves many aquifers in poor chemical status, tightening the ecological and regulatory constraints on abstraction (EEA 2017; MU 2014; Directive 2000/60/EC).

In sum, EU-driven frameworks strengthened ecosystem protection of the North Heath and steered Germany towards a more holistic water management. At the same time, years of droughts and growing sectoral pressures have raised scarcity and politicised allocation. Despite the WHG’s formal prioritisation of supply security, reliance on revocable permits, heterogeneous pricing and exemptions that often benefit agriculture or other industries, and persistent quality problems have eroded planning certainty and exposed contradictions between statutory objectives and practice.

5.2 Actor Analysis

This actor analysis maps the positions, interests, strategies, resources and micro-struggles shaping the Lueneburg Heath groundwater conflict, based on qualitative expert interviews and grey literature.

In Hamburg water issues are subject to the Ministry for the Environment, Climate, Energy and Agriculture, that acts both administratively and politically. Given its maritime location and the Elbe River, Hamburg comes with a lot of water. Since the 1970s, the city successfully reduced their total groundwater abstractions, which is attributed to the implementation of abstraction fees and water meters that both incentivises private water savings (I6 2024). Despite comparatively high self-supply, Hamburg relies on the surroundings for external water production (I1; I3 2024). The city is in increasing need of water, as water demands started rising in the early 2010s given population growth and increased per capita demand, the latter being attributed to weaker saving behaviour and the use of water-intensive luxury tools (e.g. wellness showers, private pools) (I6 2024). Prognoses of increasing water demands until 2030 are accompanied by the salinisation of groundwater bodies with renders some of them unusable (ibid.). Another issue is extremely contested ground and surfaces in Hamburg: Given urban space competition, public water authorities face difficulties to enforce their interests against renewable energy (geothermic), mobility or construction projects as well as public spaces such as parks or playgrounds; most of them bearing groundwater risks such as altered water temperature, leaking toxins or soil sealing that reduces groundwater recharge (ibid.). However, the ministerial staff are confronted with intra-institutional conflicts in which arguments regarding supply security and priority of public supply appear to lose their significance; decisions are made on a political level (ibid.). The primary objective to safeguard the water supply (I3 2024), may also be connected to economic interests, as the city collects funds through the surplus of Hamburg’s water utility, its monopoly fee and groundwater abstraction fees (I1 2024). While wastewater charges flow into infrastructure renovation, the money raised by the supply side flows into the city’s budget (I4 2024). According to one interview, annual earnings could be between 70 to 80 million euros (I1 2024). Scepticism towards alternative water sources such as bank filtration might be historically grown, however this option has not yet been discussed realistically. Hamburg’s responsible authority points to the need of mandatory implementation of nature-based infiltration in construction projects (I6 2024). Further pathways could be the continued promotion of storage and utilisation of rainwater (Rain Infra-Structure Adaptation (RISA)), grey water or sponge city concepts. However, the strong resistance demonstrated by investors, who feared economic disadvantages, illustrated the difficulties to enforce sustainable water management practices. Finally, campaigns promoting water savings in private households,

who make the largest share of the public water supply in Hamburg are considered important steps, as minimal reductions in the per capita consumption of households could compensate for additional water needs due to climate change (ibid.).

Hamburg's water utility uses arguments of supply security and legal predictability under the WHG. It seeks a long-term, predictable, and thus more secure entitlement that accommodates seasonal peaks up to 18.4 million m³, with an intended average of roughly 16–17 million m³, justified by sunk infrastructure, proximity and the high raw-water quality of the North Heath. (HW 2013; 2015; 2023b; Senat Hamburg 2016; I3; I6 2024). High raw water quality in protected areas is also addressed by arguments of profitability and cost efficiency as it reduces treatment costs. However, it reinforces lock ins and prevents discussions about alternative sources (I3; I6, 2024): Alternatives such as bank filtration are rejected as they are perceived as too cost-intensive and risky. Instead, they emphasise cooperations with Hamburg's federal authorities on monitoring, demand-side saving campaigns. Additionally, it litigates to upgrade its revocable superior permit (HW 2023b; I3 2024). Furthermore, it presents itself as a representative of the population's needs, refers to water as a common good and cities' structural dependence on surrounding water resources. The latter is legitimised through reciprocal benefits of urban–rural interdependence such as employment and economic growth (HW 2015; I3 2024). The problem is defined as rising demand, especially peak day loads. Proposed solutions include constraints on agricultural abstractions, improved sectoral withdrawal data, and nature based measures to enhance recharge (I3; I6 2024).

Opposing actor groups are environmental protection NGOs. Self-described as advocates for nature, their most prominent goal is to prevent environmental damages, especially in protected and vulnerable ecosystems due to declining surface water that leads to declining groundwater levels. As the NGOs perceive a growing imbalance between rising water demand and declining water recharge, they demand sustainable usage of water. Water management would not adequately consider nature's interests (I1 2024). To achieve their objectives, these actors are suing (ibid.) or take a stand at court and cooperate with US research institutions, with whom they jointly concluded that statements made in court by the Hamburg water supplier had been incorrect (I4 2024). To avoid biodiversity loss, they claim a complete stop of water abstractions, yet, they are open to compromise solutions, as they are aware of Hamburg's essential need for water (I1; I4 2024). Consequently, they propose solutions such as the installation of well sites in places with lower environmental impact or the use of bank filtration. Hamburg's refusal to adopt alternatives is considered proof of their profit maximisation aims. Hence, water supply should be cooperatively organised (I1 2024). Other related

struggles include the use of outdated and non-transparent evaluation methods, structural disadvantages due to unequal resources, lacking institutional capacities (time, personnel) as well as the transition from reactive water management to proactive, integrated water management with long-term strategies in line with precautionary principles (I1; I4 2024). However, the NGOs acknowledge, that water stress is a multicausal phenomenon and cannot be attributed to Hamburg's withdrawals alone. Instead, it is caused by climatic changes which alter water demands, especially by afforestation, agriculture and private households. Therefore, they call for greater restrictions on agricultural irrigation during drought periods (ibid.) and water tariffs being organised according to the polluter-pays principle (I4 2024). Additionally, they demand educational programs for water usage and (national) holistic strategies for climate mitigation (ibid.). Finally, they criticise urban-rural relations and feel disadvantaged and exploited by Hamburg's activities, through e.g. water extractions and infrastructure projects.

The public authority of the North Heath grants water authorisations. It aims to mediate water demands in a densely populated area, with high water demands by local private and industrial consumers, external water suppliers, the agricultural sector and the environment (I1; I4 2024; Zamponi 2021). Thereby, it strives for preserved room for manoeuvre (I3, 2024), preferring flexible, short term authorisations to react to climate and legal changes (Administrative Court Lueneburg 2021). The authority ordered additional evaluations as a reaction to NGOs concerns about poor measurement quality (I4 2024). Beside the lawsuit, the administration imparts between farmers and Hamburg's utility, on the assessment of crop failures and the agreement of compensations (I1 2024).

Lower Saxony's federal state authority for water management and nature conservation has a consulting function in water right proceedings. The authority approved the current permit but is restrained to Hamburg's latest demands. Self-described as an advocate for nature, who has the least chances to pursue its interests, the authority approves water withdrawals if lying within elastic boundaries that enable ecosystems to adopt to new balances (I5 2024). However, their water yield report, published in 2023, came to alarming results (Johannes et al. 2023). The main issue of declining water recharges is caused by agriculture's rising demand, with prospected rising societal peak-demands during summer worsening the issue (I5 2024). Artificial changes in ecosystems, such as the fostering of pine forests, river straightening and ditch systems contribute to rising pressure on water bodies. Their primary interest is the sustainable groundwater management to ensure availability for humans and nature with a special protection of vulnerable ecosystems. Referred to as groundwater as a resource, it calls for ecosystem-centred, adaptive governance: withdrawals should cease in sensitive areas; authorities should deploy

short, flexible, tightly monitored rights with predefined thresholds and immediate sanctions; abstractions during droughts should be refused and shifted to more robust sites; and recharge should be bolstered by ending agricultural drainage and restricting irrigation, all guided by better data and locally tailored measures. Democratisation and transparency are necessary to rebuild public trust, shared responsibility for water-savings, cross-sectoral cooperation, and a realistic recalibration of expectations given persistent pollution (ibid.).

Many forest owners worry about declining groundwater levels (I1 2024). A public forestry actor sued against increased abstractions, as they fear negative impacts for the agricultural, fishery and forestry use on their territory (Administrative Court Lueneburg 2021). Due to reduced infiltration, trees' loss of groundwater connection and secondary damages (e.g. bark beetle) forests are at risk (I1 2024). With forestry being a long-run business, owners rely on predictability and sustainable management (ibid.). Private forestry owners are under represented in the lawsuit and in water management decisions more generally (ibid.). While interests of private forestry are claimed to be insufficiently considered in decision-making processes, public forestry businesses, structurally closer to administrative and decision-making bodies, enforce their interests more easily (ibid.). Claims for compensation payments are difficult to justify, given long time horizons and verification hurdles. A precautionary principle-oriented water management could help avoiding forestry's disadvantages against the fast-moving agricultural sector (ibid.).

The agricultural sector takes an ambivalent role within this conflict. Local farmers accuse Hamburg's water abstractions responsible for dehydration and crop failures and already received first compensation payments from Hamburg's utility, despite complex causalities complicating the calculation of compensation responsibilities. At the same time, former wetlands bring new potentials for commodification through its dehydration (I1 2024). However, agricultural practices contribute to water stress, as their demands for artificial irrigation and thus for groundwater are rising (I2 2024). This is reflected in local agricultural actors who started their own lawsuit to double annual water abstractions (from 6 to 12 million m³) (I1; I4 2024; Marquardt 2022; Zamponi 2021). Furthermore, agriculture massively contributes to groundwater pollution, through increased application of fertilisers that causes nitrate pollution – with externalised costs for the water sector (treatment costs, decommissioning of wells) (I4 2024) and future generations. Thereby, the agricultural sector disadvantages public water suppliers, as treatment costs increase and some wells become inoperable (ibid.). External actors thus demand controls of fertiliser usage (I2 2024), data collection and controls of often obscure water (I1 2024), the use of alternative sources (e.g. flowing waters, rainwater, water reusage)

(I2; I5 2024), as well as the promotion of landscape water storages and smart irrigation technologies (I2 2024). The implementation of changes to unsustainable water management practices, including those associated with drainage systems and ditch structures, is recommended (I2 – I5 2024). Additionally, fields should be irrigated during the cooler parts of the day cooler periods of the day to minimise evaporation (ibid.). However, the sector had an important cultural and economic role and strong political influence through various agricultural associations (I1; I2 2024) with traditionally close ties to the German Christian Democratic Party (CDU/ CSU) (I1 2024; Tosun 2017). As the CDU/ CSU is frequently part of governing coalitions and holds agricultural ministerial posts (Pappi et al. 2008), the agricultural sector has a strong political influence and the ability to advance its interests (I2; I4 2024).

The industrial sector is a major extractor nationally but is less central in this conflict. In Hamburg, the amount of water provided by the utility for industrial purposes is rather small with 4.6 million m³ (114.7 million m³ for private households and small business enterprises) (HW 2023a). Likewise, the share of self-extracted water by companies themselves is small and controlled by Hamburg's administrations (ibid.). Similar patterns occur in the district of Harburg. Many companies switched to closed water cycles and surface water for cooling processes to reduce their overall water consumption and hence their costs (I2 2024). However, aggregated data and data gaps obscure actual withdrawals (ibid.). Claims for higher water restrictions in industry are often countered with its role in securing prosperity (I3 2024).

6 Discussion

The Luneburg Heath conflict exemplifies how water quality and governance shape contested hydrosocial relations. Findings indicate an omnipresent valorisation and commodification of groundwater, based on a "modern" understanding of water as a manageable resource for societal metabolism, detached from nature, hierarchised (along water quality) and geared to suppressing and controlling nature (Linton 2010). Even actors oriented towards nature conservation tend to invoke nature's needs instrumentally. This hegemonial understanding was imprinted by prolonged governmentality processes (Foucault 2007 [1982]). Since the 1970s, regulation has tightened under the WFD, FFH and WHG. However, implementation remains fragmented. Short term and revocable licences are intended to promote caution but also create legal ambiguity. The implementation of abstraction fees, metering, and EU-driven norms lowered demand and constrained exploitation. Nevertheless, persistent gaps in monitoring and heterogeneous pricing weaken the polluter-pays principle.

Beneath allocation debates lie micro-struggles over power, recognition and environmental justice. Public supply security, ecological protection and economic uses collide with unequal capacities to participate in decision making processes. NGOs, private forestries and individuals encounter informational and financial asymmetries in legal proceedings that advantage large businesses and agricultural alliances; rural communities perceive themselves to be exploited in urban-rural exchanges; and nature remains a largely powerless stakeholder despite formal designations. Historically, public supply held a privileged claim under the WHG. However, Hamburg's water utility lost room for manoeuvre as ecological constraints and legal standards stiffened in recent years. In contrast, the agricultural sector and select industrial domains have been beneficiaries of comparatively reduced abstraction fees, less stringent regulatory oversight and consolidated reporting mechanisms. This is occurring despite the escalating demand for irrigation in the agricultural sector and the resulting constraints on available resources due to nitrate pollution. The long ecological time horizons and evidentiary burdens inherent to forestry impede the process of compensation, thus heightening its vulnerability. Overall, the data asymmetry translates into unequal accountability. The result is a distributive and procedural justice problem (Fraser 2008): the costs of scarcity and pollution (e.g. treatment, lost ecosystem functions) are externalised spatially and temporally, while sectors enjoying lighter charges or oversight benefit.

Material pressures caused by droughts occurred since 2018 have exposed the fragility of ecosystems and the limits to their capacity. Social expectations further entrench pressure by perpetuating the hegemonic norm of ubiquitous, low-priced drinking water for all uses. This sustains high per capita consumption and favours technological fixes over absolute reductions. Classed consumption patterns (e.g., private pools, opulent gardens) inflate peak demand and complicate the design of equitable tariffs. Price rises carry the potential for regressive effects, unless they are coupled with targeted protections and curbs on discretionary uses. Furthermore, urban-rural metabolism flows blur boundaries: Hamburg depends on external sources while offering employment and investment opportunities. Yet, the mutual benefit is perceived unevenly, feeding NIMBY contestation and claims of metropolitan overreach.

These patterns align with political-ecology critiques of capitalist societal nature relations, as water is commodified, governed for efficiency and growth, and enrolled in technocratic control. Solutions, including advanced treatment, closed industrial cycles and monitoring upgrades, have been proposed to mitigate symptoms, yet risk entrenching energy- and capital-intensive pathways without reducing overall flows. Conversely, calls for adaptive, ecosystem-centred

governance - short, tightly monitored rights; predefined ecological thresholds; shifting abstractions away from sensitive zones; and recharge-enhancing land use change - aim to realign use with ecological limits. Implementing polluter pays, constraining irrigation during droughts, improving fertiliser controls and closing data gaps would re weight incentives toward conservation.

A just transition requires the consideration of demand and supply. Diversifying sources (e.g., bank filtration, rainwater use, greywater, sponge city measures) is technically feasible but politically sensitive due to cost and risk perceptions. Demand-side measures, such as seasonal tariffs with social safeguards, restrictions on non-essential uses during droughts, and sustained public communication, offer a high degree of leverage. However, they also present significant challenges to entrenched lifestyles. Structural changes to agri-food regimes (input intensity, crop choices suited to future climates) and urban development (soil sealing, geothermal trade-offs) are essential to prevent peaks from outpacing recharge. Democratising water governance is central to legitimacy and effectiveness. Greater transparency, accessible data across all sectors, strengthened participation (e.g., deliberative water fora), and fairer legal support for civil society and small landholders could rebalance procedural power. Aligning fiscal instruments with environmental objectives could correct current incoherences, e.g. harmonised abstraction fees reflecting scarcity and pollution, and revenues earmarked for restoration and monitoring.

The case stands at a crossroads. Ecosystem protection and societal adaptation are at stake in future court decisions and evolving policies, or risk from short-term exploitation. Durable solutions will be needed to deal with increasing hydroclimatic variability. These solutions must prioritise ecological thresholds, reduce absolute throughputs in social metabolism and ensure fair cost sharing across sectors and classes.

7 Conclusion

This study examines the Lüneburg Heath groundwater conflict through a political ecology lens analysing actors, interests and power relations in a region once deemed water rich. The results indicate tensions between safeguarding public supply, protecting sensitive ecosystems and accommodating rising uneven demands under changing hydroclimatic conditions. The growing competition and stricter environmental legislations redistributed power, weakening the public water supply, forestry and nature, while benefitting economic sectors, especially agriculture. As the state allocates groundwater, it holds an appropriating and regulating position; future relations depend on its actions, yet fundamental changes are difficult given its

embeddedness in wider ruling structures. The conflict comprises micro-struggles over the recognition of nature's water demands vs. economic exploitation; knowledge production vs. undone science strategies (Frickel et al. 2009; Hess 2007); democratisation; and urban-rural relations given expansive social metabolisms. The conflict can be understood as an environmental justice (Agyeman et al. 2003) struggle, challenging territorial ownership of common groundwater and externalised costs. In sum, this paper argues that neoliberal capitalist rule strongly shapes society's relations with groundwater that are reproduced by a state, embedded in this very system.

This study has several limitations. It relies heavily on secondary sources for forestry, agriculture and industrial actors, potentially under-representing these perspectives. The analysis is limited to national and EU frameworks and does not fully capture transnational influences (Brand et al. 2007). Furthermore, the qualitative single-case design limits external validity, while incomplete and contested data underscore the need for further research. Future studies could focus on process analysis (Buckel et al.

2014) and the effects of proposed solutions on power relations. Climate change and environmental awareness may enable greater recognition of nature, but its position remains fragile. While conflicts hold transformative potential (Temper et al. 2018; Turner 1975), it is unclear if collective learning and re-organisation will succeed, given contemporary political shifts. Future water management should move beyond capitalism's symptomatic treatments of short-term tech- and growth-oriented fixes. Instead, sustainable long-term solutions with reduced total water uses and improved quality are needed, implying radical sectoral changes (e.g. agricultural production systems). Governance should follow principles of social fairness, accessibility and sustainability; polluter-pays principles could serve as a blueprint for a transition supporting common goods. Opening a discourse on altering water demands and democratise decision-making processes are necessary first steps to renegotiate societal nature relations. Acknowledging our interconnectedness with water within the hydrosocial cycle, it is time to make water a just, sustainably treated part of humans and the world.

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Evaluating Biodiversity Enhancement in Wind Energy - The Pretul Wind Park Case Study

Elham Eslampanah Sendi

This paper assesses the biodiversity enhancement performance of the Pretul Wind Park, Styria, Austria against the ten IUCN Good Practice Principles for biodiversity enhancement at wind and solar developments. Key enhancement measures include renaturalisation of the Schwarziiegelmoos raised bog, reforestation with over 1,500 native trees, targeted habitat improvements for black grouse and capercaillie, protective elevated footbridges and platforms to reduce trampling, and integrated scenic trails that guide tourism away from sensitive zones. The evaluation is based on analysis of EIA reports, baseline surveys (2013–2014), long-term monitoring data, official project documentation, and an interview with the operator (Österreichische Bundesforste). Seven of the ten principles are fully met, supported by early, evidence-based, additional, measurable, and timely actions that deliver verifiable net-positive outcomes. The remaining three principles, which concern stakeholder engagement, management, monitoring, reporting, and long-term sustainability, are only partly met due to regionally focused engagement, operator-led oversight, and absence of explicit perpetual or post-decommissioning mechanisms. The study demonstrates that alpine wind projects can exceed legal requirements and achieve meaningful biodiversity gains, but stronger inclusivity, comprehensive ecosystem monitoring, and secured long-term legacy instruments are essential for full IUCN alignment and genuine nature-positive impact.

1 Introduction

The rapid expansion of renewable energy sources is essential for mitigating climate change and achieving global decarbonization targets (Lee et al., 2023). Onshore wind energy, in particular, has emerged as a key contributor to this transition due to its scalability, cost-competitiveness, and substantial potential to reduce greenhouse gas emissions. However, the deployment of wind farms can pose significant risks to biodiversity, including habitat fragmentation, direct mortality from collisions (especially for birds and bats), behavioral displacement, disturbance during construction and operation, and alteration of sensitive ecosystems such as high-alpine moorlands and grasslands (Jobson et al., 2024; Marques et al., 2014; Katzner et al., 2025). These impacts are often amplified in ecologically sensitive regions like alpine areas, where species such as black grouse and capercaillie are already vulnerable due to habitat specificity and low population densities. While traditional environmental impact assessments (EIA) and

mitigation hierarchies (avoid, minimize, restore, offset) address negative effects, they frequently fall short of delivering net positive outcomes for biodiversity (Jobson et al., 2024). A growing recognition exists that renewable energy projects should not only minimize harm but actively enhance biodiversity to contribute to broader nature-positive goals amid accelerating energy transitions and biodiversity loss. The International Union for Conservation of Nature (IUCN) has therefore developed ten Good Practice Principles for biodiversity enhancement at wind and solar developments, emphasizing proactive, evidence-based, additional, measurable, stakeholder-inclusive, and long-term measures beyond mandatory mitigation (Jobson et al., 2024). Despite this guidance, empirical case studies evaluating real-world application of these principles, particularly in high-altitude European contexts, remain limited, highlighting a research gap in assessing how onshore wind projects can achieve genuine biodiversity gains while supporting spatial development strategies in mountainous regions. This paper addresses this gap through a detailed case study of the Pretul

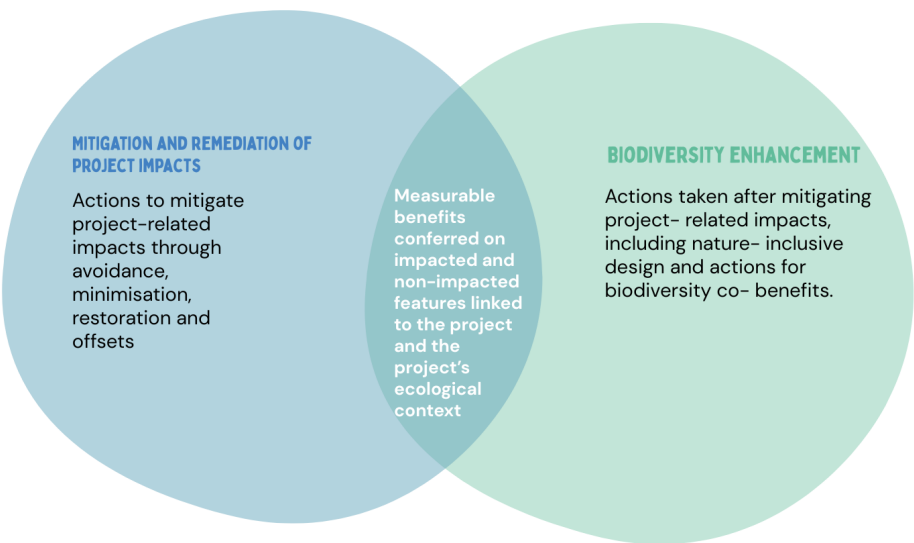


Figure 1: Mitigation vs. Enhancement (Jobson et al., 2024)

Wind Park in Styria, Austria. The main research question is: How well does the Pretul Wind Park perform against the 10 IUCN Good Practice Principles for biodiversity enhancement? Three sub-questions guide the analysis: (1) Which principles are met, partly met, or missing? (2) Are the implemented measures truly additional to legal mitigation requirements? (3) Which IUCN-recommended opportunities for onshore wind biodiversity enhancement remain unused? The objectives are to evaluate the project’s biodiversity measures, identify strengths and weaknesses, and derive recommendations for improved alignment with best practices. The paper is structured as follows: Section 2 presents the literature review; Section 3 outlines the methodology; Section 4 provides a detailed description of the Pretul Wind Park and its context; Section 5 presents the principle-by-principle evaluation of biodiversity enhancement performance against the 10 IUCN Good Practice Principles; Section 6 discusses overall strengths, weaknesses, and unused opportunities identified in the analysis; and Section 7 offers conclusions along with implications for spatial development strategies in alpine renewable energy planning.

2 Literature Review

To establish a clear conceptual foundation for this study, it is essential to delineate the fundamental differences between mitigation and biodiversity enhancement, as articulated in the IUCN framework. The mitigation hierarchy (avoid, minimize, restore/rehabilitate, offset) represents the mandatory, regulatory standard for managing adverse biodiversity impacts from development projects, including onshore wind energy. Its purpose is to anticipate, prevent, reduce, or compensate for project-

specific harm such that residual effects are neutralised or, at minimum, no net loss (NNL) is achieved. Mitigation actions are therefore compensatory and impact-specific: they directly address the biodiversity losses caused by the project itself, such as habitat clearance for turbine foundations or disturbance during construction (Jobson et al., 2024). Biodiversity enhancement, by contrast, comprises voluntary, additional conservation actions that measurably improve biodiversity beyond what is required under the mitigation hierarchy (see Fig. 1). Enhancement is not a substitute for mitigation but an extra layer of positive intervention, aimed at delivering genuine net-positive gains for biodiversity features that are linked to, associated with, or affected by the project, even if those features were not directly harmed. Key distinctions between mitigation and biodiversity enhancement are summarised in Table 1.

Aspect	Mitigation	Biodiversity Enhancement
Requirement	Mitigation is obligatory under environmental permitting (e.g., EIA processes)	Enhancement is discretionary and aspirational
Relation to impact	Mitigation counters project-induced losses	Enhancement creates additional benefits above baseline conditions
Outcome ambition	Mitigation targets no net loss (or net positive impact for directly affected features)	Enhancement targets verifiable net gain
Scope	Mitigation is limited to offsetting residual project impacts	Enhancement may target broader, project-linked biodiversity opportunities

Table 1: Mitigation vs. Enhancement (Jobson et al., 2024)

These differences are critical in the renewable energy sector, where the scale and pace of deployment demand approaches that not only avoid harm but actively contribute to reversing biodiversity decline. Building on this distinction, the International Union for Conservation of Nature (IUCN) has advanced a structured voluntary framework in its 2024 report "Opportunities for Enhancing Biodiversity at Wind and Solar Energy Developments". The report presents ten Good Practice Principles to guide the design, implementation, and evaluation of biodiversity enhancement measures (Jobson et al., 2024):

1. Target enhancement actions on biodiversity directly linked to, associated with, or affected by the project.
2. Consider enhancement opportunities early in the project cycle.
3. Ensure measures are evidence-based.
4. Establish a robust biodiversity baseline early in the project lifecycle.
5. Ensure enhancement measures are additional to mitigation actions.
6. Ensure enhancement actions are measurable with clearly defined goals and outcomes.
7. Identify and scope measures through collaborative stakeholder engagement.
8. Plan implementation within a timeframe relevant to the project.
9. Implement appropriate management, monitoring, and reporting requirements.
10. Plan for enhancement outcomes to be sustained in the long term, ideally in perpetuity.

These principles collectively promote a shift from compliance-driven harm reduction to ambitious,

scientifically grounded, and enduring biodiversity contributions. Despite increasing policy momentum, evidenced by mandatory biodiversity net gain requirements in England and emerging provisions in the EU Nature Restoration Regulation, empirical evaluations of the IUCN principles in operational onshore wind developments remain scarce. The extant literature continues to emphasise impact identification and mitigation efficacy (Katzner et al., 2025; Marques et al., 2014), with species-specific research on black grouse and capercaillie primarily documenting displacement, collision risks, and habitat avoidance rather than voluntary enhancement results (Coppes et al., 2020; Taubmann et al., 2021). In high-altitude European contexts, where wind potential is substantial but ecological recovery protracted and tourism pressures acute, documented enhancement initiatives are largely confined to project-specific environmental reports rather than systematic, peer-reviewed scrutiny. This paucity of rigorous, principle-based case studies constitutes a significant research gap: the practical application and effectiveness of comprehensive voluntary enhancement frameworks in alpine onshore wind projects remain underexplored. The present study addresses this gap through a detailed evaluation of the Pretul Wind Park against the full suite of IUCN (2024) principles, thereby contributing empirical insights into the feasibility, outcomes, and potential for refinement of biodiversity enhancement in ecologically sensitive mountainous environments.

3 Methods

This study employs a qualitative, single-case study approach to evaluate the biodiversity enhancement performance of the Pretul Wind Park against the 10 IUCN Good Practice Principles for biodiversity enhancement at wind and solar energy developments. The case study method is particularly suitable for in-depth analysis of a real-world project in its specific alpine context, allowing detailed examination of implementation, outcomes, and alignment with international best-practice guidance (K

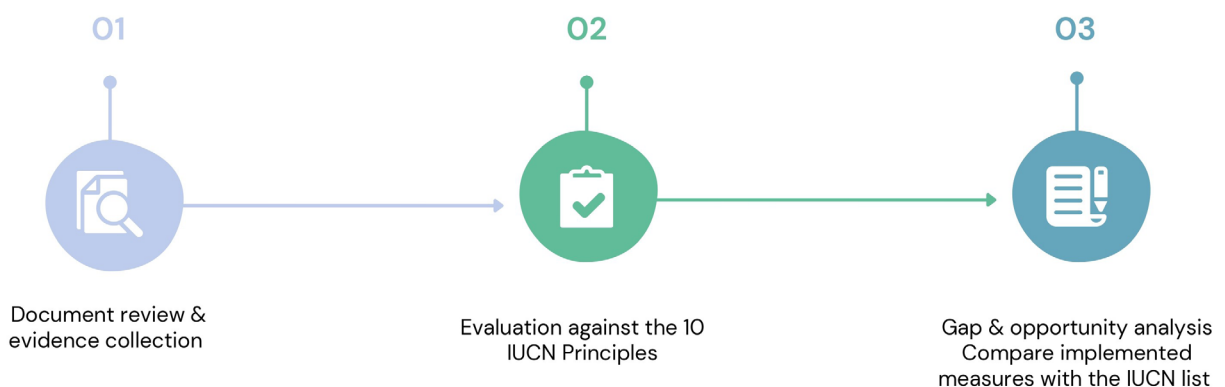


Figure 2: Methodology

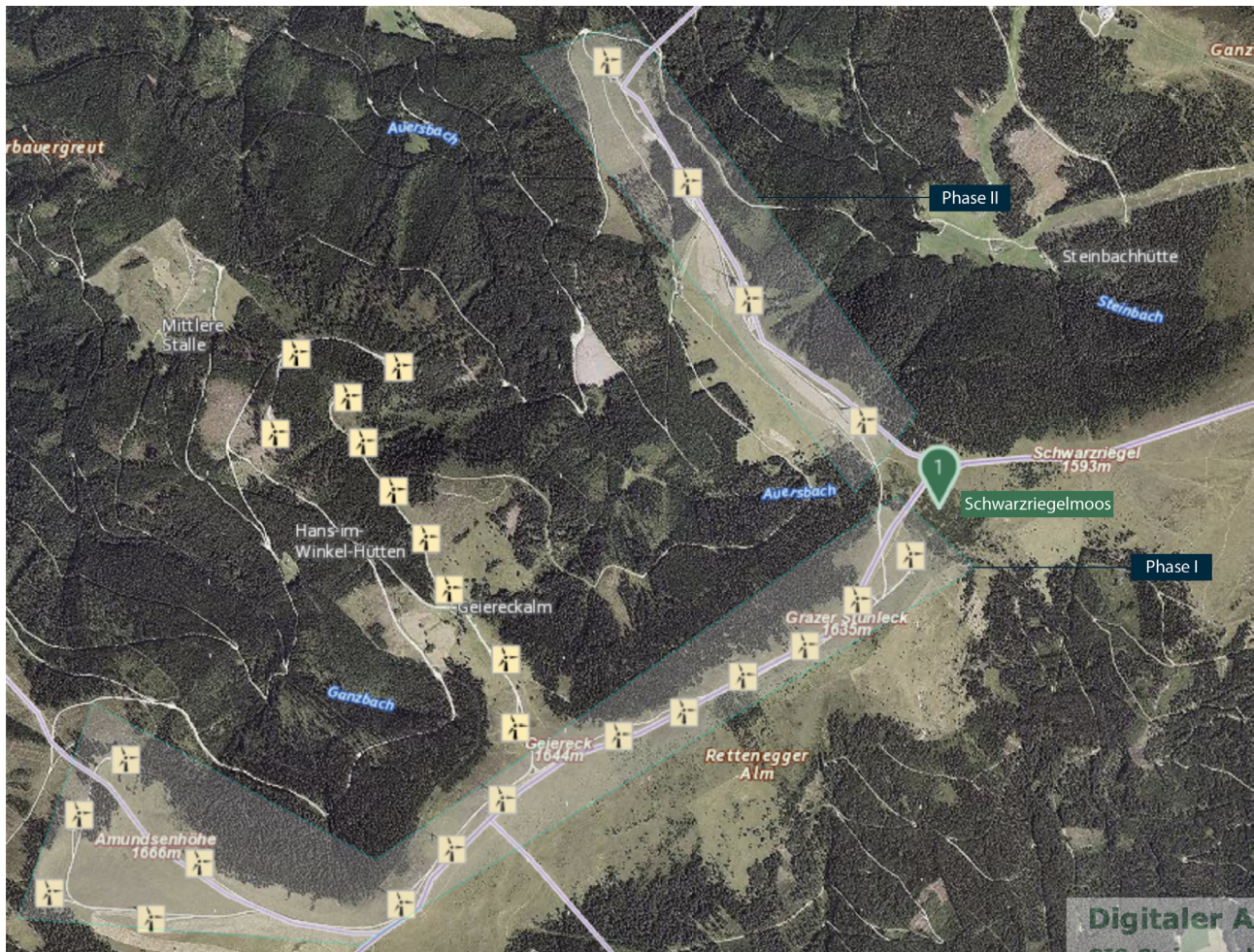


Figure 3: Project site - Source: Office of the Styrian Government

Robert, 2018). The methodological framework of this study follows a three-step process (see Fig. 2). Each principle was assessed using explicit evaluation criteria derived directly from the IUCN (2024) document, including the stated rationale, recommended actions, and key considerations. The assessment proceeded in three sequential steps: Evidence mapping: Relevant project information was extracted from official sources and mapped to each of the ten principles.

Performance assessment: Implementation for each principle was classified as:

- Met: clear, consistent, and well-documented full compliance;
- Partly met: partial fulfilment with evident gaps in scope, quantification, permanence, or outcomes;
- Not met: absent or insufficient evidence.

Gap and opportunity analysis: Implemented measures were benchmarked against the specific onshore wind biodiversity enhancement opportunities recommended by IUCN (2024), including habitat creation/restoration,

targeted species support, landscape connectivity improvements, additional ecological features, and integrated long-term monitoring.

3.1 Data Collection

Data were collected through a comprehensive document review of publicly available primary and secondary sources. Key documents include:

- Environmental Impact Assessment (EIA) reports and summaries for the original Pretul Wind Park and its extension providing baseline data, impact descriptions, mitigation measures, and enhancement actions.
- Project documentation and press releases from the operator Österreichische Bundesforste AG (ÖBf).
- Interview with the project owner, Österreichische Bundesforste AG (ÖBf), providing additional insights into project planning, implementation, long-term management, and biodiversity enhancement measures.

- Media and association reports.
- The IUCN guidance document itself, serving as the analytical framework.

All sources were accessed via official websites, repositories, linked PDFs, and an interview with the project owner. No primary field data collection was conducted; the study relies on a combination of existing documentation and expert input to ensure objectivity and replicability.

3.2 Analytical Framework

The evaluation follows a structured approach based on the 10 IUCN Good Practice Principles. These principles are grouped thematically for clarity:

- Foundational Planning and Scoping (Principles 1, 3, 4)
- Timely Integration and Implementation (Principles 2, 8)
- Beyond Mitigation: Additionality and Measurability (Principles 5, 6)
- Engagement and Oversight (Principles 7, 9)
- Long-Term Legacy (Principle 10)

Limitations include reliance on secondary sources (potential reporting bias) and absence of independent verification of monitoring data. However, the use of multiple official documents mitigates these risks and provides a robust basis for the case evaluation.

3.3 The Pretul Wind Park (Styria, Austria)

The Pretul Wind Park (Windpark Pretul), situated in the high-alpine region of Pretul Mountain at approximately 1,600 meters above sea level in Styria, Austria, stands out as a compelling example of how renewable energy infrastructure can be developed in harmony with biodiversity enhancement and ecosystem management. Operated by the Austrian Federal Forests (ÖBf), this project integrates wind power generation with proactive environmental stewardship and community benefits, aligning closely with Austria's national goals for renewable energy expansion and nature conservation (see Fig. 3).

The wind park achieved full operational status for its current phases as of 2025, building on an initial phase launched in 2017 and a significant expansion completed in 2024. According to information obtained directly from the project owner, the wind park consists of two phases. The technical specifications of Pretul I and Pretul II are presented in Table 2.

Parameter	Pretul I (2017)	Pretul II (2024)
Turbines	14 × Enercon E-82 E4	1 × Enercon E-126 + 3 × Enercon E-138
Hub height	78 m	86 m (E-126), 110 m (E-138)
Rotor diameter	82 m	126 m (E-126), 138 m (E-138)
Tip height	119 m	approx. 149 m (E-126), approx. 179 m (E-138)
Rated capacity per turbine	3.0 MW	4.0 MW (E-126), 4.26 MW (E-138)
Total installed capacity	42 MW	16.6 MW (some sources cite 16.78 MW)
Estimated annual electricity production	84,000–90,000 MWh	approx. 40,000 MWh
Equivalent households supplied	approx. 22,000–26,000	Not specified

Table 2: Technical Specifications of Pretul Wind Park Phases

Currently, the wind park comprises 18 turbines with a total installed capacity of 58.6 MW¹. Environmental considerations have been integral to the project's design and execution from the outset. Key biodiversity enhancement measures include the restoration of 40 hectares of habitat specifically tailored for black grouse and capercaillie, mitigating risks such as habitat fragmentation and disturbance. In addition, more than 1,500 native trees, including fir (*Abies alba*), sycamore (*Acer pseudoplatanus*), and mountain ash (*Sorbus aucuparia*), were planted to promote reforestation and create wildlife corridors, surpassing the mandatory ecological compensation requirements under Austrian environmental regulations (ÖBf, 2016a).

These initiatives were guided by comprehensive baseline ecological studies and fully incorporated into the Environmental Impact Assessment (EIA) process, with targeted strategies to reduce collision risks for birds and bats.

In parallel, the Pretul Wind Park generates substantial community and regional benefits, particularly by enhancing sustainable tourism in the Hochsteiermark area. Infrastructure improvements include scenic hiking trails, mountain bike routes, the Peter Berger lookout platform, and upgrades to the Roseggerhaus refuge. These features promote outdoor recreation with minimal ecological impact, incorporating sensitive design elements such as elevated footbridges and visitor platforms in vulnerable moor zones like Schwarzriegelmoos. Such measures not only stimulate local economic activity but also raise

¹ This installed capacity is sufficient to supply approximately 30,000–35,000 average Austrian households with electricity per year (based on average annual consumption)

public awareness and support for renewable energy and conservation. Ongoing monitoring has demonstrated net-positive biodiversity outcomes, including population peaks for indicator species such as black grouse, while challenges like increasing winter tourism pressures highlight the need for adaptive, long-term management strategies (ÖBf, 2024). Overall, the Pretul Wind Park serves as a practical case study, illustrating how high-altitude wind energy developments can achieve alignment with renewable energy targets, deliver measurable biodiversity gains, and contribute to sustainable regional development.

4 Results

This section provides an overview of the evaluation results, followed by a detailed breakdown of performance within each thematic cluster.

4.1 Evaluation overview

The evaluation of the Pretul Wind Park’s biodiversity enhancement measures against the 10 IUCN Good Practice Principles reveals a mixed performance. Seven principles are fully met, while the remaining three are only partly met. No principle is completely missing (see Table 3).

No.	Principle	Assess
01	Target biodiversity enhancement actions on components of biodiversity directly linked to, associated with, or affected by the project.	Met
02	Consider approaches for biodiversity enhancement early in the project cycle.	Met
03	Ensure biodiversity enhancement measures are evidence-based.	Met
04	Establish biodiversity baseline at an early stage in the project cycle.	Met
05	Ensure biodiversity enhancement measures are additional to any measures proposed in relation to mitigating impacts according to the mitigation hierarchy.	Met
06	Ensure biodiversity enhancement actions are measurable with clearly defined goals and outcomes.	Met
07	Identify and scope biodiversity enhancement measures through a collaborative and participatory process of stakeholder engagement.	Partly met
08	Plan to implement biodiversity enhancement measures within a timeframe relevant to the project concerned.	Met
09	Ensure appropriate management, monitoring and reporting requirements are implemented for biodiversity enhancement measures.	Partly met
10	Plan for biodiversity enhancement outcomes to be sustained in the long-term, and ideally in perpetuity, to deliver a lasting legacy from a project.	Partly met

Table 3: Results of the Evaluation

4.2 Foundational Planning and Scoping

Assessment: Principle met

This category covers the essential preparatory steps for effective biodiversity enhancement: targeting actions on biodiversity components directly linked to, associated with, or affected by the project (Principle 1); ensuring all measures are grounded in robust scientific evidence and site-specific data (Principle 3); and establishing comprehensive baselines early in the project lifecycle to support meaningful monitoring, outcome evaluation, and adaptive management (Principle 4). Together, these principles ensure that enhancement is focused, scientifically credible, and rooted in a reliable pre-project understanding of conditions, maximising the likelihood of delivering genuine, attributable gains in complex alpine ecosystems such as moorlands and grasslands.

The Windpark Pretul project effectively targeted enhancement measures at biodiversity components directly linked to or affected by the wind farm, consistent with Principle 1. Key actions focused on protecting and improving sensitive habitats impacted by construction, operation, and associated infrastructure. A prominent example is the protection of the Schwarziegelmoos raised bog through elevated footbridges and visitor platforms designed to minimise trampling and disturbance in this vulnerable moorland area.

Targeted habitat improvements also addressed risks to black grouse, a priority species in the alpine zone near turbines and disturbance-prone areas. These included selective forest thinning to create open flight corridors and lekking areas, as well as broader habitat enhancements to reduce fragmentation and disturbance from wind infrastructure and rising recreational use.

In line with Principle 4, a comprehensive biodiversity baseline was established early during the EIA process, with key surveys conducted in 2013–2014 and referenced in approvals finalised in December 2014 for the initial phase. The baseline included ornithological assessments (including black grouse populations), bat surveys, moorland habitat mapping, wildlife corridors, and soil/vegetation conditions. These data informed the design of both mitigation and enhancement actions (Amt der Steiermärkischen Landesregierung, 2014, 2018).

All enhancement measures were firmly evidence-based (Principle 3), drawing on specialist ecological reports, pre-construction surveys, and ongoing monitoring. For example, long-term black grouse monitoring, conducted by ÖBf in collaboration with BOKU, demonstrated positive trends, including a population peak around 2020 despite operations beginning in 2016/2017, with birds continuing to use the area and exhibiting lekking (balz) activity near turbines. These results, reported in 2021, confirmed

the effectiveness of habitat improvements and the population's good condition even under increasing winter tourism pressure (ÖBf, 2021).

Information from the project owner interview further confirmed that all proposed actions were locally specific, directly tied to identified sensitivities (e.g., moor vulnerability and grouse habitat needs), and integrated into planning from the scoping and EIA stages onward. This proactive, evidence-driven approach ensured that enhancement efforts were precisely aligned with the project's alpine context and potential impacts, fully satisfying Principles 1, 3, and 4.

4.3 Timely Integration & Implementation

Assessment: Principle met

This category focuses on embedding biodiversity enhancement into the project timeline at the earliest feasible moment and executing measures within ecologically and operationally appropriate schedules. Principle 2 requires that voluntary enhancement opportunities are actively identified and incorporated early in the project cycle, ideally during scoping, feasibility, or design phases, rather than deferred to later stages where flexibility is limited and costs rise. Principle 8 requires implementation to be scheduled so that actions have sufficient time to establish, mature, and deliver observable benefits in alignment with construction, commissioning, and operational phases. Prioritising early consideration and realistic timing prevents enhancement from becoming an afterthought or retrofit, enhancing effectiveness, cost-efficiency, and ecological credibility in long-lifecycle infrastructure projects such as alpine wind farms.

Biodiversity enhancement measures were proactively considered and integrated early in the Windpark Pretul project, fully aligning with Principle 2. Habitat improvements for black grouse and capercaillie, along with moorland protection and renaturalisation efforts, were incorporated during EIA preparation and consistently extended to subsequent phases, demonstrating sustained commitment from scoping onward.

Enhancements were grounded in detailed baseline studies and pre-construction planning conducted in 2013–2014. Implementation closely followed the project lifecycle and ecological requirements, satisfying Principle 8. For the original phase:

Moor renaturalisation at Schwarzriegelmoos (removal of invasive vegetation, hydrological restoration, grazing-exclusion fencing, and protective infrastructure such as footbridges and visitor platforms) began in 2016,

supported by collaborative "Umweltbaustelle" activities involving volunteers, mountain rescue, and youth groups (ÖBf, 2016b).

- Key infrastructure elements, nature trails, the mountain bike route through the moor, and visitor platforms, were completed between 2018 and 2019, with the Schwarzriegelmoos platform officially opened in 2018 and informational installations finalised by autumn 2019 (ÖBf, 2017).
- Habitat improvements for black grouse, including selective forest thinning for open flight corridors and lekking areas, were executed during and immediately after construction (2015–2017), with ongoing monitoring confirming effectiveness (e.g., population peaks around 2020 and sustained lekking near turbines despite operations starting in 2017) (ÖBf, 2021; EUSTAFOR, 2017).

These timelines ensured enhancement measures were delivered contemporaneously with construction impacts, enabling rapid ecological recovery in a sensitive alpine environment. For the Pretul II extension (operational since February 2024), similar measures, additional habitat enhancements for Black Grouse (Birkwild) and Capercaillie (Auerwild), amphibian ponds, and old wood islands (Altholzinseln), were implemented during the 2023 construction period (assembly completed by October 2023, grid connection in early 2024), further illustrating timely integration.

The Project owner interview (ÖBf, 2026) confirmed that enhancement planning was embedded from the earliest stages, with measures timed to align with alpine weather constraints and ecological sensitivities (e.g., avoiding breeding-season disturbance). This approach minimised delays while maximising ecological relevance, supporting species recovery and habitat integrity across project phases. Overall, the Pretul Wind Park demonstrates exemplary timely integration and implementation of biodiversity enhancements throughout its lifecycle.

4.4 Beyond Mitigation: Additionality and Measurability

Assessment: Principle met

This category centres on upholding the distinction between mandatory impact mitigation and voluntary biodiversity enhancement while guaranteeing that any positive outcomes can be objectively demonstrated and attributed to the project. Principle 5 stipulates that enhancement actions must be strictly additional, i.e., they must exceed and remain separate from any measures already required or proposed to avoid, minimize, restore, or offset the project's adverse effects on biodiversity in

accordance with the established mitigation hierarchy. Principle 6 demands that enhancement initiatives are structured around explicit, quantifiable objectives, with well-defined indicators, measurable targets, and clear criteria for assessing success, thereby enabling transparent tracking, independent verification, and credible reporting of net biodiversity gains over time. By enforcing these two requirements, the principles protect the credibility of enhancement claims, prevent the conflation of compensatory and additive actions, and provide a robust scientific basis for evaluating whether alpine wind projects such as Pretul genuinely contribute to broader nature-positive goals beyond legal compliance.

The Windpark Pretul project adheres to the mitigation hierarchy, as documented in project materials and operator (ÖBf, 2026). In addition to mandatory mitigation and compensation obligations required under the Environmental Impact Assessment EIA process and Austrian regulations, several enhancement measures were implemented that go beyond what was strictly prescribed to offset project impacts. These voluntary, additional actions, explicitly described by the project owner as exceeding regulatory requirements, include (ÖBf, 2016b; SuisseEole, 2021):

- Advanced habitat improvements for black grouse and capercaillie: establishment of guiding structures for black grouse to facilitate movement and lekking, intensive thicket management, selective thinning to create open flight corridors, and widespread retention of old wood through secured natural regeneration, while preserving individual veteran trees as biotope trees. These actively enhance structural diversity and habitat quality in ways not mandated for impact offsetting.
- Long-term monitoring programs for target species: black grouse monitoring in cooperation with the University of Natural Resources and Life Sciences, Vienna (BOKU), running through the end of 2026; and capercaillie monitoring conducted jointly with "Büro am Berg" (specialists in wildlife ecology and landscape planning). These collaborative, science-based programs extend beyond typical post-construction compliance monitoring.

Other documented enhancements, comprehensive renaturalisation of the Schwarzriegelmoos raised bog (removal of invasive overgrowth, hydrological restoration, grazing-exclusion fencing, protective footbridges and platforms), reforestation with over 1,500 native trees, and creation of wildlife zones, were framed in project communications as exceeding baseline requirements, with investments underscoring their voluntary nature. The project owner explicitly highlighted that substantially greater financial resources were allocated to these biodiversity measures compared to a standard wind

project, with the additional expenditure oriented toward securing long-term ecological benefits beyond short-term compliance (ÖBf, 2021).

These measures satisfy Principle 5 by demonstrating clear additionality: they provide benefits above and beyond the avoidance, minimization, and compensation steps required to address direct project impacts (e.g., habitat fragmentation, disturbance, or moor vulnerability).

Regarding Principle 6, the actions are supported by measurable goals and outcomes through established monitoring. For black grouse, multi-year population monitoring (in partnership with BOKU) has delivered concrete, quantifiable results: despite operations starting in 2017, the population remained in good condition and reached a recorded peak in 2020, with active lekking behaviour observed across the site, including near turbines. This provides direct evidence of net gains in population size and habitat use. Similar structured monitoring for capercaillie ensures ongoing assessment of outcomes.

Information obtained directly from the project owner interview confirms these as additional enhancements with defined, tracked objectives (e.g., population trends, habitat quality improvements). Publicly available reports and monitoring summaries further support transparency and measurability, particularly for flagship species like black grouse (SuisseEole, 2021; ÖBf, 2021). While not every minor action has exhaustive public indicators, the key enhancements, especially species-specific monitoring and habitat improvements, are demonstrably goal-oriented and results-documented, fully meeting the principle's requirements for clear, measurable biodiversity gains.

Overall, the Pretul Wind Park exemplifies strong performance on additionality and measurability, with voluntary over-delivery backed by scientific collaboration and empirical evidence of positive outcomes.

4.5 Engagement and Oversight

Assessment: Principle partly met

This category emphasises inclusive, participatory processes for identifying and scoping biodiversity enhancement opportunities and the establishment of structured, accountable systems for long-term management, monitoring, and reporting. Principle 7 requires that enhancement measures be developed through genuine collaborative stakeholder engagement, incorporating the knowledge, perspectives, and priorities of local communities, conservation experts, scientific institutions, authorities, and other relevant parties to ensure measures are contextually appropriate, socially legitimate, and

ecologically sound. Principle 9 requires dedicated long-term management arrangements, scientifically credible monitoring protocols, and transparent reporting obligations tailored to the enhancement actions, enabling adaptive management, objective evaluation of effectiveness, and public accountability for claimed outcomes. Together, these principles transform enhancement from a unilateral technical exercise into a shared, governed process better positioned to deliver credible, enduring benefits in multi-stakeholder alpine settings where land-use conflicts, ecological sensitivities, and public expectations intersect.

The Windpark Pretul project incorporated elements of collaborative engagement in scoping and implementing enhancement measures, consistent with Principle 7, though the process was primarily focused on regulatory and local practical partners rather than broad participatory involvement. Formal stakeholder input took place during the EIA procedure, involving statutory authorities (e.g., Amt der Steiermärkischen Landesregierung), hunting rights holders, local municipalities, and ecological/wildlife experts who contributed to baseline surveys, impact assessments, and measure planning.

On-the-ground collaboration was evident in key implementation activities. For the Schwarziriegelmoos moor renaturalisation, Österreichische Bundesforste (ÖBf) organised an "Umweltbaustelle" in 2016 in partnership with Bergwacht (mountain rescue) and Steiermärkische Landjugend (rural youth organisation). This involved approximately 30 volunteers (ages 16–70) in hands-on tasks such as removing invasive vegetation, restoring hydrology, fencing against grazing, and preparing protective infrastructure. These efforts were supervised by ecologists and directly shaped the practical execution of moor protection (ÖBf, 2016b).

Tourism-related enhancements—including mountain bike routes (Wind+Bike Park Pretul), hiking trails, visitor platforms, and signage, were developed in cooperation with the regional tourism association. As confirmed in the project owner interview, this partnership was voluntary but pursued for its benefits in directing visitors along designated paths to minimise disturbance while supporting local economic interests. Adaptive management, such as temporary quiet periods and routing visitors away from sensitive wildlife, reflects ongoing coordination with tourism stakeholders.

However, direct participation by independent environmental NGOs in identifying, scoping, or designing enhancement measures appears limited. This narrower focus on regulatory authorities, local implementers, and tourism partners means the process was collaborative in a targeted, regional sense but falls short of the broader participatory inclusion advocated by Principle 7.

For Principle 9, ÖBf maintains overall management responsibility as operator and landowner. Structured monitoring programmes provide measurable tracking of key outcomes. Flagship results are publicly reported via ÖBf press releases and communications (ÖBf, 2021, 2024). While not every detail receives exhaustive annual public disclosure, flagship outcomes and adaptive responses demonstrate accountability and responsiveness to pressures such as rising winter tourism (ÖBf, 2021).

In summary, the project partly meets Principles 7 and 9: it achieves effective collaboration and strong monitoring/reporting through practical, regionally focused partnerships and scientific oversight, but the limited involvement of independent environmental NGOs constrains the breadth of participatory scoping, particularly in a project emphasising biodiversity enhancement in a sensitive alpine area. This targeted approach suits the local context but does not fully align with the principle's emphasis on inclusive, diverse stakeholder processes.

4.6 Long-term Sustainability

Assessment: Principle partly met

This category emphasises the need to secure the permanence of biodiversity enhancement outcomes, ensuring they endure well beyond the project's active phases and ideally in perpetuity. Principle 10 requires proactive planning for long-term sustainability through mechanisms such as secure management arrangements, dedicated funding, legal safeguards, or integration into ongoing land-use frameworks, so that benefits persist during operation, after decommissioning, and into the future. By prioritising lasting legacy over temporary gains, the principle addresses a key risk in infrastructure projects, loss of enhancement value once resources or focus shift, and aims to create attributable, enduring positive contributions to biodiversity in sensitive alpine ecosystems.

The Pretul Wind Park demonstrates partial alignment with Principle 10. Several implemented enhancement measures, such as the comprehensive renaturalisation of the Schwarziriegelmoos raised bog, habitat improvements for black grouse and capercaillie, and reforestation with native species, are inherently self-sustaining or low maintenance once established, suggesting potential for benefits to persist well beyond the current operational phase (ÖBf, 2016b, 2021). Ongoing species monitoring programmes and the operator's long-term stewardship role as Österreichische Bundesforste (which manages large areas of public forest land) provide some informal continuity for key actions (ÖBf, 2024).

However, no explicit, formalised provisions for perpetual or post-decommissioning monitoring, legally binding commitments, dedicated endowment funds, or integration of enhancement outcomes into binding land-use or conservation instruments were identified in publicly available documentation or operator statements. The planning horizon for most measures appears tied to the wind farm's operational lifetime rather than deliberately designed for indefinite duration. While the third-phase extension and the operator's stated commitment to alpine renewable energy scaling indicate continued site attention, these do not yet constitute structured, enforceable mechanisms to guarantee maintenance, adaptive management, or monitoring in perpetuity after eventual decommissioning.

Consequently, while the project achieves meaningful medium- to long-term delivery through ecological design and institutional continuity, it falls short of the principle's aspiration for explicit, secured perpetual legacy planning. Strengthening this aspect, e.g., through a dedicated biodiversity legacy fund, formal long-term management agreement, or explicit post-decommissioning commitments, would elevate performance toward full compliance in future phases or similar alpine projects.

5 Discussion

The Pretul Wind Park stands out as a comparatively strong example of biodiversity enhancement in alpine onshore wind development, achieving full compliance ("Met") with seven of the ten IUCN Good Practice Principles, specifically those related to foundational planning and scoping (Principles 1, 3, 4), timely integration and implementation (Principles 2, 8), and beyond-mitigation additionality combined with measurability for priority species (Principles 5, 6). This performance is underpinned by early, evidence-based targeting of site-specific sensitivities (e.g., Schwarziigelmoos moor and habitats for black grouse *Lyrurus tetrix* and capercaillie *Tetrao urogallus*), proactive integration of voluntary measures during EIA scoping and construction phases, substantial additional investment beyond regulatory minima, and scientifically credible monitoring that has yielded tangible positive outcomes, including a documented black grouse population peak in 2020 with sustained lekking near turbines (ÖBf, 2021; SuisseEole, 2021). These strengths illustrate that it is feasible, even in high-altitude, ecologically complex settings, to reconcile renewable energy expansion with meaningful net-positive biodiversity contributions when enhancement is treated as an integral project objective from the outset. The project's emphasis on self-sustaining habitat restoration, coupled with collaborative long-term monitoring (e.g., BOKU partnership), provides empirical proof of concept for alpine contexts where habitat fragmentation, disturbance, and recreational pressures

intersect with wind infrastructure (ÖBf, 2021). At the same time, the assessment reveals consistent partial performance ("Partly met") on stakeholder engagement and management/oversight/reporting (Principle 7,9), and long-term legacy (Principle 10). Engagement, while effective in a pragmatic, regionally focused manner (EIA authorities, local partners, tourism associations, volunteer activities), lacks broader, systematic inclusion of independent environmental NGOs. Oversight and reporting are robust for flagship species during operational phases but remain largely operator-led. Most critically, long-term sustainability falls short of the IUCN aspiration for perpetual or post-decommissioning security: no dedicated legacy funds, binding perpetual management agreements, or explicit integration into conservation instruments were established. In the interview with the project owner (ÖBf, 2026), key challenges specific to alpine renewable energy projects were discussed. The operator noted that stricter rules and heightened wildlife protection requirements in alpine areas make it significantly harder to build wind turbines compared to lower-elevation sites, leading many developers to avoid these challenges altogether. Another major difficulty lies in accurately predicting future impacts on animal behaviour and populations, not only within the project site but also in surrounding areas, due to complex external factors like heavy snowfall, increasing winter tourism pressures, and potential climate-driven changes (ÖBf, personal communication, 2026). The operator emphasized a solution-oriented mindset, highlighting that Pretul has succeeded well thanks to deep local knowledge and comprehensive precautionary wildlife measures. To better interpret animal responses amid these uncertainties, additional monitoring was implemented beyond standard requirements, with measures extended to adjacent areas to improve robustness and predictive capacity. These perspectives help explain the project's partial gaps: the alpine environment inherently amplifies uncertainties in long-term outcome attribution and permanence, where external variables complicate reliable forecasting and necessitate adaptive, precautionary strategies. While Pretul mitigates many risks effectively, the absence of formalized perpetual safeguards reflects common constraints in alpine wind projects, regulatory timelines, project-bound financing, and the practical difficulties of securing indefinite commitments (ÖBf, personal communication, 2026).

6 Conclusions

This case study demonstrates that the Pretul Wind Park performs strongly against the 10 IUCN Good Practice Principles for biodiversity enhancement (IUCN, 2024), but falls short of full alignment.

First: It demonstrates that onshore wind projects in alpine environments can achieve substantial alignment with the IUCN Good Practice Principles for biodiversity enhancement (IUCN, 2024), particularly in early-cycle planning, timely implementation, additionality, and measurable outcomes for priority species. By embedding voluntary, evidence-based measures that exceed mandatory mitigation, such as comprehensive moor renaturalisation, targeted habitat improvements, and science-backed monitoring, the project delivers verifiable net-positive contributions despite the ecological sensitivities and technical challenges of high-altitude deployment.

Second: However, gaps remain in broader stakeholder inclusivity, independent oversight, and, most notably, long-term legacy planning. The absence of explicit perpetual mechanisms leaves enhancement outcomes vulnerable after the wind farm's operational life, limiting the project's ability to fully realise the IUCN's vision of a lasting biodiversity legacy.

Third: The findings carry important implications for alpine renewable energy spatial planning across Europe. First, they confirm that meaningful biodiversity gains are achievable under existing frameworks when enhancement is prioritised from the outset and supported by elevated investment and scientific collaboration. Second, they highlight the need for policy and regulatory evolution to incentivise or require stronger perpetual safeguards (e.g., legacy funds, conservation covenants, post-decommissioning commitments) and more inclusive stakeholder processes. Third, the planned third-phase extension (EIA submitted November 2025) represents a critical opportunity to close remaining gaps by adopting untapped IUCN-recommended measures—such as bat-

and bird-friendly operations, landscape connectivity enhancements, and ecosystem-wide monitoring, and formalising enduring governance structures.

Last: Scaling the strengths observed at Pretul, while systematically addressing the identified limitations, could significantly advance the dual goals of decarbonisation and biodiversity recovery in mountainous regions. In doing so, alpine wind projects could move from compliance-driven mitigation toward genuine, nature-positive contributions that support both climate and biodiversity targets in an era of converging crises.

In conclusion, the Pretul Wind Park illustrates that well-executed, evidence-based biodiversity enhancements can coexist with onshore wind development in sensitive alpine ecosystems, delivering real net gains, most visibly through the documented recovery and peak of the black grouse population and the successful renaturalisation of the Schwarziengelmoos moor. Yet the project's partial performance on additionality, measurability, inclusive engagement, comprehensive monitoring, and perpetual legacy planning reveals systemic gaps typical of current European frameworks, where enhancements remain largely tied to compensation obligations rather than voluntary ambition. Strengthening spatial development strategies in Austria and beyond, through mandatory long-term biodiversity commitments, broader stakeholder inclusion, explicit post-decommissioning provisions, and explicit integration of the IUCN Good Practice Principles into EIA and funding criteria, could transform such projects from good practice examples into scalable models of genuine nature-positive renewable energy infrastructure, advancing both climate and biodiversity objectives in high-value mountain regions.

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Who is entitled to speak for nature? A qualitative analysis of representation and guardianship in Rights of Nature initiatives

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In this article we examine several Rights of Nature (RoN) initiatives. Building on previous research by Kahui et al. (2024), we focus on the question of how guardianship models that speak on behalf of nature and natural entities are legitimised and to which worldviews they are connected. We follow the understanding of O'Neill (2001) that nonhuman and inarticulate beings can only be represented by proxy and based on epistemic claims, combined with care. Our findings show that the cases rarely rely on one source of legitimation but often stem from a combination of care, epistemic claims and political authority. Rather than resolving the normative problem of representing nature, Rights of Nature initiatives institutionalise new configurations of legitimacy that reshape how environmental interests are articulated within political and legal processes. While frequently framed as a departure from anthropocentric governance, RoN initiatives remain embedded in political negotiations over authority, knowledge, and responsibility. Their potential therefore lies less in transcending politics than in redistributing power over how nature's interests are defined and defended. These findings carry implications for public administration and institutional design: where guardianship responsibilities are clearly defined and distributed across multiple actors, RoN initiatives appear better equipped to translate legal recognition into effective environmental governance and accountability.

1 Introduction

In the face of continuing climate and biodiversity crises, scientists and advocacy groups are calling for increased action and the implementation of innovative and alternative modes of governance that abandon logics of infinite growth and exploitation of nature. Some argue that at the basis of human-induced environmental destruction lies a notion of human exceptionalism that does not sufficiently acknowledge the inherent worth of nonhuman beings and the dependence of humanity on intact natural and ecological processes. One approach attempting to incorporate more complex ways of human-nature relations is the Rights of Nature (RoN) movement. RoN initiatives try to enhance the outcomes of environmental policy by granting rights to nature or natural entities. They argue that our legal systems are anthropocentric, viewing nature as a collection of resources to be extracted. To change that view the legal

standing of nature needs to be re-defined by making it a bearer of rights. Hundreds of these initiatives have already emerged around the world. While these initiatives generally assign a high worth to nature, they emerge within varying contexts and worldviews. In this paper, we focus on guardianship and representation. Although nature is constituted as a bearer of rights, it cannot articulate its own interests. Most initiatives therefore employ models of guardianship in which individuals or groups speak on behalf of nature. While much research examines the legal design and implementation of RoN, few studies address the normative problem of representation. We argue that the appointment of guardians places them in a position of political and legal power. It therefore matters to examine on what grounds guardians are deemed competent to speak for nature and which worldviews underpin these guardianship models.

We examine 12 of these initiatives in a qualitative comparison, asking Who is entitled to represent nature in Rights of Nature cases and how is that representation legitimised? We argue that Rights of Nature initiatives do not resolve the problem of representing nonhuman entities. Rather, they institutionalise new combinations of political authority, epistemic knowledge, and relational care that reshape environmental governance and redistribute power over how nature's interests are defined. That is why it becomes relevant to analyse the logics of legitimizing guardianship. To approach this question, we first introduce various worldviews and value systems that describe how societies and individuals value nature and provide a literature review on issues of representation of inarticulate beings, especially of nature. In a descriptive comparison we analyse 12 RoN initiative first introduced in a comparative study by Kahui et al. (2024), reassessing them through the lens of representation.

The current state of crisis

In 2009, almost 20 years ago Levin et al. (2009, p. 1) already called to look at the global "Climate Change" as a "Wicked Problem." – a complex matter that cannot be addressed in a single government policy but rather requires a variety of solutions to "limit ourselves in our actions." As Climate Change progresses and is now commonly referred to as the Climate Crisis or Climate Emergency (Ripple et al., 2020, p. 8), the urgency to find solutions to limit our actions that have an impact on the progress of rising temperatures and biodiversity decline grows dramatically. As for now, 95% of earth's land surface excluding Antarctica shows human activity, 51% is heavily modified (Kennedy et al., 2019). Under the most modified Biomes (30-50% heavily modified) are also the most Biodiverse Biomes with few Tropical Forests habiting 13% of Plant diversity in just 0.2% of World surface area (Mittermeier et al., 2002). This development is leading to a continued decline of global biodiversity (IPBES, 2019, p. 10ff.), with wildlife populations on average declining by 73% since 1970 (WWF, 2024, p. 7). Biodiversity loss affects climate change negatively and while climate change affects biodiversity negatively as well, this becomes a vicious downward spiral (Pfenning-Butterworth et al., 2024, p. e270). The call for solutions to "limiting our actions" is therefore relevant as ever.

Need for Overcoming Anthropocentrism

The unprecedented exploitation of our planet follows the principle of Anthropocentrism. In contrast to ecocentric worldviews "that place importance [...] on nature as a whole as having inherent worth in themselves" (Raymond et al., 2023, p. 3). It centers around the importance of nature and its functioning, stressing concepts such as ecosystem stability (Murali et al., 2026, p. 5). Anthropocentric worldviews generally prioritise humans, claiming superiority of humans over nature, and neglect any ethical worth of nature itself (Raymond et al., 2023, p. 3). It has

been argued that, as a result of its "failure to recognise and address the natural world in ethical terms" (Washington et al., 2021, p. 286), such an approach is inherently incapable of addressing ecological collapse. Finally, pluricentrism refers to an understanding of "the world as a relational sphere or network of interdependencies across biophysical, sociocultural, economic, and, in some cases, spiritual dimensions that elude a strict centre-periphery dichotomy and challenge human–nature dualisms" (Murali et al., 2026, p. 5). Where ecocentrism places value on nature and ecosystem integrity as its moral centre, pluricentrism stresses more diverse forms of relationships and connections, including those of humans and non-humans. The intertwinedness of diverse beings becomes the centre of moral consideration

Emerging in early Greek mythologies and spreading since, an anthropocentric worldview is the dominant paradigm in western countries later globalised around the world to most industrialised countries. "Worldviews are the 'lenses', through which individuals and groups perceive, interpret, inhabit and modify the world" (Raymond et al., 2023, p. 2), each defining general habits, behaviours and interactions. On a smaller scale but closely connected to present worldviews, there are different value systems that define the position of non-human natural entities in those systems and the accompanying human-nature relation. The three kinds of valuations of nature are generally referred to as intrinsic, relational and instrumental (ibid., p.3f.). The intrinsic value of nature exists independent of human use, preferences, or benefits. Nature is morally considerable simply because it exists, not because it serves human ends. Relational values refer to meaningful relationships and responsibilities between humans and nature. This includes cultural identity, care, stewardship, kinship, moral obligations, and reciprocal relationships. The instrumental value of nature lies in the benefits, services, or utilities ecosystems and species provides to humans. At present this is argued to be the dominant paradigm in human-nature relations. Most indigenous and pre-colonial populations related to nature via its intrinsic or relational values and only through modernist thought, capitalism and colonialism, have non-human entities been reduced to capitalised resources (Washington et al., 2021, p. 289). That most western cultures see non-human entities solely as resources that exist to be exploited ignores the fact that humanity is dependent on Nature to survive. That is why overcoming this human exceptionalism is seen by some as a prerequisite for ecological preservation (Horn & Bergthaller, 2022, p. 90f.). These distinctions between anthropocentric, ecocentric, and pluricentric worldviews are crucial for understanding who is considered capable of representing nature and why. The way nature is valued shapes assumptions about who may legitimately speak on its behalf.

While worldviews and value systems are closely related, they operate at different levels of analysis. Worldviews describe the broad philosophical orientation through which societies and individuals understand the human-nature relationship. Value systems operate at a more specific level, describing how nature is assessed and what worth is attributed to it. The two are connected but not identical, e.g. ecocentric worldviews tend to emphasise intrinsic values; pluricentric worldviews tend to emphasise relational values; Instrumental values tend to follow anthropocentric worldviews, treating nature as a resource for human interests. However, as our cases will show, RoN initiatives frequently draw on multiple value logics simultaneously which is why we treat worldviews and values as orientation points on a continuum rather than as fixed, mutually exclusive categories.

The Rights of Nature movement

Gaining increasing popularity in recent years, the Rights of Nature Movement is a compound term for legal initiatives around the world, mostly originating in The Americas followed by prominent successors in Australia and New Zealand (Putzer et al., 2022, p. 91). These Initiatives try to increase the effectiveness of environmental protection policy through recognition of non-human natural entities as legal persons and bearers of rights. This allows nature “standing in court and a wider possibility to take nature science evidence into consideration in deciding on environmental matters” (Darpö, 2021, p. 13). As of 2025, 615 initiatives in 57 countries have been registered (Kauffman et al., 2025). Initiatives differ in emergence, legal provision, quality, and effectiveness in protecting the entities they refer to. Often but not always, the concept constitutes a legal-philosophical act in integrating understandings of intrinsic and/or relational values of nature into legal systems that emerged in anthropocentric systems and reproduce them since (Darpö, 2021, p. 13).

The matter of Representation

While empowering non-human natural entities to personhood in legal cases opens the door for them to be part of decision making in the first place, it imposes the question of representing those who cannot speak as a matter of power distribution by – again – humans and not the actual entities. The only remaining source of legitimacy to “speak for the voiceless” are epistemic claims, i.e. “having knowledge of the objective interests of those groups, often combined with special care for them” (O’Neill, 2001, p. 496). This so-called proxy representation of one interest group representing another bears its own problems, “as it was used to justify the representation of women by husbands and servants by masters.” (ibid., p. 95) In our case, that not only means that identifying needs of non-human natural entities but also them being represented by a group with at least in western economical development-driven cultures contradictory interests.

Many attempts in analysing and comparing RoN-Cases, have been made. These primarily take the legal frameworks into consideration and establish categories of Guardianship models and legal provision to identify causes of success and failure. Following the idea of relational spatial theory in which the focus lies in context and relations between entities, we see an essential importance in the cultural contexts, underlying worldviews and value systems in which RoN-Cases emerge. Therefore, this paper attempts to answer the question of Who is entitled to represent nature in Rights of Nature cases and how is that representation legitimised?

2 Methods

To answer the question, we will compare several Rights of Nature cases which have already been summarised in a comparative analysis by Kahui et al. (2024). This descriptive study compared the emergence and design of various legal models where nature or natural entities have been granted certain rights. However, our research focuses on the arguments that legitimise legal personhood and the representation of nature by appointed guardians. This involves interpreting the design, emergence and implementation of these frameworks. We limit our analysis of cases to the selection of this study because it includes some of the most prominent and detailed documentation of RoN initiatives. However, we omit initiatives which lack detail and literature needed for a detailed investigation. This applies to municipal RoN ordinances in the U.S and RoN in state constitutions in Mexico. The remaining initiatives analysed are listed in table 1.

Title	Year enacted
Constitution of the Republic of Ecuador	2008
Mother Earth Law, Bolivia	2010
Victorian Environmental Water Holder, Australia	2011
Oregon Water Trust, USA	2003
Te Urewera Act, New Zealand	2014
Te Awa Tupua Act, New Zealand	2017
Atrato River case, Colombia	2016
Fitzroy River Declaration, Australia	2016
Magpie River Declaration, Canada	2021
Mar Menor Act, Spain	2022
Court Ruling on the Ganges and Yamuna rivers, India	2017
Court Ruling on the Turag River, Bangladesh	2019

Table 1: List of analysed RoN initiatives

By analysing legal documents and results of previous studies evaluating these cases, we attempt to categorise models of guardianship and their legitimisation as well as underlying worldviews. We apply the typology of worldviews and knowledge systems surrounding nature

as defined by Raymond et al. (2023, p. 3f.). By examining each case individually, we attempt to find patterns and similarities among the cases.

The main categories for our framework are as follows:

- Type of guardianship - Are there personal guardians or can anyone demand the rights of nature to be respected? How is the guardianship organised?
- Type of legal provision? Are rights of nature stated in a constitutional article, law, court ruling or declaration?
- Dominant worldview – Raymond et al. (2023, p. 3f.) proposes three worldviews regarding the relationship between humans and nature. We try to extract which worldview is dominant in the formulation and implementation of RoN cases.
 - * Ecocentric: emphasis on the inherent worth of nature
 - * Anthropocentric: human needs are prioritised; nature is relevant for its use value.
 - * Pluricentric: focus “on reciprocal, intertwined and embedded relationships between humans and other beings, and nature’s elements and processes (i.e. with no centre)” (Raymond et al. 2023, p. 3f.).
- Legitimization of guardianship: here we focus on the types of guardianship established in RoN cases and on how the granting of guardianship is legitimised, whether it is through epistemic claims, care, political authority or otherwise.

Regarding the categorization of worldviews, we draw on the processes of emergence as described by Kahui et al. (2024, p. 9ff.) and the Eco Jurisprudence Monitor (Kauffman et al., 2025), as well as official and legal documents, and statements of advocacy groups involved in the process of granting legal personhood or certain rights to nature. In practice, the value language used in these sources – whether nature is framed as having worth in itself or as providing services to humans – serves as the primary empirical indicator from which we deduce the dominant worldview. Therefore, this work will involve some interpretation as to what worldview arises in each case. While an initiative might originate from advocates of an ecocentric worldview, the wording of legal provisions might reflect another. Relevant interpretive questions include: What exactly is being protected? Which rights are granted to nature? What are the duties of guardians? If the initiative mostly stresses the benefits of ecosystems, natural entities, nature for humans, e.g. by providing clean drinking water or space for recreation, we deem this view of nature as anthropocentric, reflecting an instrumental

valuation. Initiatives stressing intertwined dynamic relationships of coexistence of all beings and elements, and the connections of humans to the land, are assumed to stem from a pluricentric worldview, typically expressed through relational values. Thirdly, initiatives foregrounding intrinsic values by stressing living beings’ and ecosystems’ right to exist and thrive, are treated as ecocentric. As several cases combine multiple value logics we identify the combination rather than forcing a single classification, treating worldviews as orientation points on a continuum rather than discrete, mutually exclusive categories.

To examine the legitimization of guardianship we are going to analyse the design of the different guardianship models and the appointment of guardians. Who are the guardians? Who chooses the guardians? On what ground are guardians deemed competent to represent the interests of nature? Are guardians directly affected by harm inflicted on the ecosystem, river etc.? The goal here is to find out if there is any substantial knowledge about or connection to the protected natural entity that would imply an adequate understanding of and care for nature. Since nature is inarticulate to humans, “representation must necessarily be by proxy” (Lawrence, 2022, p. 554) and through epistemic claims (O’Neill, 2001, p. 497). Following this logic, guardians with deeper local or expert knowledge could provide an adequate proxy for the needs and interests of nature.

Through combining these questions, we should arrive at an evaluation of how nature is conceived and what constitutes an adequate representation of it. Conclusions to draw might be if the RoN has any benefits compared to other models of environmental law.

3 Results

Rights of Nature cases emerge in highly diverse contexts with differing advocates and reasonings. The models chosen to establish legal personhood for and rights of nature vary by legislative level, commitment, and detail. The common goal of all cases is to promote improved environmental outcomes by strengthening the legal standing of natural entities. The presentation of our findings follows the main questions of our analysis, firstly characterizing the cases by design and emergence, then focusing on value systems underpinning their reasoning and lastly, presenting the models of guardianship and the “epistemic claims” that might be used to legitimise them. While this chapter provides general trends within our data, the appendix (which can be accessed in the online publication) includes a detailed table with information regarding the subquestions for each initiative.

Legislative levels & the structures of guardianship

The cases explored show a variety of legal models. While in Ecuador rights of nature have been established in the constitution, they are more often defined in national laws. For instance, in Bolivia the Law of the Mother Earth (Ley de Derechos de la Madre Tierra, 2010) presents general rights for all of nature, while in New Zealand and Spain the rights of certain bodies of water have been established through national laws (Kauffman et al., 2025; Rehnstrom, 2025, p. 351). Other cases had RoN established through court rulings (Colombia, India, Bangladesh) and through declarations by Indigenous communities (Fitzroy River, Australia; Magpie River, Canada). However, these cases stand on less clear legal ground: the case of the Ganges and Yamuna rivers has been overturned by the Supreme Court of India, and it is still unclear how the declarations in Canada & Australia will be interpreted in court (Kahui et al., 2024, pp. 7 & 16). Two outliers in the selection of RoN cases are the Victorian Environmental Water Holder (VEWH, Australia) and the Oregon Water Trust (OWT, United States). Here, neither legal personhood nor rights were granted to natural entities, instead non-profit corporations have been set up and authorised to secure and manage water rights to ensure the health of water ecosystems. In that way, they serve as representatives of ecosystems to support their functioning. Even though they are not strictly examples of RoN, we have decided to include them as, firstly, they are part of the study by Kahui et al. (2024), and secondly, they still provide an innovative model of representing nature. Therefore, they serve as valuable comparisons to the other true RoN cases.

What unites most cases is their origin in the struggle against continued degradation of ecosystems that has not been effectively halted by previous environmental policies. The initiators of RoN initiatives are often local & indigenous communities, environmental & human rights NGOs or sometimes individual politicians and officials.

Kahui et al. (2024, p. 3f.) provide categories for the description of models of guardianship. The main differentiation of cases is between those which allow all citizens to take legal action on behalf of nature (Public Guardianship) and those which appoint certain persons or groups to function as legal guardians of nature/natural entities (Environmental Legal Personhood, or ELP). Among those with appointed guardianship we can further distinguish between Direct ELP (guardians speaking directly on behalf of the river) and Indirect ELP (indirect action on behalf of ecosystems, e.g. by reserving water rights for environmental processes). The majority of RoN cases fall under the Direct ELP category, only the cases of the Ecuadorian Constitution and the Bolivian Law of the Mother Earth employ the Public Guardianship model. The two cases of Indirect ELP are the VEWB and the OWT as institutions securing water rights for environmental needs. Thus, they functionally act as guardians, without

articulating a commitment to Rights of Nature. While the Mar Menor Lagoon in Spain has its guardianship divided between three committees, Article 6 of the Mar Menor Act also allows “[a]ny natural or legal person [...] to defend the Mar Menor ecosystem and may enforce the rights and prohibitions of this law” (Mar Menor Act, 2022, p. 134). This case therefore combines both the Public Guardianship and the ELP model.

Value systems

To approach an evaluation of value systems underpinning RoN cases, we focused on what exactly is being protected, which values of nature are implicitly mentioned within declared rights, and how the guardians’ duties are defined. The following analysis groups cases into clusters based on dominant value orientations. These groupings are heuristic rather than definitive — most initiatives draw on more than one value logic, and the clusters are best understood as regions on a continuum rather than discrete categories.

In the majority of our cases, the natural entities protected are aquatic ecosystems (sometimes including their basin). The prevalence of initiatives giving rights to rivers has been noted as a trend within the Rights of Nature movement. This might be due to rivers having a distinct and relatively permanent shape that makes their delineation easier than that of other natural features (Cano-Pecharroman, 2018, p. 6). Apart from that, in New Zealand a mountainous, forested region has been granted rights, and in the two cases with Public Guardianship models, rights have been established for all of nature.

Next, we looked at what values of nature are explicitly named, which relates to the exact rights being granted to rivers. In many cases, values are not explicitly or clearly stated. In 5 of the cases (Spain, Canada, Colombia, OWT, VEWB) the main reasoning for the RoN implementation is the importance of the ecosystem. What needs to be protected is the ecological integrity (VEWB, Australia), the ecosystem and biodiversity which depend on clean water (Colombia), or the general ecological value of a diverse ecosystem (Spain). Accordingly, the rights granted in these cases refer to nature’s rights to evolve naturally, fulfill ecological functions, and to be restored and preserved. The ecological value is stated as the central argument for protection. We therefore call this the Ecological Value Cluster. Because this wording places worth on natural systems themselves without connection to another cause, we assign it to an ecocentric worldview.

In 5 other cases (Bolivia, Ecuador, 2x NZ, Fitzroy River AUS), the ecological or natural values of ecosystems are combined with cultural or spiritual values that connect people and nature. This is the case where Indigenous understandings of the world are explicitly of importance. For example, the Ecuadorian Law of the Mother Earth

is rooted in the belief in a holistic earth system, where the balance of human activities with natural processes is stated as a central principle (Kahui et al., 2024, p. 10; Ley 071 (Ley de Derechos de la Madre Tierra, 2010, Art. 2). 3 of the cases (Ecuador, Bolivia, Fitzroy) utilize similar wordings to the rights declared in the first cluster. In NZ on the other hand, the river and the forest more generally possess “all the rights, powers, duties, and liabilities of a legal person”. This we call the Indigenous Value Cluster and argue that it fits best into the definition of pluricentrism, as it does not value nature merely for its existence and the importance of ecological integrity, but for the complexity of present and ancestral relations between people and their surroundings.

Interestingly, the declaration of the Rights of the Magpie River (CA) – an Indigenous initiative – does not explicitly mention the spiritual or ancestral value of the river. Instead, the same focus on ecology as in the Ecological Value Cluster is prevalent. However, the recreational value of the river for tourism – especially for kayaking – is also given high importance in the declaration. The Magpie River declaration therefore eludes easy classification. Unlike other Indigenous cases in our selection, it is neither explicitly based on ancestral nor spiritual connection to the river, instead combining ecological integrity arguments with recreational and tourism value. This makes it the most genuinely mixed case in our analysis, drawing on both ecocentric and anthropocentric logics simultaneously. This further illustrates that even with Indigenous-led initiatives, the value logics underpinning RoN cannot be assumed from the identity of their advocates alone.

The remaining cases of India and Bangladesh are somewhat unique. In the Indian case of the Ganges and Yamuna rivers the main values recognised were a) the sanctity of these rivers in Hinduism b) the importance of these rivers as water source for 50 % of the Indian population, as an ecosystem service so to say. The court ruling in Bangladesh refers to the river ecosystems as something that needs to be protected, but also about navigability of waters (Kahui et al., 2024, p. 18).

While these value statements could allow us to categorise the cases neatly into anthropocentric, pluricentric and ecocentric, they must be contextualised. Kahui et al. (2024, p. 5f.) have already provided summaries of the emergence of initiatives: Most of them stem from struggles to prevent pollution, exploitation and appropriation of ecosystems. Pollution of the Atrato River in Colombia has repeatedly led to child deaths (Richardson & Bustos, 2023, p. 238); degradation of the Mar Menor lagoon in Spain has led to “ecological death” and a foul smell that has kept tourism away (Kahui et al., 2024, p. 16); and the Magpie River declaration, as noted above, combines ecological and recreational value logics without emphasising the ancestral or spiritual connections typical of the Indigenous Value Cluster. Even if the initiative states only the ecology

or biodiversity value of ecosystems, they emerge from humans experiencing the negative consequences of environmental degradation. What the clustering reveals, therefore, is not that cases belong to fixed categories, but that certain value logics tend to co-occur, and that where they do not, the combination itself points to the political negotiations through which RoN initiatives are shaped

Legitimizing guardianship of nature

As stated before, in absence of its own articulation nature can only be represented by proxy and through epistemic claims. Therefore, we investigated the reasons for why certain guardians and models of guardianship were selected, and whether guardians are making any epistemic claims. In cases of Public Guardianship, there is no specific guardian stated. Instead, any person can take legal action on behalf of nature, making all citizens of the respective country potential guardians. Under the vision of Pacha Mama or Mother Earth which recognises all individuals and elements as kin entwined in complex relationships, all individuals have sufficient connection to their surroundings that would summon a motivation to care for and even sue on behalf of Mother Earth. Belief in the kinship of all beings could therefore serve as the legitimization of public guardianship.

Among the cases with appointed guardians, we identify three sources of legitimacy that are used in varying combinations: Political authority where members of government & administration are appointed; care & connection where Indigenous communities or advocacy groups become guardians; or epistemic authority where scientific expertise is the basis for speaking on behalf of nature.

Many models of guardianship rely on Indigenous communities with their ancestral, spiritual or religious connection to the land or the river as representatives of nature. Indigenous values are seen as being supportive of integrated human-nature- relationships that do not rely on dualist separation of both. Knowledge about interactions with and care for nature passed down for generations supposedly make for a more reflected view of nature beyond exploitation. This we deem representation based on care – the Indigenous mode of interacting with nature is deemed to be in line with the ecological integrity of nature. In the Whanganui River case for example, the river is an integral part of the Indigenous identity, and the rights of the river are intertwined with the rights of the Indigenous Whanganui Iwi (Macpherson & Ospina, 2018, p. 9ff.). Here it also becomes evident how Indigenous guardianship models can represent a pluricentric rather than ecocentric worldview – nature is valued through its connections to generations of Indigenous people and is seen as an integral part of everyday practices. Similarly, the inclusion of the Innu First Nations as guardians of the Magpie River (Canada) is based on the “recognition

of indigenous legal traditions [which] are based on a symbiotic relationship with the land.” (Minganie Regional County Municipal Council, 2021).

Indigenous knowledge is seldom the only knowledge claim made to support the mandate of guardianship. It may be supported by some form of scientific advisory, experience in environmental management and in working with Indigenous communities. Sometimes guardianship comes in the form of government officials and their expertise in (environmental) governance.

The most comprehensive model of guardianship has been enacted with the Mar Menor Act in Spain where guardianship has been divided between three councils:

“a Committee of Representatives composed of competent representatives of the Public Administrations and the public of the coastal municipalities; a Monitoring Commission (the guardians of the Mar Menor Lagoon) and a Scientific Committee comprising an independent commission of scientists and experts, universities and research centres.” (Mar Menor Act, 2022, Art. 3)

In this distribution we can find all forms of legitimising guardianship stated earlier:

1. Environmental policy as a political matter—representation through elected guardians
2. Representation through care – a Monitoring Commission where members are selected based on previous involvement in advocacy for the lagoon.
3. Guardianship based on epistemic claims – scientific findings on the health and restoration of the ecosystem.
In other cases, not all these legitimations are combined. The commissioners of the Victorian Environmental Water Holder present themselves as capable guardians because of their experience in governance and business management as well as in working with Indigenous communities, implying a care for the land influenced by Indigenous worldviews (VEWH, 2025). The Atrato River Case in Colombia established two guardians – one appointed by the government, one by the local advocacy group of the Indigenous and Afro-Colombian community. Additionally, an advisory group formed by the Humboldt Institute and WWF Colombia (Atrato River Act, 2024, Art. 4). Ergo, legitimisation of guardianship here is a combination of political responsibility, care, and scientific knowledge. Only few cases rely solely on political responsibility as legitimisation of guardianship. These are the court rulings in India and Bangladesh that established rivers as living and legal persons and declared members of the government as legal guardians (Kahui et al., 2024, p. 7). This foundation of guardianship can be problematic because governments change with legislative periods and epistemic claims about the rivers can depend on the political stance of the representatives. Accordingly, the case in India has been overruled because of unclear definitions of guardianship and liability (ibid.).

To summarise, only the cases in India and Bangladesh rely on one type of legitimisation of guardianship. This suggests an implicit recognition that no single actor can legitimately claim comprehensive knowledge of or authority over nature’s interests. It also shows that even in RoN cases remain a political process of individuals and groups formulating their visions and strategies for better environmental outcomes – the framing as RoN mainly allows a change in the framing of environmental policy, altering the weighting of arguments.

4 Discussion

Representation and the Limits of Proxy Authority

This study asked who is entitled to represent nature in RoN cases and how such representation is legitimised. Our comparison shows that RoN initiatives do not eliminate the fundamental problem that nature cannot authorise its representatives. Instead, they institutionalise different combinations of political authority, epistemic expertise, and relational care as substitutes for authorization.

As Lawrence (2022, p. 554) notes, representation of nonhuman entities must necessarily be by proxy. Similarly, O’Neill (2001, p. 497) argues that speaking on behalf of nonhumans requires “epistemic claims, coupled with care”. In the cases examined these two dimensions repeatedly appear as sources of legitimacy. Indigenous groups can appoint guardians themselves justified through claims of ancestral connection and responsibility toward the land. Epistemic claims for the functioning and well-being of ecosystems are sources of legitimacy for scientific advice being included in models of guardianship, e.g. in Spain, Colombia, Oregon.

One must acknowledge that these are all limited sources of legitimisation and that given the inability of nature to authorise representation, representing nature remains contestable (O’Neill, 2001, p. 497). What our cases demonstrate is not the solution to this problem, but rather varying strategies for managing it. Models that combine multiple forms of legitimacy—such as the Whanganui River, the Atrato River, or the Mar Menor—appear institutionally more robust than those relying solely on governmental appointment, as in India and Bangladesh.

Indigenous guardianship and the risk of essentialism

RoN cases draw heavily on Indigenous knowledge systems to legitimise guardianship. These cases often emphasise pluricentric worldviews in which humans and nature are understood as interconnected and valued through their intertwinedness. Such framings support the claim that Indigenous communities possess particular competence to represent natural entities.

Yet the way this mode of legitimization is adopted within legal and political frameworks carries the risk of reproducing essentialist narratives. When RoN initiatives justify Indigenous guardianship primarily on the basis of an assumed inherent harmony with nature, they risk reproducing the trope of the "Ecologically Noble Savage" (Rodrigue-Allouche, 2015, p. 6), thereby echoing the colonial myth of the Noble Savage. Therefore, while Indigenous guardianship often brings valuable relational knowledge and care, external framings that treat it as ontologically superior or inherently more authentic risk essentialising Indigenous peoples and forcing them into a predetermined role. Indigenous guardianship still operates within political and legal institutions and is itself embedded in negotiations of power. Recognizing this prevents RoN from becoming a depoliticised narrative of harmony and instead situates it within broader struggles over land, sovereignty, and environmental governance.

Rights of Nature as Political Process

The distribution of guardianship across multiple stakeholders demonstrates that RoN does not replace political authority over nature with ecocentric governance. Rather, it restructures political processes. Because the needs of nature must be articulated by guardians, and because guardians often represent different interests, the interests of nature become politically contested. RoN therefore does not replace political power over nature with self-determination, but it shifts weight of varying interests and claims on how humans should interact with nature (Petel, 2024, p. 14).

As Tanasescu argues, "the question of who has the power to represent a nature with rights is central to understanding their potential" (Tanasescu, 2022, p. 16), and that RoN are "about creating new relations through which environmental concerns may be differently expressed" (ibid, p. 17). Our cases illustrate that initiatives often spring from local communities which are being harmed or endangered by environmental degradation. Arguing for RoN strengthens the normative weight of environmental claims against polluting and harmful activities. Examples are the Atrato River case where polluted water had led to the death of 34 children and poisoned many others, and the Fitzroy River declaration stating concerns about "extensive development proposals" (Traditional Owners of the Fitzroy catchment, 2016, p. 1) and their impacts.

Thus, RoN should be understood less as the legal recognition of intrinsic value alone and more as a reconfiguration of political authority. It formalises new relations between communities, states, and ecosystems and alters the balance of justificatory power in environmental decision-making. This insight strengthens our central claim: RoN does not resolve the problem of representation but reorganises how representation is structured and legitimised.

Parallels to justice of future generations

The normative instability of representing nature parallels debates about representing future generations. Like nonhuman entities, future persons cannot authorise representatives or be present in decision-making processes. As O'Neill observes, "the central problem is that for many of those affected by decisions, two central features of legitimisation – authorisation and presence – are absent. [...] Given the limited sources of legitimacy [...] the contestability of claims [...] are I suspect ultimately ineliminable" (2001, p. 497).

Interestingly though, some argue that interests of future generations – a group that also cannot be represented in a legitimate way – coincide with those of nonhuman entities. But in contrary to interests of non human entities, those of future generations can be represented without ontological controversy: "[...] It is sufficient to define the demands of intergenerational justice as a duty to ensure that persons born in the future enjoy core human rights to health, life, and subsistence" (Lawrence 2022, p. 559) – human rights which are well established in the international order. In contrast, representing nonhuman entities requires expanding the moral and legal community. The epistemic and normative basis for such representation remains more controversial. While ecological justice arguments emphasise intrinsic value, these claims lack the same institutional entrenchment as human rights discourse.

This comparison clarifies both the promise and fragility of RoN. It suggests that while ecological and intergenerational justice may converge in practice—since protecting ecosystems often benefits future humans—their normative foundations differ significantly. RoN therefore operates in a more contested normative terrain.

Worldviews and Political Struggles

Finally, our findings relativise the importance of explicitly stated worldviews. Although ecocentric, anthropocentric, and pluricentric wordings can be identified in legal texts, RoN initiatives often emerge from concrete struggles against environmental degradation. Communities mobilise RoN not merely to express philosophical commitments but to gain stronger legal standing against harmful activities. In cases such as the Atrato River or the Fitzroy River declaration, the recognition of nature's rights strengthens political resistance to pollution and extraction. The adoption of relational or intrinsic value language enhances the normative force of these claims. Yet the underlying dynamic remains political: actors use RoN strategically to reshape legal and institutional power relations.

Thus, worldviews matter not only as philosophical orientations but as resources within political struggles. RoN provides an alternative lens through which environmental conflicts can be reframed and renegotiated.

5 Conclusion

This paper examined who represents nature in Rights of Nature initiatives and how such representation is legitimised. Our analysis shows that RoN does not resolve the fundamental problem that nature cannot authorise its representatives. Instead, it institutionalises new configurations of legitimacy by recognizing political authority, epistemic expertise, and relational care as grounds for speaking on behalf of nature. In doing so, RoN shifts environmental governance from a framework centred primarily on property and state authority toward a more pluralised political process in which different actors compete to define and articulate nature's interests.

Although Rights of Nature initiatives are often presented as a departure from anthropocentric legal frameworks, our findings suggest that they do not transcend the political and normative challenges of representation. Nature still requires human proxies, and its interests remain subject to interpretation and contestation. Yet this does not render RoN a merely symbolic shift toward ecocentrism. Rather, it indicates that RoN operate within political institutions while expanding the range of actors and justifications through which environmental claims can be articulated.

In doing so, RoN reshapes environmental governance without depoliticizing it. Whether these institutional innovations will lead to more effective environmental protection remains an open empirical question and requires continued monitoring of implemented cases. Developments such as the Mar Menor initiative in Spain

suggest that RoN is not confined to specific Indigenous or post-colonial contexts but may increasingly influence environmental debates in Europe and beyond. The long-term significance of Rights of Nature will therefore depend less on their symbolic departure from anthropocentrism and more on how their guardianship structures operate in practice.

At the level of institutional design, our findings suggest several lessons relevant to public administration. First, clearly defined roles and responsibilities for guardians – as seen in the New Zealand acts and the Mar Menor model – appear to support more effective and accountable governance than models that delegate guardianship to government officials without further specification, as in India and Bangladesh. Second, distributing guardianship across multiple actors with different sources of legitimacy (political authority, scientific expertise, and community care) appears to reduce dependence on any single institution and makes guardianship more resilient to political change. Third, and most broadly, RoN initiatives demonstrate that environmental interests can be institutionalised within existing public legal frameworks without requiring a fundamental departure from established governance structures. Whether these institutional arrangements translate into measurably better environmental outcomes remains an open question, but the design of guardianship, meaning who holds it, on what grounds, and with what responsibilities, is where the practical significance of Rights of Nature is ultimately decided.

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Michael Getzner ist Universitätsprofessor für Finanzwissenschaft und Infrastrukturökonomie am Institut für Raumplanung, TU Wien. Seine Forschungsschwerpunkte umfassen Finanzwissenschaft, Infrastrukturökonomik, Ökologische Ökonomik und Kulturökonomik.

Tommaso Gimelli

Tommaso Gimelli is a Project Assistant and PhD candidate at the Department of Public Finance and Infrastructure Policy (TU Wien), where he works on transformative climate adaptation in European mountain regions within the Horizon Europe MountResilience project. His research uses comparative survey methods and experimental scenario design to study public support for adaptation finance, with particular attention to contribution rules, governance arrangements, trust and perceived legitimacy. He combines quantitative analysis, policy-oriented writing and impact-assessment work to examine how adaptation policies can be designed, financed, evaluated and communicated across diverse regional contexts.

Jonas Gurman

Jonas Gurman studiert Raumplanung an der Technischen Universität Wien. Aus seinem Bachelorstudium der Geographie bringt er ein Interesse an Gesellschaft-Umwelt-Verhältnissen und deren räumlichen wie diskursiven Manifestationen mit, das auch die vorliegende Arbeit geprägt hat. Daneben sammelte er praktische Erfahrung bei der Stadt Innsbruck und der Mobilitätswerk GmbH, wo er an der Entwicklung von Fuß- und Radverkehrsstrategien mitwirkte.

Rebecca Hauschild

Rebecca Hauschild holds a master degree in political sciences. Currently she is a pre-doctoral researcher at the Centre for Public Finance and Infrastructure Policy at the Department of Spatial Planning of the TU Vienna.

Anna Franziska Kalhorn

Dlin Anna Franziska Kalhorn ist als Projektassistentin am Forschungsbereich Finanzwissenschaft und Infrastrukturpolitik der TU Wien tätig und forscht vorwiegend zu Fragen der sozial-ökologischen Transformation und den sozial-räumlichen Auswirkungen des Klimawandels. Sie hat Raumplanung an der TU Wien sowie Sozioökonomie an der WU Wien studiert

Yanik Kieser

Yanic Kieser studiert zuerst im Bachelor und nun im Master Raumplanung und Raumordnung an der Technischen Universität Wien. Er bewegt sich zwischen konventioneller Planung und angewandter Kunst, wo er versucht neue Verbindungen zu finden und herzustellen, mit einem Fokus auf öffentlichen Räumen. In der Praxis setzte er dies in verschiedenen Projekten der Kuration und Produktion von Kulturveranstaltungen um. Zuletzt war er als Mitglied des Teams der Stadtkuratorin Leipzig an Projekten in unterschiedlichen räumlichen Kontexten beteiligt, die sich auf Kulturproduktion und kritische Denkmalpflege im öffentlichen Raum konzentrierten.

Tatjana Neuhuber

Tatjana Neuhuber ist Senior Scientist am Forschungsbereich für Finanzwissenschaft und Infrastrukturpolitik am Institut für Raumplanung. Ihr wissenschaftliches Interesse gilt sozialer und räumlicher Ungleichheit sowie der Frage, wie soziale Infrastrukturen positive Veränderungen bewirken können. Mit ihrer Arbeit verbindet sie theoretische Ansätze mit praxisnahen Analysen, um greifbare Lösungen für gesellschaftliche Herausforderungen zu entwickeln.

Anna-Theresa Renner

Anna-Theresa Renner ist Associate Professor am Forschungsbereich Finanzwissenschaft und Infrastrukturpolitik des Instituts für Raumplanung an der Technischen Universität Wien. In ihrer Forschung beschäftigt sie sich vor allem mit regionalen und räumlichen Variationen im Zugang zur Gesundheitsversorgung, und den Effekten einer ungleichen Verteilung von Gesundheitsdienstleistungen auf die Bevölkerungsgesundheit und die Patient*innenmobilität.

Antonia E. Schneider

Antonia Schneider ist Post-Doc Forscherin und Universitätsassistentin am Forschungsbereich für Finanzwissenschaft und Infrastrukturpolitik am Institut für Raumplanung. Ihre Forschungsschwerpunkte umfassen die Analyse wirtschaftlicher Ungleichheiten, den Wohnungsmarkt sowie umweltökonomische Fragestellungen. Ihr wissenschaftlicher Ansatz ist dabei stark quantitativ ausgerichtet, mit besonderem Fokus auf die Analyse raumbezogener Daten, Kartografie und ökonomische Bewertungsmethoden.

Elham Eslampanah Sendi

Elham Eslampanah Sendi macht derzeit ihr Masterstudium in Raumplanung und Raumordnung an der TU Wien. Ihre fachlichen Schwerpunkte umfassen räumliche Analysen, Verkehrsplanung sowie die Integration erneuerbarer Energien in die räumliche Entwicklung. Sie interessiert sich vor allem für innovative und nachhaltige Konzepte in der Raumplanung.

