Designing Devolution

Extraction Infrastructure Transformations for a Post-Capital Norrbotten

KIRTHAN SHEKAR

Designing Devolution

Extraction Infrastructure Transformations for a Post-Capital Norrbotten

Kirthan Shekar

[5524482]

MSc Thesis

Mentors

Nikos Katsikis

Taneha Kuzniecow Bacchin

2023/2024: Graduation Lab

Transitional Territories Studio

MSc: Architecture, Urbanism, and Building Sciences

Track Urbanism

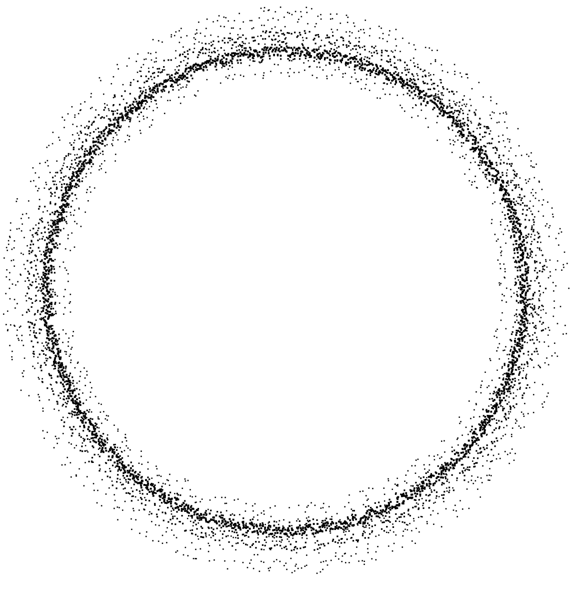
Faculty of Architecture and the Built Environment

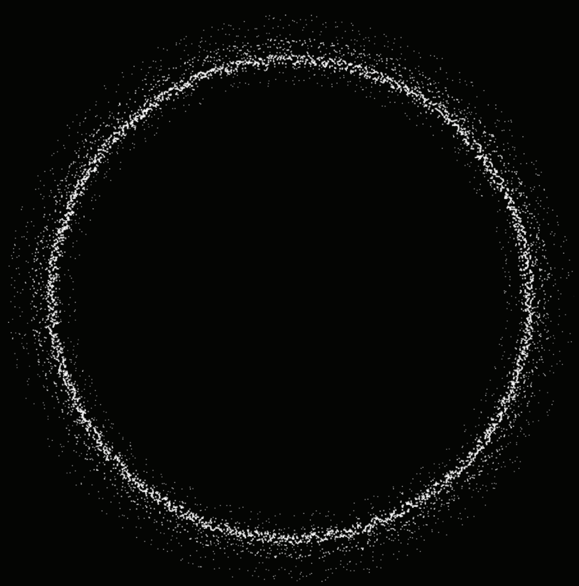
Delft University of Technology

24 June 2024

This report is submitted for completion of the graduation thesis project in the Transitional Territories Studio.

All images, diagrams, and graphics are created by the author or are in the public domain, unless stated otherwise. Sources for additional data are mentioned within the page and at the end of the report.





“Nature, no longer a passive substance upon which humanity leaves its footprint, becomes an active bundle of relations <u>formed and re-formed</u> through the historically and geographically specific movements of humans with the rest of nature.”

— Jason Moore

Abstract

This thesis explores the post-extraction potentials of Arctic infrastructural landscapes, focusing on Kiruna and the Norrbotten Technological Megasystem, to propose a transformation towards a post-capital landscape of co-existence. It interrogates the historically mono-functional, sacrificial, and determinate nature of these landscapes, emphasising the need to rethink extraction practices and their socio-ecological impacts. Combining design theory, political ecology, and economic geography this study articulates transformation strategies that couples sacrificial and repair processes, decentralises control to empower local and indigenous communities, and introduces indeterminacy to accommodate ecological and social uncertainties.

The research posits that by reconfiguring the spatial logic of extraction infrastructures through their post extraction transformation potential (post-project), it is possible to devolve power, regenerate nature-cultures, and most importantly foster interdependencies and ecodependencies which can guide and regulate anticipated extraction (anti-project). The thesis presents a meta-project that scales these principles to the broader Norrbotten region, advocating for a devolution of control that encompasses economic, ecological, and social dimensions and use spatial production and accumulations as a guide to the territorial transformation.

Ultimately, the thesis contributes to the discourse on post-capital futures, offering insights into the role of design in mediating between extraction practices and the material manifestations within affected landscapes. It calls for an epistemic shift towards viewing human and nature as dialectic, advocating for a co-produced future that respects both ecological integrity and cultural heritage in making the landscape of co-existence.

Acknowledgements

I am profoundly grateful to everyone who made it possible in the making of this project.

First and foremost:

Nikos Katsikis, my first mentor who has been a constant and challenging inspiration for showing unlimited directions that the project could take while at the same time keeping me in focus with his emphasis on design logics and love for critical cartographies.

Taneha Bacchin, my second mentor for continuously enriching critical approaches by installing methods of care in design research through her experience and curiosity in critical theory and Arctic landscapes, besides her humility, which teaches me more.

Special thanks to:
Vera Vince, for the keenness in the Arctic and critical, engaging, and reflective conversations, along with the constant 'yapping'.
Nancy Nguyen, for being the support system and repeatedly taking time to study the project and reflect with me.
Tim van Oospronk, for his shared interest in extraction landscapes and for studying with me everyday (almost everyday).
Harit Naik, for his constant support in ideating and helping me with the models.
Kim Schneider, Merel Garristen, Serah Bremer, Lorenzo Novajra and **Ariana Valcarcel** for their uplifting yet calming presence, with a lot of tea.
Transitional Territories Studio peers and teachers who I could learn a great deal with and from.
Polis Study Associaton, for organising the Big Trip and making it possible to travel to the Arctic through funding opportunities.
Big Trip Documentary Collective of 2024, for creating a film on Kiruna with a critical lens and providing a space to make supplementary material that could support my thesis.
Berta Flaquer, for taking time to introduce me to the ways of life of the Sámi community through her eco-feminist approach.
Nils Joel Partapouli, for sharing with me and the documentary collective about the Sámi worldviews and indigenous conflicts.
Valeria Federighi, for providing me an opportunity and writing with me and Taneha about Kiruna as a landscape of narratives.
Neha Harish, for the shared design ideologies, support and push, although living in the other side of the globe.
Madhuri Rao, for being the teacher who installed the critical approach to design since my undergraduate architecture years.

Last, but not least:
Sumathy Shekar and **Shekar Nanjaiah**, my parents for their unconditional support in the production of this thesis and supporting me in times of distress, directly and indirectly, and also my sister and friend, **Chaitanya Shekar**, for sharing an experience of graduating together.

All in all, with this heartfelt gratitude, I dedicate this graduation thesis to those who believed in me when I didn't believe in myself.

Contents

The motivation of the thesis is to unpack the paradoxes of green transition and wilderness territories. It tries to disclose the historical and continued extraction processes in the Arctic landscape that have been continuously altering its natural and cultural composition. Personally, having been exposed to dense tropical landscapes, an additional motivation is to use this thesis as an opportunity to learn about unfamiliar landscapes. The global conversation about the future of the Arctic is an important geopolitical one. The subject rose from the eagerness to understand more-than-city and more-than-human processes that characterise extended urbanization. I have been interested in understanding the ontological and epistemological notions of what is urban, where the urban ends, and the difference between the urban and the city. Extended urbanisation, particularly the extractivist projects, has always challenged the idea of the green, and the increased demand for critical raw materials will continue and, moreover, increase the creatively destructive cycles of extraction and the socio-ecological conflicts in the extraction territories. I am using this thesis to experiment with the disclosure of these conflicts and alterations in the design of a post-extraction project. It simultaneously explores, on the one hand, what happens after extraction and, on the other hand, how post-extraction potentials can inform the spatial design of the extraction landscapes. I intend the project to question the concept of design and its agency in mediating between the practice of extraction in the planetary dimension and the material manifestation in the fabric, building, and object. Understanding political ecology, (critical) design theory, and its relation to the ontology of things would help in rethinking the landscapes of extraction from the perspective of post-extraction. These questions motivated my choice of the graduation studio and my mentors. Often considered a wilderness and an extremely changing landscape, the biophysical composition of the Arctic is rapidly changing, which challenges the notion of conservation of these sensitive landscapes with opportunities for increased resource extraction potential in these territories. In this regard, I intend to use the thesis to explore how post-extractivist thinking can be a form of conservation and co-production of nature and culture itself.

Introduction

Arctic as an Operational Landscape, where more-than-city processes form the conditions for urbanisation, is primarily seen through the extraction potentials and shifts, emergence of oceanic trade routes, and production of nature. The Arctic hinterland is a product of the metabolic rift, where the rift between the social metabolism (demand dynamics) and the ecological metabolism (supply dynamics) creates conditions for the exploitation and accumulation of capital and infrastructure (Moore, 2014). The geopolitics of these rifts allowed for high infrastructuralisation currently seen through instances of transpolar sea routes and the race for Arctic resources, and historically through the colonisation of Svalbard for coal and the colossal mining of iron in Kiruna. Techno-extractive logics are capital- and knowledge-intensive and have provided and still provide grounds for increased geopolitical tensions. The ecological surplus in the Arctic is therefore commodified and exploited, forming reciprocal landscapes for consumption in the world-city and creating an unequal accumulation of capital and geography. Thus, the formation and reformation of the Arctic hinterland go through constant creative destruction, creating conditions for differential urbanisation (Brenner & Schmid, 2011). The externalities of this urbanisation have a high impact on the perception of the wilderness of the Arctic. But also, this urbanisation calls for the world-city as a hinterland, as accumulating capital and infrastructure also accumulate knowledge, scientific, and cultural development (André & Baumard, 2020; Sörlin, 2023).

One such instance of extractivism in the Arctic is Kiruna, a mining city that has the reputation of having the world's largest underground iron mine (LKAB, 2023a). Located about 200 km north of the Arctic Circle, this Swedish town historically has a reputation for the intensity of production, urban transformation, and conflicts with indigenous Sámi land practices. The operational 150-year-old mine of Kirunavaara with a current depth of 1365m for iron ore is currently estimated to produce up to the year 2048 (LKAB, 2022; MDO, 2023). While this cycle of extraction slowly reaches its end, the recent discovery of an increased concentration of rare earth elements (REE) and phosphorus (P), in addition to the iron in the Per-Geijer deposit, continues to place Kiruna on the world map for its critical resources. Although there has been a proposition for a moratorium on all extraction practices in the Sápmi—indigenous lands of the Sámi community (Swedish Sámi Parliament, 2014), these minerals are integral to the European economy and the green transition, and the debate of green colonisation continues. The new mine is planned to start production in 2038, starting a new cycle of extraction (LKAB, 2023b). The historical and geographical accumulation of the capital and global infrastructure for the operationalisation of Kiruna and the neighbouring iron mining settlements forms the territorial project of the Norrbotten Technological Megasystem (Hansson, 1998 in Sjöholm & Luciani, 2019), which stretches from the Arctic Ocean to the Bothnian Bay. The extraction in the territory is operated by the Swedish state-owned company LKAB which supplies more than 80% of Iron Ore for Europe.

Extractivism projects have been envisioned as determinate, monofunctional and sacrificial landscapes with the following post-extraction repair as an act of giving back to nature-cultures – by the decommission and decay of the extraction infrastructures and 'giving back' to the indigenous communities, or 'restoration' of the ecological disturbances (Sörlin, 2023). LKAB, responsible for the damage caused, is also responsible for the repair, economic development, and urban transformation of Kiruna. However, the historical infrastructural accumulation in the territory and the anticipation of the new mine present Kiruna and the supporting megasystem as an opportunity to envision the post-extraction transformation capacities of the systemic components of extraction for socio-ecological regeneration by hybridizing the actions of sacrifice and repair. This requires an epistemic shift from the concept of human-and-nature dualism to human-in-nature dialectic (Moore, 2014), thinking in the terms of nature-cultures (Harraway, 2008), and common worlds (Latour, 2017).

Derelict funicular line for coal transportation in Longyearbyen
[Photograph by Shaun O'Boyle]

Tailing piles in Longyearbyen
[Photograph by Shaun O'Boyle]

Ground caving due to underground mining in Kiruna
[Photograph by Lennart Durehed - Arkdes, 2019]

Moving buildings in Kiruna
[Photograph by Jessica Nildén - Arkdes]

Problem Statement

Arctic extractivism projects have historically been conceived acts of colonisation of nature-cultures generating, sacrificial and monofunctional landscapes.

The repair and diversification of these sacrificial landscape is a post-extraction process and this reflexive rationalisation of extraction through repair tends to normalise the socio-ecological destructive act.

There is a need to envision the infrastructural landscape through their post-extraction potentials for socio-ecological regeneration simultaneously during the design and operationalisation of critical extraction processes.

Research Question

How can post-extraction potentials inform the design agency to transform Arctic infrastructural landscapes towards a post-capital landscape of co-existence?

Sub-questions

[SQ1] How can post extraction transformation of the current mine create a spatial logic to devolve power and regenerate nature-cultures?

[SQ2] How can the new spatial logic inturn inform the mining of the anticipated deposit?

[SQ3] What are the spatio-temporal limits of this new logic in the process of the devolving the Norrbotten Technological Megasystem?

Elaboration

The case of Kiruna and the Norrbotten Technological Megasystem is expanded upon throughout the thesis in order to differentiate the primary research question. The purpose of this is to provide further explanation regarding the necessity of utilising various levels of understanding to provide inferences to the primary research question.

[SQ1]

The post-extraction transformation potential of the currently operating mine and its relation to the city of Kiruna is the focus of the first sub-question. Understanding the elements of the extraction apparatus, and processes that create and enable reparative processes, as well as their socio-ecological consequences would be necessary to develop the spatial logic for devolution to contest the monofunctional, sacrificial and the determinate nature of extraction landscape in the making of the landscape of coexistence.

[SQ2]

The aim of the second sub-question is to understand the spatial implications of the spatial logic and design the proposed mine in anticipation of the socio-ecological conflicts. It is required to demonstrate the temporal dynamics of the new spatial logic reacts to seasonality and regulation of the socio-ecological processes.

[SQ3]

The third sub-question aims to upscale the proposed spatial logic to understand the spatial implications in the process devolution of the extraction infrastructures at the territorial scale of the Norrbotten Technological Megasystem.

Hypothesis

The perspective of post-extraction potential to create conditions for spatial formations for extraction operations would result in a more sensitive and careful approach to extraction projects. To accomplish this, the spatial transformations would need to demonstrate a response to the dynamics of time. My position is to stop mining in Kiruna after the extraction cycle of the Per Geijer deposit and this will help in the transformation of the territory towards post-capitalism
The response of infrastructure landscapes to both natural and social processes results in a hybridisation of damage and repair through actions that could add multi-functionality, socio-ecological regeneration, and programmatic indeterminacy. To alter the infrastructure's function along time and generate new conditions after its functional tenancy, regulating actions entail strategising and modifying the infrastructure. The generated spatial logic provides the opportunity to react to different uncertainties. The rate of technological development and creative destruction processes seek for the transformation principles to be dynamic, which can allow for the landscape infrastructures to adapt to seasonality for its regulation. This design experimentation of hybridising repair and temporal manipulations can lead to the outcome of formulating a protocol of care to devolve extraction infrastructure at different scales. This formulation necessitates the design experiments and speculations necessary to envision a spatial logic to diversify (re)productive functions, modify economic hierarchy, and decentralise political agency. At the territorial scale, the spatial logic can repurpose the fixed capital accumulated in the form of infrastructure and the social reproduction in the form of cities—schools, hospitals, public spaces, etc.—for reducing the pressure on the landscape and creating conditions for coexistence—settlers and indigenous communities, human and more-than-human, social and ecological.

Methodology

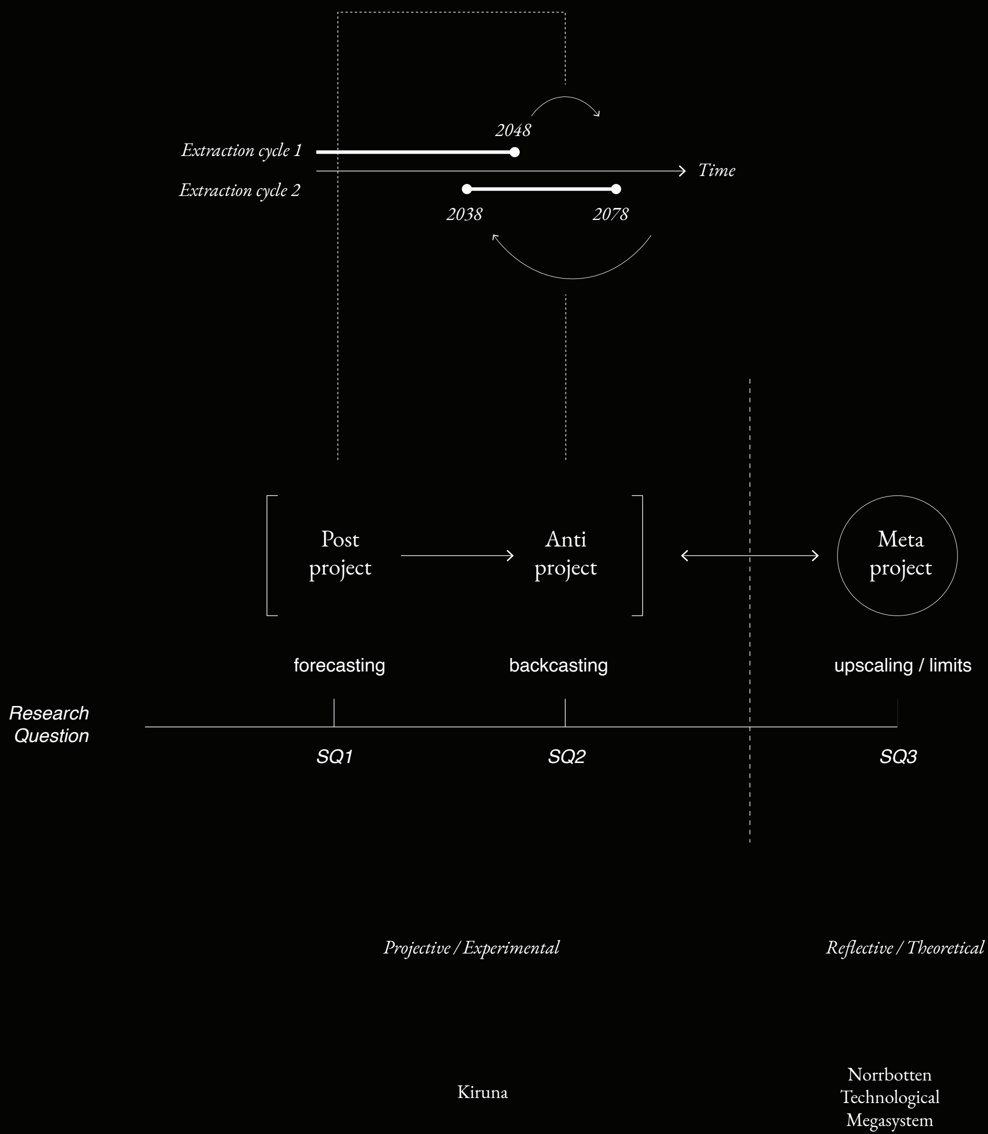
The thesis is framed in the aspects of extraction landscapes being devoid of social integration in addition to the environmental implications because of the dominating agencies of corporation backed by the economic significance of the land use. Research by design in the project would be used as a method to transform and re-realise the potential of the accumulation of fixed capital in the territory through devolution of agencies as an act of decentralising, diversifying and giving back to nature-cultures. Thus, the main disciplines informing the thesis are landscape morphology, political ecology and economic geography. The critique is backed by environmental history and humanities as the design strives for a post-capital transformation of the territory.

Project Framework

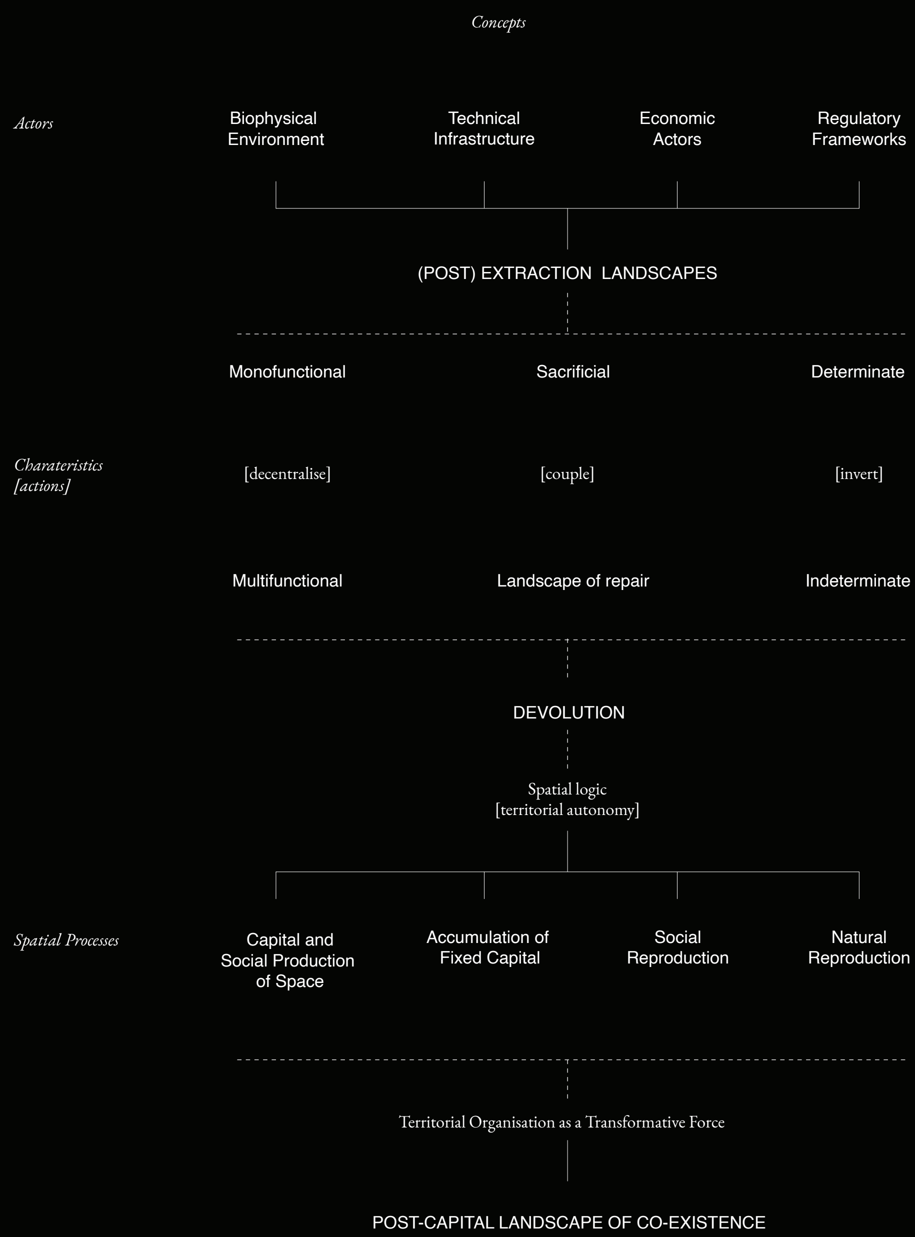
The project uses Kiruna as a case to understand the spatial implications of green transition/ minerals, presence/absence of indigenous communities, conflicts in land practices, climatic crises, geopolitics, and the associated potential for increased urbanisation. The current situation of Kiruna, with the plan of the closure of one extraction cycle and the anticipation of a new extraction cycle, is the basis of the project framework where design is used as an analytical method.

The closing extraction cycle (to 2048) can be used to investigate SQ1, where the post-extraction transformation potentials of the current mining infrastructures and the altering environment around them are formulated as a Post-Project. This project forecasts the ecological, social, and economic dimensions of the current mine and the supporting infrastructure to envision spatial logic to devolve the agencies, ecologically rehabilitate for social integration. The anticipated mine, which is scheduled to start operations in 2038, will be used to explore SQ2. The spatial logic of devolution of envisioned in the post-project structures the social programming of the anticipated mine creating a new paradigm. This backcasting forms the Anti-Project. In this process, the methods of synchronous and chronological actions are tested.

Since the extraction landscapes are a part of the larger territorial system called Norrbotten Technological Megasystem , the spatial logic is upscaled to devolve NTM the at the geographical scale. This forms the Meta-Project exploring the SQ3 where the limits of the spatial logic is tested – with the dimensions of time and space. The meta-project is theoretical and reflective and focuses on overlap of economic geography and urban design.



Project framework



Conceptual and theoretical framework

Theory

Operational Landcapes
Planertary Urbanisation

Brenner, N, Schmid, C & Katsikis, N

Post Extractivism
Gudynas, E and Sörlin, S

Infrastructural Landscapes
Technical Lands
Belanger, P and Waldheim, C & Nesbit, J

Constructs of Time
Braudel, F and Heringman, N

World Ecology
Moore, J

Space-Technology Nexus
Swyngedouw, E

Post Capitalism
Harvey, D

Discipline

Landscape Urbanism
Spatial Morphology

Economic Geography
Political Ecology

Environmental History
Environmental Humanities

Conceptual Framework

Actors of Extraction Territories

Biophysical Environment – includes more-than-human actors like the geographical features such as geological deposits, topography, climate and the domesticated animals – reindeers and biodiversity.

Technical Infrastructure – includes the mining apparatus with the systems of logistics.

Economic Actors – include the primary actors of the state-owned mining company / corporation (LKAB) and the conflicted indigenous community (Sámi) and ancillary economies like tourism, trade and knowledge which are dependent or support the production economy.

and **Regulatory Frameworks** – includes the local governance bodies Kiruna Kommun (municipality), Norbotten Ian (county), Swedish Sámi Parliament, European Commission Internal Trade, Swedish Environmental Agency, Swedish State

Characteristics of Extraction Territories

Functionality – Extraction territories are monofunctional due to the technical specificity. The post-extraction design aims to overcome the monofunctionality to diversify the programme of the landscape.

Sacrifice and Repair – Extraction landscapes are sacrificial with the actions of repair decoupling time and space of damage and repair. Post-extraction landscapes aim to couple the actions by terraforming – creation of habitat and terrain, and degrowing to reduce the pressure on the landscape. The biophysical environment also affects the social processes that depend on it. The indigenous Sámi community was primarily a reindeer-hearing nomadic community. The colonisation for resource extraction affected the natural and social land practices, causing social conflicts.

Determinacy – In conception, mining cities and territories are determined by the production activity of the singular mining company, labour demand and supply and accessibility making them determinate landscape. But this character allows for accumulation of population and social reproduction in the form of ancillary spaces such as public spaces, schools, recreational facilities which are indeterminate. In the extraction territories the determinate landscape dominates the indeterminate. The thesis aims to invert and test the agency of the indeterminate interfaces to guide spatializing extraction.

Spatial Processes

Capital and social production of space – by formation of territories by appropriating the landscape for extraction.

Accumulation of fixed capital - through spatial concentration of infrastructures for extraction, logistics, accessibility and support.

Social Reproduction – through processes that ensure the continuation of societal structures and relationships to sustain communities and the ways of life, health and well-being

Natural Reproduction – the processes of repair of the extraction territories to aim towards restoring the ecological performance of the landscape

Devolution

In governance terms, **devolution** refers to decentralizing power from the higher authority to the lower administration bodies. In the thesis, the extraction infrastructure itself can be decentralised as an act of giving back to empower local communities and economies, decentralizing decision making, enhancing collaboration and economic reconfigurations. Devolution is the guiding theme for the spatial logic of the post-extraction, post-capitalism design experiments where the infrastructures enable coexistence and support the decentralized governance and local management.

Territorial Autonomy

This refers to the degree of self governnace and self-organisation that allows for the community to control their own affairs. The concept in the devolution involves *decentralisation* of LKAB, decentralising power, framing post-extraction landscape management and increasing the degree of territorial autonomy in the extraction territories. It includes the concepts of *stewardship* and *commons.*

Theoretical Framework

Planetary Urbanisation + Operational Landscapes

In ‘Towards a New Epistemology of the Urban?’ Brenner and Schmid (2015) summarise their ideas of emergent planetary urbanisation by developing on Lefebvre’s (1970) ontological study. The main premise of this study, ‘The Urban Revolution', is that the world is completely urbanised. Planetary Urbanisation defines its theories on the thesis that urban growth is observed in non-city spaces—the hinterlands in addition to the concentrated cities. Due to the growth and dependencies, these hinterlands undergo social, economic, ecological, and infrastructural transformations to support the socioeconomic processes in the concentrated urban, forming three moments of urbanization: concentrated, extended, and differential urbanisation (Brenner & Schmid, 2015) Operational Landscapes (Brenner & Katsikis, 2020) explain the need for understanding urban development as a multi-scalar tissue that requires an understanding of non-city dynamics. The externalities of the process of urban growth in which cities are concentrated centres of consumption where production and logistics have spatial and social repercussions on the hinterlands (ibid.). There are three systems in planetary urbanization: (i) systems of primary commodity production, (ii) systems of extraction, and (iii) systems of logistics. Although this thesis primarily discusses the systems of extraction, all three systems are interdependent as they form the territorial fabric of urbanisation. Operational Landscapes discusses the spatial and temporal dynamics and dependencies of more-than-city urbanisation. The theory can be used to understand the systems of extraction and the processes that make or remake them.

(Post) Extractivism

The conditions for defining extractivism by Gudynas (2021) are referred to in formulating the project. According to him, extractivism is defined by the (i) high volume or intensity of extraction, (ii) little or no processing of the raw materials at the site of extraction, and (iii) exportation of more than 50% of the resources (Gudynas, 2013, 2021). He also defines predatory extractivism as the one that results in ecological amputation enclaves, which are large geographies that have little to no remediation to their original ecological state. Mining is a direct mode of extractivism from the environment, where the ecological processes are not modified beforehand to extract the surplus; instead, the extraction is in its raw form. These three extractivisms are observed in Kiruna. The mining in Kiruna is operated by the national mining company (LKAB), the management and access are controlled by the government. This allows for the operating costs to be higher than for private entities. But environmental performance is highly variable. Although Gudynas’ (2013, 2021) work discusses the politics, economy, and ecologies of extraction in the global south, the defining conditions and observations are applicable in the Arctic to understand extractivism modes and the transition conditions. Sörlin (2023)on the other hand, discusses the paradigms of resource extraction in the Arctic. He provides different cases that discuss the environmental history, resource colonisation, path dependencies, extractivism mechanics, and post-extractivism transition trajectories of Arctic resource urbanisation. This provides the theoretical and contextual grounding of Kiruna in the larger Arctic transect.

Infrastructural Landscapes

The theory of infrastructural landscapes is used to understand and experiment with landscapes as infrastructures and infrastructures as landscapes. Bélanger (2016) discusses these aspects to understand urbanism and a process beyond engineering. The agency of design and the understanding of terraforming as a design principle are synthetic outcomes when infrastructure is considered a site. In Landscape Infrastructure, Bélanger (2013) discusses ecology as an engineering process, emphasising the interaction between landscape architecture, civil engineering, and urban infrastructure. Urban infrastructure is to be considered both the site and the system where it is designed, constructed, and continuously reconstructed (ibid.). Infrastructure is an interface by which we interact with the biological and technological worlds. He discusses the aspects of regionalisation where the notion of the division of the city centre, peri-urban, and neighbouring cities will give way to a cross continental understanding of resource, financial, and social networks. Here he also looks at resource flows and the circular economy, where he discusses the similarities between urban conditions and constructed ecologies. For instance, it would be good if we looked at waste being absorbed into the recirculating economy through down-cycling and up-cycling. Design strategies can be launched between short-term, immediate interventions that are sequenced over a long-term, gradual process with larger ecological and geopolitical effects.

Technical Lands

Technical lands (Nesbit & Waldheim, 2022) are areas that are identified as "exceptional" due to their remote locations, spatial delimitations , secured accessibility, and vigilant management. The political nature of defining land as "technical" involves making certain areas of the planet invisible and inaccessible (Gallison, 2022). This concept is relevant to the study of post-extraction landscapes in the Arctic because it emphasises on political boundaries that obstruct production and governance. This calls for rethinking the Arctic post-extraction, and using more participatory governance structures, and challenging and possibly redesigning the spatial logics that now inform social programming of these spaces.

Space-Technology Nexus

Swyngedouw(1992) emphasises the dual nature of spatial organisation by examining it as a result of social relationships as well as a force of production. He argues that although social dynamics have an impact on spatial forms, these forms also have an impact on economic activity and can either stimulate or hinder production. Spatial design and regulations could benefit from the insights offered, especially when it comes to balancing private interests and public goods. They could guide the territorial transformation that leverages the economic forces and geographical organisation of the fixed capital in the form of infrastructure and social reproduction through population.

Post-Capitalism

David Harvey (2014) highlights the fundamental relationship between capital accumulation and spatial developments, explaining how capital movements shape the production of space, which is inherently uneven. Harvey contends that accumulations and capital flows produce a patchwork of underdevelopment and development, with some cities or regions becoming hubs of vibrant economic activity while others are left out. This dynamic reveals how capitalist imperatives drive the reconfiguration of spaces to suit accumulation needs, often at the expense of social equity and environmental health. It is crucial to understanding the social and ecological transformations within urban and rural landscapes. By integrating this perspective, the thesis can explore the complexities of spatial transformations in Arctic regions, where post-capitalistic attempts into extraction redefine both the physical and socio-economic landscapes.

World-ecology

The production of nature in the form of ecological surplus and its appropriation is discussed in the works of Jason Moore. The appropriation of ecological surpluses by paid and unpaid work is used to understand human and more-than-human forces that are informed by urbanisation. Moore (2014) discusses the epistemic rifts in the ideologies of society and nature. In producing knowledge, the shift from the perspective of human-and-nature as a dualism to the perspective of human-in-nature as a dialectic is necessary to understand the co-production of nature and society. The environmental history account of the North Atlantic in his work Amsterdam is Standing on Norway (2010b, 2010a)shows the link between the production of nature and the production of societies. Here are metabolic rifts between ecological dynamics and social dynamics that lead to the accumulation of capital and material. The literature provides grounding in the political ecology of extraction infrastructures. Capitalism is not acted on nature; it is acted through nature (Moore, 2014).Understanding the formation of world-ecology, where capitalism is a form of ecology itself, is important to form design principles for post-extraction and post-capitalism.

Constructs of Time

The processes of urbanisation are a series of actions over time that collectively form different conditions for further social, economic, and ecological processes. Situating the project at different scales of time is necessary to understand the temporal context. The different constructs of time range from the geological time to the time of the event The term "deep time" (Heringman, 2015) refers to the scale of geological and cosmic time, which represents the formation of the elements and the resources themselves. The longue durée, moyen durée and le'venmentieal (Braudel, 1980). The longue durée represents the geographical time where the actions and implications of the ecological alterations are evident. The moyen durée represents the socio-economic time where the economic and social forces define its rate. The technological innovations and their feedback are discussed in this time frame. Lastly, le'venmentieal represents the individual or the event time where the elemental and functional transformations are discussed.

Methods

Since the thesis is intended to be a project of disclosure, it uses an abductive approach to research, where tentative theoretical and contextual observations are tested using design experiments. Research by design is the fundamental method used, which is embedded in the framework of the Transitional Territories Studio. The project methods include primarily critical cartography and design for analysis and synthesis.

(Simultaneous and repetitive) Analysis and Synthesis

Since the project has inferences from the post-project that form the design conditions of the anti-project, there is a continuous exercise of analysis and synthesis, which are either progressive or simultaneous. This analysis or synthesis is either cartographic, theoretical, or reflective at different stages of the project.

Literature review

This method provides the theoretical underpinning of the thesis premise in the analysis of the problem and critiquing the current extraction paradigm of 'sacrifice and repair'. The existing literature is used to provide different accounts and positions for myself and the project in the discourses of political ecology and landscape urbanism.

Interview

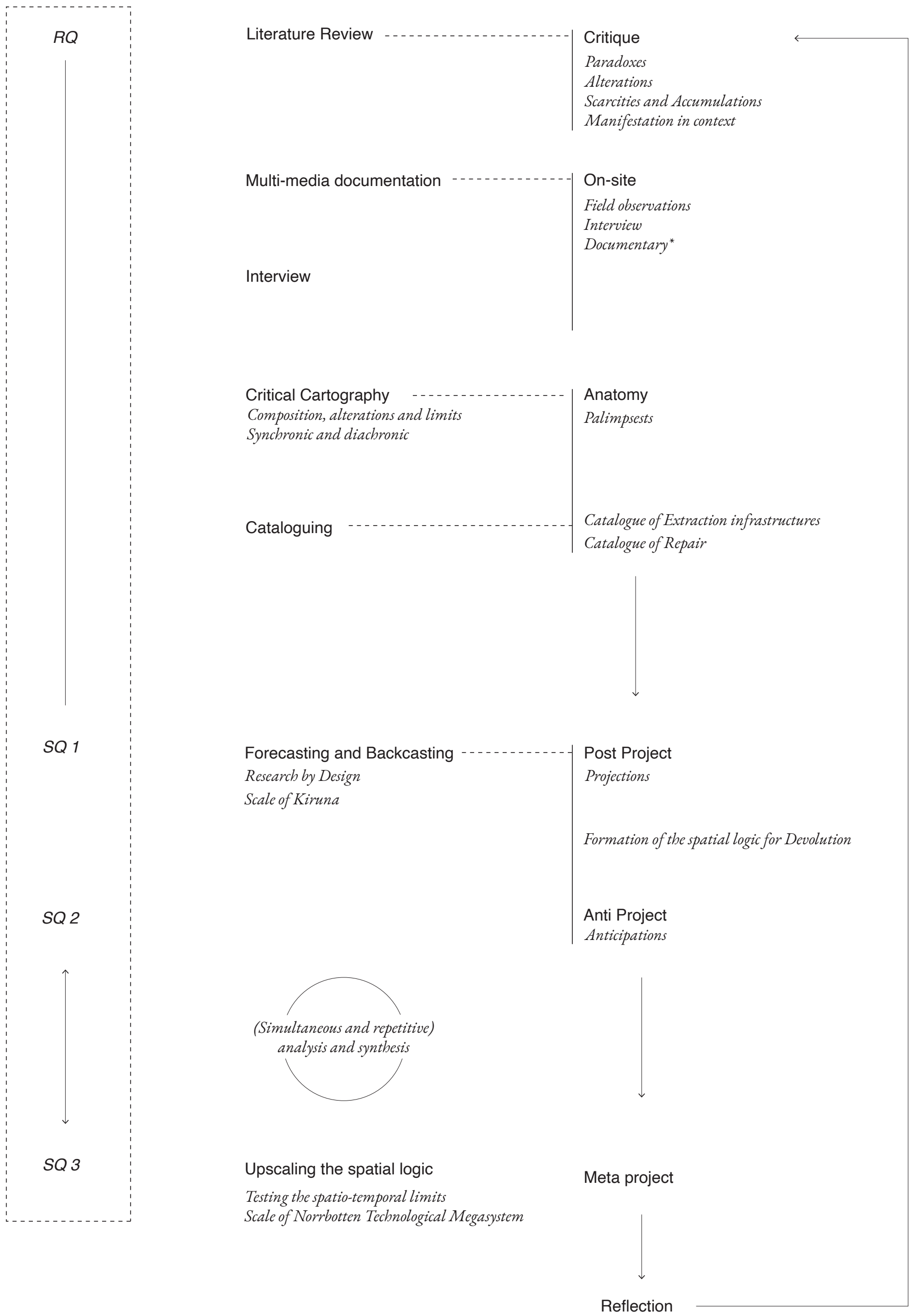
This method is used to get an overview of the way of life of the Sámi community, their notions of interdependencies and eco-dependencies. It is also used to elaborate on the conflicts of the land practices, political inclusion and engagement and their position on the mining corporation, and green transition.

Field Visit

On-site documentation using methods of photography is used as a method of documenting the monofunctional, sacrificial and determinate landscape. The site observations provide the grounds for comprehension of the site conditions and project my theoretical position in the real conditions. Field observations will help in the documentation of the scales of alterations and study of the methods of repairs used. Parallelly, with Polis – Platform for Urbanism and Landscape Architecture, the method of documentary-making is used to create a collaborative narrative with the other participants of the trip using interviews and collective observations and interpretations. Although the documentary is not a product made with a purpose or a specific aim directly arising from the thesis methodology, it can be presented as supportive evidence with clear attributions.

Critical cartography

This method is used in generative exercises for both design analysis and synthesis. Cartography here spatial projections to synthesise synchronic and diachronic drawings of the territory and architecture of extraction. The current states, socio-ecological interactions, and limits of mining infrastructure and the biophysical environment provide a foundation to frame the project.



Methods framework

Cataloguing

This method is used to syntactically overview the elements, which [i] analyses mining infrastructure and the methods of repair and [ii] synthise spatial transformations of the extraction infrastructures though indeterminate interfaces in from the elemental to the territorial scale.

Stakeholder Analysis

The method provides the complexities of the different stakeholders that effect and are effected in the extraction territories. This is essential to rethink the spatial logic for devolution of the extraction territory and the regulatory framework.

Forecasting and backcasting

The forecasting method is used in design to project the currently operating mine and the territory to provide a strategic vision for its post-extraction function for socio-ecological regeneration. The backcasting method is used in design to project backward the potential post-extraction transformation of the mining territory of the anticipated mine to inform its spatial design conditions before the mining operation.

Design speculation

The method of speculative design is used to experiment with ideas for transformation based on the existing literature, on-site observations, theoretical and contextual analysis, and synthesis. The iterative process creates diverse conditions for reactions to socio-ecological processes at various scales.

Structure of the Report

The chapter *Critique* provides a critical understanding and positioning of the project and Kiruna in the discourse of paradoxes, scarcity, sacrificial landscape, and spatial accumulations. This provides the theoretical premise and positioning of the project. The following chapter *On-site* grounds the literature to the context with the interview with a Sámi reindeer herder, artist, and youth politician. The site observations are used to introduce the monofunctional, sacrificial and determinate characteristics of extraction landscapes. The chapter *Anatomy* systematically analyses the extraction infrastructure and the territories though these characteristics using critical cartography and catalogues.

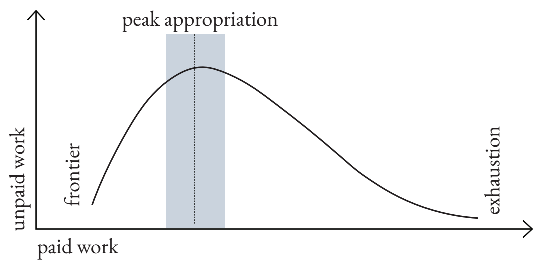
The chapter *Towards Devolution* [Post-Project] discusses design actions to make the post-extraction landscapes multifunctional, reparative and add programmatic indeterminacy for social integration. This creates the spatial logic of devolution and the agencies discussed in the chapter *Architecture of Devolution* [Anti-Project] where the new spatial logic informs the design of the anticipated mine though the indeterminate interfaces. The final chapter *Territories of Devolution* [Meta-Project] upscales the spatial logic to propose design actions for multifunctionality, degrowth and indeterminate interfaces though devolution of the technological Megasystem.

Critique

This chapter provides the critical overview and position of how exploitation shapes the broader socio-ecological framework in Kiruna and the Norrbotten Technological Megasystem through lenses of political ecology, environmental humanities and economic geography.

Our conception of the Arctic often consists of the pristine images of showering aurora borealis and otherwise uncanny images of placelessness in the vast sea ice. The concept of wilderness is a social construct, and it is one that is based on dual thinking of nature and society. This dualism between nature and society is problematic due to the delineation leading to the current state of a less habitable world (Moore, 2006). The map of the Last of the Wild (WCS & CIESIN, 2009) includes the Arctic with other 'wild' areas such as the Sahara, Amazonia, and AntArctica. But when closely observed, most of these territories have been historically operationalised for their natural resources. The Arctic Monitoring and Assessment Programme has increased evidence that the threats of climate change through pollution like acid rain and permafrost thaw are changing the biophysical composition of the Arctic environment and will affect the planetary natural cycles, including food(Gabrielsen, 2005). The rapid melting of the sea ice is a visible marker of the Anthropocene, where human activities in the rest of the world are the root cause of the changing biophysical environment. Environmental reporter Cone describes the wilderness paradox of the people living in the Arctic, despite living away from the pollutant sources are the most contaminated (ibid.). Therefore, the so-called wild is not inherently wild.

In the Arctic, on the one hand, we realise the accelerating climatic phenomena of pollution and Arctic amplification, polar ice loss, etc., but on the other hand, we observe that historically, we have been depending on it for resources including wood, fish, minerals, oil, and more(Moore, 2010b). Since the 16th century Dutch hegemony in resource frontier exploration and its reliance on the Arctic, leading to popular expressions like 'Amsterdam is standing on Norway', the Arctic hinterlands, although minimally inhabited, have been undergoing rapid alteration. This dependency and the alteration have been accelerating with the discovery of new resources and the technological innovation in extracting itself, resulting in the accumulation of capital. The work of nature in the Arctic is through resource formation, and the temporal dimension of this unpaid work of nature is appropriated for consumption in the world-city, making the Arctic a global hinterland. Although the Arctic was once a frontier for resources, it is currently in the midst of peak appropriation. The paid work of extraction (infrastructure, labor, etc.)



Paid work and unpaid work definining appropriaiton

per unpaid work (the effort of nature in creating the natural resources) is at saturation. For further appropriation, higher paid work results in the production of fewer resources, leading to the phase of exhaustion where economic effort has lesser capital returns. The state of the Arctic as a resource storehouse due to the abundance of mineral resources—both carbon and metallic—is always in flux. While one cycle of extraction ends, there is a possibility of discovering newer deposits and continuing the extraction in the Arctic. This leads to the Norwegian paradox which states that it is often observed that resource-rich states have high economic performance despite lower research and development investments. It is synonymous with the Innis' staples thesis (1920), where the economic development of Canada was due to the appropriation of resources for staple commodities—fish, fur, lumber, agricultural commodities, and minerals—by British colonial practices. Since the capital is accumulated for appropriation of the available resources, the GDP is high due to the production of nature being valued through capital, and the population, however, in these territories, is less. It is possible to shift to newer extraction projects with a minimum investment in the social and human development of the state itself. This creates further metabolic rifts and creative destruction. This is detrimental to the territories of extraction because of the localised effect of global demand.

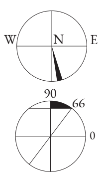
The discovery of rare earth elements in the mining town of Kiruna and the Norwegian seabed creates a green dilemma. We need these resources for the green transition from carbon-based energy systems to renewables. But the appropriation of these resources is detrimental to the social and ecological composition of the landscape. In Kiruna, historically, the extraction of iron has resulted in social conflicts such as interference with the indigenous land practises of the Sámi community, often the migratory reindeer herding practice, ground subsidence leading to displacement, and ecological conflicts such as environmental pollution (Sörlin, 2023). The processing of the newer resources with apatite and rare earth will have larger implications due to the presence of radioactive elements and a higher nitrogen and phosphorus content, which causes eutrophication of the water systems and alteration of the chemical composition of the soil systems (Balaram, 2019; García et al., 2020). While there is an increased and immediate demand for the critical minerals due to the geopolitical and climatic emergencies for the faster green transition, it is also important to understand at what and whose cost we are extracting and enabling the processes in the transition.

Abandoned coal mine in Longyearbyen
[Photograph by Shaun O'Boyle]

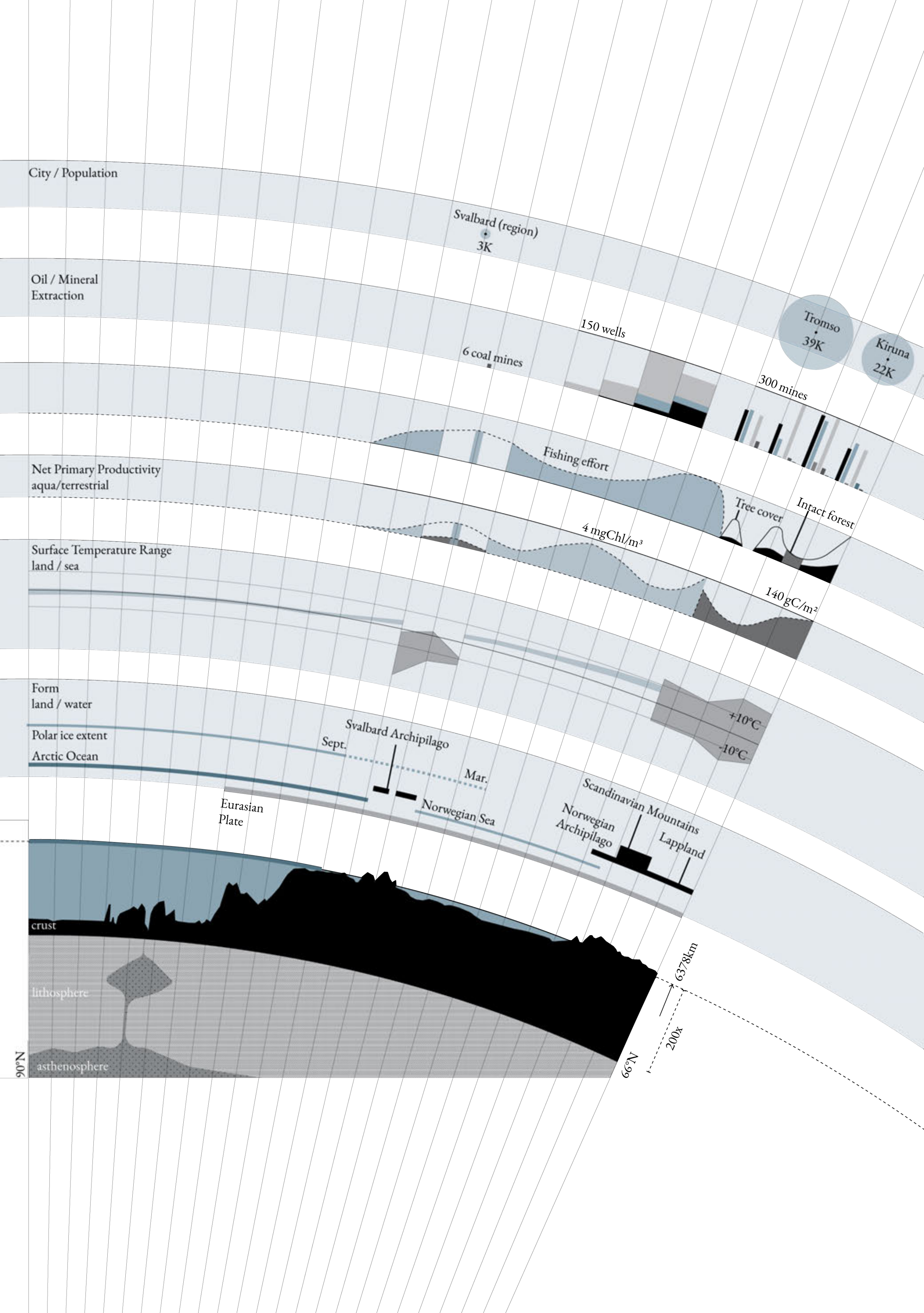
Space Ground Stations in Longyearbyen
[Photograph by Reuben Wu - Raytheon]

Ecological surpluses in the Scandinavian Arctic Transect

The drawing illustrates the variation of different ecological surpluses along the Scandinavian Arctic transect and their relation to the landscape forms.



| 0 | 150 km


City / Population
Svalbard (region)
3K
Tromso
39K
Kiruna
22K
Oil / Mineral
Extraction
150 wells
6 coal mines
300 mines
Fishing effort
Net Primary Productivity
aqua/terrestrial
Tree cover
Intact forest
4 mgChl/m³
140 gC/m²
Surface Temperature Range
land / sea
+10°C
-10°C
Form
land / water
Polar ice extent
Arctic Ocean
Svalbard Archipilago
Sept.
Mar.
Eurasian
Plate
Norwegian Sea
Scandinavian Mountains
Norwegian
Archipilago
Lappland
crust
lithosphere
asthenosphere
90°N
66°N
6378km
200x

Norrbotten Technological Megasystem

The map illustrates the geographical location of Kiruna and the NTM in the Sápmi - indegenous lands

- Swedish demarcation of the Sápmi
- Marine transport
- Sea bathymetry
- Topography
- + Inhabitation in NTM
- — Malm Rail

0 500 km


ww
20.2253° E
Norrbotten Technological
Megasystem
Kiruna
67.8558° N
Arctic Circle
66° 34’ N

The discovery of the resources for critical raw materials in the Arctic is an outcome of the financial interests in the materials themselves and the technological capabilities for the exploitation of the Arctic. The geopolitical motives for the exploitation of critical resources are the mechanisms of market control and the transitions towards self-reliance, cutting path-dependencies (Sörlin, 2023). The rate of technological transformation leading to the exploitation is infinitely higher than the geological formation of the minerals, and this makes them finite resources. Unless we rethink the processes of extraction, the scarcity of these critical resources is highly anticipated—scarcity not through the availability of resources but the relative scarcity due to the political and societal consequences of unsustainable extraction.

Resources are social constructs because, although the ecological surplus is already present in earth's systems, the functional values that are attached to it make it a resource on three bases: [i] socio-economic, [ii] socio-technical, and [iii] geopolitical (Katsikis, 2023). While the industrial revolution and the need for iron created the material basis of societal needs which constitutes the socio-economic basis of resources, the socio-technical basis for the exploitation of the resources was formed by the ability to undertake land surveys, and the technological development of the territory to enable extraction. In the case of the Norrbotten Technological Megasystem, Malmberget was the first mine where iron was extracted and transported to Lulea (Carrasco, 2020; Sotoca, 2020). But in 1902, the connection of the railway, like from Narvik on the Norwegian coast to Kiruna, and its extension to connect to the railway, like connecting Malmberget and Lulea. The whole stretch from Narvik to Lulea created the Malm Rail (Iron Rail). Along with the railway line, the construction of the dams on the Lule River to power the extraction activities was an enabler for industrial-scale mining of iron in Kiruna. Kiruna was founded as a mining town to operationalise the extraction of iron ore in Kirunavaara and the Luossavaara mountains. The settlement was located to the east of the mine, and historically, this landscape was used for reindeer migration by the indigenous Sámi who had lived in this area since the last ice age (Swedish Sámi Parliament, 2014). Lastly, the need for control over the material market of the material in demand and the path towards self-sufficiency create a geopolitical ground for the formation of the resources to either identify or resolve conflicts between resource use and claims. While the availability of the material is guided by the geological composition in the deep time (Heringman, 2015)and the longue durée (geographical time), the socio-economic, socio-technical, and geopolitical grounds for resource making depend on le moyen durée (socio-economic time) (Braudel, 1980). The demand for these resources changes over time and creates dynamic conditions of scarcity—economic crises and mining booms.

Satellite image of Kiruna
[retreived from ESRI]

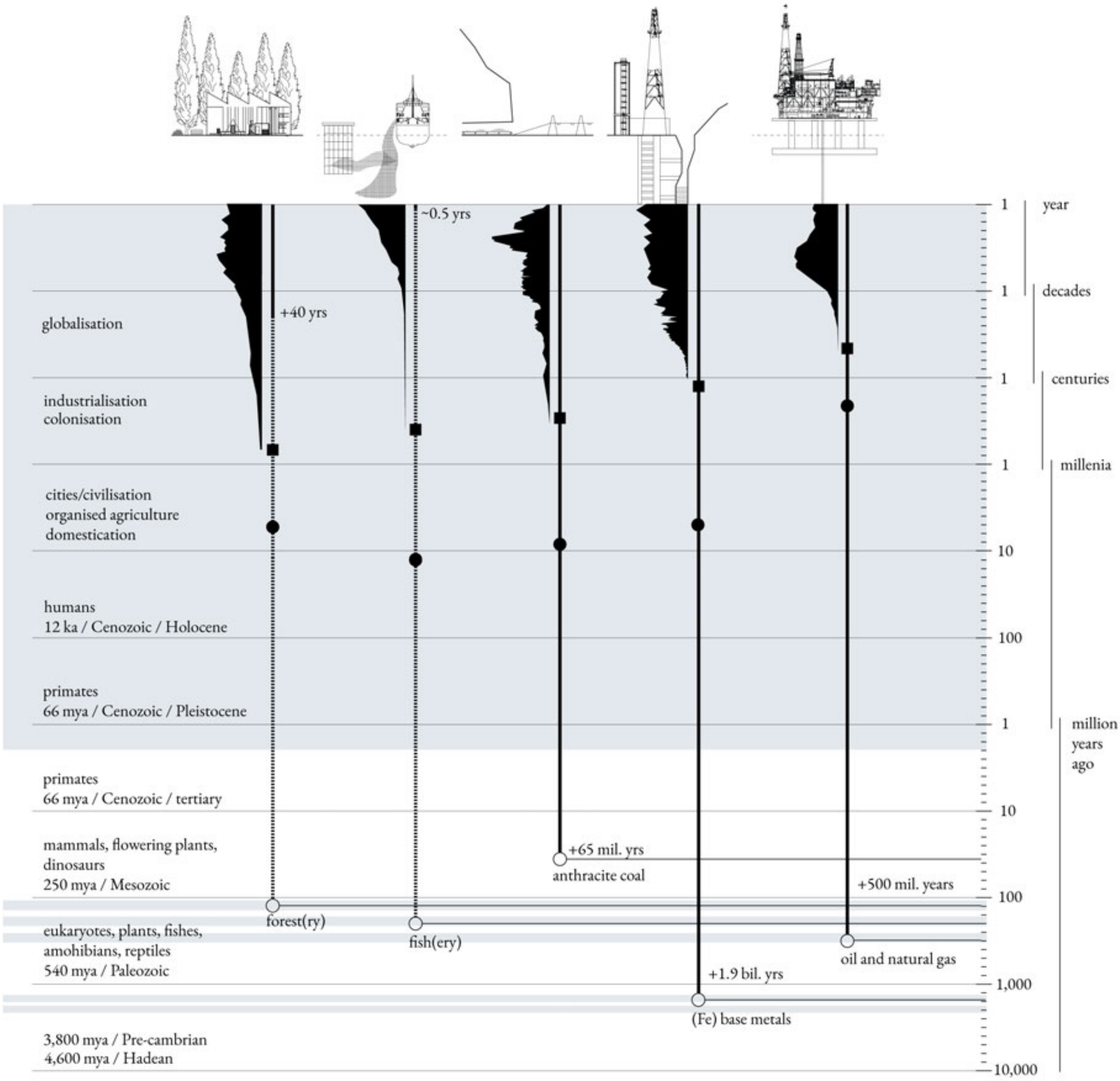
The mining boom in 2018 allowed for an increase in mining depth, up to 1045 m to 1365 m below ground level. Exploration at a further depth led to the discovery that the ore body was smaller and the mining was ongoing(Sörlin, 2023). The current hauling level of 1365 m is estimated to yield up to 2048 m (LKAB, 2023a). This opened up the quest for newer deposits for exploitation in the surroundings of Kiruna. The material estimation in the new Per Geijer deposits located to the north of the city proved profitable. The precise technological ability to estimate the chemical composition of the resources proved that there was a higher concentration of apatite in the material. Kiruna-type ore is composed of magnetite, hematite, and apatite ore. Magnetite and hematite are processed for iron, whereas apatite has a high concentration of phosphorus and rare-earth elements (REE). Phosphorus is one of the main raw materials in the production of fertilisers and REE is extensively used in green technologies(LKAB, 2023c). The transition towards a post-carbon economy relies on REE because it is used in advanced electronics, efficient batteries, powerful magnets, renewable energy production like wind turbines, defence systems, optics, and more. This intensifies the material need and the [i] socio-economic need for resource formation. Extraction of apatite in isolation is not profileable (LKAB, 2023b). But its concentration with the iron ores provides the financial feasibility for its extraction. The technical capability to identify and extract these resources provides the [ii] socio-technical feasibility grounds for the formation of the deposit. This is achieved through the accurate estimation of higher concentrations of lanthanides to the precise concentration of the elements from Ce-58 to Lu-71 and the advanced methods of precision extraction of the ore. The [iii] geopolitical motive for extraction is back on the European path towards self-reliance. The EU Critical Raw Materials Act was revised to create the fifth version of the Critical Raw Materials List in 2023 based on the parameters of its link to the industry across supply chains, modern technology, and its link to ‘clean’ technologies (European Commission, 2023). Two groups and two individual materials out of the 70 raw materials are found in the apatite ore in high concentrations, viz., phosphorus, phosphate rocks, light rare earth elements, and heavy rare earth elements. The recent geopolitical crisis with Russia creates pressure on the supply of phosphorus because the supply to Europe used to be supplied by Russia. The crisis creates demand for phosphorus and defines its scarcity. The global REE market is monopolised by China (LKAB, 2023c) In the path towards self-reliance and, to cut the path- dependency, the discovery of REE defines its scarcity.

The currently operating mine and processing plant in the Kirunavaara deposit extracts and processes iron from magnetite and hematite to create iron pellets (LKAB, 2023a). Historically, the mine has yielded a total of 1.5 billion metric tonnes of ore. The waste rocks containing the apatite rocks are collected to create large mountains of tailing piles to the west of the mine. The ground water pumped from the underground is used to process the ore, and the processed water is collected in a tailings pond south-west of the mine. The anticipated mine is currently in the phase of approval where LKAB has applied for the plan for mining concessions and environmental permits. The process of extraction for the anticipated mine in the Per Geijer deposit is similar to the current Kirunavaara mine. But in addition to hematite and magnetite processing, it will include apatite concentration plants in the form of flotation cells. This process creates the apatite concentrate rich in phosphorus and REE, which will be transported to Lulea, where a circular industry currently being established will convert the concentrate to extract phosphorus and rare earth elements for further processing and manufacturing of fertilisers and green technologies (LKAB, 2023b). The current resource statement for the Per Geijer deposit states that rare earth oxides are available at a concentration of 0.18% of the total 734 Mt of ore(LKAB, 2023b). The global demand for REE in 2025, which is 30.5 megatonnes (Stormcrow, 2020), would require about 23 times Kiruna.

Temporal rate of resource formation and appropriation

The drawing figure describes the temporal dimension of formation of resources and their anthropogenic appropriation with respect to the deep time

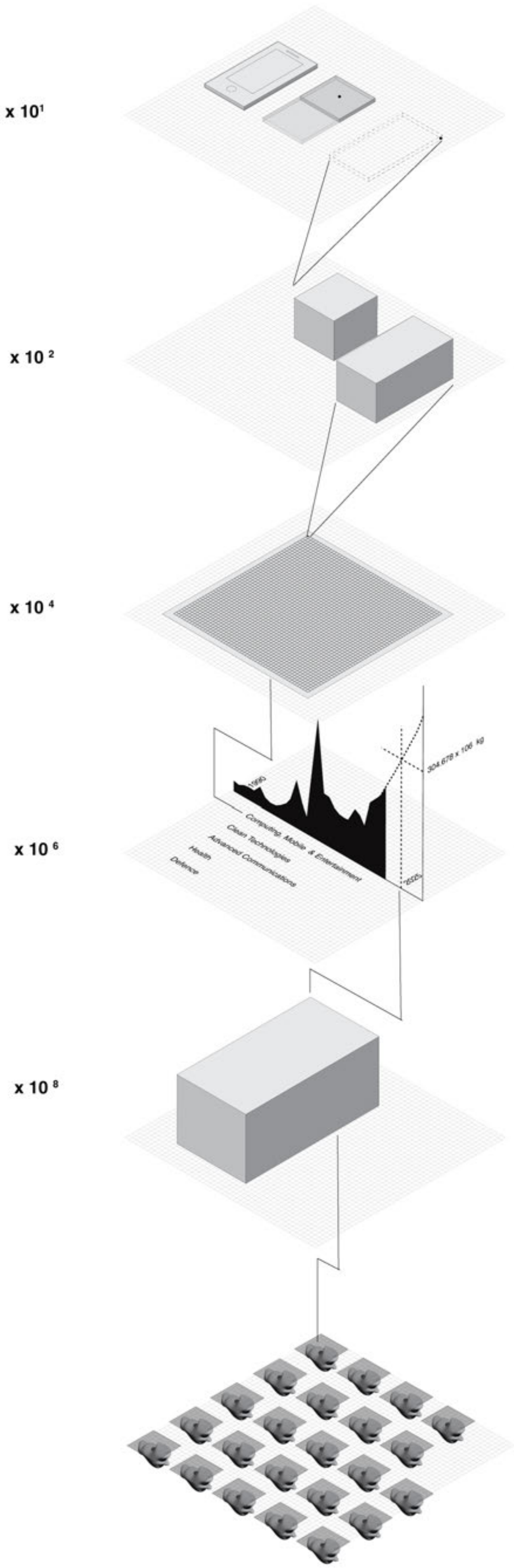
■ Real subsumption shift
● Formal subsumption start
○ Early formation - evolutionary, organic, inorganic
Glaciation
Time of formation of resource before harvest
Time since species evolution



globalisation
industrialisation
colonisation
cities/civilisation
organised agriculture
domestication
humans
12 ka / Cenozoic / Holocene
primates
66 mya / Cenozoic / Pleistocene
primates
66 mya / Cenozoic / tertiary
mammals, flowering plants,
dinosaurs
250 mya / Mesozoic
eukaryotes, plants, fishes,
amohibians, reptiles
540 mya / Paleozoic
3,800 mya / Pre-cambrian
4,600 mya / Hadean
+40 yrs
~0.5 yrs
+65 mil. yrs
anthracite coal
+500 mil. years
forest(ry)
fish(ery)
oil and natural gas
+1.9 bil. yrs
(Fe) base metals
1
year
1
decades
1
centuries
1
millenia
10
100
1
million
years
ago
10
100
1,000
10,000

Rare Earth Mineral Demand Footprint on Kiruna

The illustration highlings the Rare Earth Metal ore and sea-bed area required to be mined for production of one product with an example of an iPhone and its 2022 sales. The demand of REE increasing about 400x due to its significance in 'clean' technologies, wiukd require 23 times Kiruna's REE content.



iPhone / **140g**

Metal / **70g**

REE / **0.2g**

Ore / 0.18% / **112g**

iPhone sales - 2022 / 225.3 million

Ore / **25.194 x 10^4 tonnes**

REE demand - 2025 / **30.468 x 10^6 tonnes**

Ore / **169.26 x 10^8 tonnes**

Per Geijer Deposit Ore Estimate / 734 Mt

23 x Kiruna

Mining has historically been seen as a national sacrifice due to its socio-economic characteristics, power dynamics, and environmental impact (Skorstad, 2023). In 2004, LKAB announced underground extraction of iron ore in Kiruna, causing a town to be physically relocated. As surface buildings are relocated creating ghost towns and 'mine city parks' on the surface, 10 large detonations occur every night at 1365m below the mine reference level. Residents are accustomed to the sounds and tremors of these detonations.

[Elaborated in the working paper in the appendix : Federighi, V., Bacchin, T. K., & Shekar, K. (2024). *Which Landscape: Material traces of an integrated design and research approach in Kiruna*.]

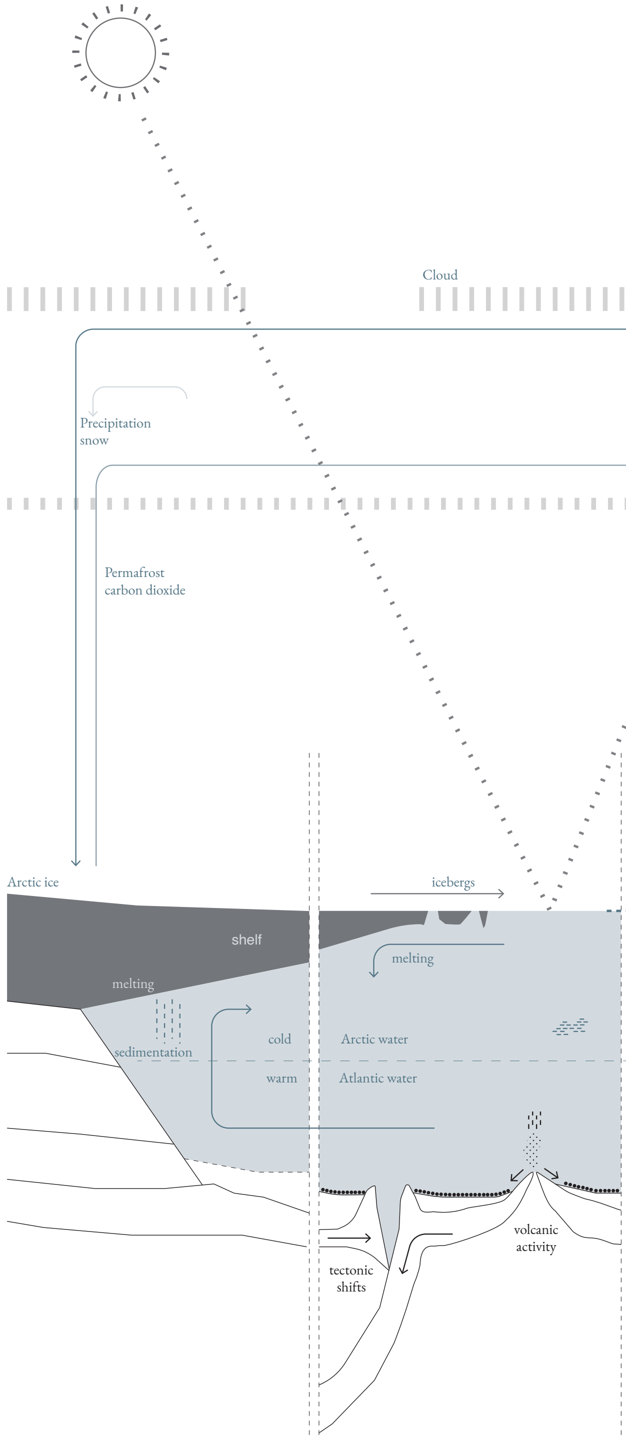
The chapter paradoxes explain extractivist processes as an act of colonisation of nature-cultures. The tendency to use the approach of repairing or compensating for the damages caused to social and ecological systems to justify and normalise extraction is problematic. The appropriation of ecological surpluses in the hinterlands has large infrastructural configurations, and the operationalization of these landscapes provides the basis for forms of habitation and hinterland dynamics (Brenner & Katsikis, 2020). These appropriations are dynamic and are subjected to constant processes of creative destruction because the scarcity of resources constantly changes based on ecological, economic, and social forces. They continuously reconfigure the earth systems—atmospheric, hydrological, and terrestrial. These reconfigurations alter the material composition of the landscapes at different spatial and temporal scales. On the other hand, social dependencies are formed between the Arctic hinterland and the agglomerate heartland, where extraction practises depend on the cities for knowledge and technological research and development, creating a loop. There are also socio-spatial alterations due to interference with indigenous land practices. Theoretically, this reflects the co-production of nature as a means to the formation of the city.

The alterations in the earth systems added to the socio-economic forces alter the definitions of the Arctic other than the geographical definition of the Arctic circle at 66°N. These definitions include temperature, permafrost, bioclimatic zones, treelines, tectonics, and exclusive economic zones at their own temporal rates. The alterations in the biophysical composition of the landscape are due to an increase in greenhouse gases in the atmosphere. The IPCC reports that over the past 20 years, the surface air temperature in the Arctic has warmed by more than twice the average world temperature, with feedback from the melting of sea ice and snow cover accelerating the warming (Meredith et.al, 2022). Climate-induced alterations in the polar waters, sea ice, snow, and permafrost will lead to shifts in habitats and biomes, resulting in changes in the distribution and population sizes of ecologically significant species (ibid.). These definitions in turn inform the operationalisation of production, processing, logistics, and inhabitation in the Arctic.

In Kiruna, the process of extraction of operationalised magnetite iron and anticipated apatite REE and Phosphorus is the means to the formation of the settlements Kiruna, Malmberget, etc, and the infrastructural configuration of the Norrbotten Technological Megasystem (NTM) (Sotoca, 2020). It is a part of the 'Malm territory, a remote area in the Swedish-Norwegian Arctic and sub-Arctic region that has been closely associated with the extraction of iron ore since the 1500s. This region, located around 66.5° latitude, has gradually evolved into industrial-urban landscapes despite its sparse population and isolation. This land was originally inhabited by the Sámi community. During the 18th and 19th centuries, mining activities in the Arctic region of Fennoscandia shifted their focus towards extracting iron ore. However, consideration for the interests of the Sámi people remained insignificant. The Sámi were often excluded from mining employment due to their perceived unreliability and strong attachment to their traditional lifestyle. The enduring motif prompted the Sámi to actively seek ways to evade employment in mining (Sörlin, 2023). The resource colonisation in Kiruna had adverse effects on the natural systems, with environmental pollution, ground subsidence, and large mining waste production altering the biodiversity of the region. The extraction process includes underground blasting and overground processing of the ore. This process produces a colossal amount of waste that looks like mountains, but instead they are mountains of reactive and non-reactive waste. A large water body that looks like a body is a tailing pond from the processing plant. The large spatial claim interferes with the reindeer migrating routes, which creates a bottleneck for the migration corridor. The extraction territories in these hinterlands are sacrificial in nature because they are primary zones impacted by the negative externalities of resource consumption in agglomerates scattered throughout the rest of the world, creating a reciprocal landscape (Hutton, 2020). Iron, which accounts for 93.6% of all the metals mined, is used in all processes and sectors of consumption, either in production, processing, or logistics. The remediation ideology, however, for these sacrificial landscapes is based on repair after the functional tenure of the extraction process. The footprint of the extraction is either contained and compensated post-extraction or compensated in a different location. In Kiruna, the industrial operationalisation of the extraction processes dating back to 1980 has been managed by the Swedish state-owned company called Luossavaara-Kiirunavaara Aktiebolag (LKAB). It manages all the processes, including extraction, processing, transportation, mechanical equipment design and development, production of explosives, urban transformation, and ecological remediation. It is contradictory in nature because the organisation LKAB responsible for the degradation of the landscape is also the one enabling the repair.

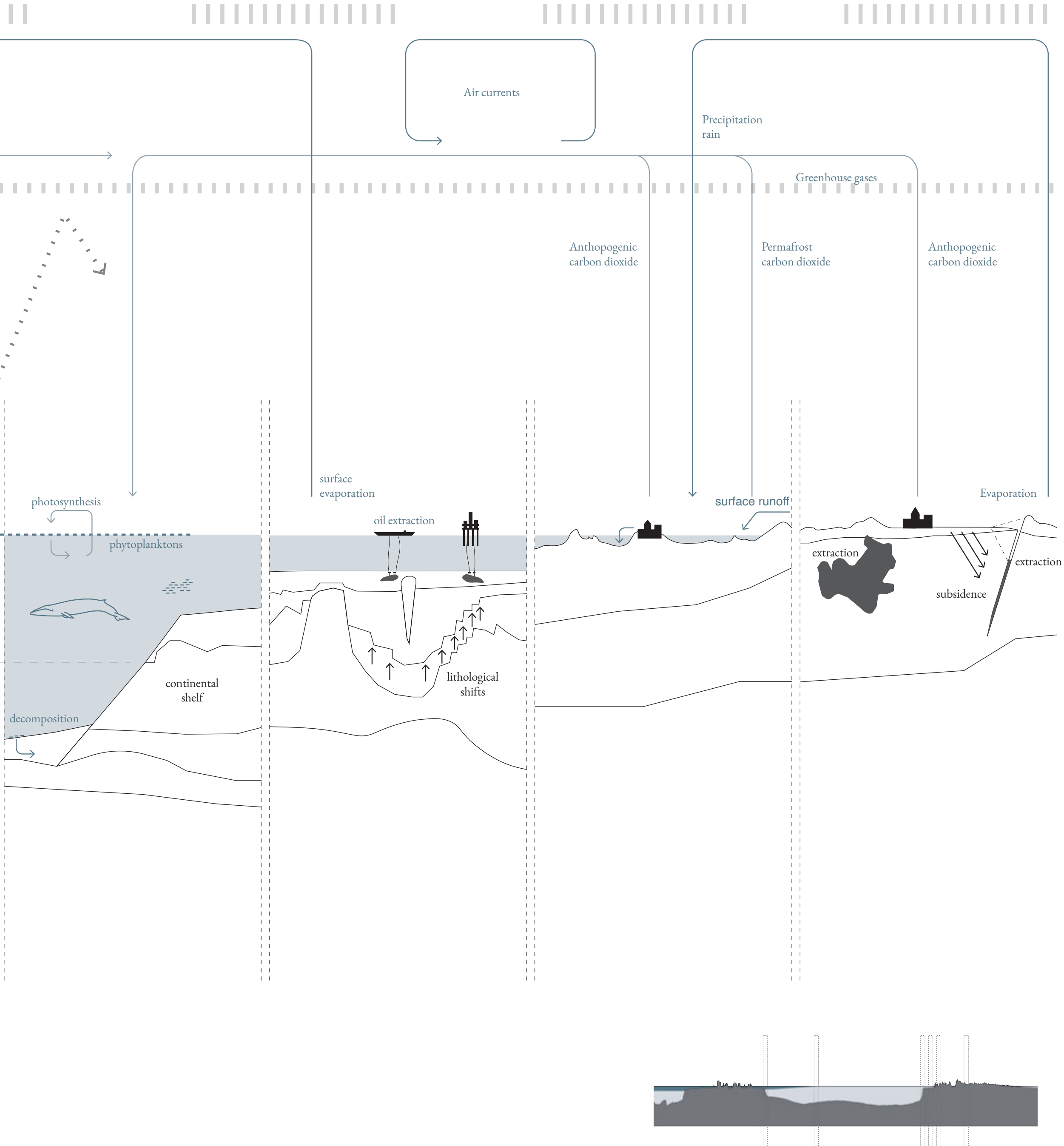
In addition to the current mining processes, which use the techniques of cutting, drilling, blasting, transportation, stockpiling, and processing creating dust, the processing of REE from the anticipated mine is even more detrimental to the natural systems. Studies at REE sites around the globe suggest that the complex composition of the large tailings can lead to radioactive pollution (Bai et al., 2022). The extraction of light rare earth elements causes atmospheric pollution, increasing the concentration of heavy metals in the air and the concentration of radioactive dust (ibid.). The radioactive presence in REE resources, including uranium and thorium, challenges the production process (García et al., 2020). Areas in China have raised a major socio-environmental concern due to the health impacts of REE ore processing (Balaram, 2019). Bayan Obo mine in China employs 7,000 people, of whom 3000 are exposed to thorium-containing dust (ibid.). The processing can also lead to alterations like the higher concentration of REE in plants, as in the uranium-REE mine in Australia (Nkrumah et al., 2021). HREE-processed tailing water can leach and cause acidification of soil and groundwater(Bai et al., 2022). Due to the use of ammonia and sulphate-based flotation processes, the landscape is susceptible to leaching, which causes a high concentration of ammonia (NH3). This can cause eutrophication in the water bodies, which affects the ecological balance in the aquatic systems.

The idea of repair is a reactive iteration on the conventional paradigm of nature conservation. Based on the density of 'nature', zones are demarcated as conserved areas, national parks, with a boundary around them to restrict development inside them. These boundaries are static with the intent of political jurisdiction. Euclidean land use classification delineates the biophysical environment, and this culls the systemic understanding of geography and ecology. But in contrast, the dynamic ecological processes do not conform to these boundaries. Bélanger (2013, 2016) discusses the paradigm of landscapes as infrastructures. Here, design strategies can be launched between short-term, immediate interventions that are sequenced over a long-term, gradual process with larger ecological and geopolitical effects. He also looks at infrastructural ecologies, where infrastructures act as landscapes and are strategic interventions that span small, immediate intervals across different scales. The main point he tries to make is that it is necessary for the processes of infrastructural systems to interact with ecological systems on a larger scale. The landscape of urbanisation goes beyond the grey matter of the cities and operates dynamically across several overlapping regions, with the development of infrastructure premised on ecology as a catalyst for infrastructural reform and a driver of urban morphology (Bélanger, 2013). Urban infrastructure is both the site and the system where it is continuously constructed and reconstructed. It is necessary to look at landscapes as infrastructures and infrastructures as landscapes (ibid.). If extraction infrastructures are seen as landscapes for envisioning transformation, the extraction goes beyond the paradigm of sacrifice and repair.



Forms and Processes

The section illustrates in parts, the various biogeochemical processes in and between the different systems: atmos, hydros and lithos. Mainly the processes resulting in teh melting of the Arctic sea ice, formation of the REE nodules in the abyssal plains of the Arctic Ocean, subsidence and impacts of underground mining.



Air currents
Precipitation
rain
Greenhouse gases
Anthopogenic
carbon dioxide
Permafrost
carbon dioxide
Anthopogenic
carbon dioxide
surface
evaporation
photosynthesis
oil extraction
surface runoff
Evaporation
phytoplanktons
extraction
extraction
subsidence
continental
shelf
lithological
shifts
decomposition

Arctic circle 66°N

Arctic sea ice

Bio-climatic zones

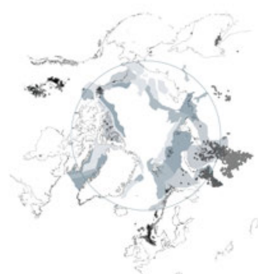
Permafrost extent

10°C July isotherm

Arctic Monitoring Assessment Program Line

Permafrost extent

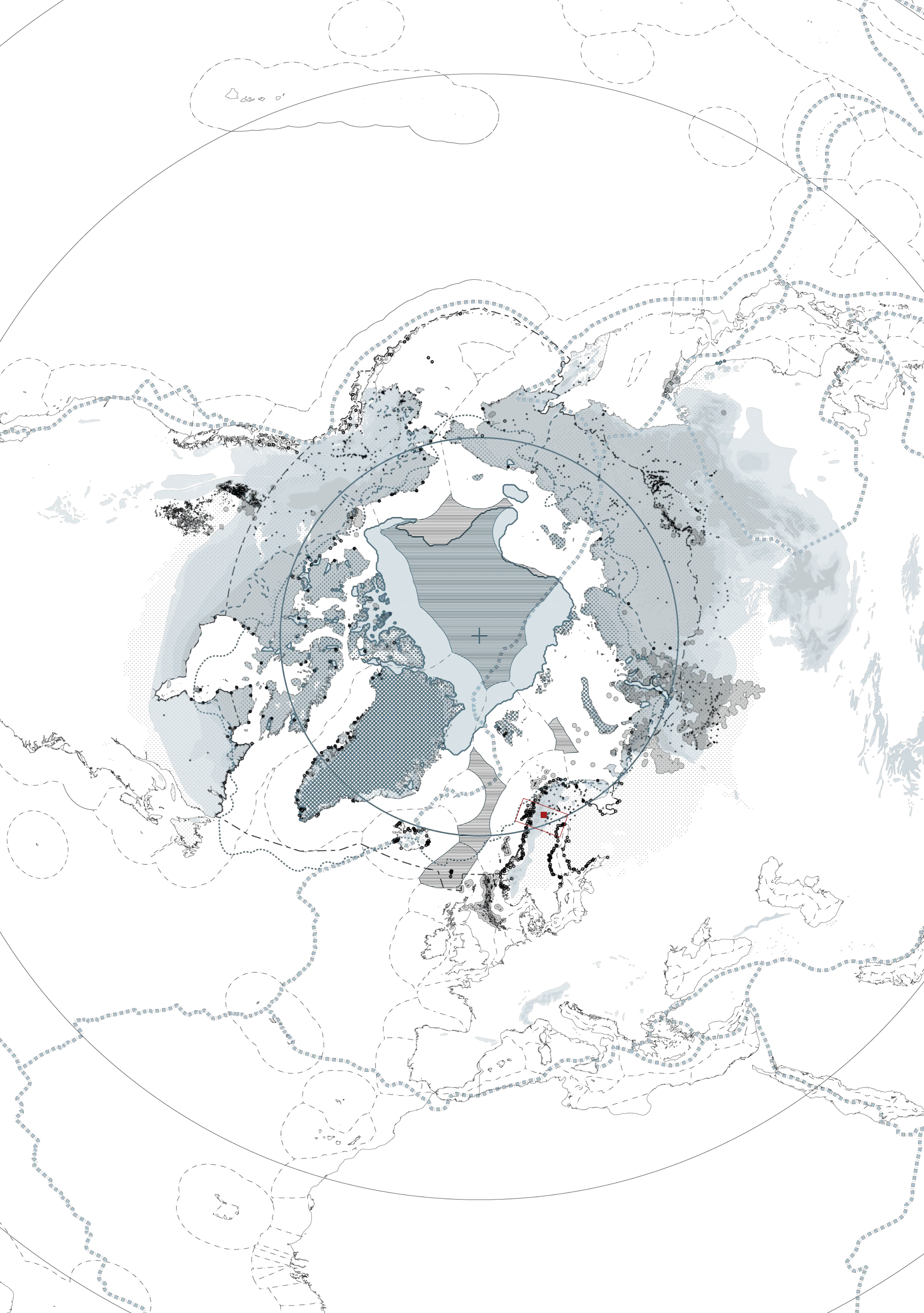
Tectonic boundaries



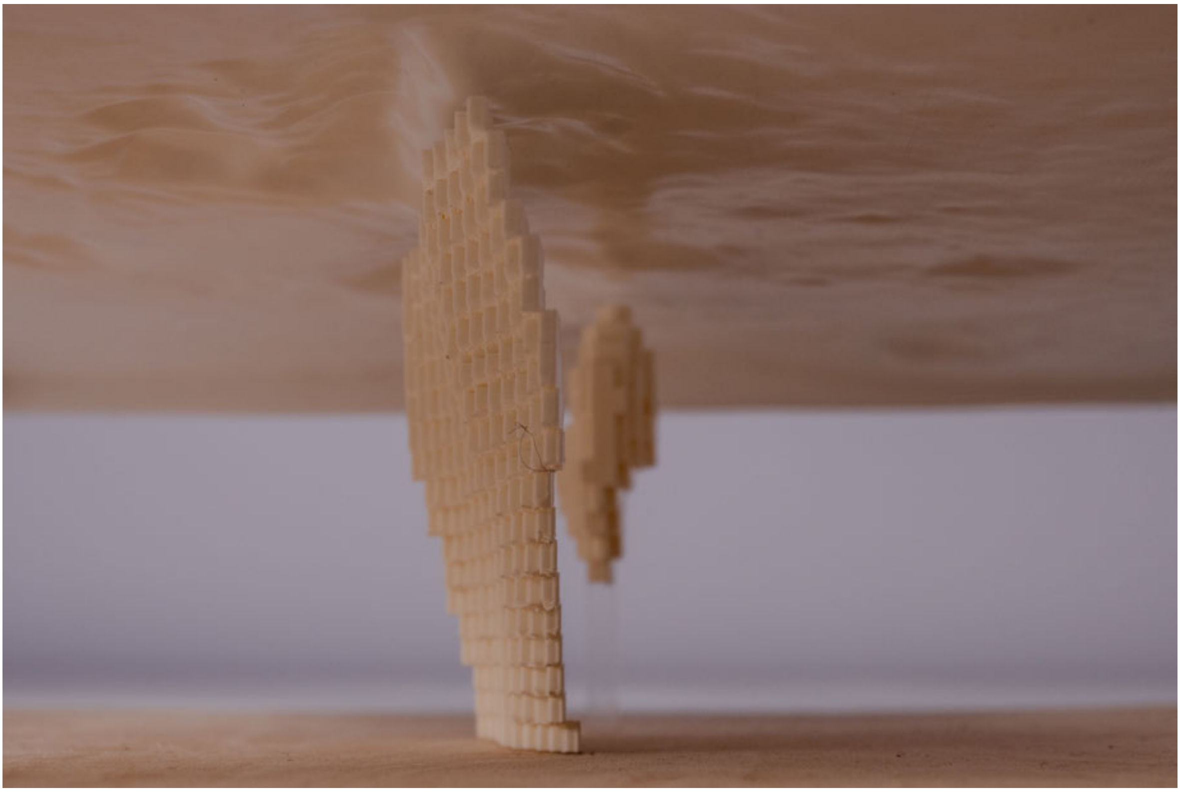
Oil and Natural gas fields and potential zones

Changing definitions of the Arctic

- Ports
- Settlements
- Oil fields
- 66°N Arctic Circle
- Tectonic boundaries
- Exclusive economic zones
- Tree line
- 10°C July isotherm
- High Seas
- Bioclimatic zones: High-arctic / Low-arctic / Sub-arctic
- Ice extent: September / March
- Permafrost extent: Continuous / Discontinuous / Isolated / Sporadic
- Norrbotten Technological Megasystem / Kiruna



Collosal mining landscape of Kiruna
[Photograph by LKAB]



Subterranean model of the Kirunavaara ore body in the front showing the oblique occurrence of the deposit

Terrain model of the Kiruna showing surface deformations: tailing piles in the left and the caving deformations in the right.

Ellis (2014) explains the epochal shift from holocene to anthropocene through the ability to accumulate and upscale resources: material, infrastructure, and most importantly, strategy and knowledge. The higher rate of cultural evolution than biological evolution, resulting in socio-ecological legacies, explains the tendency of this accumulation to create the human niche (ibid.). Moore (2010a) argues that capitalism is not acted on but through nature, because nature is not a territory where we leave a footprint, but nature is formed and reformed through its appropriation with historical, specific societal movements through understanding the dialectic between nature and society and its intimacy vs. dualism. In that sense, capitalism simultaneously produces and is produced by nature (coproduction). The epistemic shift from humanity-and-nature to humani¬ty-in-nature is needed to understand it as a whole and, in turn, to understand capitalism as world-ecology, accumulation of capital, power relations, and coproduction of nature as a whole (Moore, 2014).

Although Ellis's (2014) touches on the aspect of intensification of agriculture in regions suitable for large-scale agriculture, providing opportunities to transform the abandoned regions into urban and "rewilded areas", the idea of global society as a whole is missing. Transposing this to the thesis problem in the case of resource extraction, it refers to the formation and alterations of cities and their ecologies. Ellis's (2014) map of the anthropogenic biomes does not cover the alteration of the high-Arctic areas. But these areas are being altered through intense extraction processes, and the thawing of permafrost, and the creation of new biomes. The growth of the global world through the resource frontiers resulted in the creation of social construction of the unequal production of nature, unequal social settings, and unequal geographies, which have their own implications.

Providing an brief environmental - history account, Moore (2010b) explains metabolic rifts, commodification of nature, and capital accumulation in the Early Capitalism stages, using the case of the Dutch hegemony to deconstruct the logic between resource frontiers and colonisation. Before the capitalist regime, the social and ecological metabolisms were balancing and keeping each other in check because the social processes relied on the natural processes because you procured the resources from your immediate surroundings. The search for frontiers for resources led to a split between the social and ecological metabolisms because, now that the two metabolisms are separated from each other, there is a tendency to exploit nature to its limits. And once the resources were exhausted, the quest for new frontiers followed, intensifying capital accumulations. This is the metabolic rift (Moore, 2010b). Amsterdam had to rely on the forests of Norway and the mines of Sweden and Finland for shipbuilding, which makes Scandinavia a springboard to search for other resource frontiers and accelerate capital accumulation by increasing metabolic rifts. The increasing geographical expansion of commodity production was one of the initial steps towards an ecological/anthropogenic regime where we undermined the socio-ecological condition to satisfy the demand. Thus, the production of nature and the production of capital are dialectical. The shift from formal subsumption to real subsumption here is quick due to the same rift. With the use of techno-extractive processes, the environment is further exploited to extract resources beyond its natural capacity. Progressive exhaustion of the capacity to contribute to ecological surpluses leads to mechanisation of the hinterland geographies. Industrial operationalisation of extraction environments through extensive infrastructuralisation. This process renders the environments dependent on mechanical processes that depend on continuously changing techno-extractive logics. The processes of extraction are dependent on non-anthropological parameters like weather, soil, geology, etc. The theory of formal subsumption and real subsumption based on the Marxian labour theory (1967) explains the shifts in extractive logics. In the first state of formal subsumption, the productive forces were human and mechanical. (Boyd et al., 2001). With industrialisation, there was a shift to the state of real subsumption, where nature was converted from an extraction environment to a productive force. This was done with the intensification of mining and the logic of extracting the resource through improved precision and more extensively based on technologies that enabled the intensification. This process of shifting from formal to real subsumption was the moment where the dependencies of the extraction created a complex web and, in process, created the planetary impacts. In addition, it develops tendencies for creative destruction, which is the means to destroy current productive practises to improve the methods of production to make the system more efficient (Brenner & Katsikis, 2020).

Creative Destruction by biological definition is the tendency of the biological systems to destroy the old processes from within in the process of creating a new one. Joseph Schumpeter (1943) translates this into economics where he explains the ability of the economic structure to revolutionise from within destroying the old structure creating a new one. This is fundamental to the processes of Capitalism. While the social and natural environment alters economic action and condition the industrial change, they are not primarily responsible for it.

"The fundamental impulse that sets and keeps the capitalist engine in motion comes form new consumer good, new methods of production or transportation, new markers and new forms of industrial organisation that the capitalist enterprise creates"
(Schumpeter, 1943).

Since renewal is the cause of most urban changes and there is economic redevelopment resulting in functional adaptation in many buildings, the formation of new theoretical understandings of urban evolution is necessary at all scales in space and time (Batty, 2007). The new market for REE in Kiruna leads to a higher influx and change in the social fabric. The development of new methods of extraction is the basis for the transformation potential. In addition to designing for the processes, creative destruction calls for proactive design for transformation. The technological development currently tends towards the recycling of waste and the notion of urban mining. The ability and the techno-extractive logics of extracting and recycling can creatively destroy the current processes of extraction that rely on the geological availability of resources. Extraction processes always accumulate infrastructure at different scales to enable extraction—mining, processing, logistics, and inhabitation—for a global market. This accumulation, instead of forming grounds for repair and renaturalisation, can provide the foundation for new planetary processes—for a greater good than just the extraction of material from the Earth. Petropolis of Tomorrow (Bhatia & Casper, 2013)provides an account for the transformation of the offshore oil territories in Brazil and the role of design speculation in it. The functional transformation to use the accumulated infrastructure shifts the perception of extraction as an act of transformation to the transformation of the extraction apparatus itself for socio-economic regeneration. The extraction apparatus in the Norrbotten Technological Megasystem can be designed for its functional transformation, from the extraction of iron and rare earth elements from the geological deposits to the extraction of the material from the waste through urban mining.

From extraction of geological accumulation to extraction of bioaccumulation

The systems of extraction exploit the ecological surplus, which is in the form of geological deposits, and the processing of these minerals downstream in their various forms is accumulated by the urban processes in the cities. Labban (2014)explains this process as bioaccumulation in the process of creating a planetary mine. Bioaccumulation, by definition, is the progressive concentration of substances in an organism at a higher rate than its ability to dispose of them. The matter that is extracted from the earth is accumulated in various forms through its consumption after processing, fabrication, and manufacturing. These materials by the nature of human consumption, are unevenly accumulated in zones of concentrated urbanisation (Brenner & Schmid, 2011), creating a network of a planetary mine (Labban, 2014). The spatial accumulations are uneven depending on the diverse rates of extraction of the geological reserves, downstream processing, and diverse values of consumption and discard (Labban, 2014). For instance, the iron ore extracted at a depth of 1.3 km in Kiruna is shipped through Narvik to the many fabrication facilities like Tata Steel in the Netherlands (Baan et al., in Carrasco, 2020) and then manufactured and accumulated in various forms, ranging from the spoon on the dining table to the reinforcement in the bridge in various territories. The planetary mine here is a product of capitalist industrialization. “The natural wealth excavated from the depth is piled up on the surface” (Bridge, 2009 in Labban, 2014). The accumulation of global infrastructure for iron extraction in Kiruna has a potential for transformation after the depletion of the ecological surplus. Instead of disassembling, the territory can be reconfigured to change its function from extracting minerals from the geological deposits to the extraction of minerals from metallic and electronic wastes from planetary mine. The emergence of the transpolar shipping route in the Arctic allows for this change and strategically places the Kiruna and the supporting technological megasystem to shift the function from the extraction of geological accumulation to extraction from bioaccumulation.

Accumulation of Fixed Capital and Social (Re) productions

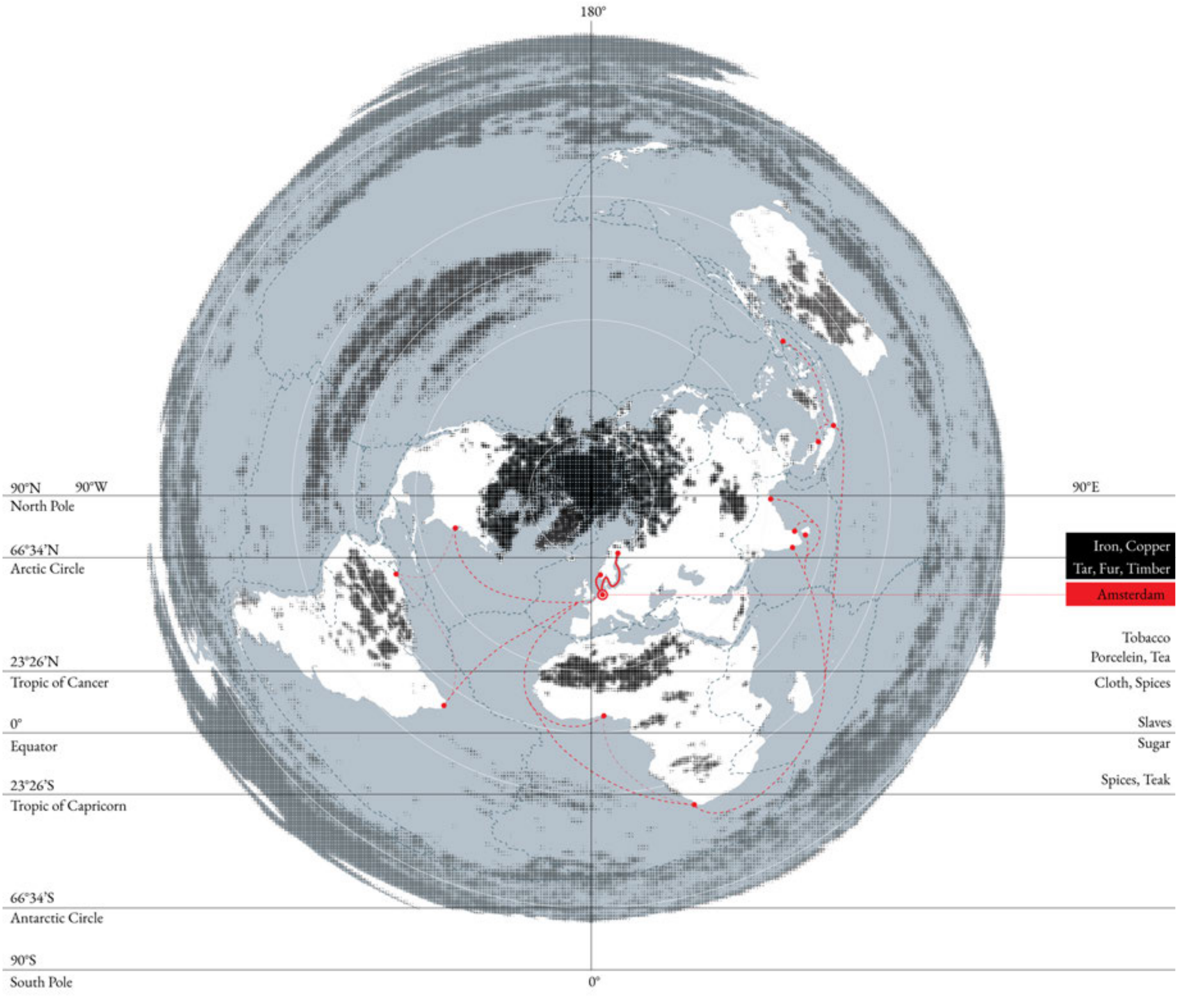
In the economic dynamics that define the Arctic, particularly in the Kiruna and the Norrbotten Technological Megasystem, the "Space-Technology Nexus" as discussed by Swyngedouw (1992) is crucial for understanding how technological appropriation and spatial organisation overlap to form forces of urban and territorial production. Here, the nexus not only suggests co-existence but it is an integrated wherein space and technology co-evolve, informing the creation and perpetuation of infrastructural and social architectures (Swyngedouw, 1992).

Public fixed capital in Kiruna includes infrastructures like roads, schools, and hospitals, which are essential for the social reproduction. Private fixed capital consists of mining facilities and associated logistics infrastructures owned and operated by LKAB. These two shape the economic in the extraction territory. Private fixed capital is accumulated through infrastructural expansion. In Norrbotten, the accumulation of fixed capital is represented through massive infrastructural investments to support extensive mining operations which is privately appropriated. The main function of the infrastructure is facilitating the extraction and transportation of iron-ore. But it supports and conditions the regional economy. There is a need to use this accumulated capital to foster multifunctional landscapes that contribute to a diversified economy. The transition needs the shift from privately appropriated to co-operatively shared resources advocating for a post-capital territorial organisation of co-existence. The notion of collective goods becomes central. While territorial organisation is a force of production , its aspect of 'indivisibility of use-value' and 'its rootedness in space' (Swyngedouw, 1992) can be used as a transformative force to reorganize the territories of extraction towards post-capitalism. Here the forms of spatial and territorial organization can be utilized to maximise communal benefit. In the capitalist state, collectively produced goods – territory is privately appropriated. The post-capitalism should move towards shared cooperative appropriation of socially produced goods. This approach resonates with Marx's emphasis on co-operation as a collective force (Marx, 1977 cited in Swyngedouw, 1992), suggesting that modern-day “guilds” or co-operative entities manage resources and infrastructures. There can be an attempt to include the indigenous Sámi communities whose cultural and economic practices – mainly reindeer husbandry have been conflicted by traditional extractive economies. In a nutshell territorial organsiation is a transformative force for design.

Amsterdam is standing on Norway

The map illustrates the last of the wild and the resource dependencies of the Dutch golden age on Scandinavian resource frontier which provided it the springboard to explore new frontiers in the 17th and 18th century.

- Last of the wild v2
- New colonisation explorations
- Scandinavian connections
- Tectonic boundaries
- Amsterdam
- Dutch colonies 17-18th cent.

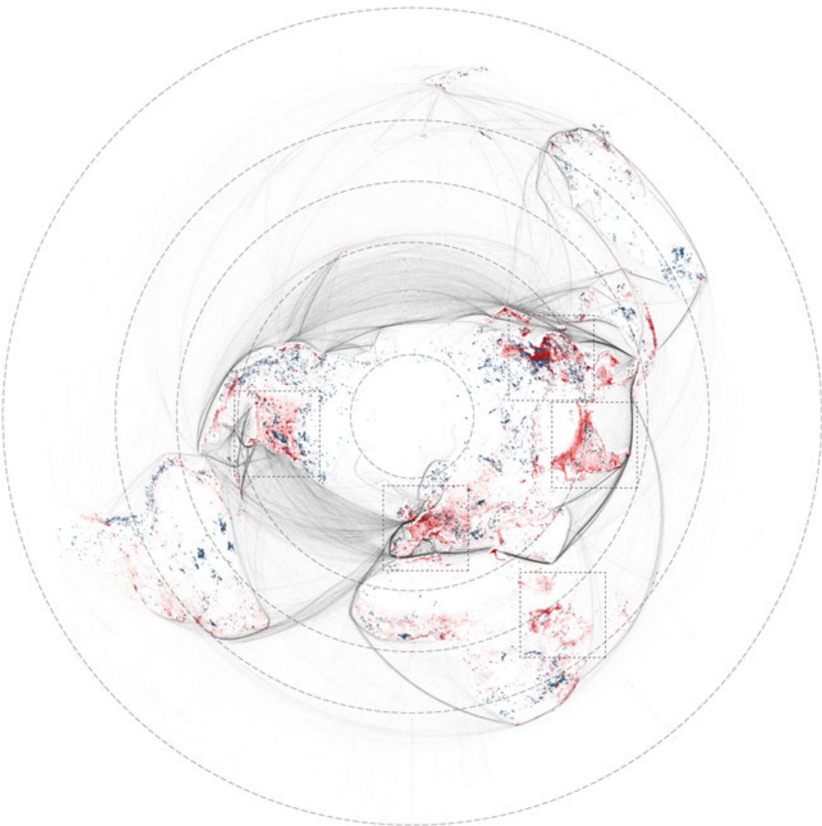


180°
90°N
North Pole
90°W
90°E
66°34'N
Arctic Circle
Iron, Copper
Tar, Fur, Timber
Amsterdam
Tobacco
Porcelein, Tea
23°26'N
Tropic of Cancer
Cloth, Spices
0°
Equator
Slaves
Sugar
23°26'S
Tropic of Capricorn
Spices, Teak
66°34'S
Antarctic Circle
90°S
South Pole
0°

Planetary Mine

The map illustrates the geological mines - geoaccumulation with respect to human influence density which is a proxy for the accumulation of materials in the form of waste - bioaccumualtion

- Human Influence Index - Planetary Mine
- Marine transport
- Geological mines
- Geographical lines



On-Site

This chapter provides an account of the conditions observed on the ground through an interview with a Sámi reindeer herder and youth politician and a photo essay on the nature of extraction landscapes in Kiruna.

Literally Crumbling to the Ground

Interview with Nils Joel Partapouli
Sámi reindeer herder, artisan and youth politician
Årosjåkk, Kiruna

by Kirthan Shekar and Nancy Nyugen
[with support of Polis - TU Delft Student Platform for Urbanism and Landscape Architecture]

The interview discusses the insights of the Sámi community focusing on the conflicts of the Sámi livelihood and the extractive practices. It critically discusses the cultural and environmental disruptions, manifestation of green colonisation and the Sámi relation with nature. The interview underscores the urgency for the design and planning paradigm to involve the traditional knowledge of the indigenous population highlighting the necessity to transform extraction landscapes with care to regenerate culture and ecology.

[Kirthan Shekar]
Who are the Sámi and tell us abput your livelihood?

[Nils Joel Partapouli]
So, the Sámi people are... The Sámi people are Europe's only indigenous people. We have been here in northern Scandinavia since the Ice Age ended. So, it's a people that lives across all of the borders. So, from Norway, across northern Sweden, Finland and Russia as well. The Sámi people have traditionally lived on reindeer herding, on hunting, on gathering handicrafts and also trading with other people around the area. And, yeah, it's a very diverse culture. We have a lot of different languages, we have a lot of different clothing practices. Even our traditional practices differ a lot from region to region. And, like I said, with the languages... So, in Sweden, where I live, there is five Sámi languages. There's Northern Sámi, which is the biggest. And then there is Lule Sámi, then there is Pite Sámi, Ume Sámi and South Sámi. Like I said, daily life is these kinds of cultural practices. Reindeer herding, hunting and fishing, gathering handicrafts. But also, a lot of Sámi people work with music, with song and joik, which is the traditional Sámi way of throat singing, you could say. And also just normal everyday life, you know. Just working in a boutique or, you know, like a majority... Like the jobs that exist in a majority society, so to speak. We are very diverse people, a lot of politicians.

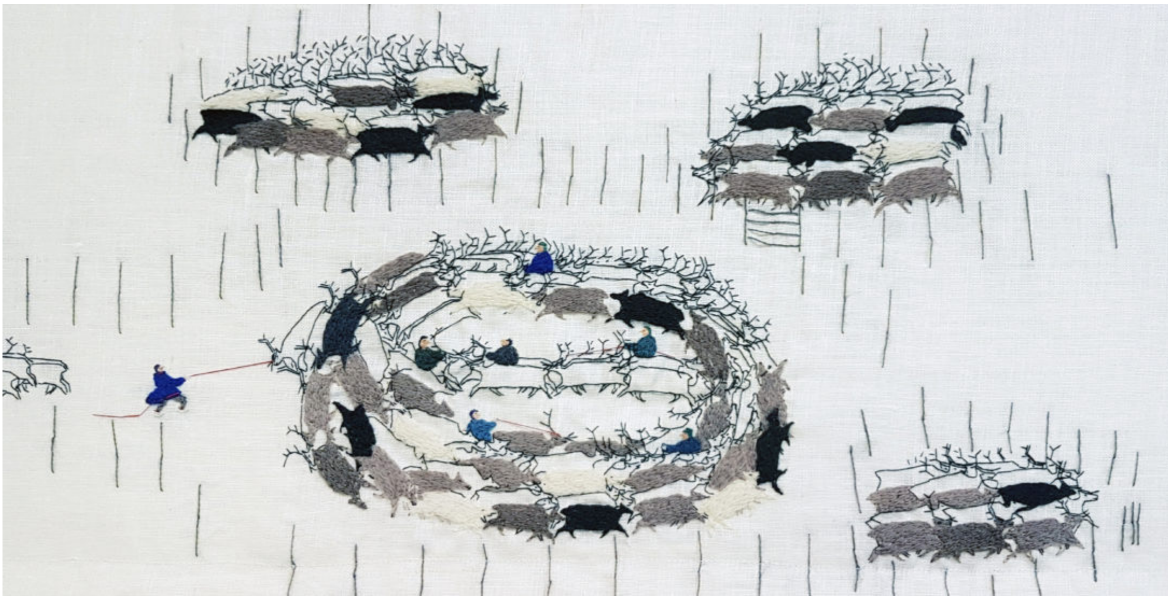
[KS]
There is a very nice relationship between Sámi and the natural forces that happen there. You have a very beautiful way of connecting with nature and trying to base their practices on the natural forces that are there. Can you just explain more about the Sámi views and the relationship with nature that you have? With time, with sun, with moon. You have day and night.

[NJP]
The Sámi culture is very, very rooted in nature. And like I said, our cultural practices are very nature-based. And eventually the religion, the old Sámi religion, which is extinct nowadays, mostly extinct at least, it formed around the nature. So we live, you know, this has gone down generations and generations. We don't practice our religion as we used to do, but a lot of the thoughts we have inherited. As a Sámi person, I feel a lot of responsibility when I'm out in nature. Because we're taught and grown up with the belief that everything has a soul in it. So it is my responsibility to protect the land and the resources for the next generations to come.

There's an old saying that I <u>do not receive the land and the resources from my ancestors. I am merely keeping it for the next generation.</u> So I do not own anything. I only have responsibility to protect and to use responsibly the resources and to thank nature for what it has given us.

And it is, in a way, it's a little bit poetic to say it that way, but that is really what a lot of Sámi people are, you know, it's been instilled in us. Because it's been passed down generation after generation. And it's born from our old religion, which is mostly extinct nowadays. We used to have gods for every single aspect of nature, the sun, the moon, the earth, the heavens, the winds. And you would pray to these, you would pray and give offerings to these gods to help you in both mundane tasks, but also longer journeys you had to do.

The Sámi people used to be a nomadic people. And we used to follow the reindeers. So during the summer, the reindeers will migrate to the east. And then in the autumn, they will go a little bit more in the center inlands, but kind of the border between mountains and the forest. And then the winter, they're supposed to be in the winterlands, which is to the west in the forests. And then spring, they will go up again to these kinds of center lands. So the Sámi people used to follow the reindeer.



Section of an embroidered fabric Historja, 2003 by Britta Marakatt-Labba
[Photograph by Catherine Wang / KORO - Haetta, 2022]

So they lived a very nomadic life. They had these Sámi tents we call lavvu. They are very similar to the tentipi of Native Americans. So there's a lot of interesting stories about how to store things in these different lands, because you can't be traveling with your winter equipment during the summer, for example. So the Sámi people have always been very, how to say, very, very skilled in navigating and knowing the land, what resources there are.

[Nancy Nyugen]
And kind of having this awareness of the need to maintain the land for next generations, like what you were saying, do you feel like now in the modern life, you're in a way also practicing this? Or how do you feel like you're now using these ideas to live your life?

[NJP]
I would probably say that it is a thing that is very unconscious. I don't really think of this huge responsibility I have. Instead, it's something that simply exists, something that is very natural for me. Like I said, it's something that's been instilled. It's not something I have to think about and to wonder how will I do or anything like that. It's just I'm grown up with it. And that's just something I do.

[KS]
So one thing that we also have learned is that the Swedish industries that you have the migration from the south, the Swedes from the south came and there was colonization of this army. There were aspects where I think for the past 200 to 300 to 400 years, they have been colonizing the land and adding the ideas of, I mean, you do that. Your land is not your land, but they're imposing the concepts of property, western concepts of those aspects. And like these aspects, how did the establishment of Swedish industries impact the Sámi community and their way of life?

[NJP]
So, yeah, it's very clear. Like the first impact is, of course, on the land. That is very clear. These industries were mostly mining or forestry, deforestation. So that is a very clear first sign is that you have to destroy the land, which

are very important for ranger herders and for hunters and also fishermen, because you will be polluting water.

So that's a very obvious first sign. But I also want to talk about the culture that industrialization brought upon the Sámi people, which is very, it is a very macho culture. You have to be very, a very strong man and very serious and you don't take shit and that sort of thing. It is very clear that is something that changed in the Sámi community. My mother had told me that when she was younger and the old, the real old men then, they were very humble. They were very aware and very kind people. But with the growing mine industry in Kiruna, that culture changed very much so that the young men, when she was young as well, they grew up to be very, very arrogant. And thinks a lot about just money and being the best and the best. So that is something, that is something that's very, not a lot of people will talk about because it's much clearer to see. Oh yeah, mine will, you know, destroy a land. But for me, it's as important to talk about how the culture between Sámi men and women have changed a lot. And like the core beliefs that we've grown up with aren't as important anymore. It's more important to have a lot of money and big machines and you're very strong and big and handsome. And that is, it's very sad.

[NN]
Just as a reaction or as a question. So you're saying that these Swedish industries that came also created the division in the Sámi community itself?

[NJP]
Yeah, for sure. It's a little bit deeper than that. It's, the Swedish, Norwegian and Finnish states have for a long time, they've been, I don't remember the term in English, but it's sort of this political move where you divide, divide and conquer, that's what it's called. So the states have been very, very, in the beginning of the, so you could say the Swedification, you could say, where, you know, this is a long time ago, this is like 1500s, where the Swedish state wanted to make the Sámi people Swedish, because then they can own the whole land for war and such. And in the beginning it would be very much, it was a lot of violence, it was very physical, you know, kill off Sámi people, kill off our shamans, so that the religion would die out. But that didn't work out that well. Sámi people are very, what's the word for it? Sámi people are very resilient. So what they then turned to instead is this divide and conquer, where if you can divide the Sámi people, they will start fighting between themselves. So that's what these states have been doing for a long, long time, and it's worked pretty well. Inside our, you know, inside our community, there is a lot of feuds. So, you know, we could be between family and family, but also different communities. And that's a result of the Swedes and the other national states dividing and conquering.

[KS]
Actually, when you're talking, I actually feel that, like the gender divide also, like to say that you are masculinizing the jobs, like you're making more, like you're saying this is for the man to do, this is for the woman to do. So those concepts also were something, I think, so it was a colonial principle to say, you know, you divide people so you can control them. Yeah, I think it would be great to have your views on this masculinization of jobs.

[NJP]
So, yeah, it's very clear in the reindeer herding community, how just what you were saying about the whole genderification of jobs. It's very clear that the reindeer herding has become a more of a masculine work. Even as a young boy, you're expected to be the one to inherit the reindeer herd in your family and to work with it. Personally, in my family, my mother has always been, she's always worked with reindeers. So when she married my dad, he would become like the, you could say the head reindeer herder. But when they had my oldest sister, it was very natural for her to inherit a reindeer mark from her own reindeer. So I've grown up with the belief, it's the

view that, you know, it doesn't matter if you're a man or a woman, you're a reindeer herder as well. But it was very shocking when I was a teenager, I was learning to know, like, she's a friend of mine now, but when I was learning, getting to know her, I was very shocked that her little brother received a reindeer mark before her. And I told her, I was like, that is super weird. Like, you're the eldest. Why didn't you get? And she kind of told me that it's probably because he's a boy. So that is something that is very clear. But it's different, it's different across Sápmi as a whole. The area where I live in, it's very, it's very, it's not weird for a woman to be working with rangers. There are actually a little bit south from where I live, it's, there's a lot of female ranger herders that has it as their first job, their lifestyle. But I know, but I know a lot of areas in Sápmi where it is very uncommon for women to be ranger herders. So yeah, it differs.

[KS]
How did the Sápmi and the land practices change historically, like to say, like, you know, they had some form of land practices, how did they change gradually or at the moment or something like that? So can you just elaborate on that?

[NJP]
Yeah, like I said, the Sámi people used to be a nomadic people, like entirely nomadic, where everything you owned, you had on you and the reindeer was your property. So you used the reindeer for, for food, for clothes, but also travel and for, for bargaining when you, when you trade stuff with the Swedish and Finnish people that live locally. So that's something that's very, it would be, it would be so, it would, it would honestly be fantastic to see how these people lived, because you had to be very, you had to be very clever. You had to have a lot of knowledge. That you work well, both individually and together with other people to survive harsh winters and long traveling during the summer. So that's something that's very much changed is we are much more based nowadays. So of course we have our house. This is, this is where I live.

I tell people I live here in Årosjåkk and we aren't as we don't have, because of the mine and all of the industries, industrialization around us, we don't have the ability to go as far east and as far west as we historically did. So we don't really have a need to have, you know, a lot of houses all over the place, because that's something, it was a gradual transition from being, you know, you had all of your property on your, on yourself and on your reindeer, but then people would build houses and cottages in different areas. So we, my family, we have our house here in Årosjåkk and during the summer where we mark our reindeer calves in the mountains, we have a cottage there and in the west, no, I mean in the east, in the winter lands, we have a house there as well because my grandparents and my mother, they used to live, their whole winters, they used to live in the forest with the reindeer, but we can't access those lands anymore. So we don't use that house as much as we used to do. So that's something, it's very clear to see how, how our life is changing in my lifetime as well. My mother has told me a lot of stories about this village, it's called Vettasjärvi. And yeah, she's been there her whole, her whole, like, young adulthood. She's been there the whole winters, but I have, I have barely been there.

[KS]
That account actually gives you much more, much, gives a personal view on, on the practices that actually change historically. And yeah I think that's nice. You have this mining situations all around the north of Sweden, of course, it's mostly concentrated in Kiruna and Malmberget and that area. But still, like, what are the, what is the Sámi standpoint on the whole mining situation? There might be some differences also, but, but what is the, what is the standard standpoint of this mining situation?

[NJP]
I don't think I've met any Sámi people that is for the mining that are entirely and truly believe that this is

something good and something sustainable. I think most, Sámi people will agree that the mining is only hurtful for, for our lands, for our living. It is, of course, very good for the state because they get a lot, a lot of money and they can sell to Europe. But this money doesn't come around to either, either a Sámi people, but also it doesn't come to the local people as well. It is very expensive to live here in the north and you need a lot more resources to survive. But we don't get anything. All the money goes out into the world. Of course, you get your salary, but the infrastructure and the city doesn't get anything back. So it's, it's just, you know, it's just, ****** everything.

It's just like I've talked about this so much my whole life, my whole upbringing, how the mining destroys our land, but you can see so clearly now that the mine is also destroying the whole city. People will believe that Kiruna is this very rich town and there's so much possibilities, there's a lot of future, but the municipality doesn't have any money because the money doesn't come around, it just disappears from Kiruna.

LKAB is doing fantastically, they are thriving, but the city itself is <u>literally crumbling to the ground</u> and there's no money.

There is, there's nothing that can save it anymore. And people are finally starting to realize it. It's been a long road, but people are starting to see that this isn't sustainable, this doesn't work. This is kind of what I, this is also kind of what I mean when I said in the beginning that every Sámi person's life is very individual.

[KS]
As you told, the town is crumbling down, literally crumbling down. And yeah, I mean, I would say no Sámi would be like towards this aspect of the mines, the mine sinking, the ground sinking and stuff like that. What is the Sámi view on the relocation of the town?

[NJP]
Relocating the city is, it is stupid. It is stupidity. It is, it's so expensive. And the whole reason for this is because of the money. It's sort of this big monument of greed, of how much LKAB wants to earn. And it is literally making the whole city fall into its hole that they are mining. So, like, just even the thought of it is just baffling. It's so stupid.
It's such a waste of money. Like I said, it's, there's so, there's so, like, just incredible amounts of money that are being handled so irresponsibly. And it's just, nothing's gonna hold. I don't know if you heard, but the bathhouse in Kiruna, I heard you were visiting, if you saw it, beside the center, that building, it isn't done yet, but it's cost us over a billion Swedish crowns. And it's still going, it's gonna be even more.

And regarding the design, the architecture of the new center, a lot of people, a lot of people I know say that the new city center is very unpersonal. There is no soul. There is no personality. It is very sterile. It is very, it is very modern Scandinavian design. And it's just boring. It's just the same thing. It is very cramped. And the architecture does not take into consideration the nature we have around us.

So, for example, there is a lot of, there is a lot of flat, there's a lot of flat roofs and also roofs with very different kind of shapes and geometries, because that's interesting to look at. But what happens is during the spring, the snow that's stuck in these nooks, and if it's just flat, you know, it's just on the roof, it will start melt and then it will seep through the buildings and there will be leakage. So that happened with the municipality building. It was the first one to be erected. And the first spring they had to put buckets inside because there was so much leakage all over the building. And same thing happens in the fall. There's a lot of rain. Rain will seep into these nooks and crannies and they will seep through. So it's, people are not happy with the new look, the new architecture, how much it costs, how much it costs to repair it. And it's a shit show all around.

Street in New Kiruna

And you asked about kind of the Sámi influence. Kiruna is very keen to not show off the Sámi culture and people when you're, you know, for the residents, for tourists in these tourist shops and, you know, propaganda, you could call it, then they are very keen to use Sámi pictures and movies and joiks and to show off reindeer and all that. It's very good for tourism. But when it comes to daily life in Kiruna, there is nothing at all. There is only, yeah, there's only at the municipality building, there is the door handle. The door handle is an old Sámi handicraftsman who done it for the old municipality building. So that's, that's that, probably. There are some pictures in the hotel, but other than that, there is no naming conventions. There are no kinds of colors or, you know, that sort of thing to indicate that this is Sámi area, this is Sámi land.

[NN]
Were the Sámi community involved in the design of the new city center as well?

[NJP]
Not at all. Nothing, nothing at all. Not our Sámi community, not our neighboring Sámi community, not the Sámi organization in Kiruna. Nothing at all. Usually what happens when sort of the municipality and LKAB discusses things with Sámi people, it's mostly they discuss unto themselves, they send a letter or maybe a call or something and say, this is what we've decided. What do you think?The Sámi people will say, most likely they will say that's a very horrible decision. We think this is better. But they can still go through with this decision because it's already done. What they've done is informed us, but they can then say that they have had local discussions with the Sámi people. It's very false, all of it.

[NN]
And were there any protests from the Sámi people? Is something happening publicly or is this a very quiet process?

[NJP]
In Kiruna, Kiruna is a very quiet place in that regard. There's a lot of this quiet culture, you could say, where you don't really make a fuss about anything. Just be happy. You can go to the mine and earn a lot of money and that's good and you don't need to think about anything else and don't complain. So the only people who will speak up, not the only people, but most of the time the people who speak up and protest and that sort of thing is the Sámi community and reindeer herders. And there's also this culture in Kiruna where you're not supposed to agree with the Sámi people. It's not very good. So if you agree with the Sámi people, that's not really good. It's not really pretty. You're supposed to just keep on working, get your money and that's all.

Last summer, I was a part of a sort of a protest, you could say. It was the youth in our Sámi community and then in our neighboring Sámi community. So I'm from Lervas and the other youth in Gabna. We staged this ceremony in the middle of the city center where we mourned and took farewell of the land we cannot use around Kiruna anymore. So the mountains there are literally destroyed. The whole area, the backside of the mine, you cannot use anymore. There are roads and railway roads, which narrows our possibilities. So we had this dual memory ceremony and also this protest telling people that the land cannot take it anymore. We're literally on the last straw. We cannot have

Memorial ceremony for the lost pastures in Kiruna in 2023
[Photograph retrieved from Min Odda Giron]

any more mines. We cannot have any more infrastructure because this is our livelihood. Ranger herding, hunting, fishing. We will not be able to do it in the future because the Swedish state just keeps on taking and taking and taking and taking. And it's in small doses every time. So, you know, LKAB or some other, not organization, but other company will come and say like, this small area, we will take it. It's nothing. It's just a small area. And another one will say this small area we can take. There's nothing here, this small area. And, you know, over time it will just increase, increase, increase, increase. And we'll just, it will just take everything.

[KS]
I mean, when you're saying about like this company, this company's LKAB or this other small subsidiaries, which actually take the land, like expropriate the land from you LKAB has proposed a new mine in the north of the town, like the new deposit. And wanting to like extract the minerals from that and giving it a label of like it is necessary for green transition because there are precious rare earth minerals because that can help in the geopolitical crisis to like get less dependent on China because right now we are depending on China for those minerals. What is your view?

[NJP]
Yeah. It's, it's, it's so like all of this, you know, even, even though I know that all of these fancy words, they are just propaganda. That's all it is. It's still, for me, it's just so, it's just so stupid. How can you say that opening another mine is a green act? It is, it is just idiotic because mining, whether it's underground or overground, is, it cannot be, it cannot be something that is green. It's not something that is reusable. To be ecological, it's meant to be that you can refurbish or you can reuse or you can, in some sort of way, the circular motion. But it's not possible because all you do when you mine is you extract minerals from the earth and destroy it. That's all it is. There is no, there is no green mining. It's not possible to have it.

And it's also very clear how much indigenous people are worth to these mining companies because it's, it's so easy for them to take our land and to also narrow our possibilities for our livelihoods in the name of saving the world. This is going to save Europe. This is going to give us batteries. This will, this is for the future. But it's, it's in a way that will destroy us, the indigenous people. We are not worthy of, we are not worthy of surviving, essentially.
Because what this mine does is it will, for our neighboring Sámi community, Gabna, that will make it impossible for

Tailing pile from the train approaching Kiruna

them to do traditional reindeer herding, where you move with your reindeer herd on foot or with machine, but you're still with them. Because if there is a big mine there with infrastructure that will just blow out in all directions, they will not be able to reach the winter lands anymore.

But like I said, it's okay because it's Sámi people, it's reindeer herders, it's not a big deal. We can offer them because of saving the world, but that's not what LKAB is interested in. They are only interested in profit. And it's also worth thinking about what is LKAB. It is a state-owned company, and if you're a private company, then you're supposed to be working for profit. You're supposed to be working for monetary gain. But the state is not supposed to be working for profit. They are supposed to work for the people and for the society. But LKAB just keeps on showing day in and day out, year in and year out, that they do not care for the local residents in Kiruna, for the municipality, or the Sámi people or the reindeer herders. They are only for profit.

I do not believe in the slightest that this mine is to save Europe and to transition into some green whatever, whatever. It's not that. It's only profit. They have found this huge way that they can extract and have more money. That is what I believe in. And I think a lot of Sámi people believe that as well.

[KS]
But do you think there's an alternative to extraction or involvement in decision-making? Is there an alternative for this idea of extraction?

[NJP]
I don't know, but I don't think so. Yeah, that's a tough question. But yeah, I don't believe so myself. No, because you could always… You can if you want to as a mining company. You can be more aware of the effect you have on the land, the water, the air. So you can be more, so to speak, green. You can be more, you know, doing more refurbishing and stuff like that. For example, I believe there was a study published like maybe a year ago or maybe two. That essentially what they discovered was that in the… Around Kiruna, there are these huge, like, almost like mountains of waste. Just, you know, just rock and ground. But they discovered that there was like a huge percentage of material you could refurbish from this waste, what LKAB calls waste. LKAB has the means to research these kinds of things and to find solutions so that they could reuse these, like I said, these mountains of waste. When you go by train

from Kiruna, you will be in like a valley of just rock and ground. And they could probably, you know, decrease the size of all of this with a lot because there is so much material still there. But LKAB refuses to do it for whatever reason. Probably, you know, research money, whatever. I don't know. But there is ways to be more efficient with your extracting. But it's very clear if you take that step and if you don't, it's very clear what your goal is.

[NN]
And do you feel like there can be an alternative in the involvement of decision-making so that maybe the Sámi community can have more voice in how the city is transforming?

[NJP]
Yeah, of course, I believe that. There is a lot of expertise in Sámi people and reindeer herders that is not valued at all. And that is a result of a very racist system. I don't remember the term for it right now. But it's when you make a system and when it's built on racist beliefs, you will just inherently, you know, in the laws, between the lines it says, do not trust these people. So that's something that LKAB and Kiruna is literally built upon. Do not take into consideration the views of the Sámi people and the reindeer herders. Because they only want everything for themselves and they do not want anything good for Kiruna and the city and all of this. That is inherently what the system is built upon. And they can say in some sort of way that we have discussed this with the Sámi people. When it comes to land and water, there are no better experts than the people who live, who move and live there and work there almost every single day, every year round. There are no better experts than Sámi people and reindeer herders. But that knowledge is not valued because we don't have a diploma. We haven't gone to school for five years. We have only done this our whole lives, our parents' lives, their parents' lives and so on and so on.
So, when it comes to decision-making, the first step is to acknowledge that the system, you know, making decisions, making laws, it is skewed against the Sámi people and reindeer herders. It has been for a long time. And the second step would be to value our knowledge and expertise and actually take into consideration what we say. An example of that is where the new city centre is placed. It's originally a wetland. They had to dry these wetlands for several years. I remember when I was going to school, they were drying out these lands for so many years and putting so much rock under it because that's where they were building the new city centre. And the name of the place in Sámi, it's Beikkusáhpi, which means a windy wetland, essentially. And people have noticed that when the new city centre was built, it is very windy there and these narrow, like, almost corridors that they have built just exaggerates it. So it will almost, year-round, it's blowing so much into, like, to the municipality building, it's just blowing. And that's something that if the municipality would have taken some kind of decision with the Sámi people, they could have told that this is, as simple as this, this is a bad place to put the centre because it's very windy. That's all, but it didn't happen. Also, who builds anything on a wetland? It just keeps on showing how incompetent and how much dreaming there is of this building, of this city centre.
Like, it's just unimaginable.

[NN]
Very sad to hear how unfair the system is. We have our last question. And that is, is the Sámi community benefiting from the economic development due to the mine?

[NJP]
So, in a way, you could say, it's a little bit controversial, but this is how life is around here. I know a lot of Sámi people and a lot of reindeer herders who work in the mine, because there is no other way to make ends meet. Being a reindeer herder is very expensive. You have to have the equipment, you have to have buildings, you have to buy food for the reindeers during the winter. That is very, very expensive. So there is a lot of money that goes out, but not a lot of money that comes in when you're a reindeer

herder. There are only a couple of opportunities during the year where you can sell reindeer. And you cannot sell that much because, of course, you need to have your herd if you're supposed to be surviving. So a lot of reindeer herders and Sámi people will work in the mine because the salary is great there. There is so much money you can make and you do not need to work as much. And a lot of the times you will be working for two weeks straight and then you're free for two weeks. Then you can be out with the reindeer. And LKAB knows that as well. They have made a point that if Sámi people are working in the mines, then of course they like it, they approve of it. But like I said, it's only because you cannot meet the ends otherwise. There is no other work in Kiruna that is... Well, there are, of course, if you search for it. But working in the town as a cashier, for example, that's not possible if you're a reindeer herder. You need more money for it. So it's... Like I said, it's controversial. I know a lot of my friends who work in the mines. They will say that the mine is already here and it will not disappear. So I can work there. And it's to kind of protect... It's sort of to protect yourself in a way. For a lot of people it's the only way to be a reindeer herder, is to actually work in the mine, which is very ironic and it's sad in a way. Personally, I have chosen that I will never work in the mine because of principle. Like I cannot tell people that I do not approve of the mine, I do not see a future with the mine, and then also work there.

[KS]
Thank you very much for the interview. If you were to ask a question to summarise your standpoint what is it you would ask?

[NJP]

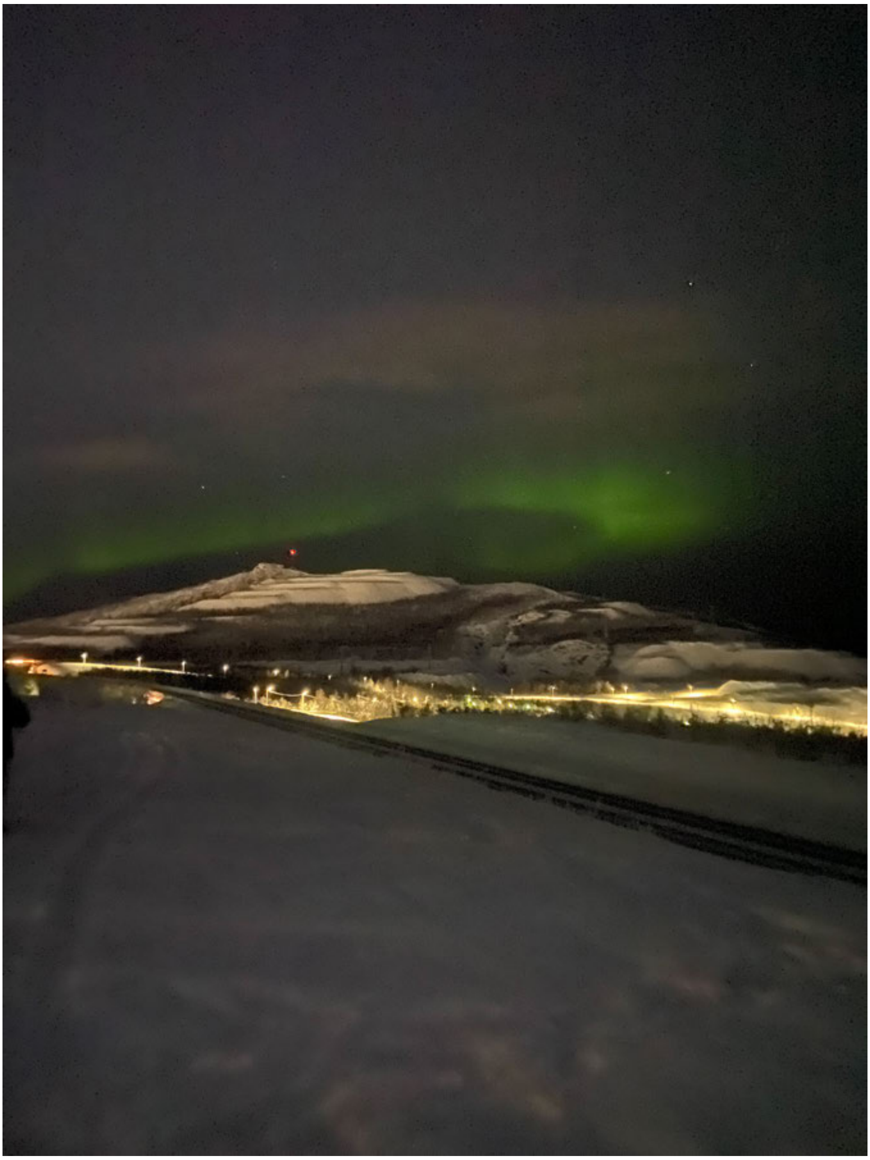
When it come regarding green mining, what do you think is truly green and ecological. The Sámi way of living that has been, you know, its existed for thousands of years, the land where we have lived is pretty much unchanged. Or just over a hundred years, of LKAB existing and they have destroyed two mountains and they are burrowing a third mountain, moving a city because of that and just destroying and narrowing our traditional way of living. What is truly green?

Historical open-pit layers and deformation zone of Kirunavaara mine

[left] Freight rail forming logistically extensive landscape
[right] Ore wagons for the transportation of iron ore

[left] Extent of the mining surface deformations, processing plant
and the tailing piles with the old town in the foreground
[right] Tailing pile used for waste rock storage

[left] Luossovaara surface deformations from previous mining
[right] Formation of ghost town with buildings ready for demolition or relocation in Old Kiruna



[left] Luossovaara mine in a night with the Aurora Borealis
[right] Frozen River Torne near Jukkasjärvi

[left] Thermal plant and residential area in Old Kiruna
[right] Abandoned Tuolluvaara mine near New Kiruna

[left] Presence of Extraction landscape in the background in any location Kiruna
[right] Places such as schools and public places representing the social reproduction

[left] Logistical Zone in Kirunw which is heavily industrialised
[right] Buildings ready for demolition in Kiruna

Anatomy

This chapter uses the perspectives of monofunctional, sacrificial and determinate landscapes to analyse the territories of extraction through critical cartography and systematic cataloguing of the mining infrastructure and methods of repair. This analysis provides the inferences for transformation actions through design.

Kiruna is a example of "Technical Landscapes" (Gallison, 2022) where global knowledge practices have transformed the physical geography of land. Extractive landscapes rely on performative parameters such as surveying geographical location, identifying geological composition, and extracting resources (Nesbit & Waldheim, 2022). The mine's core features a complex network of tunnels called drifts, excavated using periodic explosions to access and extract the 80m thick iron ore deposit. The mine's intensive mining methods have considerable ecological repercussions, with heavy metals, greenhouse gases, dioxins, and particulate matter emitting pollutants that contribute to air quality degradation and health risks to surrounding communities. The iron-ore processing facility processes the extracted magnetite ore into pellets and powder, emitting heavy metals, greenhouse gases, dioxins, and particulate matter, contributing to air quality degradation and posing health risks to surrounding communities (Swedish Environmental Agency, 2022). The processing of iron also necessitates large amounts of water, which are deposited into tailing ponds and recirculated, impacting the natural biodiversity of the area. Beyond the mine and mineral-rich geological formations, the Norrbotten Technological Megasystem (NTM) encompasses a number of other features, such as the exportations from Norway's Narvik to the Norwegian Sea and Sweden's Lulea to the Bothnian Bay, and a network of hydropower dams on the Lule river to power the machine. The Megasystem extracts iron ore in the form of magnetite and hematite in Kiruna, Svappavaara, pelletises them in Kiruna, and transports them across the Scandinavian mountains to Narvik by Malm Rail, where it is exported. On the other side, the iron ore extracted and pelletised in Malmberget is transported to Lulea, where SSAB (Svenskt Stål AB) processes it into steel and exports the steel through the Bothnian Bay. The entire transect of the NTM consists of other forms of social and natural production, but the LKAB's mining operations for iron define extractivism because of the mining intensity, export orientation, and primary processing functions. Extractive landscapes are characterised by generation of different types of spatial interventions, such as extraction enclaves, support areas, and connecting networks (Gudynas, 2021). In the case of Kiruna, the functional role of the mine is to extract and process iron from deposits. The logistical area supports the iron ore mining and processing operations, with an expansive network of railway tracks, conveyor belts, warehouses, and control buildings. The monofunctional landscape of Kiruna is an instance of extended urbanisation, with operational landscapes situated far-beyond dense population centers forming the hinterlands. Brenner and Katsikis (Brenner & Katsikis, 2020) argue that operational landscapes have become more industrially intense, infrastructurally dense, and specialized. The monofunctional network of the iron movement extends to the global commodity chain and markets fueling extraction, intensifying the definition of technical lands. The question of harnessing sociotechnical capacities for more just, democratic, non-violent, culturally vibrant, and ecologically sane forms of collective existence is raised , prompting a critical rethinking of spatial design in programming landscapes beyond the technocratic approach to extractive landscapes.

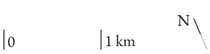
[Elaborated in the working paper in the appendix : Federighi, V., Bacchin, T. K., & Shekar, K. (2024). *Which Landscape: Material traces of an integrated design and research approach in Kiruna*.]

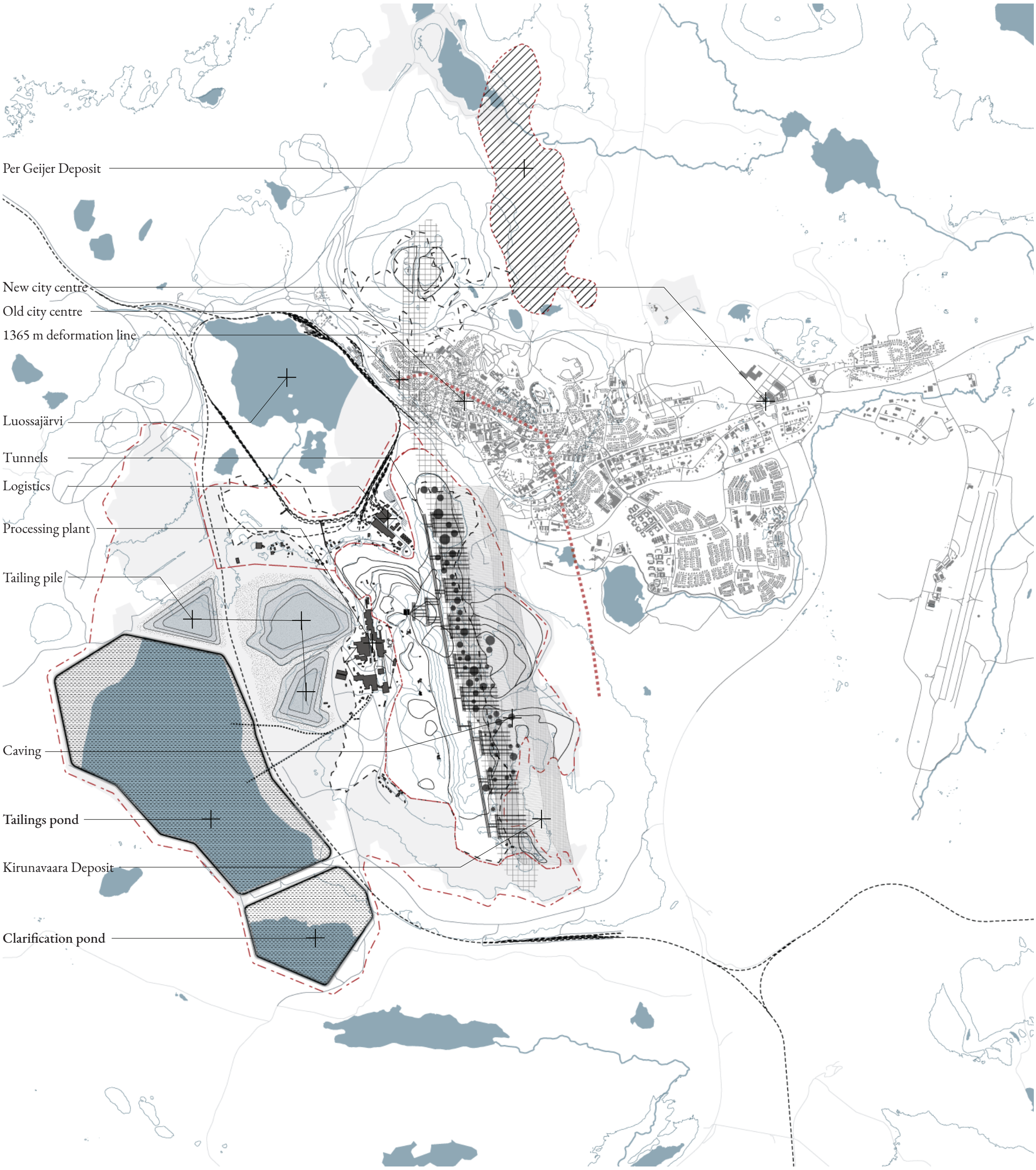
Mining

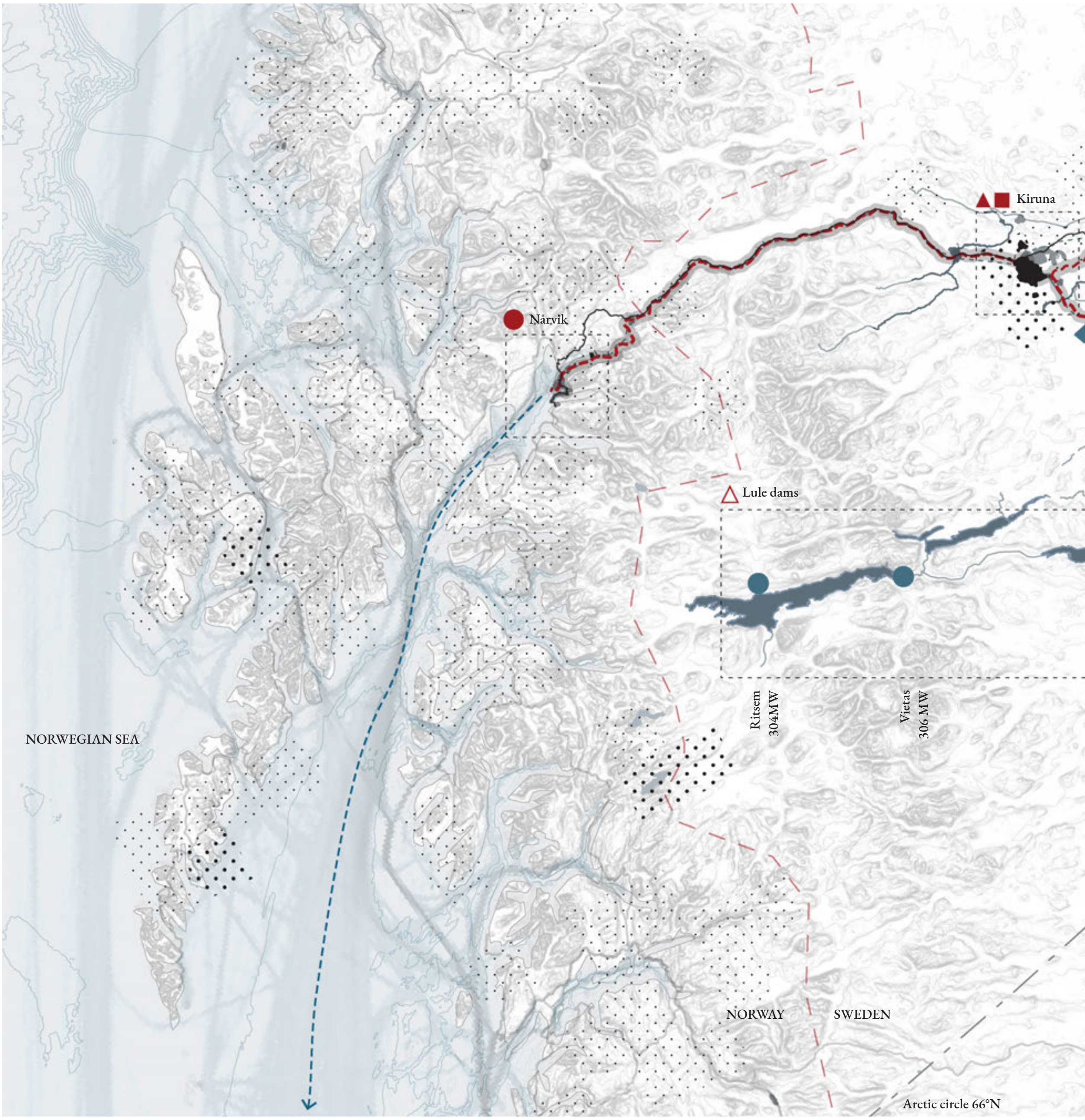
Processing

Logistics

Composition of Mining infrastructure in Kiruna




Per Geijer Deposit
New city centre
Old city centre
1365 m deformation line
Luossajärvi
Tunnels
Logistics
Processing plant
Tailing pile
Caving
Tailings pond
Kirunavaara Deposit
Clarification pond

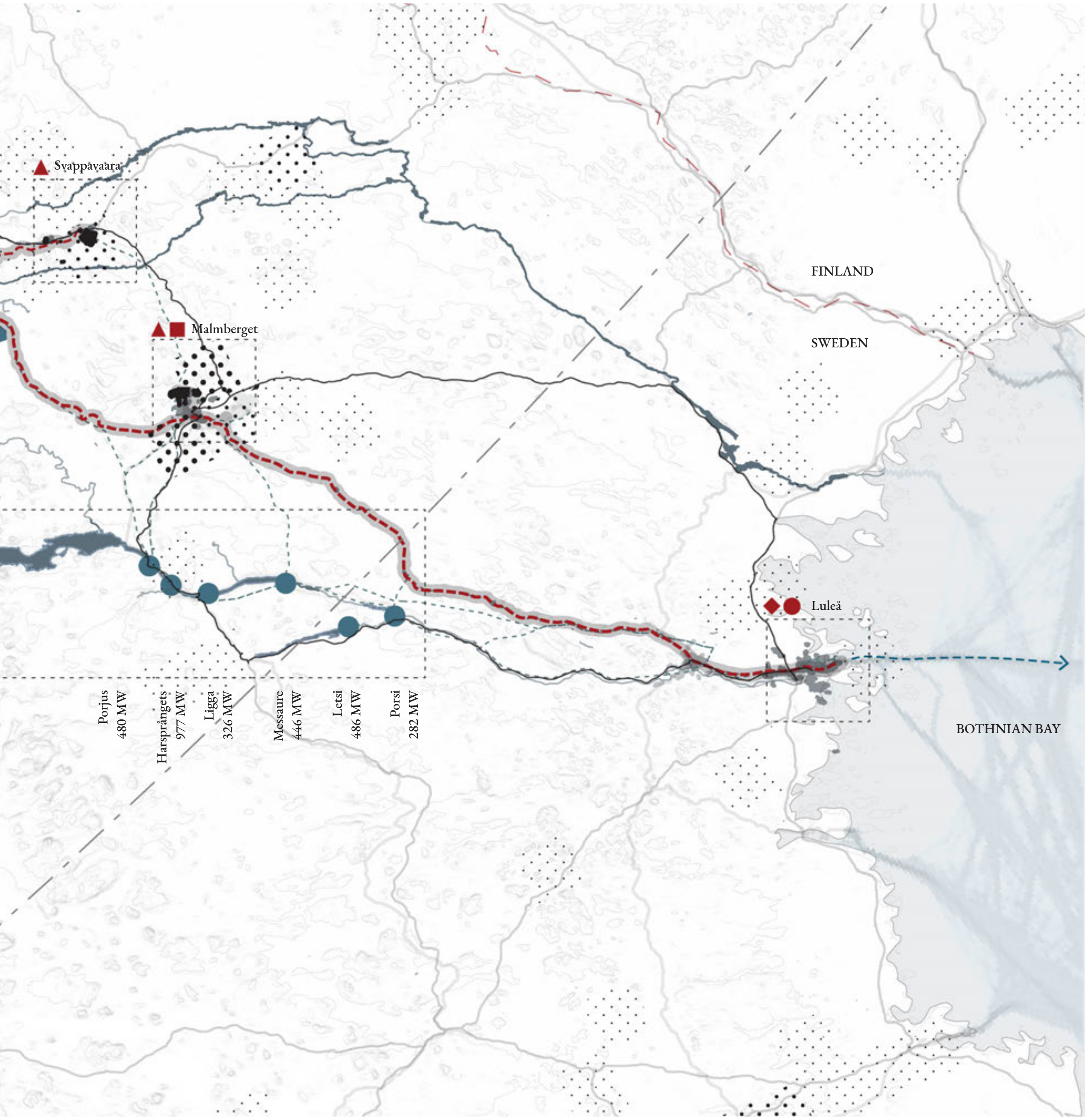


Composition of the Norrbotten Technological Megasystem

- Mining
- Processing
- Power plants
- Steel plant
- Export
- Mining intensity

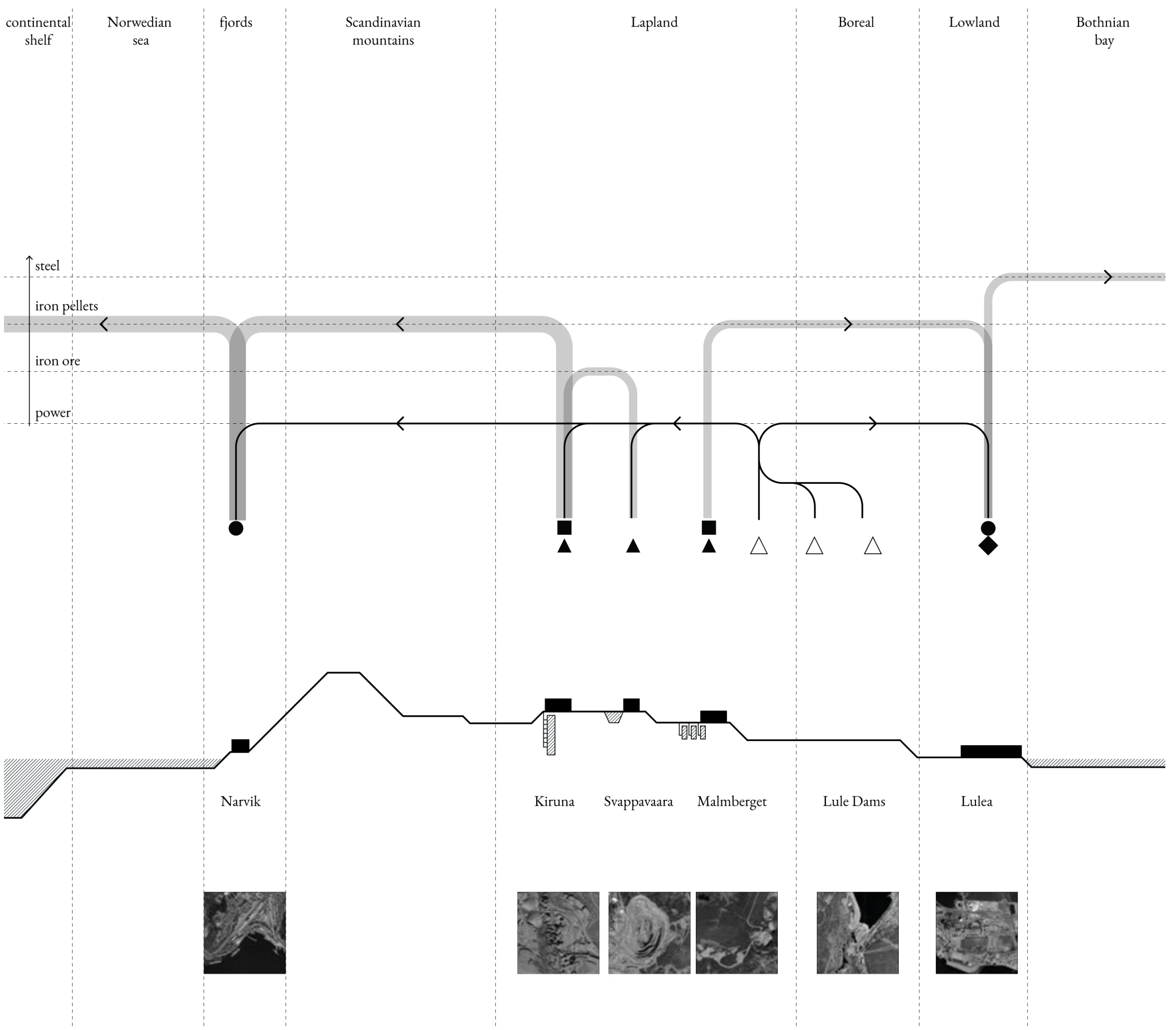
- Power network
- Road network
- Ore transport
- Shipping
- Arctic Circle
- National boundary

0 50 km N

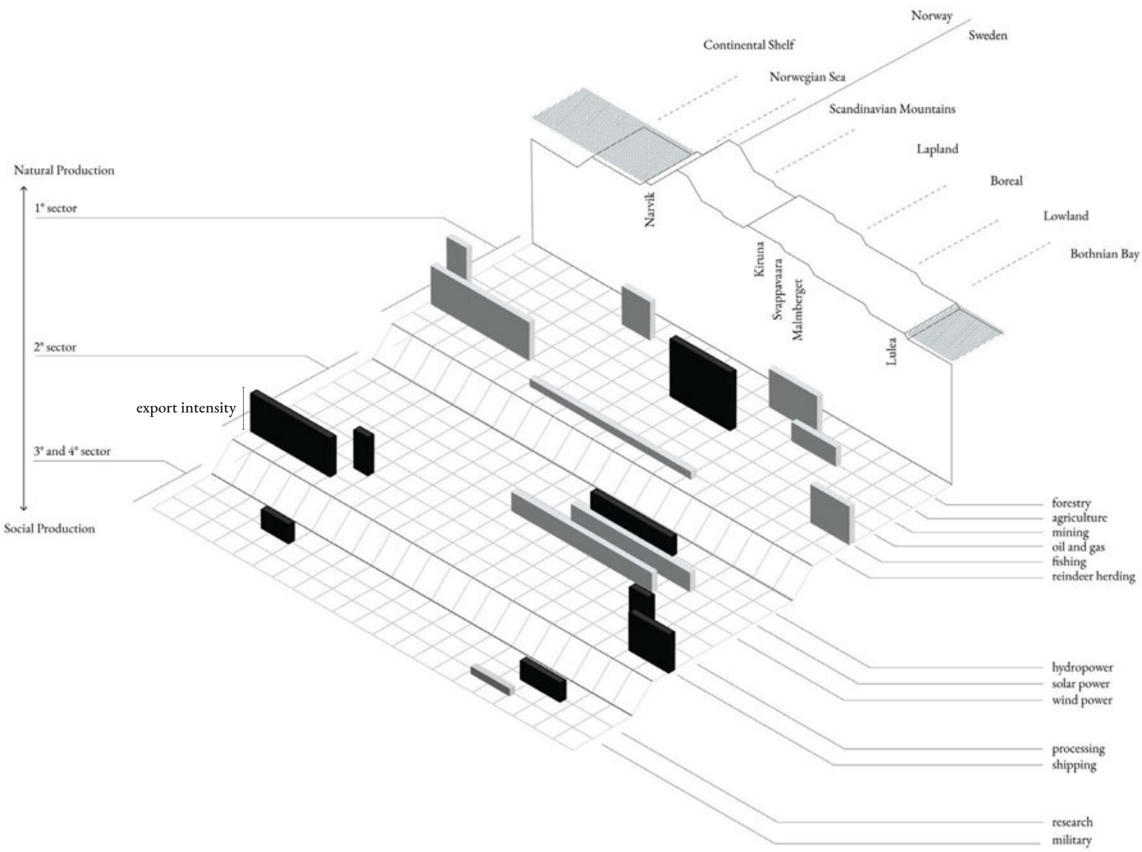

Svappavaara
Malmberget
FINLAND
SWEDEN
Luleå
BOTHNIAN BAY
Porjus
480 MW
Harsprångets
977 MW
Ligga
326 MW
Messaure
446 MW
Letsi
486 MW
Porsi
282 MW

Flows of energy and materials in NTM

- ▲ Mining
- ■ Processing
- △ Power plant
- ◆ Steel plant
- ● Export


continental shelf
Norwedian sea
fjords
Scandinavian mountains
Lapland
Boreal
Lowland
Bothnian bay
steel
iron pellets
iron ore
power
Narvik
Kiruna
Svappavaara
Malmberget
Lule Dams
Lulea

Economic Sectors in the NTM transect


Norway
Sweden
Continental Shelf
Norwegian Sea
Scandinavian Mountains
Lapland
Boreal
Lowland
Bothnian Bay
Narvik
Kiruna
Svappavaara
Malmberget
Lulea
Natural Production
1° sector
2° sector
export intensity
3° and 4° sector
Social Production
forestry
agriculture
mining
oil and gas
fishing
reindeer herding
hydropower
solar power
wind power
processing
shipping
research
military

Catalogue of Mining Infrastructure

Ground Condition  underground, gound, overground

Spatial form  tunnel, deep/shallow pond, stacked heap, organic line, dam

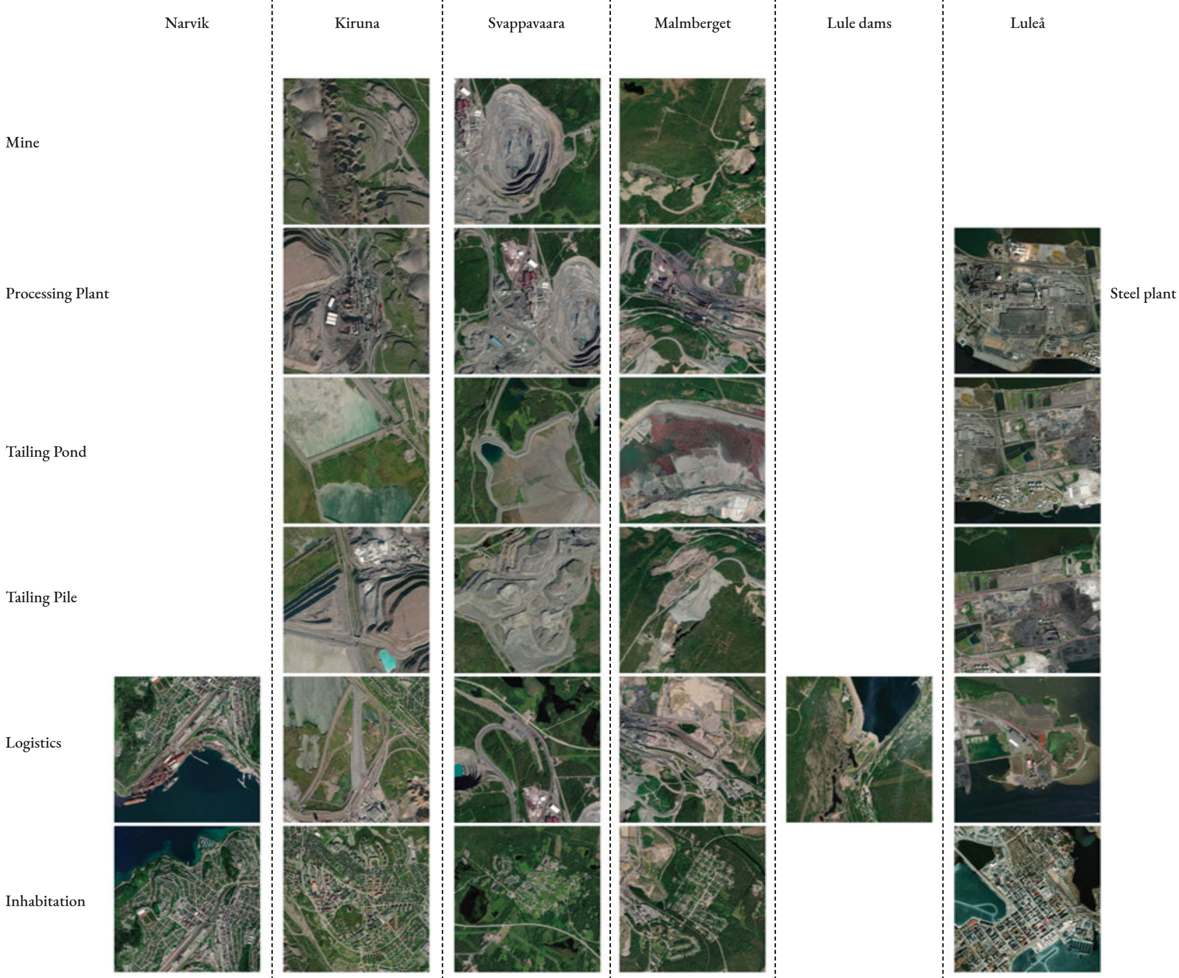
Spatial organisation  repetition, centralised, cluster, linear, grid

Function

Physical alterations

Chemical alterations

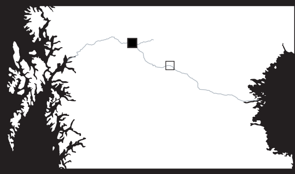
Transformation potential  restoration, adaptive reuse, terraforming, retain function

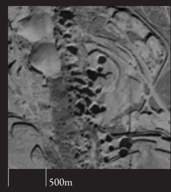

Narvik
Kiruna
Svappavaara
Malmberget
Lule dams
Luleå
Mine
Processing Plant
Steel plant
Tailing Pond
Tailing Pile
Logistics
Inhabitation

Underground mine

KIRUNA (& MALMBERGET)

Extraction





Function

underground mining of magnetite ore at a current depth of 1365m below ground level

Spatial form

tunnels / vertical+horizontal for ore conveying and hoisting

Spatial organisation

repetition / linear and horizontal for ore extraction based on infrastructural and operational efficiency

Physical alterations

ground deformations / local caving above the mines and zonal subsidence due instability of the hanging wall.

local water table reduction / due to continuous pumping out of ground water

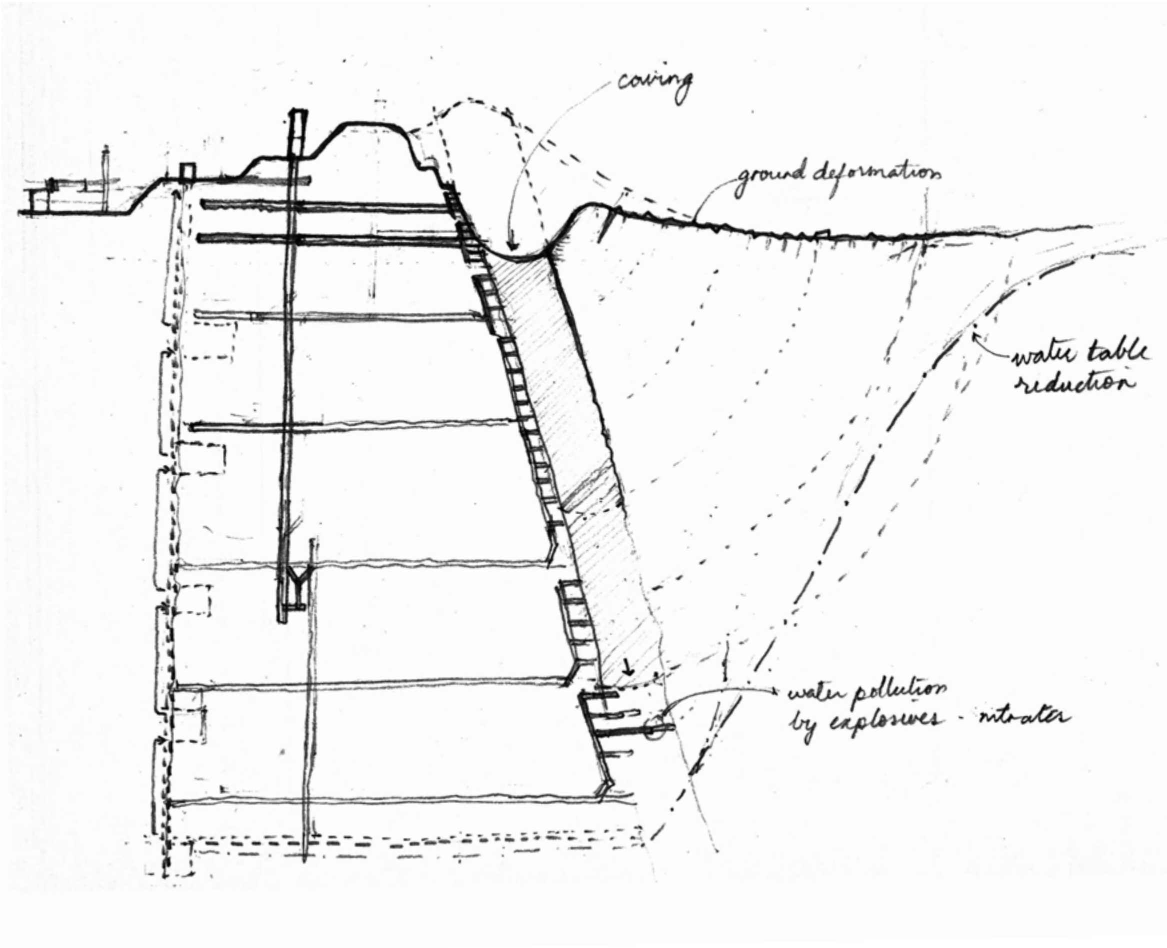
Chemical alterations

ground water pollution / with nitrates due to use of heavy explosives and reaction with water from precipitation.

Transformation potential

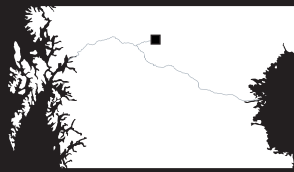
adaptive reuse / of tunnels to function as data centres to utilise on the temperature in the depth

ecological restoration / to work as a public trail park



Section of the underground mine illustrating the alterations

Open-pit mine



SVAPPAVAARA

Extraction

Function

open cast mining of magnetite ore at a depth of 550m

Spatial form

quarrying / large open pits

Spatial organisation

centralised / expanding by depth and area

Physical alterations

ground deformations / large open cast bowl formation

local water table reduction / due to continuous pumping out of ground water

Chemical alterations

ground water polution / with nitrates due to use of heavy explosives

air pollution / mining dust due to use of explosives

Transformation potential

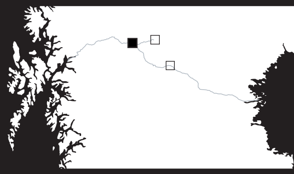
terraforming and ecological restoration / to function as a retention pond

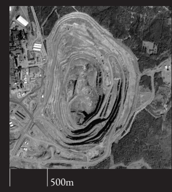
Leveäniemi open pit in Svappavaara, 2023
[photograph by LKAB]

Ore processing plant

KIRUNA (MALMBERGET & SVAPPAVAARA)

Processing





Function

Processing of the ore to produce iron pellets and powder by sorting, concentrating and pelletising

Spatial form

geometric built form / linear, rectangular and circluar (for buildability and spatial optimisation)

Spatial organisation

cluster / for functional specialisation

Physical alterations

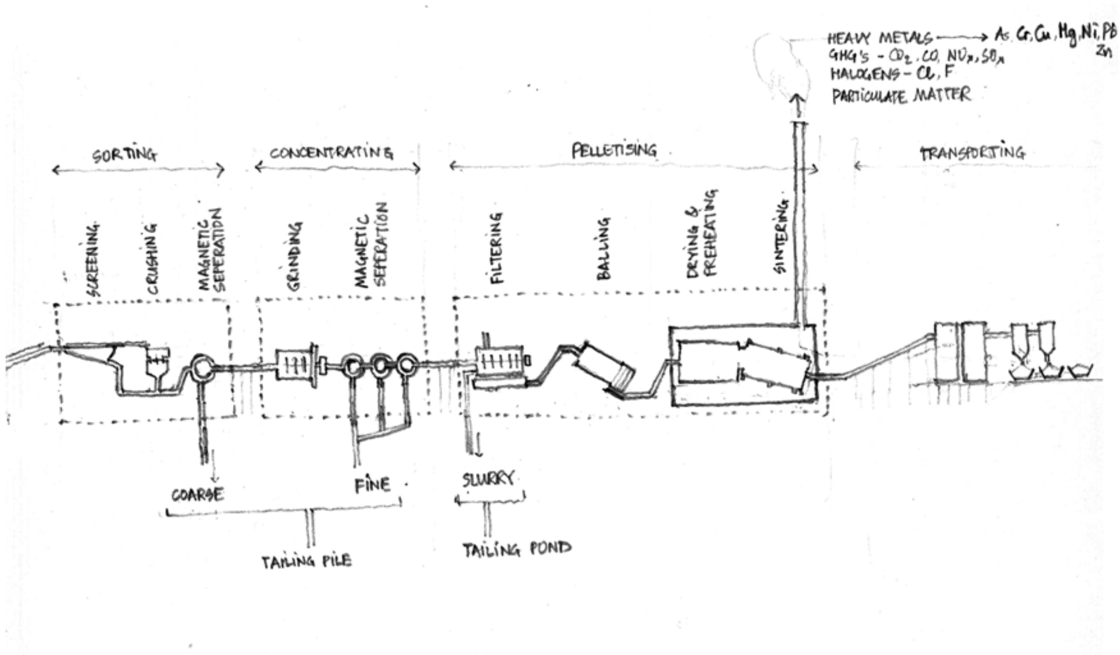
large buildings & structures / visible from the city - dominance + presense

Chemical alterations

air pollution / release of Heavy metals, GHGs, halogens, dioxins and particulate matter which causes environmental and health problems

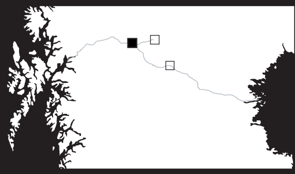
Transformation potential

adaptive reuse / of built elements to function as mining and processing research and skill developement centre



Process of iron ore processing in Kiruna and the clusteral functions

Tailing pond



KIRUNA (MALMBERGET & SVAPPAVAARA)

Processing

Function

retention pond for evaporation and filtration of tailings mixture and clarification pond for sedimentation

Spatial form

shallow water bodies / two ponds embanked by a tailing dam

Spatial organisation

linear / for functional specialisation

Physical alterations

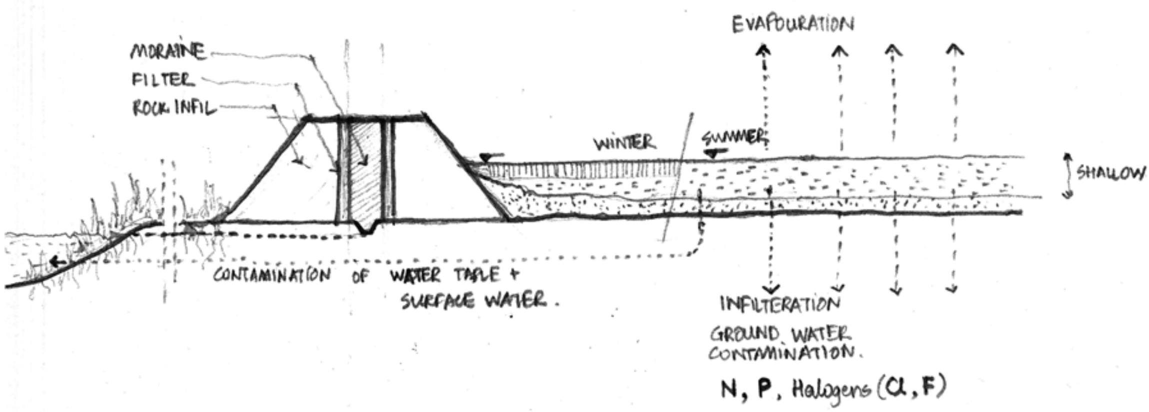
open deforested concessed area / interfering with reindeer migration paths

Chemical alterations

water pollution / N and P causing nutrient excessing and eutrophication in the water bodies and increase in halogens - Cl and F in the water causing ecosystem disturbance and effect human nervous system)

Transformation potential

soil regeneration, reforestation, degrowth / functioning of greenhouses from the surrounding permafrost thaws and concession for reindeers

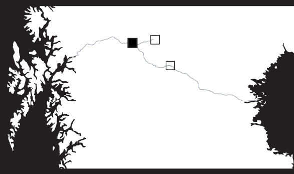


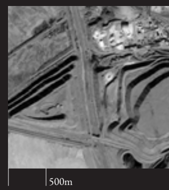
Part section of the tailing ponds and the tailing dam illustrating the alterations in the natural systems

Tailing pile

KIRUNA (MALMBERGET & SVAPPAVAARA)

Processing





Function

storage of solid mining waste

Spatial form

mounds / with layers of coarse (reactive+peripheral non-reactive) and compact fine tailings)

Spatial organisation

cluster / addition of mounds

Physical alterations

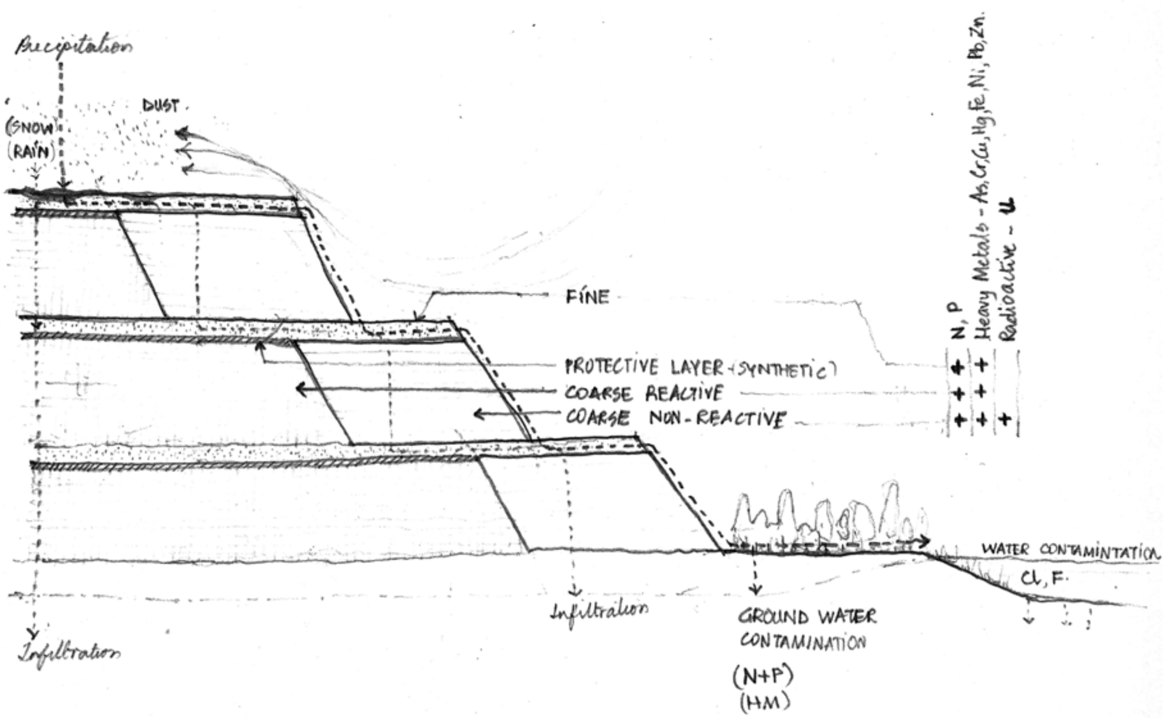
large dominant landscapes / of waste piles

Chemical alterations

ground water and soil contamination / through rection during precipitation and subseguent infiltration causing increase in heavy metals, N and P content in soil

Transformation potential

terraforming and ecological restoration / slow reduction by apatite concentration processes

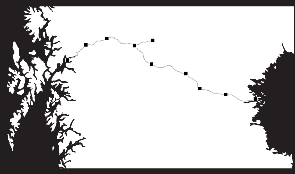


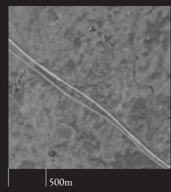
Part section of the tailing pile illustrating the structure and alterations in the natural systems

Ore transport

NARVIK to Luleå

Logistics & support





Function

transportation of ore shared with public transportation

Spatial form

organic tracks

Spatial organisation

continuous linear

Physical alterations

spatial inteference / with reindeer migratory routes

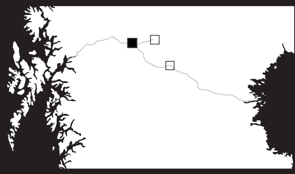
environmental impacts / accidential occurances of ore railway derail.

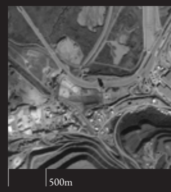
Transformation potential

retain function / function as material and public transportation

Derailing of the ore railway in Narvik
[photograph by LKAB, March 2023]

Loading docks and bays





KIRUNA (MALMBERGET & SVAPPAVAARA)

Logistics & support

Function

loading of the metal pellets to the trains and parking and maintenance of train

Spatial form

geometric built form / converyors and hoppers tracks bays (operational efficiency)

Spatial organisation

repetition

Physical alterations

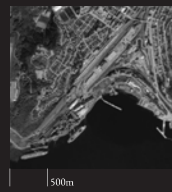
large spatial claim / of train trackswith historical deforestation

Transformation potential

adaptive reuse / and building to accommodate offices and cultural spaces

Pellets trasfer loading silo and the wagons
[photograph by Thomas Nilsen, Barents Observer, 2020]

Ship loading dock



NARVIK (& LULEÅ)

Logistics & support

Function

loading of the metal pellets to the ships for export

Spatial form

geometric built form / linear, rectangular and circluar (for buildability and spatial optimisation)

Spatial organisation

cluster / for functional specialisation

Physical alterations

large buildings & structures / visible from the city - dominance + presense

Chemical alterations

air pullution / GHGs

water pollution / heavy metals, suspended solids, N, P, halogens

Transformation potential

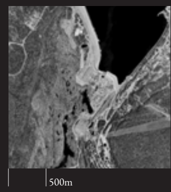
adaptive reuse / recycling sorting plant

Loading dock of Narvik
photograph by LKAB

Hydropower dams

RIVER LULEÅ

Logistics & support



Function

production of hydropower to supply for LKAB operations

Spatial form

dam

Spatial organisation

repetition / linear

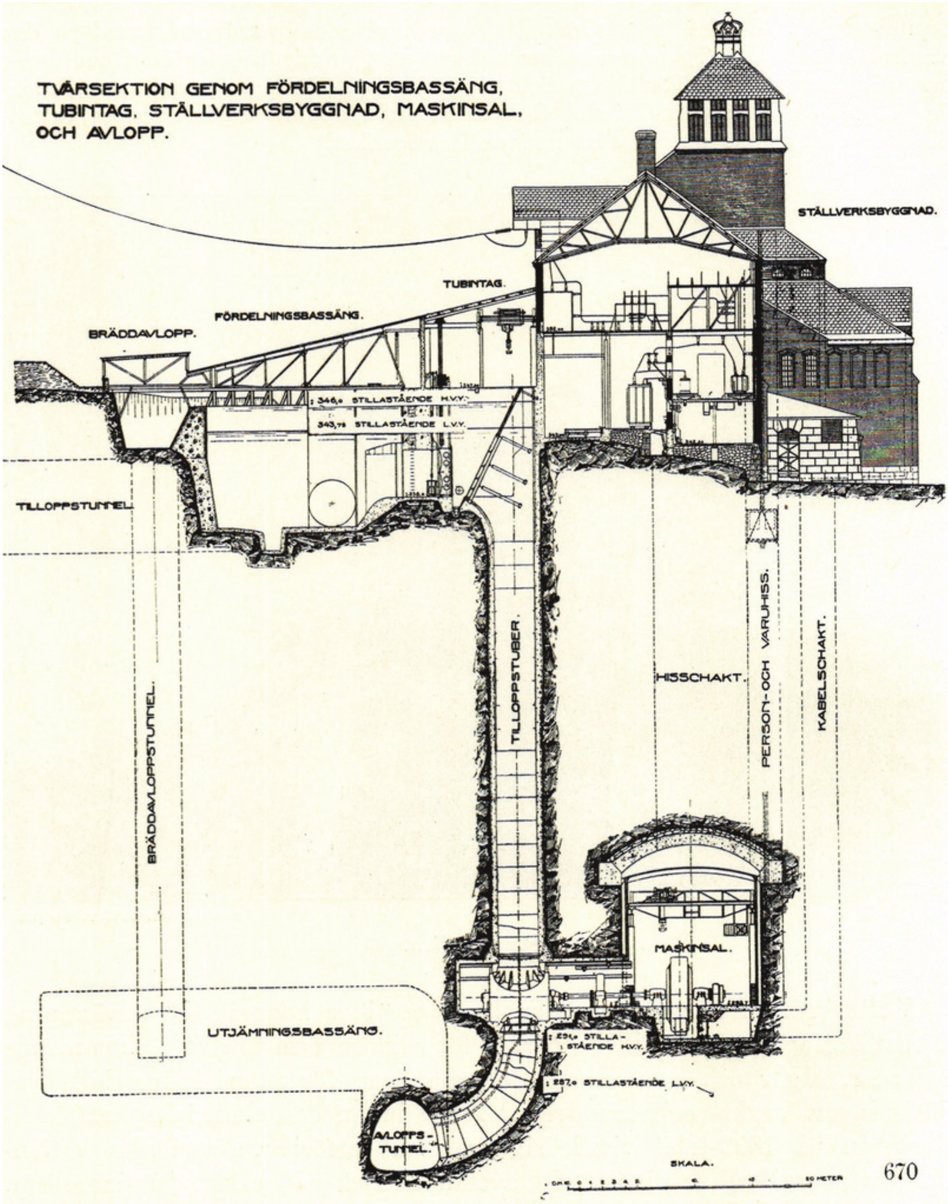
Physical alterations

ecosystem disturbance / checking the flow of river Lule causing ecosystem disturbances

Ritsem (304MW), Vietas (306), Porjus (480), Harsprångets (977), Ligga (326), Messaure (446), Letsi (486), Porsi (282)

Transformation potential

retain function / to supply power for alternate demands



Section of Porjus hydropower plant near Gallivare, 1915'
[documentation from Hansen, 'Sveriges Vattenfall']

Steel processing plant

LULEÅ

Secondary processing

Function

processing the iron pellets to produce steel

Spatial form

geometric built form / linear, rectangular and circluar (for buildability and spatial optimisation)

Spatial organisation

cluster / for functional specialisation

Physical alterations

large industrial buildings & structures / visible from the city - dominance + presense

Chemical alterations

air pollution / release of Heavy metals, GHGs, halogens, dioxins and particulate matter which causes environmental and health problems

water pollution / N and P causingnutrient excessing and eutrophication in the water bodies and increase in phenols, cyanides, halogens - Cl and F in the water causing ecosystem disturbance and effect human nervous system)

Transformation potential

retain function / for production of green steel - HYBRIT technology

Steel production plant in Luleå
[photographs by Patrik Ohman, SSAB, 2022]

Management facilities

KIRUNA (MALMBERGET, SVAPPAVAARA, LULEÅ & NARVIK)

Logistics & support

Function

operation, management, research and development offices

Spatial form

geometric built form / buildings

Spatial organisation

grid / orthogonal

Physical alterations

built fabric

Transformation potential

Adaptive reuse / to accommodate offices and cultural spaces

Image of LKAB Bolagskontor, Kiruna
[photograph by Arild Vågen CC BY-SA 4.0]

These instances of normalisation of sacrifice create grounds for increased tolerance towards the exploitative nature of extractivism towards the reproduction of natural and cultural dependencies. The construction of dams on the Lule River, which allowed power extraction, negatively impacted the indigenous land practices of the Sámi people, who have lived in the area since the last ice age. The landscape is traditionally used for reindeer grazing by the Sámi community, which uses the stretches between the Scandinavian Mountains as summer grazing areas and the lowlands for winter grazing. These dams interrupted reindeer migration, fragmented landscapes, and claimed grazing areas. The Swedish crown used property ownership and nature conservation principles to restrict Sámi land practices, altering their cultural landscape and affecting all living systems, plants, animals, and non-living matter. The alteration in topography, manifested through the physical configuration of the land, is the most prominent manifestation of the ecological influence in Kiruna. Subterranean material is extracted, resulting in the formation of a 4 km long cavity and the accumulation of waste tailing piles in the mountains. These piles are of similar size to the pre-existing mountains They are aspects of terraforming where earth is altered for anthropogenic appropriation. The indigenous community's cultural landscape undergoes transformation, as they perceive the natural elements such as sun, wind, earth, and water as possessing spiritual essence and rely on the ecological conditions of the territory for their daily existence. However, it is important to note that the significant alteration of the landscape affects not only reindeer husbandry, but also all living systems including plants, animals, microbial life, as well as non-living matter such as geological materials.

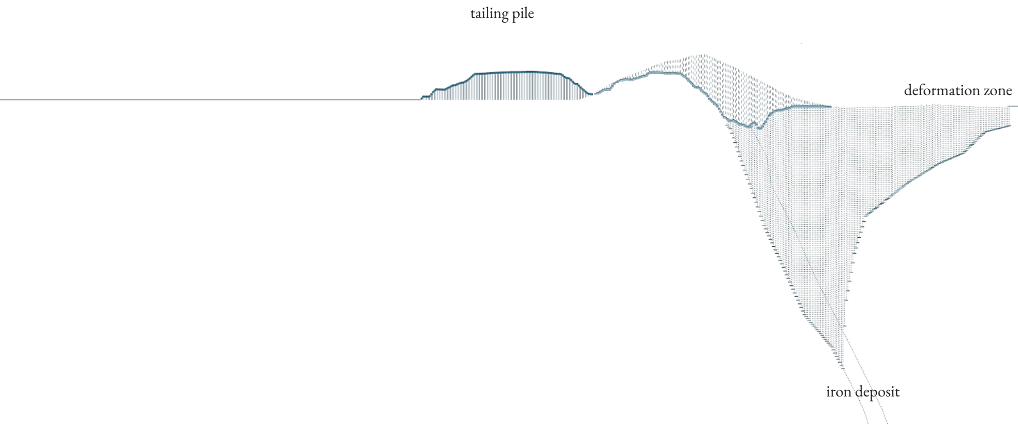
[Elaborated in the working paper in the appendix : Federighi, V., Bacchin, T. K., & Shekar, K. (2024). *Which Landscape: Material traces of an integrated design and research approach in Kiruna*.]

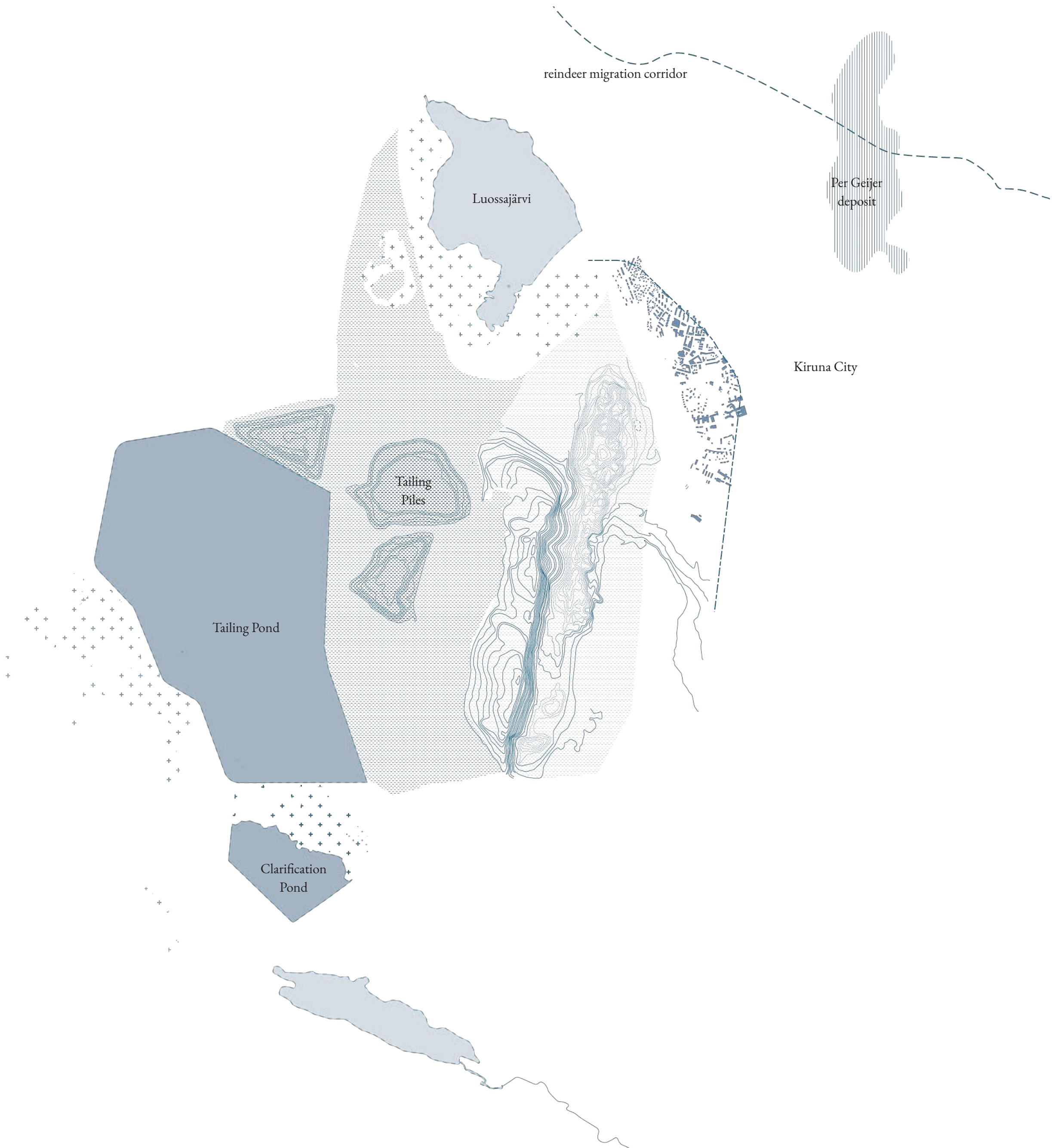
The matrix of repair systematically analyses the damage to the environment and the repair conditions. The parameters for the damage include the containment of the damage (contained / uncontained) and reversibility (reversible / irreversible damage). The parameters for the repairs include the temporal nature of the repair (temporal extent and post-extraction remediation / continuous remediation) and the place-specificity of compensation (spatial extent and if the location of effort is decoupled from the location of impact).

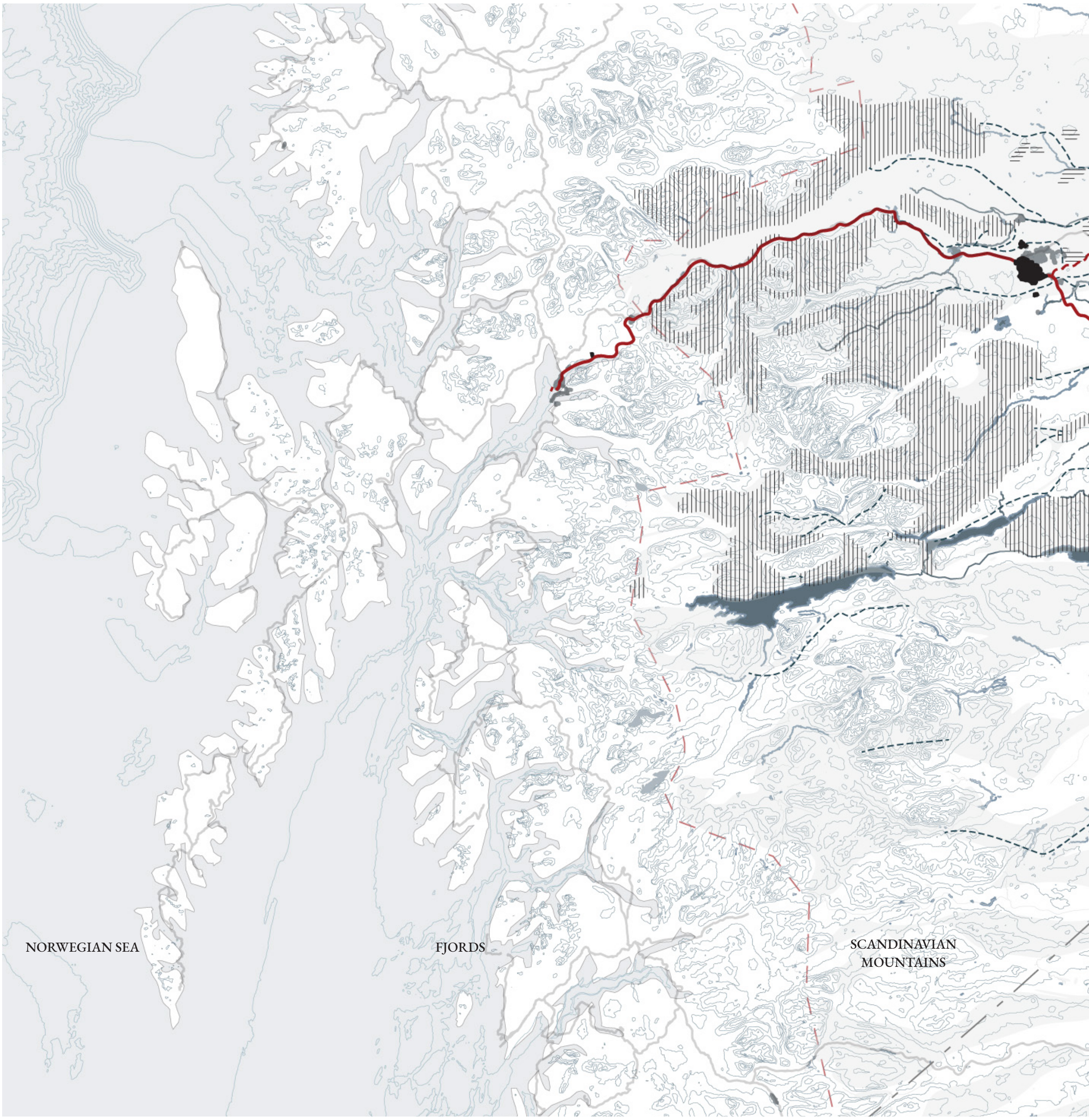
Composition of the Sacrificial Landsape in Kiruna

- Contaminated soil
- Contaminated wetlannds
- Contaminated water
- Deformation zone
- Tailing Pile
- Buildings to be displaced
- Deformation extent
- Migration route
- Per Geijer Deposit

0 2 km N


tailing pile
deformation zone
iron deposit


reindeer migration corridor
Per Geijer deposit
Luossajärvi
Kiruna City
Tailing Piles
Tailing Pond
Clarification Pond



Composition of the Sacrificial Landscape in the NTM transect

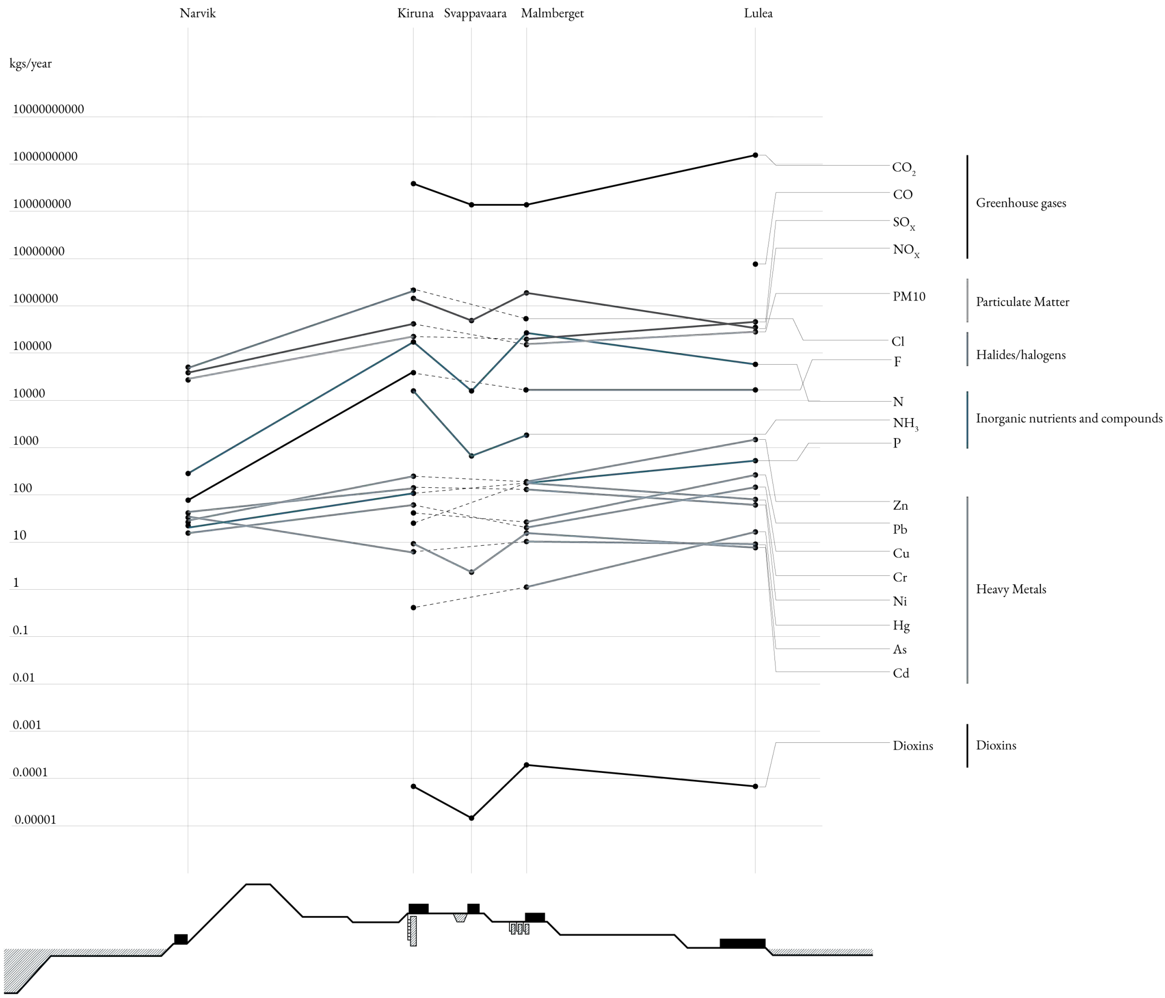
- Mines
- Bathymetry
- Topography - Mountains
- Rivers
- Reindeer - summer grazing
- Reindeer - winter grazing
- Migraion routes
- Ore transport
- Arctic Circle
- National boundary

0 50 km

N


BOREAL / SAPMI
LOWLAND
BOTHNIAN BAY

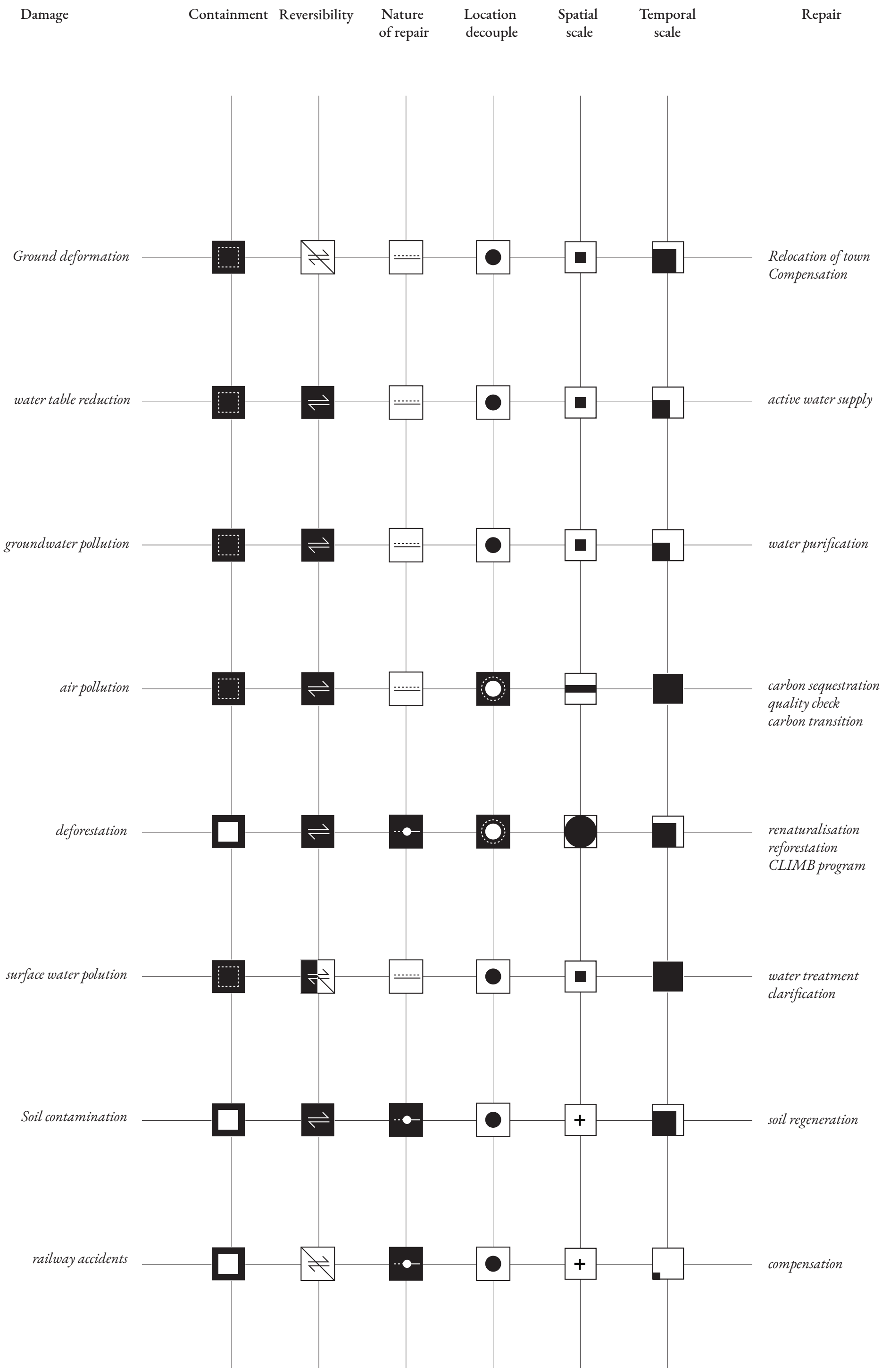
Environmental Pollution across the NTM



Narvik
Kiruna
Svappavaara
Malmberget
Lulea
kgs/year
10000000000
1000000000
100000000
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
CO_2
CO
SO_X
NO_X
PM10
Cl
F
N
NH_3
P
Zn
Pb
Cu
Cr
Ni
Hg
As
Cd
Dioxins
Greenhouse gases
Particulate Matter
Halides/halogens
Inorganic nutrients and compounds
Heavy Metals
Dioxins

Matrix of Repair

Contained damage
Uncontiained damage
Reversible damage
Irreversible damage
Continuous remediation
Post-extraction remediation
Place-specific compensation
Placeless compensation
at location of damage
city scale
territorial scale
planetary scale
instantaneous
years
decades
above centuries


Damage
Containment
Reversibility
Nature of repair
Location decouple
Spatial scale
Temporal scale
Repair
Ground deformation
Relocation of town
Compensation
water table reduction
active water supply
groundwater pollution
water purification
air pollution
carbon sequestration
quality check
carbon transition
deforestation
renaturalisation
reforestation
CLIMB program
surface water polution
water treatment
clarification
Soil contamination
soil regeneration
railway accidents
compensation

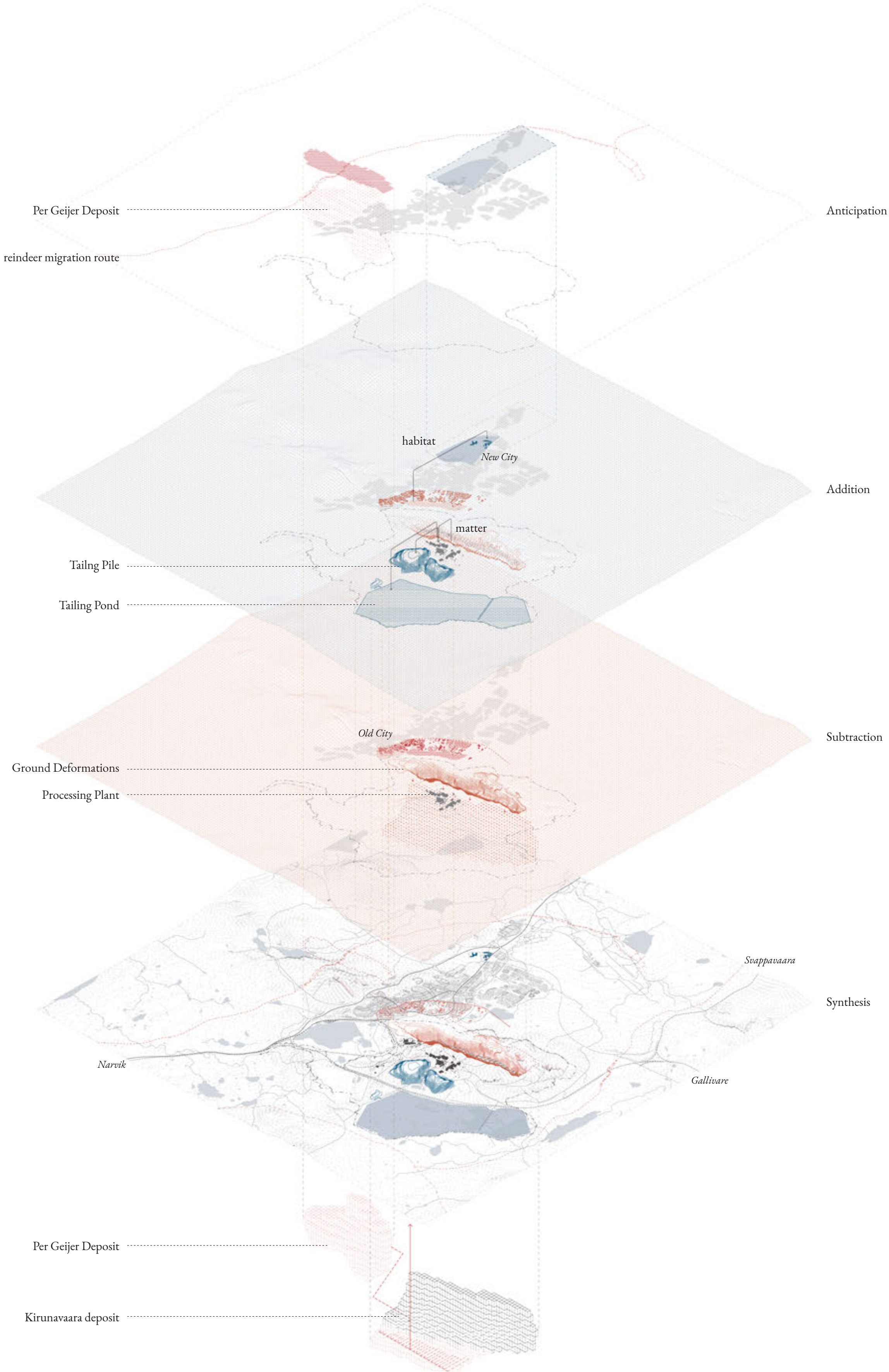
Mining cities are determinate in nature during their establishment, as the urban processes are determined by the economic dependency on the mine. The city's infrastructure accommodates the workforce and is designed to ensure accessibility. Additionally, the city provides housing for the families of the workers, necessitating the presence of schools and hospitals, which are determined by the LKAB mining company which is the dominating agency in the territories. One of the main instances of this is when the mine deepened, the city physically is moving due to the ground deformation. But the mining continues due to the economic significance of the extraction. The ancillary economies are either dependent on the mining infrastructure (e.g., tourism) or support the sustenance of the mining activities (e.g., market in the city). This can be read in the palimpsest drawing, which illustrates the permanent, persistent, and temporary elements in the city—the terrain, buildings, and infrastructure. Along time, however, the accumulation of social reproduction in the form of the public spaces and facilities adds indeterminacy to the city, but not the mine itself. At the territorial scale, in the production of the Norrbotten Technological Megasystem, the infrastructures that facilitated extraction determined the territory's spatial organisation and capitalistic and colonial exploitation patterns, (Morata et al., 2020). The accumulation of fixed capital in the form of infrastructures for extraction also allowed for the accumulation of social reproduction in the form of settlements/ communities in the territory which are indeterminate. The social reproduction labor (e.g., Sámi community, teachers, nurses) is undervalued compared to extraction-related jobs creating social and economic disparities (Morata, 2023). This reinforces the determinate nature of the landscape, where the focus is on supporting extraction rather than holistic community development. The infrastructure also supports other economies like nature tourism in Abisko and the ski-resorts in Riksgransen, which flourished due to the new accessibility. However, the system has a capacity to support the 'other' economies. If a iron-train is derailed, the accessibility in the territory is significantly affected. The extraction activity thus determines the functioning of the territory.

Palimpsest of Kiruna

The critical reading represents the displacement effects of the current underground mine causing ground subsidence. The mine being the permanent element determines the subtraction and addition of matter (geological) and habitat (city) through terraforming. The extraction of the anticipated deposit intensifies the conflicts with the indigenous Sámi land practices based on the reindeer herding routes.

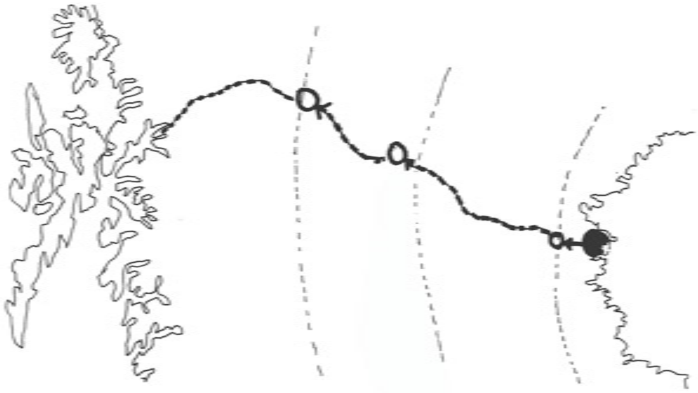
Addition
Subtraction
Permanent
Persistant

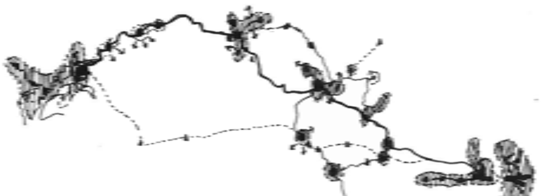
0 | 2 km | N

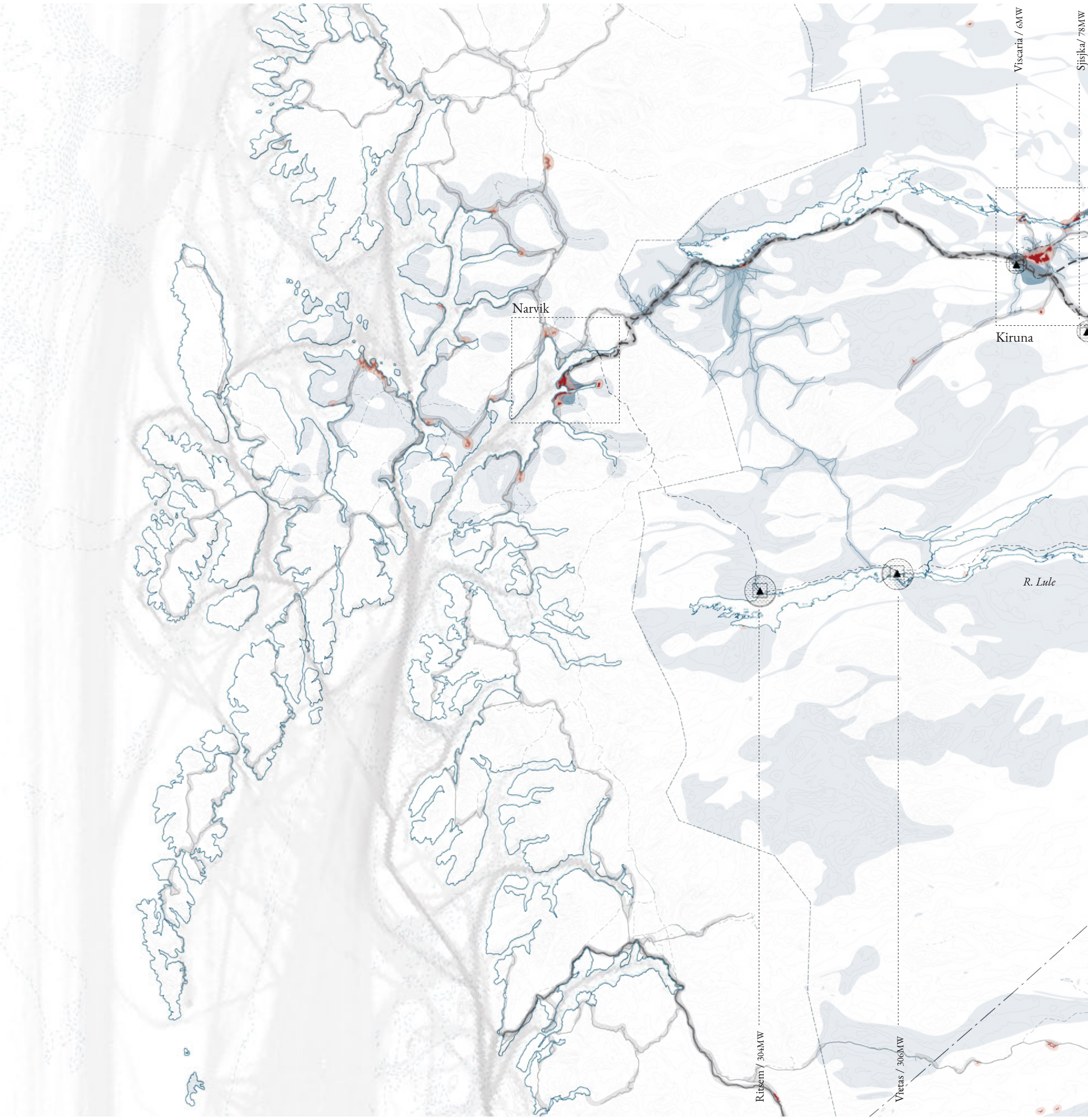

Per Geijer Deposit
reindeer migration route
Anticipation
habitat
New City
Addition
matter
Tailng Pile
Tailing Pond
Old City
Subtraction
Ground Deformations
Processing Plant
Svappavaara
Synthesis
Narvik
Gallivare
Per Geijer Deposit
Kirunavaara deposit

Spatial production of the Norrbotten Technological Megasystem

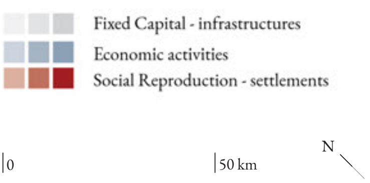
- settler colonisation from the coast towards the inland
- formation of the technological megasystem
- accumulation of fixed capital in form of infrastructures
- accumulation of social reproduction in the form and ancillary economies

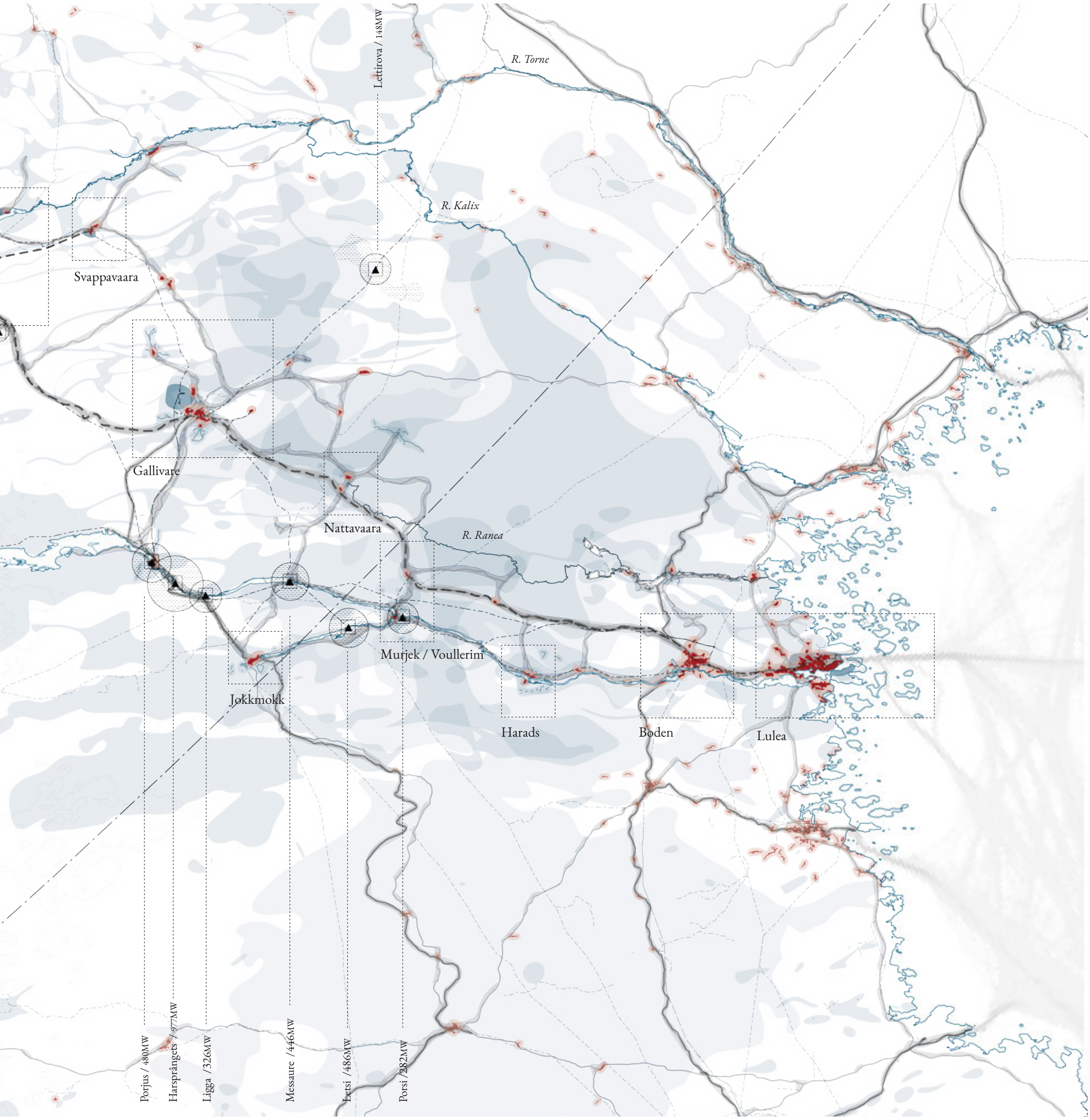






Accumulation Drawing - Spatial Production of the NTM territory





R. Torne
Lettirova / 148MW
R. Kalix
Svappavaara
Gallivare
Nattavaara
R. Ranea
Murjek / Voullerim
Jokkmokk
Harads
Boden
Lulea
Porjus / 480MW
Harsprångets / 977MW
Ligga / 326MW
Messaure / 446MW
Letsi / 486MW
Porsi / 282MW

Diversification of Programme
This is necessary to reduce the dependency on a single economic activity. This diversification includes introducing various programs that support different sectors such as tourism, and education. By doing so, the landscapes provides a broader range of opportunities for local communities.

Hybridisation of Sacrificial Processes and Repair Processes
Integrate restorative measures into the life cycle of extraction activities. During design of new mining projects, implement ecological restoration projects that begin as soon as an area is disturbed. This hybrid approach ensures that reparative steps are already in place to repair.

Need for Ecological Safety for Social Regeneration of Extraction Landscapes
The degradation caused by extraction activities necessitates robust safety measures to protect both natural and human environments. Ensuring ecological safety is critical for the social regeneration of extraction landscapes as it is crucial to maintain community health. Social regeneration can be supported through ecological rehabilitation, which helps restore the natural balance and supports the re-establishment of local communities and their practices.

Need for Indeterminacy in Programming to React to Uncertainties
This allows for flexibility and adaptability to future uncertainties. This involves designing spaces that can evolve over time, accommodating changing environmental, economic, and social conditions.

↓

Decentralisation of Agencies – Devolution
These action requires rethinking of the agencies that control, govern and dominate in these territories. Devolution strategies are necessary to transfer power and decision-making to local and indigenous communities. This can be achieved by establishing local governance bodies, creating ecodependencies, and ensuring that local stakeholders have a significant say in the planning and execution of extraction and restoration projects. Decentralisation also emphasises on a stewardship and responsibility, leading to more socio-ecologically just practices.

↓

Use of the Spatial Organisation of the Territory for the Devolution of Norrbotten Technological Megasystem
By agency of spatial design, in addition to supporting the decentralisation of economic activities and governance, spatial accumulation can be used to reconfigure the territory.

Towards Devolution

[Post-Project]

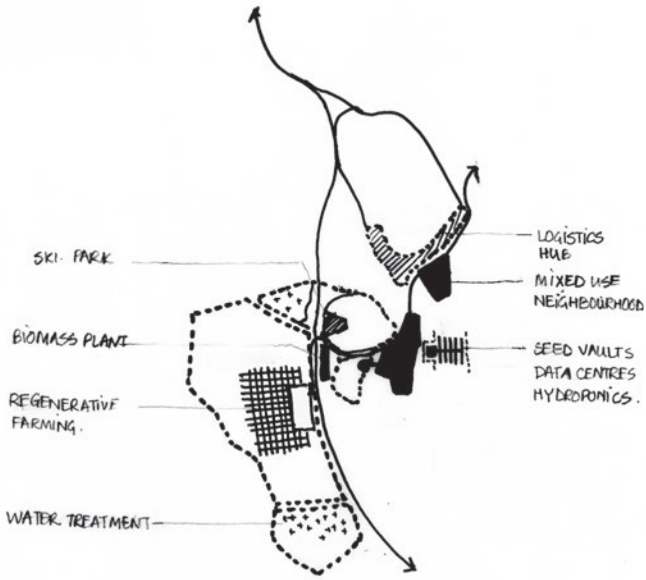
This chapter uses design to forecast post-extraction transformations of the Kirunavaara mine and elaborates on creating multifunctional spaces, hybridising spatial functions and repair, and integrating indeterminate interfaces into extraction landscapes. All these interventions require rethinking of agencies calling for the strategies for devolution. The spatial logic resulting from devolution guide the spatial functioning and guide the vision.

Kirunavaara Mine

To transform the extraction landscape to become multifunctional, the land currently operated and effected by the mining company is first fragmented into its elements to diversify the land-use. This is based on the transformation capacities of the elements following the logic of the spatial form, organisation, and the functioning. In addition, the elements are individually proposed with multiple transformation functions, each with its own economic dimension ranging primary to quaternary sectors. They are either shifted, added, subtracted, or persistent, which is summarised in the matrix of programme diversification. This enables many stakeholders to interact with the landscapes, challenging their 'anti-visual character' (Graham, 2022) It then allows for the social programming of extraction landscapes and blurs their 'exceptional status' (Nesbit & Waldheim, 2022). Since there are multiple functions, each having their own industrial and material ecologies, the synergies among the transformation elements are identified to establish interdependencies: energy, biomass, carbon dioxide, waste, knowledge, data, etc. This multifunctional landscape necessitates conditions for devolution among the agencies that operate and interact with each other. This allows for the collectively produced space to be collectively appropriated than by a single corporation.

Spatial Actions at the scale of the Kirunavaara mine

- Diversification of program and devolution of agencies
- Finding synergies between different local industrial ecologies


SKI. PARK
BIOMASS PLANT
REGENERATIVE FARMING.
WATER TREATMENT
LOGISTICS HUB
MIXED USE NEIGHBOURHOOD
SEED VAULTS
DATA CENTRES
HYDROPONICS.


HEAT
CARBON DIOXIDE
BIOMASS
WASTE / RECYCLE MAT.
KNOWLEDGE
DATA COMPUTATION.

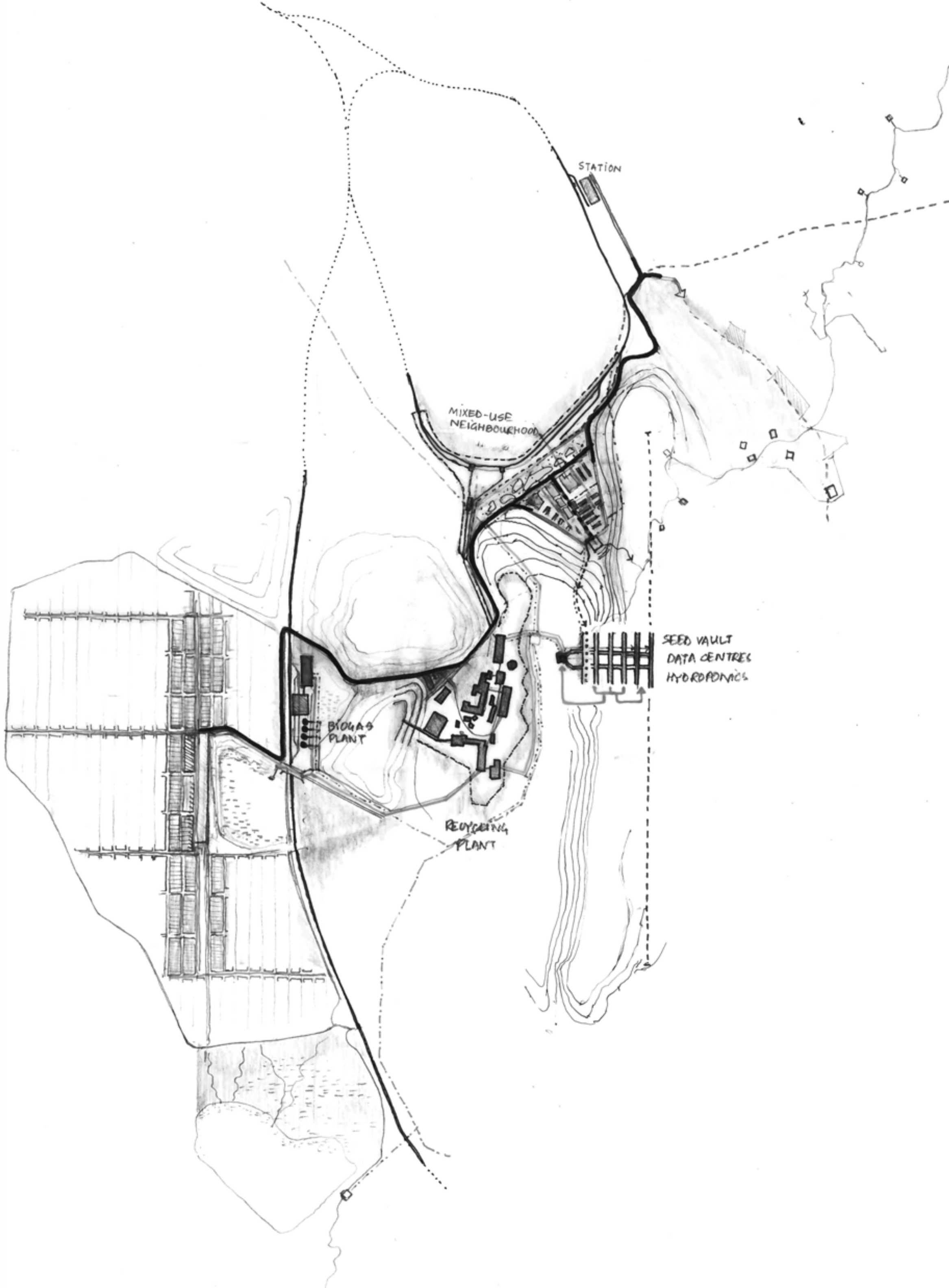
Parent Element	*Transformation Function*	*Spatial action*
		= *persistant* + *addition* - *subtraction* Δ *program shift*
Tailing Pond	*Regenerative permacultures*	=
	Biomass Plant	+
	Rewilded wetlands and forests	-
Tailing Pile	*Ski + Hiking Park*	+
	Tailing Storage	=
	Rewilded mounds	-
Processing Plant	*Recycling Plant*	Δ
Underground Mining Drifts	*Multihabitation drifts - intensive agriculture, seed vault, interpretation centre, data storage*	Δ
Logistical Area	*Storage Silos*	+
	Loading and Unloading Bays	=
	Sorting Facilities	Δ
Operation and Control	*Mixed use neighbourhood*	Δ
Deformation Zone	Heritage Park	+
	Rewilded forests	-

Matrix of Program Diversification

Social Dimension	*Economic dimension*
	(1) *primary*
	(2) *secondary*
	(3) *tertiary*
	(4) *quarternary*
Exchange of traditional ecological knowledge, creating land commons	(1) energy crops for biomass plant
Arctic energy - research and knowledge facility	(2) heating and CO_2 for permacultures and intensive agriculture
Wilderness transition area - Reindeer migration	(3, 4) tourism and knowledge
Recreation	(3) Tourism
	(1) Reserve for Rare Earth Elements, construction material
Wilderness transition area	(0) retreat
Skill develelopment facility, Public interpretation centre	(2) material circularity
knowledge archival	(1, 3, 4) food production, tourism, knowledge
	(2) logistics
	(2) logistics
	(2) logistics
Main public inteface, social housing	(3) commercial, housing,
Knowledge Archival, Public functions	(4) Tourism, Recreation
wilderness transition area	(0) retreat

Composition of the Multifunctional Landscape

0 1 km N


STATION
MIXED-USE NEIGHBOURHOOD
SEED VAULT
DATA CENTRES
HYDROPONICS
BIOGAS PLANT
RECYCLING PLANT

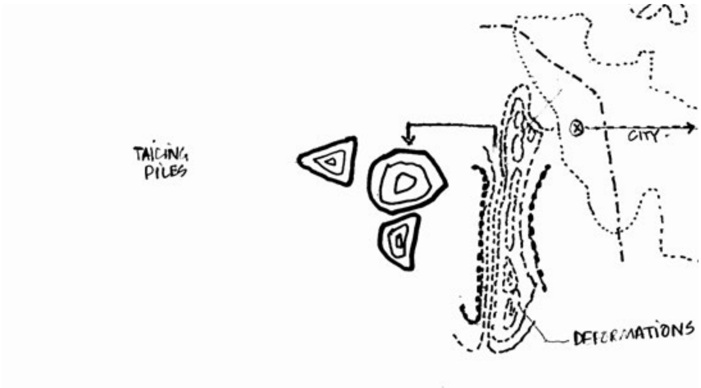
The transformation functions have ecological dimensions which aims at hybridising the social and economic program with repair. These are in the form of terraforming where the actions of moving earth can create conditions to use tailing piles as REE sources. LKAB currently has plans to search the piles for their REE content. Terraforming is also a response to the significant landscape deformations which has altered the memory of the landscape and the human and more-than-human associations with it where terraforming is also a form of creating a memorial landscape.

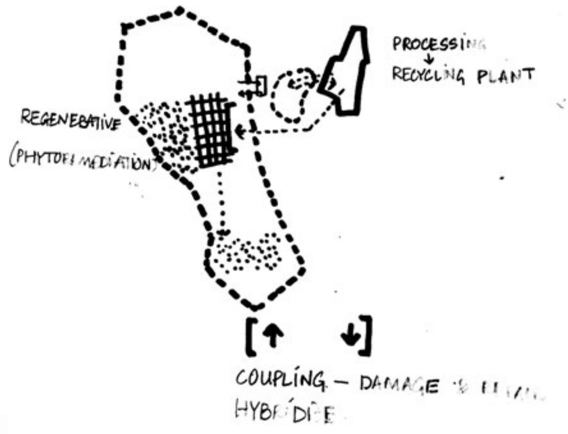
The reparative actions aim to couple the damage and repair spatially and temporally, by regenerative processes like phytoremediation, rewilding and identifying and enhancing the synergies between different industrial ecologies of the multifunctional landscape. This strengthens the eco-dependencies of the elements and the landscape. The actions of repair are also means for degrowth and condensation to reduce the fragmentation pressure on the landscape to allow for the more-than-human processes like reindeer migration, subterranean ecological processes etc.

The transformation functions have their own rhythms based on the seasons. The landscape of repair can help regulate their activity in the socio-economic time – 'le moyen durée' (Braudel, 1980) represented in the annual scale. But in the geographical time – 'longue durée' (ibid.) there is a need for ecological rehabilitation of the landscape to reduce the toxicity, so that it is safe for social integration. This is based on the degree of contamination of the landscape and the time required for the landscape to stabilise for the healing. After stabilisation, based on the method of repair in some cases like the support and administration area transforming to mixed use neighbourhood the social integration can be parallel to the reparative processes. These processes are systematically elaborated in the matrix of socio-ecological repair of the programmatic transformations and spatialised in the composition of repair at the scale of the current mine.

Spatial Actions at the scale of the Kirunavaara mine

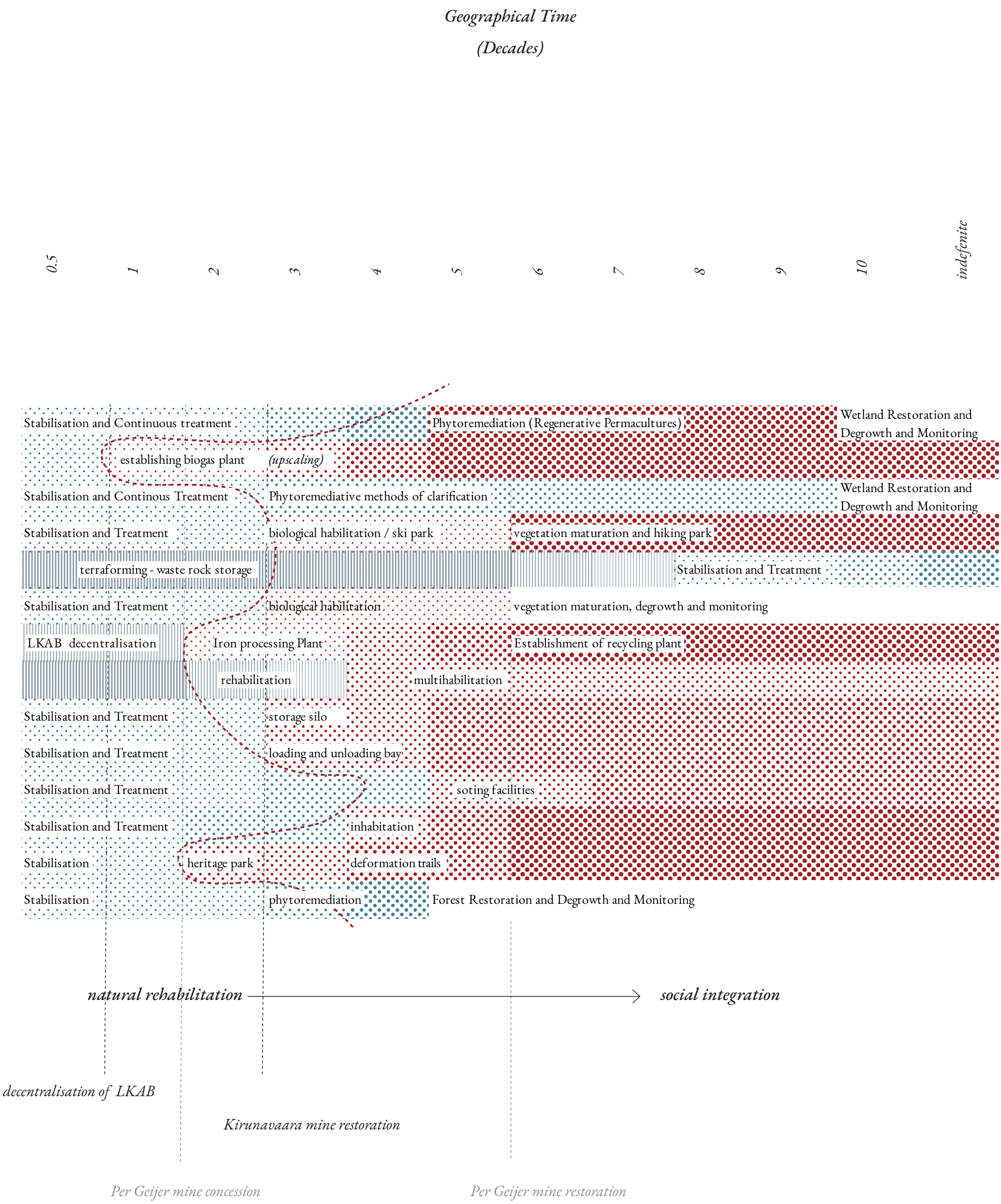
- Terraforming material masses and reducing spatial footprint
- Coupling Damage and Repair
- Compacting the spatial footprint


TAILING
PILES
CITY
DEFORMATIONS


PROCESSING
RECYCLING PLANT
REGENERATIVE
(PHYTOREMEDIATION)
COUPLING – DAMAGE

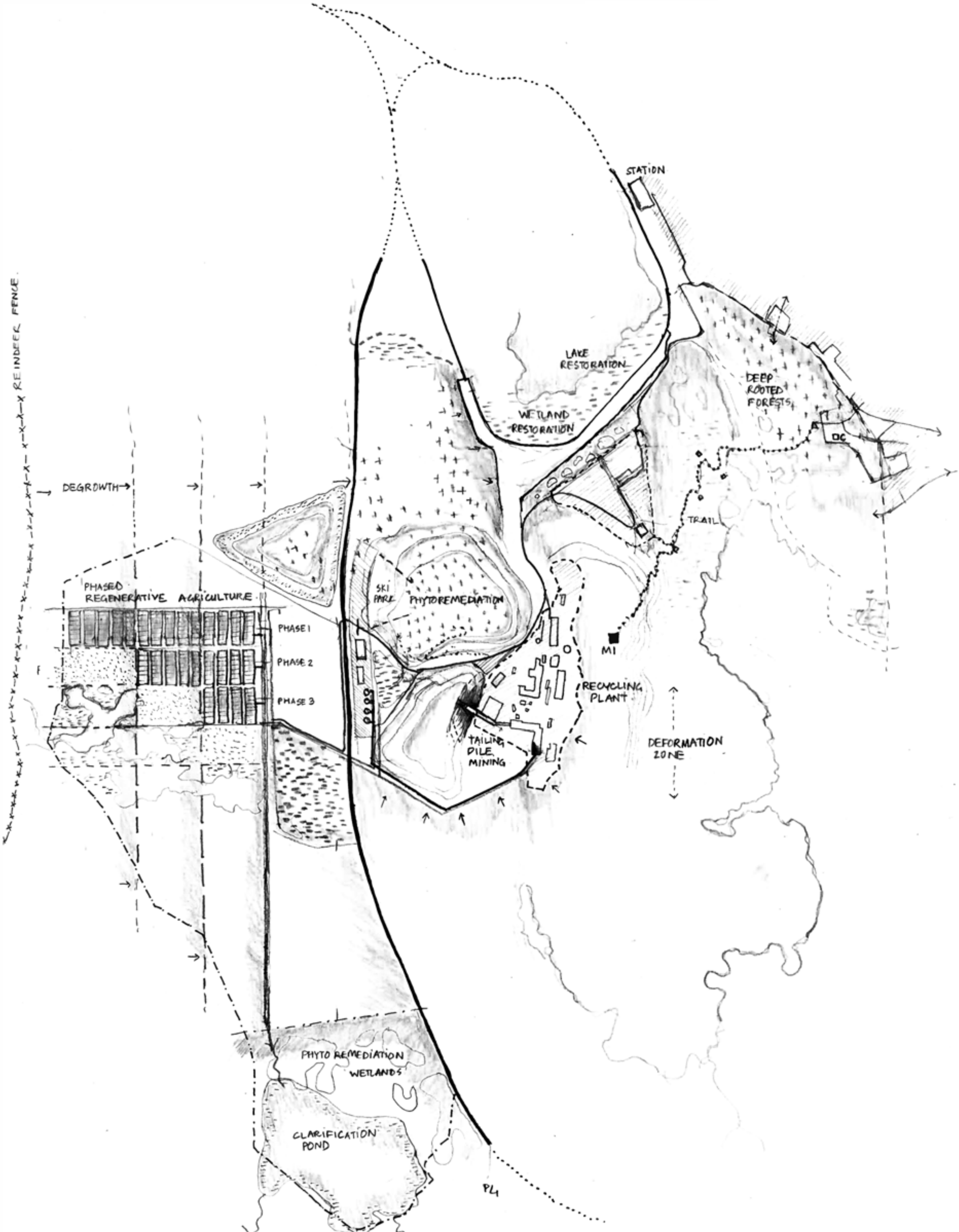

DEGROWTH
+
DECOLONISATION

Matrix of Socio-ecological Repair of programmatic transformations


Geographical Time
(Decades)
0.5
1
2
3
4
5
6
7
8
9
10
indefenite
Stabilisation and Continuous treatment
Phytoremediation (Regenerative Permacultures)
Wetland Restoration and Degrowth and Monitoring
establishing biogas plant
(upscaling)
Stabilisation and Continous Treatment
Phytoremediative methods of clarification
Wetland Restoration and Degrowth and Monitoring
Stabilisation and Treatment
biological habilitation / ski park
vegetation maturation and hiking park
terraforming - waste rock storage
Stabilisation and Treatment
Stabilisation and Treatment
biological habilitation
vegetation maturation, degrowth and monitoring
LKAB decentralisation
Iron processing Plant
Establishment of recycling plant
rehabilitation
multihabilitation
Stabilisation and Treatment
storage silo
Stabilisation and Treatment
loading and unloading bay
Stabilisation and Treatment
soting facilities
Stabilisation and Treatment
inhabitation
Stabilisation
heritage park
deformation trails
Stabilisation
phytoremediation
Forest Restoration and Degrowth and Monitoring
natural rehabilitation
social integration
decentralisation of LKAB
Kirunavaara mine restoration
Per Geijer mine concession
Per Geijer mine restoration

Composition Repair at the scale of Kirunavaara mine

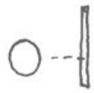
0 1 km N


STATION
REINDEER FENCE
LAKE RESTORATION
WETLAND RESTORATION
DEEP ROOTED FORESTS
DC
DEGROWTH
TRAIL
PHASED REGENERATIVE AGRICULTURE
SKI PARK
PHYTOREMEDIATION
PHASE 1
PHASE 2
PHASE 3
M1
RECYCLING PLANT
TAILING PILE MINING
DEFORMATION ZONE
PHYTO REMEDIATION WETLANDS
CLARIFICATION POND
P4

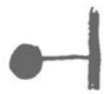
Kiruna as a mining town was developed around the centrality of the mine and the supporting infrastructures: determinate, which then allowed for different forms of supporting economies and public functions to develop around the city: indeterminate. In the proposal, the indeterminate city (the public functions, representing social reproduction) forms the new core around which the economic functions are diversified, and agencies are devolved. This is spatialised through a series of public spaces which stretches the fabric of the city into the mining district. These centralities become the anchor points for temporal changes and the regulation of different programmes, which then provide buffers and conditions for reacting to long-term uncertainties and changes. They form interfaces that become catalysts for establishing interdependencies and eco-dependencies, organising the actions of ecological repair and social integration. The spatial logic for identifying the interfaces is the liminal spaces between the multifunctional landscapes. They form interfaces between different spatial programmes and stakeholder interactions, forming spaces of negotiation and regulation between the decentralised functions and agencies, thus informing the devolution in the landscape. The indeterminate interfaces are devoid of fixed programmes allowing for multiple human and more-than-human functions to occur simultaneously. In some areas, they allow for spaces of co-production, archival, and exchange of knowledge. They allow for the interaction and material trade between the Sámi and the Swedish population. At the scale of the city, they form a network where they are interfaces between each other.

Inverting the value of the determinate and indeterminate city

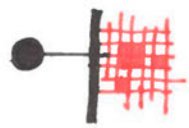
Deposit
Resource



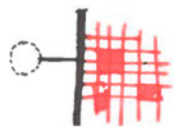
Mine
Capital production



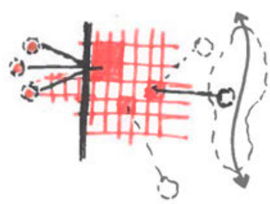
Mining Town
Social reproduction



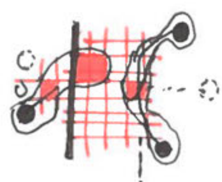
Invert
Determinacy



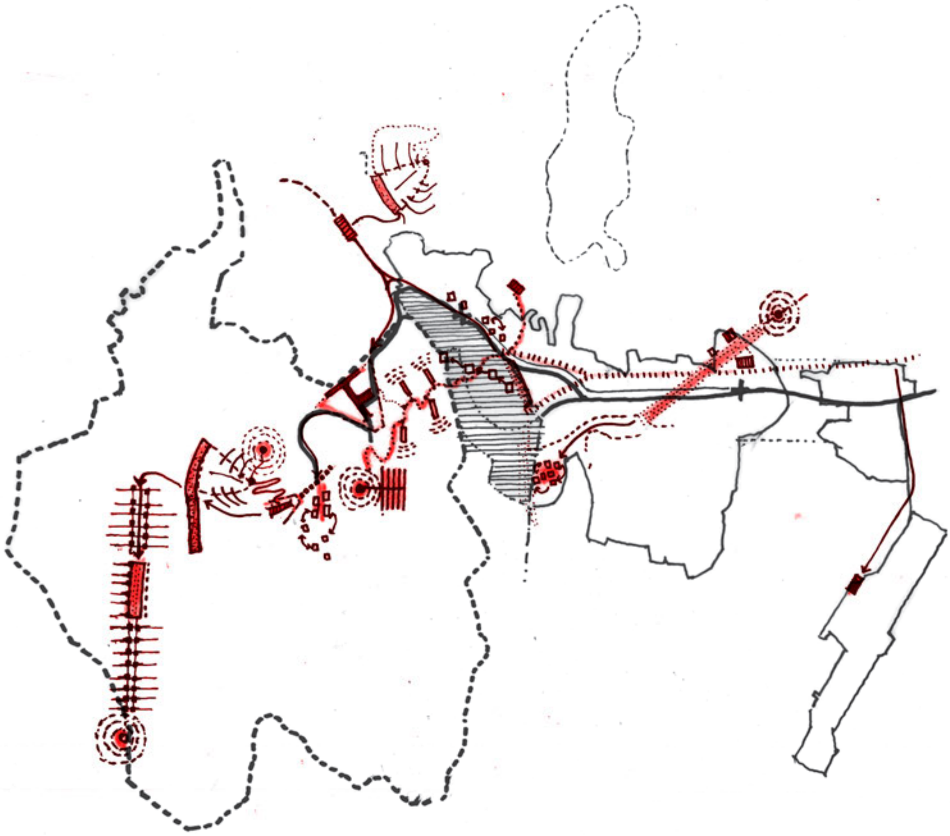
Decentralise
Economic Production



Couple
Sacrifice and repair

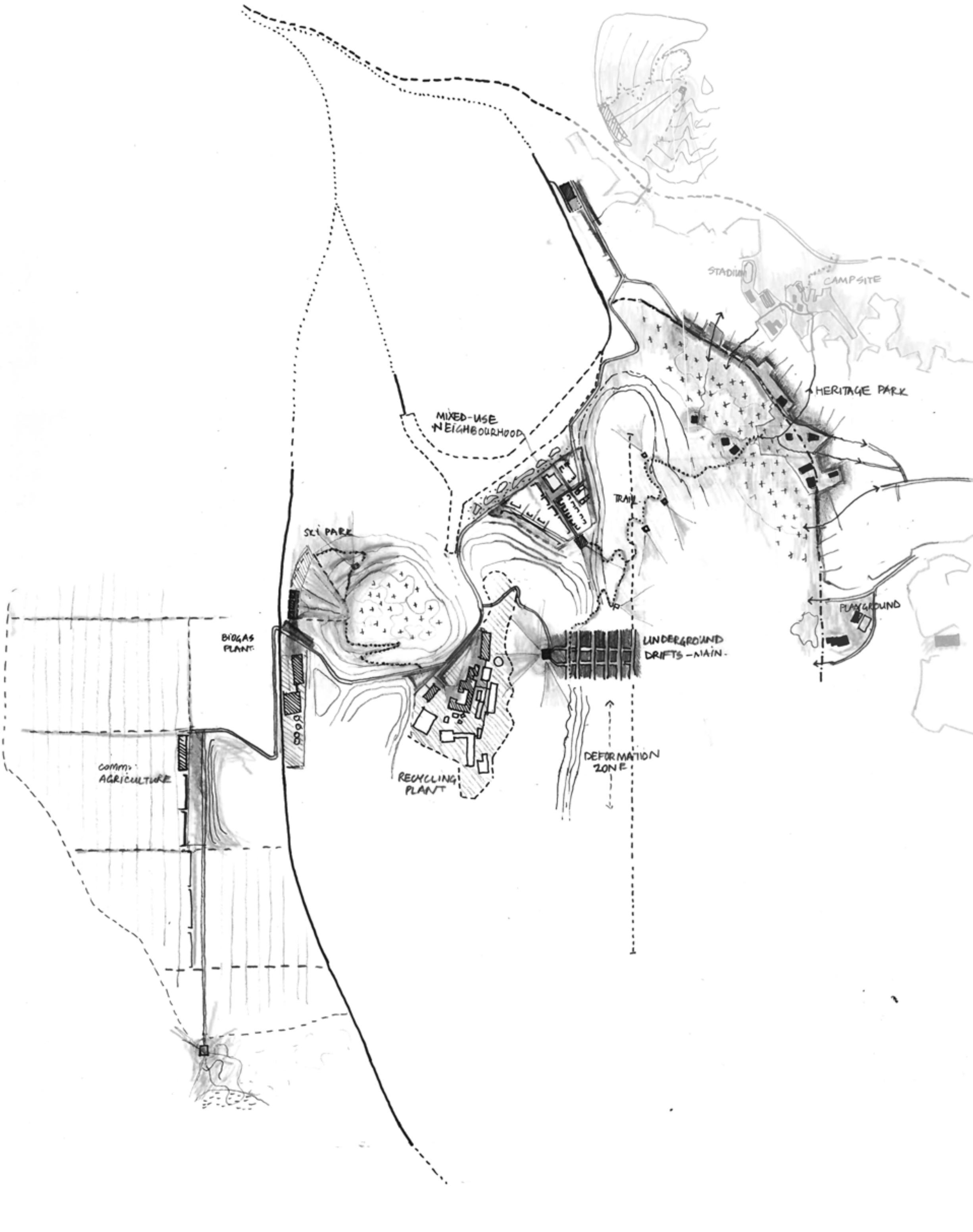


Fabric of indeterminate interfaces



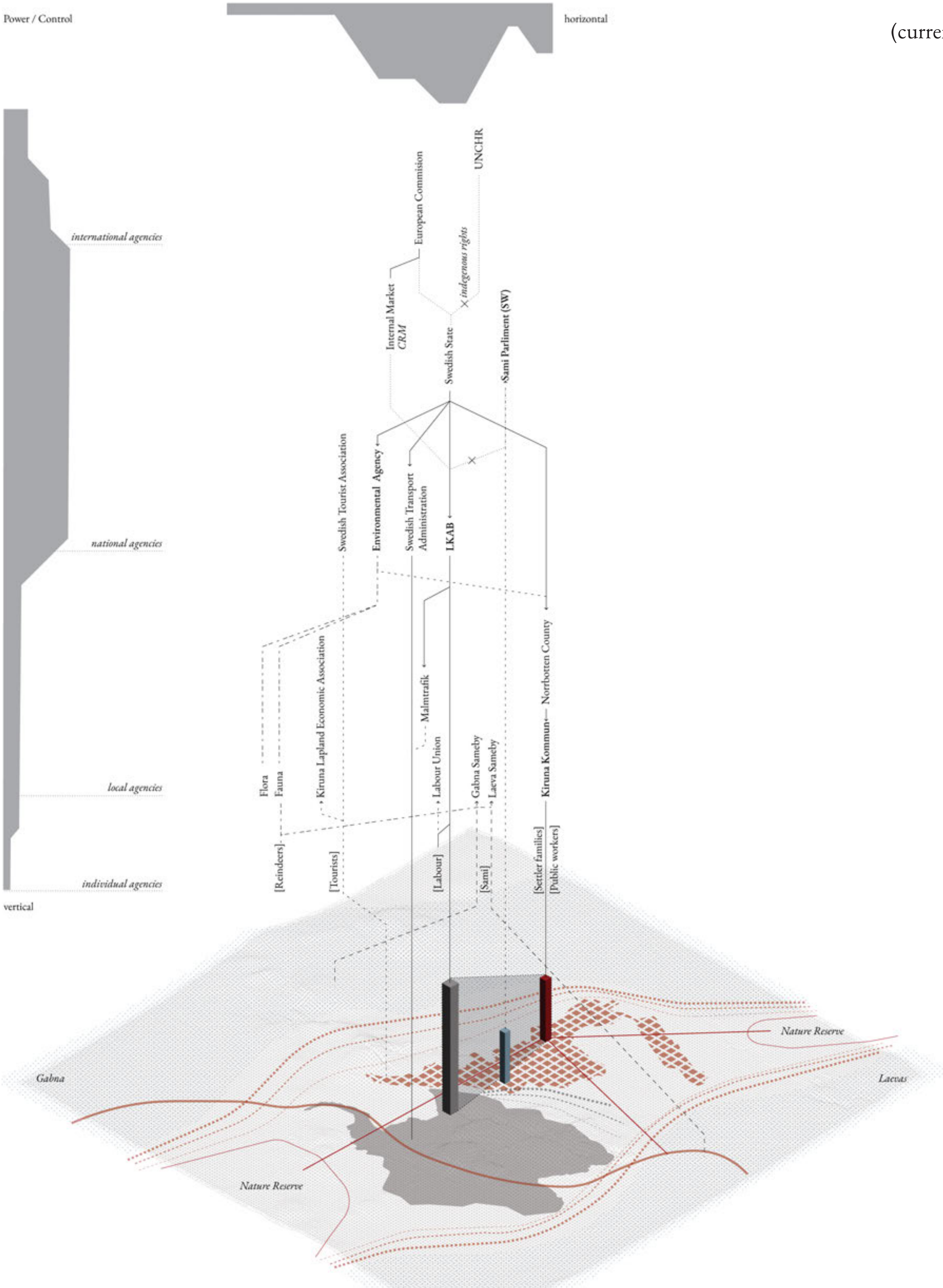
Integration of indeterminate interfaces for social functions

0 1 km N


STADIUM
CAMPSITE
HERITAGE PARK
MIXED-USE NEIGHBOURHOOD
TRAIL
SKI PARK
PLAYGROUND
BIOGAS PLANT.
UNDERGROUND DRIFTS - MAIN.
COMM. AGRICULTURE
DEFORMATION ZONE
RECYCLING PLANT

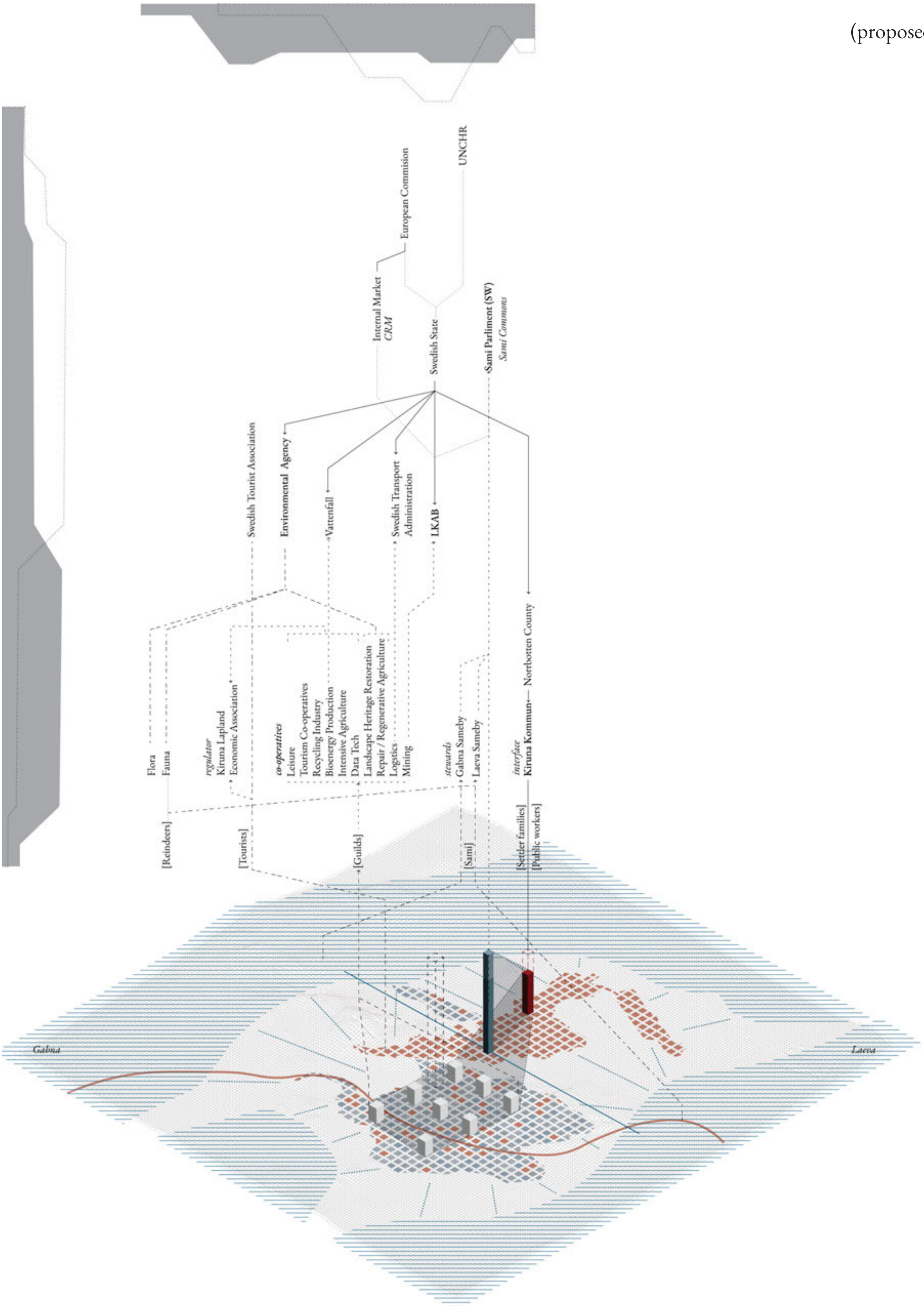
The spatial transformations towards an extraction landscape that is multifunctional and reparative with indeterminate interfaces need the rethinking of the power structures governing them. The current dominating agency is central to the state-owned company LKAB which with them making the landscape of sacrifice hold the power and the capital resources to handle the repair. It is paying for the relocation of the town, building the facilities in the new city centre, monetarily compensating for the land value based on the market. The mining is also supported by the European Commission through the Critical Raw Material Act which strengthens the need for the new mining concession for the Rare Earth Elements. LKAB is also the state corporation which along with the mining also manages the operations of the railway, housing, mechanical, explosive production etc., through their subsidiaries. Which are linked to the Swedish Railway Company – SJ AB and State Electrical Company – Vattenfall AB. The governing body – Kiruna Kommun has lower power in the city due to the economic value of the mine. Kiruna also houses the Swedish Sámi Parliament which represents the Sámi affairs of all the Samebys in Sweden. The local Sámi communities which are affected by the extraction industry are the Gabna and the Laevas. As elaborated in the interview with Nils Partapouli in the second chapter, there is a trend of exclusion between the local Swedes and the Sámi. Historically conservation ideas of creating nature reserves were colonial ideas for the State ownership and regulation of the use functions of the land. This is managed by the Kommun and the County but regulated by the environmental agency. Tourism is regulated by Kiruna Lapland Economic Association (KLEF) and Swedish Tourist Association (STF). With the main intent of giving back to the nature-cultures, the devolution: decentralisation to increase the autonomy of the lower bodies can help create a better conditions for managing the land. The transition includes actions of [i] Decentralisation of LKAB, and self-organisation of co-operatives of guilds for managing and operative different economic activities which are regulated by Kiruna Lapland Economic Association (KLEF). At the scale of the mine, each of the spatial post-extraction functions have multiple overlapping stakeholders. [ii] empowering land stewardship and traditional knowledge exchange through the practice of commoning. Each Sameby will have its commons which they are stewards of the Sámi common land. The current nature reserves are returned to the indigenous community managed by the Swedish Parliament. [iii] The city then acts as an interface between the commons and the co-operatives responsible for the public utilities and amenities for the communities. The role of the higher agencies turns from controlling and managing to coordinating between the decentralised system, the state and the international agencies. The power is vertically shifted now more towards the lower local and individual agencies and horizontally made dispersed cross communities, than the previous condition where the power was concentrated on the state.

(current)



Reorganising Agencies

(proposed)



UNCHR
European Commision
Internal Market
CRM
Swedish State
Sami Parliment (SW)
Sami Commons
Swedish Tourist Association
Environmental Agency
Vattenfall
Swedish Transport
Administration
LKAB
Norrbotten County
Flora
Fauna
regulator
Kiruna Lapland
Economic Association
co-operatives
Leisure
Tourism Co-operatives
Recycling Industry
Bioenergy Production
Intensive Agriculture
Data Tech
Landscape Heritage Restoration
Repair / Regenerative Agriculture
Logstics
Mining
stewards
Gabna Sameby
Laeva Sameby
interface
Kiruna Kommun
[Reindeers]
[Tourists]
[Guilds]
[Sami]
[Settler families]
[Public workers]
Gabna
Laeva

Decentralisation of the mine area and decentralisation of power and control

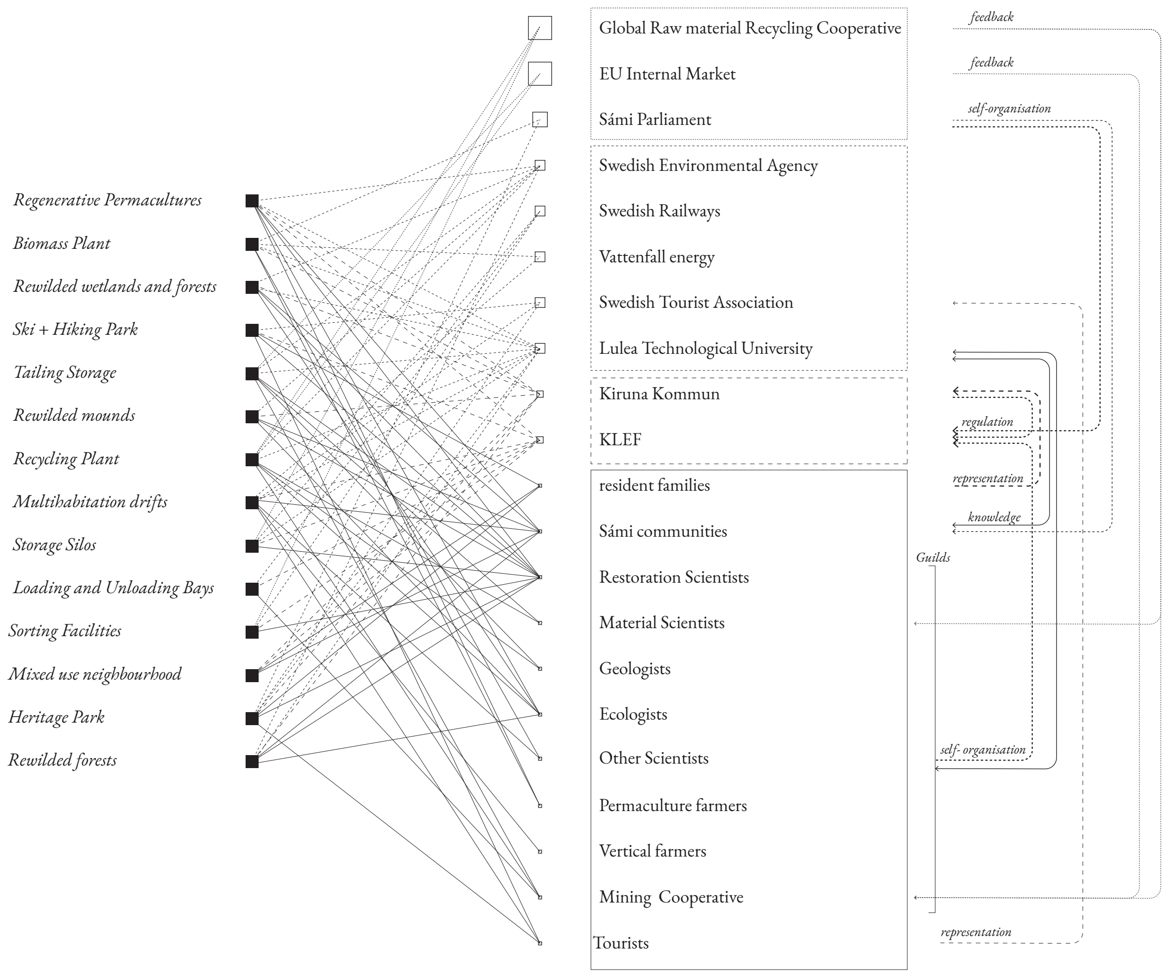
Guild Cooperatives	Mining	Labour guilds
self organisation	Logistics	Specialists
	Landscape Heritage Restoration	
	Repair / Regenerative Agriculture	
	Bioenergy Production	
	Recycling Industry	
	Intensive Agriculture	
	Data Technology	
	Tourism Co-operatives	
	Recreational areas	

Empowering Land Stewardship and Traditional Ecological Knowledge exchange

Sámi Commons - Sámi Parliament	Gabna commons	Reindeer herders
Stewardship	Laeva commons	Artisans
		Artists
		Knowledge archivists

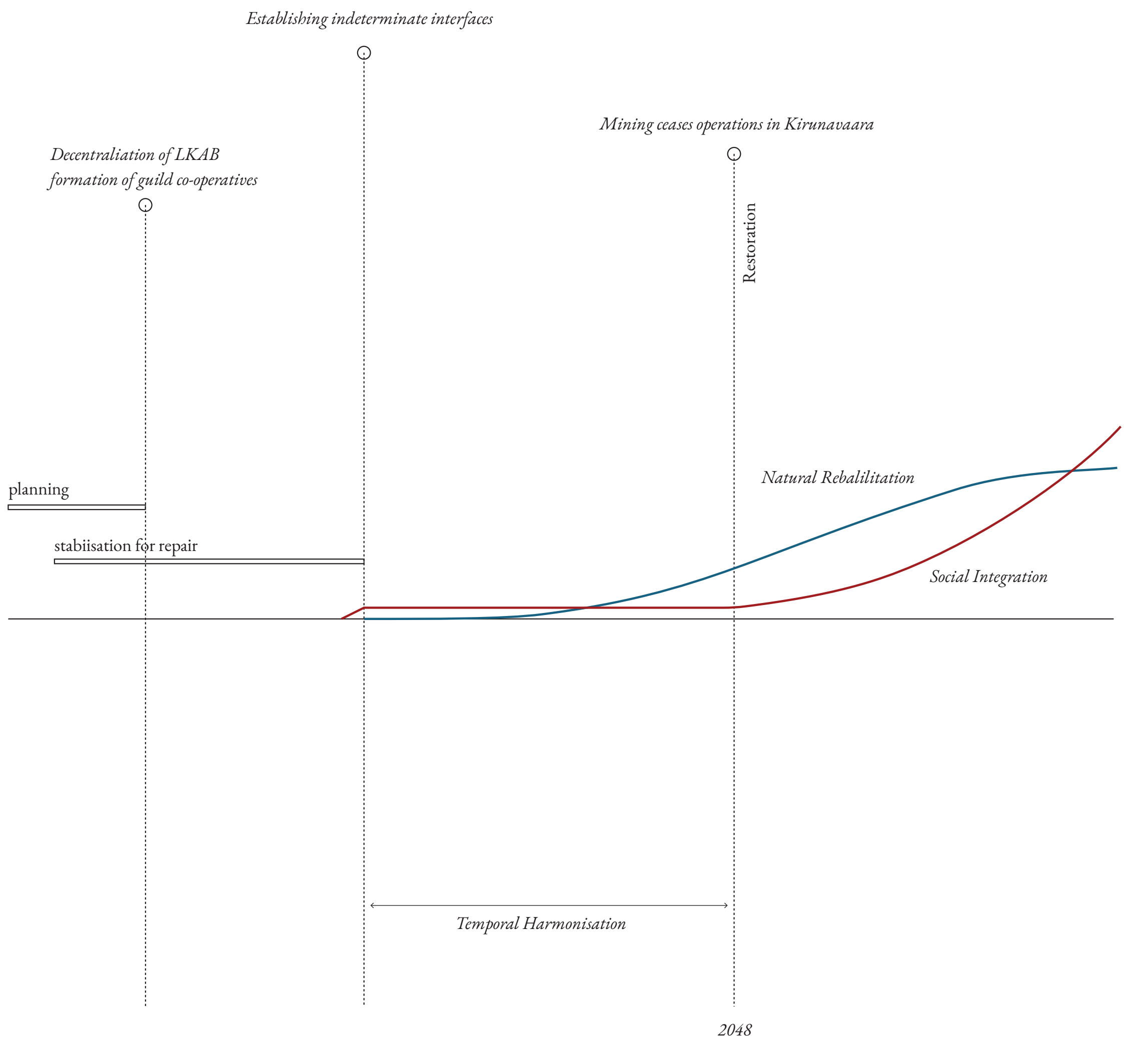
City as a interface between the Sámi and the co-operatives

Kiruna Municipality	Schools	Public Workers
Regulation of Land Management and	Hospitals	
Public Utilities	Lulea Technological University	
		Researchers
		Scientists



Regenerative Permacultures
Biomass Plant
Rewilded wetlands and forests
Ski + Hiking Park
Tailing Storage
Rewilded mounds
Recycling Plant
Multihabitation drifts
Storage Silos
Loading and Unloading Bays
Sorting Facilities
Mixed use neighbourhood
Heritage Park
Rewilded forests
Global Raw material Recycling Cooperative
EU Internal Market
Sámi Parliament
Swedish Environmental Agency
Swedish Railways
Vattenfall energy
Swedish Tourist Association
Lulea Technological University
Kiruna Kommun
KLEF
resident families
Sámi communities
Restoration Scientists
Material Scientists
Geologists
Ecologists
Other Scientists
Permaculture farmers
Vertical farmers
Mining Cooperative
Tourists
feedback
feedback
self-organisation
regulation
representation
knowledge
Guilds
self- organisation
representation

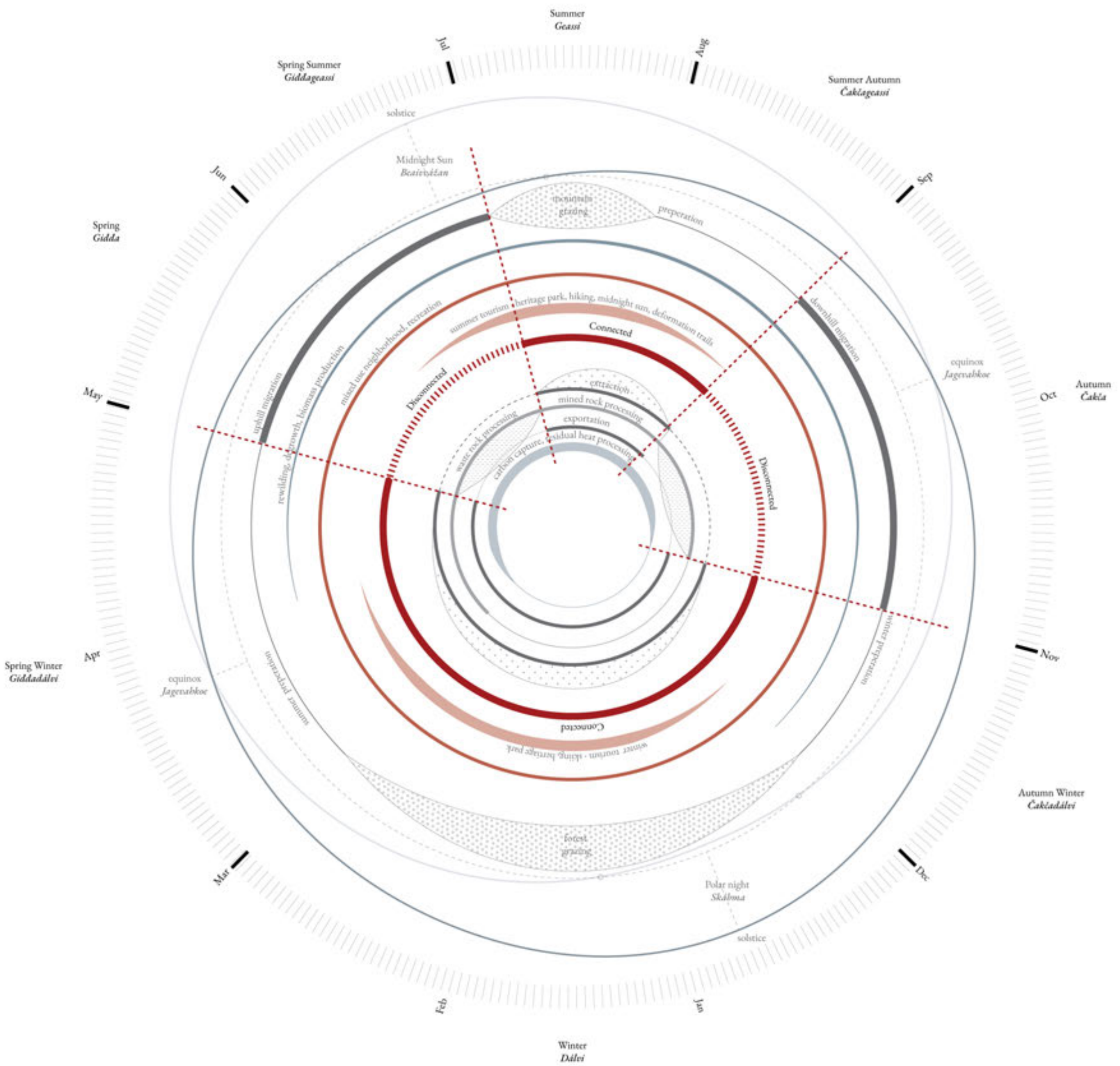
Rate of Natural Rehabilitation and Social Integration


Establishing indeterminate interfaces
Mining ceases operations in Kirunavaara
Decentraliation of LKAB
formation of guild co-operatives
Restoration
planning
stabiisation for repair
Natural Rebalilitation
Social Integration
Temporal Harmonisation
2048

Kiruna has its temopral rhythms based on the seasonal variations, ranging from polar nights in the long winter to the midnight sun in the short summers. These seasons regulate the soil condition and the movement of more-than-human actors like the reindeer, which in turn inform the land practice of the indigenous community between the winter forest pastures downhill and the summer mountain grazing pastures. In Kiruna, tourism is in season, from the autumn-winters to the winters, summers, spring-summer, and summer, which depend on natural phenomena like auroral activity and the ability to enjoy the 'wilderness'. Since extraction is a year-round, all-day activity, causing spatial conflict during the reindeer migration periods in the springs and autumns and placing significant pressure on the infrastructure system, devolution measures can aid in regulating mining activities to be seasonal and active during the summers and winters. This necessitates two states: [i] when the settlements establish connections with each other and the global network for material and human flows; and [ii] when these settlements become disconnected, significantly reducing material and human movement, thereby enabling the city to remain dynamic and multifunctional. Ground transport and logistical infrastructure, which connect the settlements, are the spatial elements under regulation.

The indeterminate areas as public spaces function as spatial regulators for functional changes and allow for interactions between simultaneous activities and mediate spatial reprogramming subjected to change in time. This would allow for flexible use of the space but also function as anchor points along which the spaces change and respond to uncertain conditions in the longue durée. Uncertain conditions pertain to technological advancements, climatic conditions, changing political conditions etc. The interactions between multiple agencies and the public space would allow for the indeterminate interfaces to respond to these uncertain conditions.


Summer
Geassi
Jul
Aug
Spring Summer
Giđđageassi
Summer Autumn
Čakčageassi
solstice
Midnight Sun
Beaivváčan
mountain grazing
Jun
Sep
Spring
Giđđa
preperation
summer tourism
uphill migration
Luleå + Narvik
extraction
equinox
Jagevahkoe
Autumn
Čakča
Oct
May
downhill migration
calving
Apr
Spring Winter
Giđđadálvi
equinox
Jagevahkoe
extraction
Nov
winter preperation
summer preperation
Narvik
winter tourism
Autumn Winter
Čakčadálvi
forest grazing
Mar
Dec
Polar night
Skábma
solstice
Feb
Jan
Winter
Dálvi



Summer
Geassi
Jul
Aug
Spring Summer
Giđđageassi
Summer Autumn
Čakčageassi
solstice
Midnight Sun
Beaivváčan
Jun
Sep
mountain
grazing
preperation
Spring
Giđđa
summer tourism - heritage park, hiking, midnight sun, deformation trails
Connected
downhill migration
mixed use neighborhood, recreation
rewilding, dogrowth, biomass production
uphill migration
Disconnected
extraction
mined rock processing
exportation
waste rock processing
carbon capture, residual heat processing
equinox
Jagevahkoe
Oct
Autumn
Čakča
May
Disconnected
Spring Winter
Giđđadálvi
Apr
equinox
Jagevahkoe
summer preperation
winter preperation
Nov
Connected
winter tourism - skiing, heritage park
Autumn Winter
Čakčadálvi
forest
grazing
Mar
Dec
Polar night
Skábma
solstice
Feb
Jan
Winter
Dálvi

connected

northern lights
mining
frozen waters
winter grazing
processing
skiing
terraforming (addition)

disconnected

no tourism
no mining
thawing
uphill migration
permaculture remediation
biomass production
tourism off-season
terraforming (subtraction)

connected

midnight sun
mining
thawing
minimum reindeer activitiy
processing
permaculture remediation
biomass production
hiking
terraforming (addition)

Seasonal Variation

disconnected

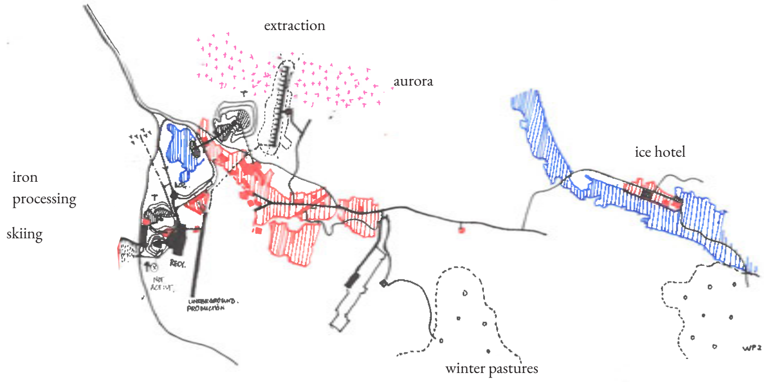
northern lights
no mining
freezing
downhill migration
permaculture remediation
biomass production reduces
tourism off-season
terraforming (subtraction)

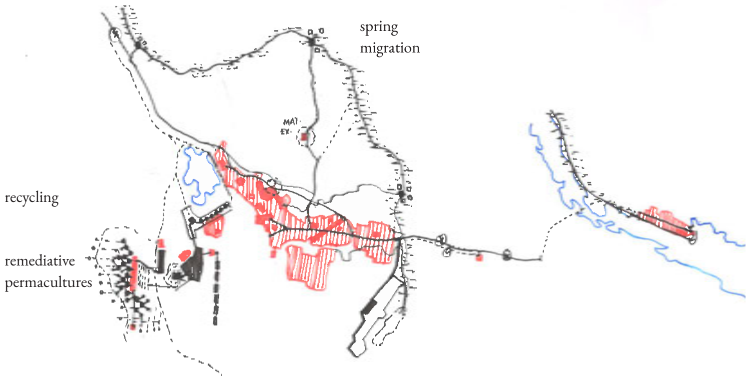
Winter

Spring

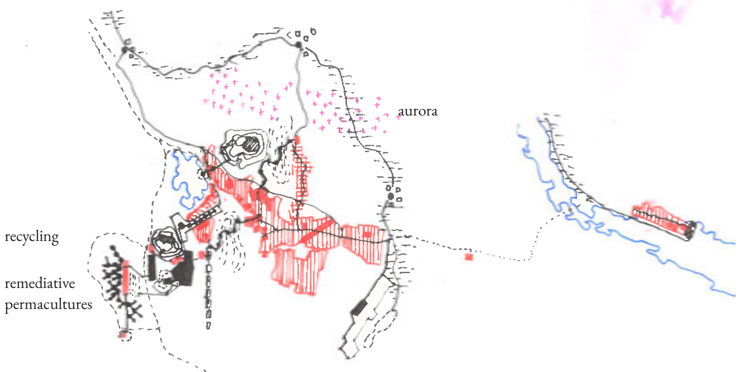
Summer

Autumn


extraction
aurora
ice hotel
iron
processing
skiing
winter pastures


spring
migration
recycling
remediative
permacultures

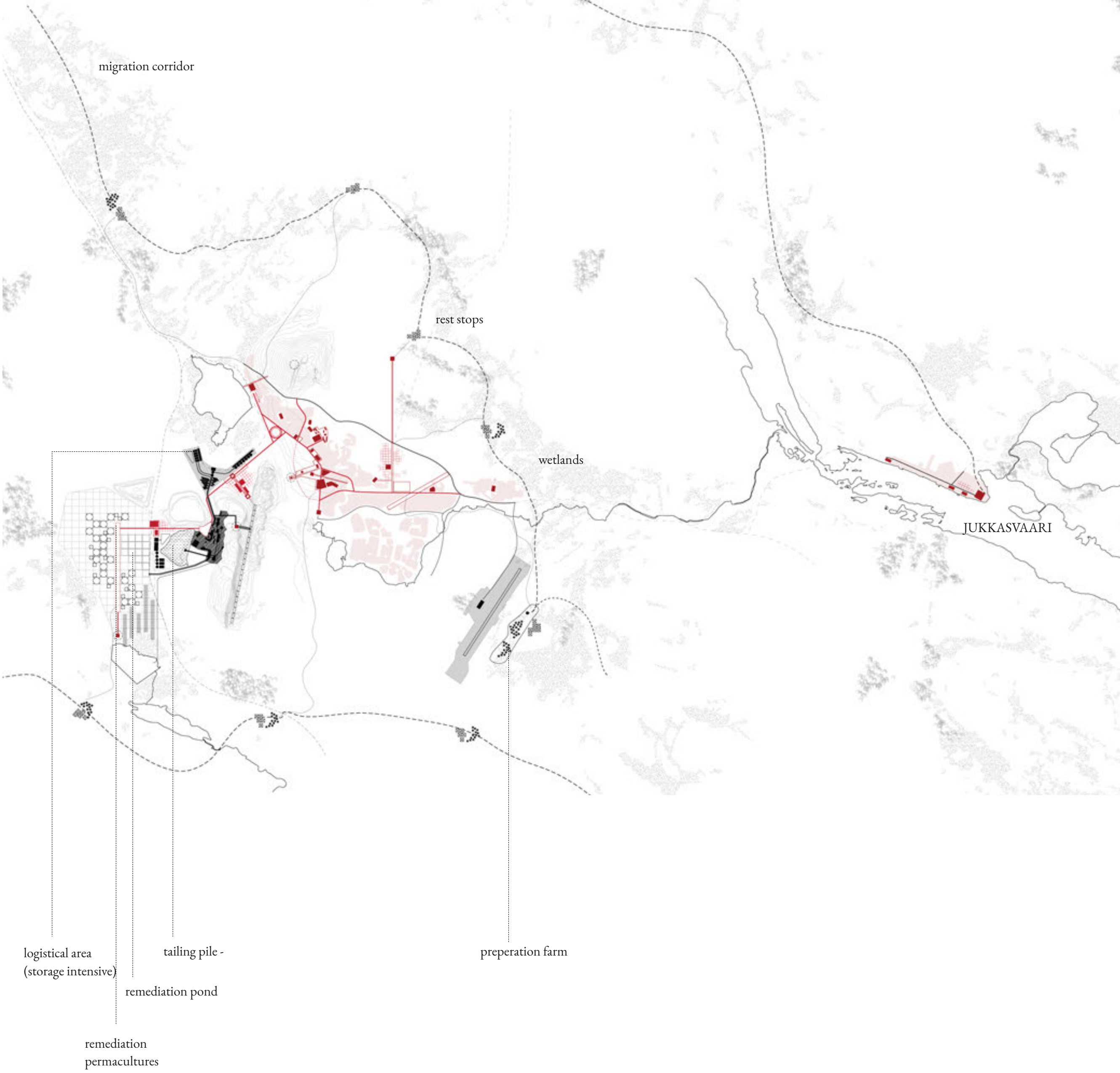

hiking
extraction
iron
processing
remediative
permacultures
hiking


aurora
recycling
remediative
permacultures

Connected State - Summer / Winter

indeterminate interfaces

|0 |3 km N



Disconnected State - Autumn / Spring

Architecture of Devolution

[Anti-Project]

This chapter summarises the functions of the indeterminate interfaces. These functions informing the spatial logic of devolution is then used to backcast the develop design conditions of the anticipated mine. Subsequently, the spatial and institutional mechanisms of the indeterminate interfaces are elaborated through public space design. Firstly a design scheme is conceptualised in a selected interface in the Kirunavaara mine area for the Post-Project. Subsequently, the design inferences are backcasted to elaborate the spatial and institutional mechanisms in a proposed interface in the anticipated though a public space design.

The indeterminate interfaces are spatially manifested in the form of public spaces. The spatial strategy for then introduction of the public spaces in extraction environments follow the various functions of these interfaces.

Interface as catalysts for socio-ecological repair
The public space as an introduced spatial element in the delimited sites provides focal points to seed the ecological repair. Following the ecological repair, these points function as points for social integration.

Interface as a spatio-temporal regulator
These public spaces allow for flexibility of use which can guide the temporal Regulation between seasonal activities. In the longue durée they also allow for reacting to uncertainties of climate change, technological development etc.

Interface between spatial functions and stakeholders
These public spaces form spatial conditions for organisation of the decentralised functions and new fucntions that increases the agency of repair and lower level negotiations in extraction landscapes. It also allows for establishing cross-dependecies with respect to knowledges and decisions between the stakeholders - mining, restoration and other guilds, economic association the local Sámi community and the municipality as the interface between all

Interface between neighbouring interfaces
The public spaces function as spatial interfaces between the neighbouring ones creating a fabric of these new public spaces at the scale of the city.

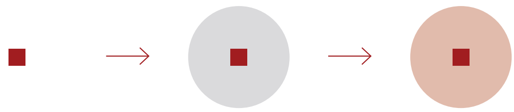
Functions of Indeterminate interfaces

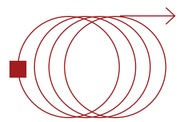
Catalyst for socio-ecological repair

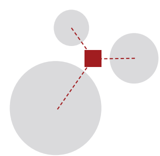
Saptio-temporal regulator

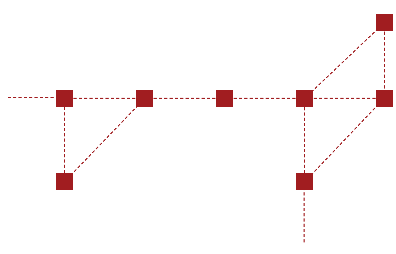
Interface between spatial functions and stakeholders

Interface between neighbouring interfaces



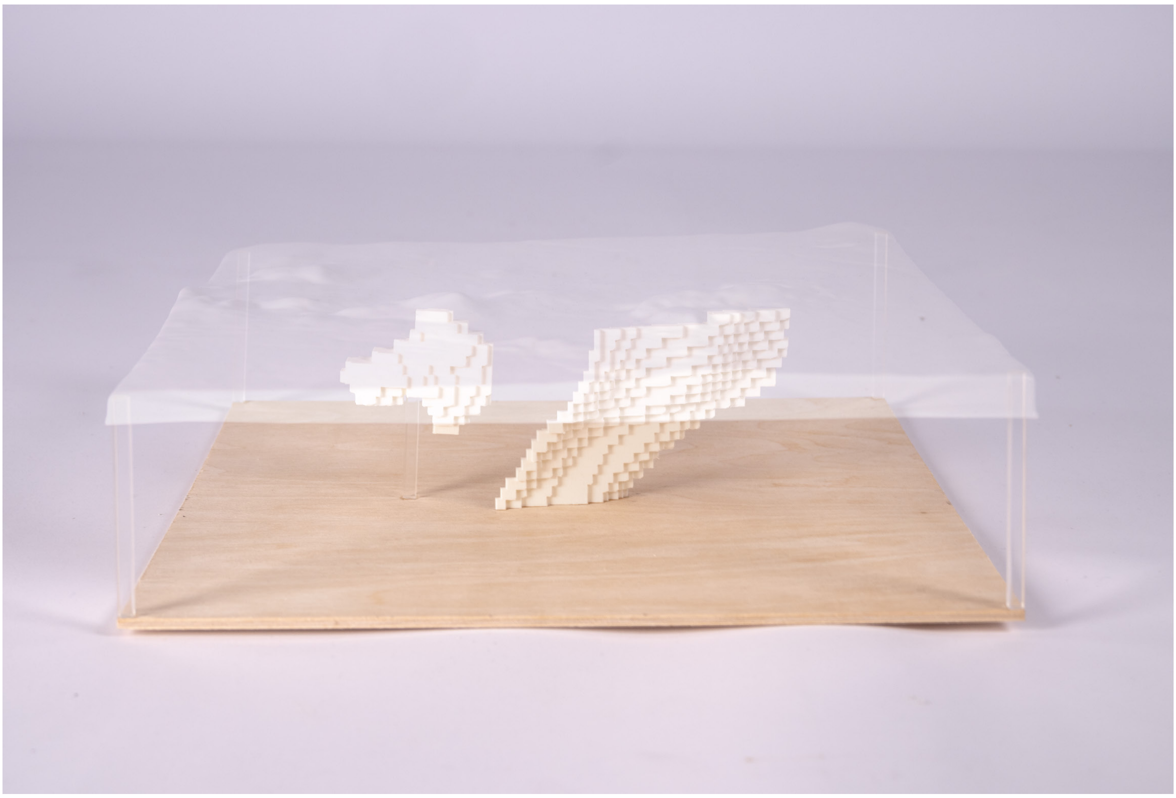




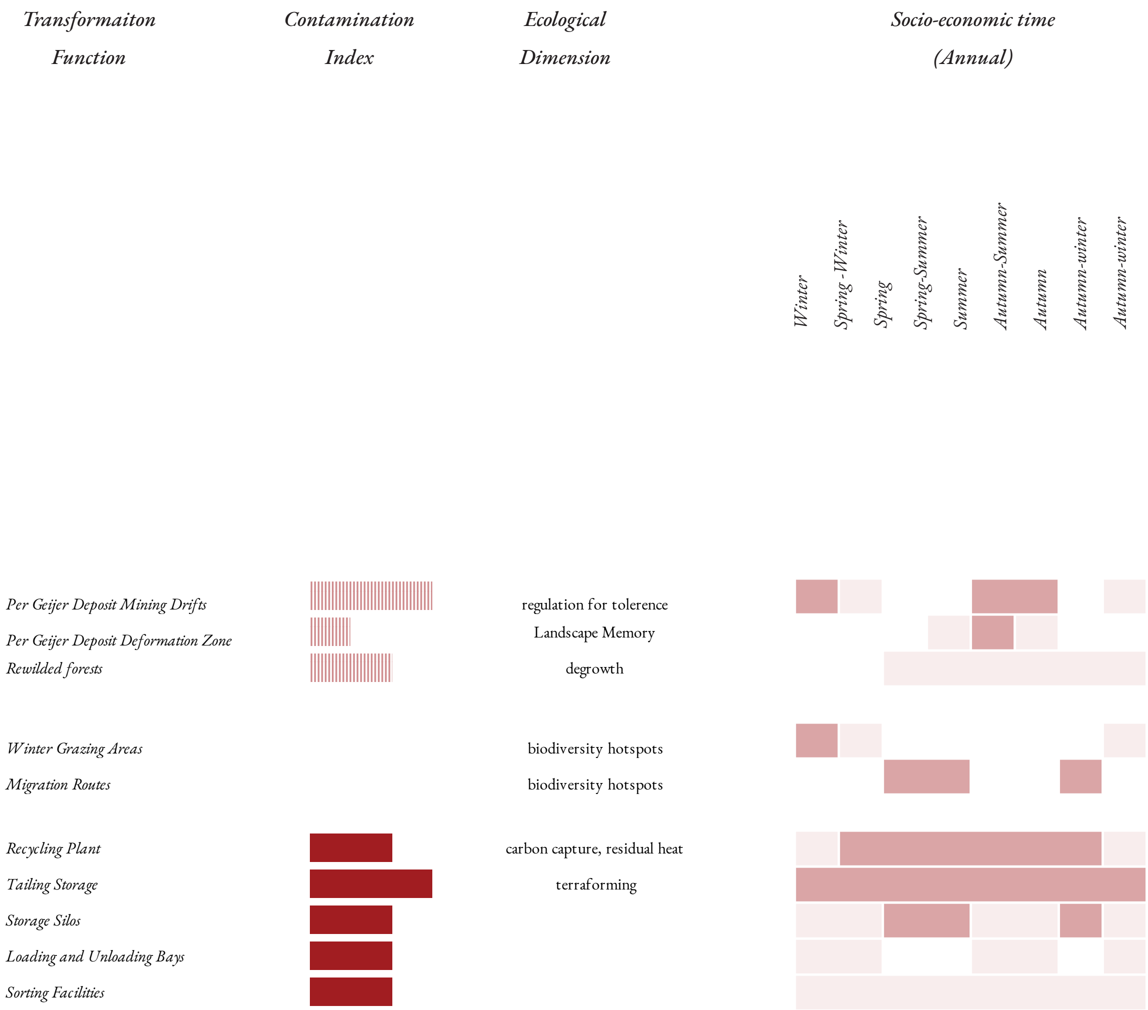


If we conceptualise the anticipated mine (2038) from the Per Geijer deposit through the new spatial logic of devolution and the indeterminate interfaces, it incorporates not only the economic dimension of mining but also the social dimension of skill development, knowledge exchange, and negotiation space. The anticipated deformation zone undergoes intermittent repairs instead of post-extraction repair. After the deposit has been depleted, the deformation zone can programme tourist trails, house public functions, and archive landscapes. It is also a space for degrowth, transforming into a wilderness transition area. The current plans suggest that the mine is connected to the processing plan deep underground which reduces the footprint on the city above ground. In the proposal, the mining activity is regulated to function in the winters and summers. During this state, the city is connected globally, and the waste rocks are stored in the tailing pile close to the processing plant. During the spring and autumn, there is no mining, and the processing plant extracts the rare earth from the tailing pile. The mining drifts are then rehabilitated to house multiple support functions. The indeterminate interface regulates the production and migration seasons. In addition, they are social spaces for negotiation between the actors.


towards Kurravaara
Per Geijer Deposit



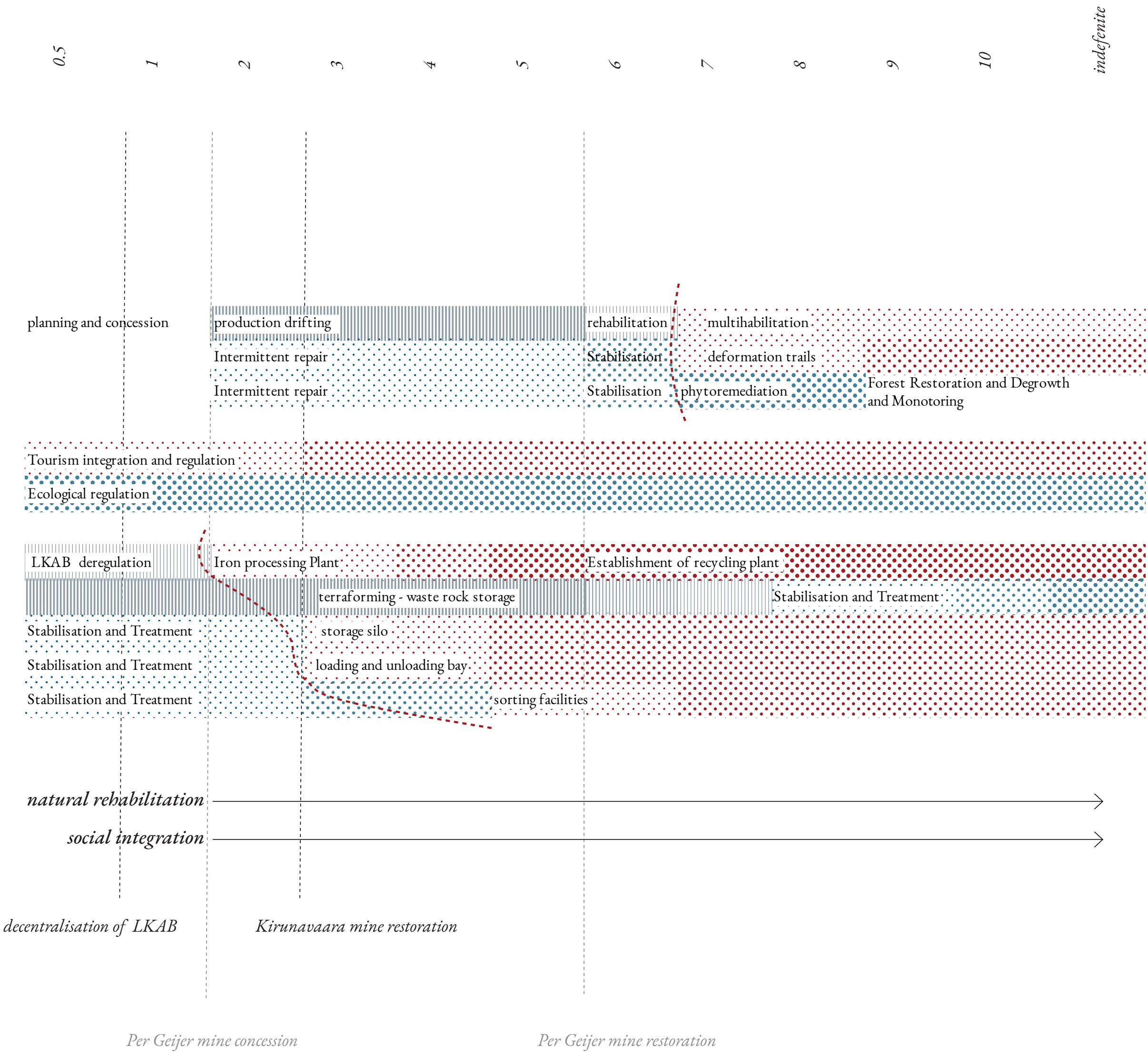
Model of the terrain of Kiruna and the underground ore bodies showing the Per Geijer and Kirunavaara deposits

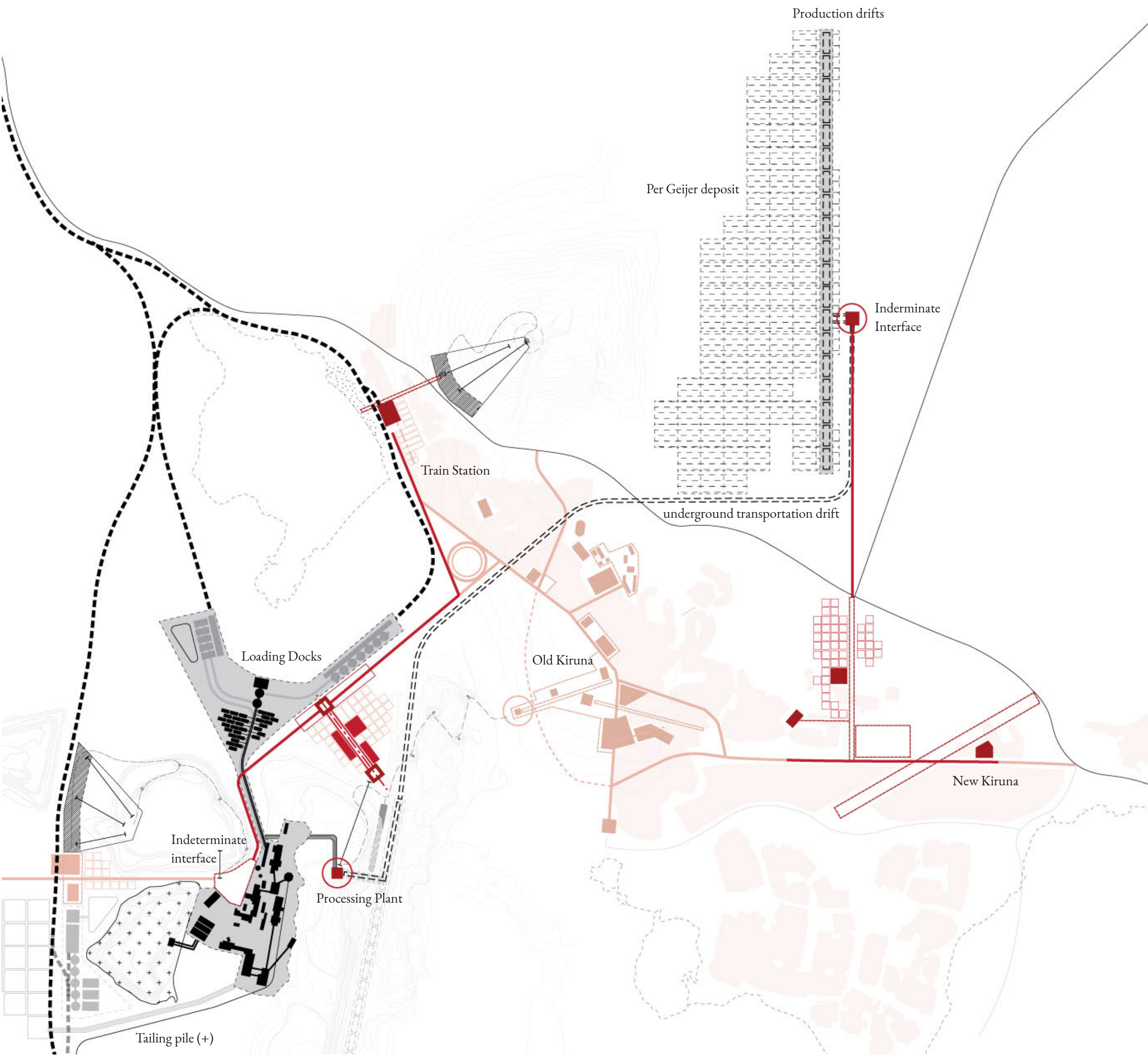


Program of the Anti-project - thinking extraction from the devolution perspective

Geographical Time

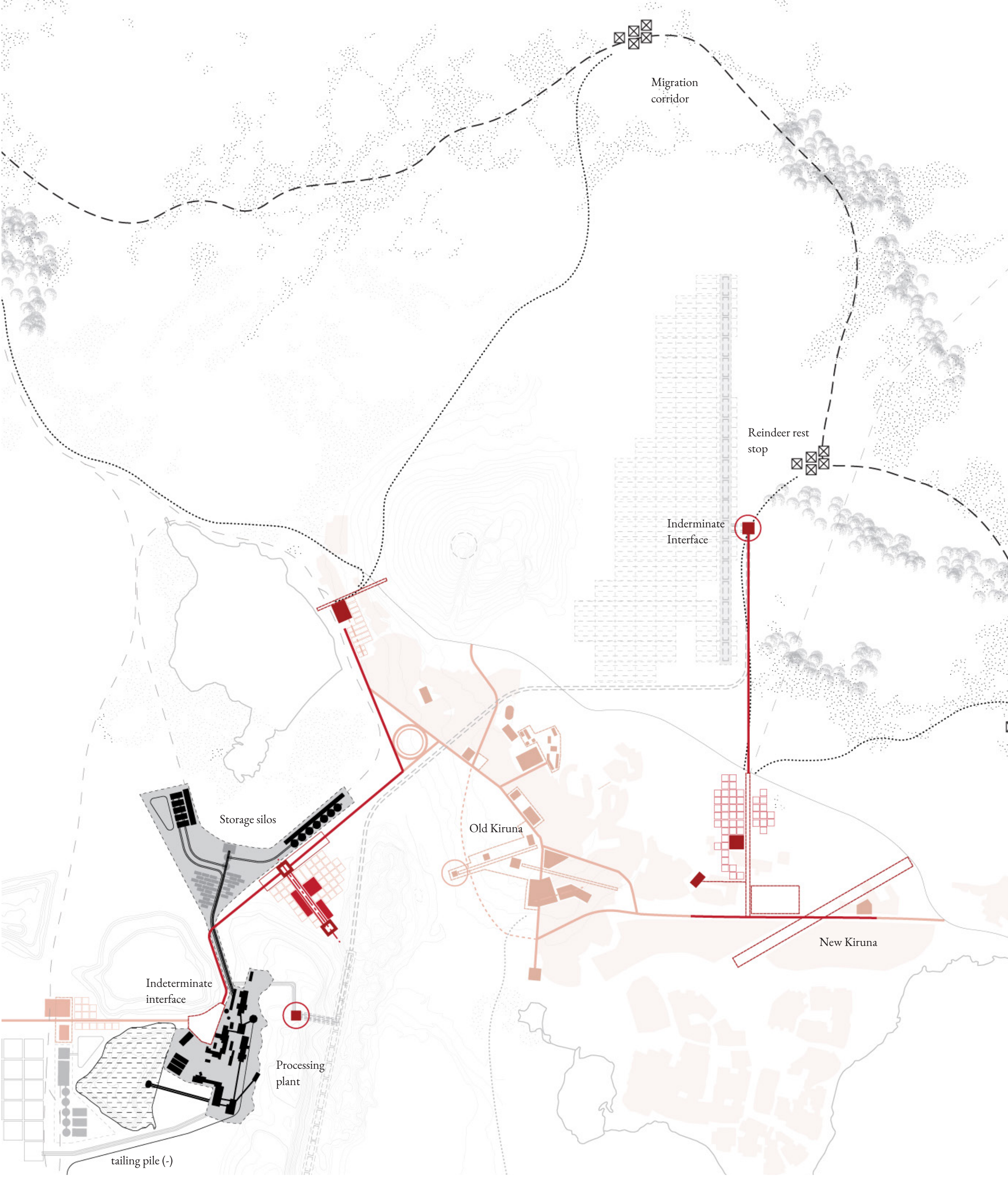
(Decades)





Connected State - Summer / Winter

indeterminate interfaces

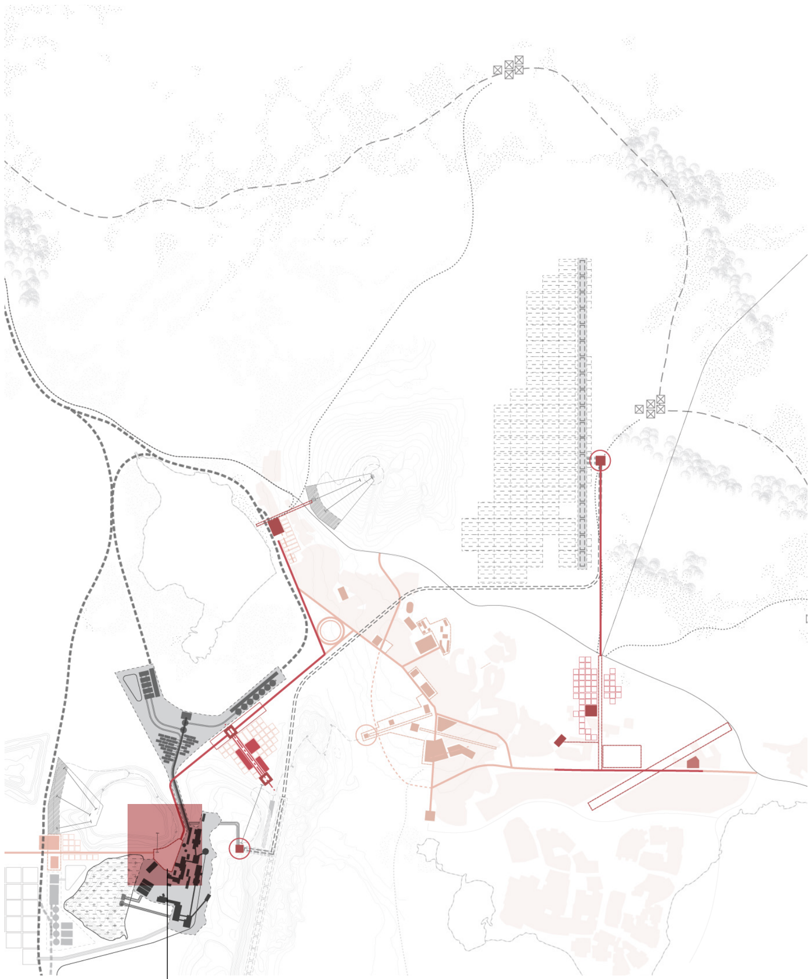


Disconnected State - Autumn / Spring

The role of the indeterminate interfaces in devolution is to act as a catalyst for organising and regulating ecological rehabilitation and social integration. This section elaborates on two of the many indeterminate interfaces in Kiruna. The first one is in the old mine area between the processing plant and the tailing pile [Post-Project] and the second one is between the proposed deposit and the migratory wetland routes [Anti-Project].

In the Post-project it is the spatial interface between functions like processing/recycling, hiking trails, and ski park on the tailing pile towards the north and the waste rock storage facility on the tailing pile in the south, which can be the first REE reserve. Each of them has its own annual rhythm, and the interfaces are the spill-ins for these functions. They are also the interface for the stakeholders in the different programmes: the guilds of restoration scientists, mining cooperatives, global recycling cooperatives, Kiruna municipality, students and trainees, tourists, inhabitants, and more. Programming these interfaces, it houses the socio-ecological rehabilitation centre, the landscape memorial for the contaminated land and the lost landscape, recycling skill development, and a vocational training school. It can also serve as an interface between human and more-than-human elements. By programming these areas over time, they can house the facilities required for ecological repair and focal points of social integration.

In the Anti-Project , the social function includes the Gabna Sameby, who are the stewards of the land and use the land for reindeer migration, the miners cooperative guild, mining skill development, and vocational training. The interface forms the space for negotiation and exchange of traditional knowledge, a Sámi interpretation centre, a marketplace for material exchange, and also the node for the reindeer herding equipment temporary storage that is shared. The interface can also house the school for sustainable mining and serve as access to the drifts for the miners. Mine thus becomes a lab. The ventilation tower or the mine can be programmed to house a tourist view point. The interface also houses facilities for biodiversity and natural health monitoring the wetlands, forests, water, and soil.



Interface for demonstration

Interface for Stakeholders

Restoration Scientists

EU Internal Market

Global Raw Material Recycling Cooperative

Ecologists

Kiruna Kommun

Kiruna Lapland Economic Association

Swedish Environmental Agency

Laeva Sameby

inhabitants

Students / vocational trainees

Tourists

Sport enthusiasts

individual *local* *national* *EU* *global*

Interface for Spatial Program

Socio-ecological Rehab / Regulation Centre

Landscape Memorial - Waste Rocks

REE reserve - Toxic containment - Terraform pile

Processing and recycling plant

Recycling Technologies Skill Development School . Vocational Training

Safelty Control / Regulator point

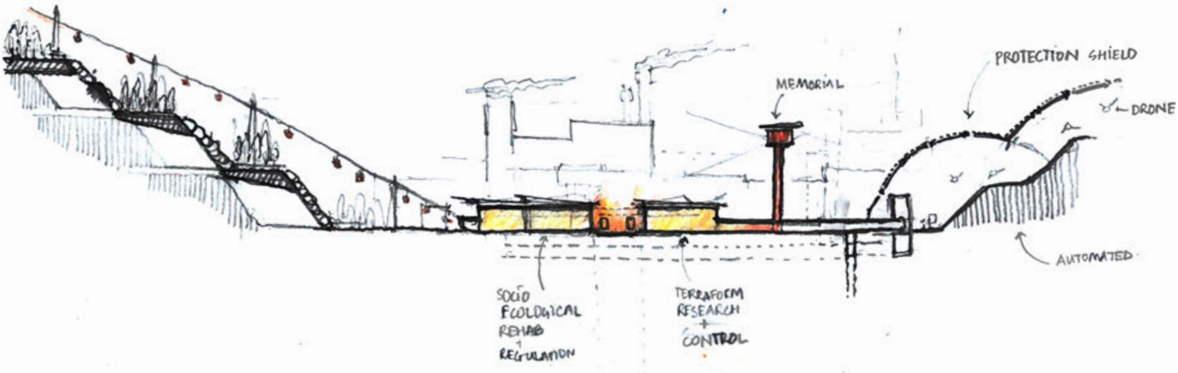
EU Internal Market Office

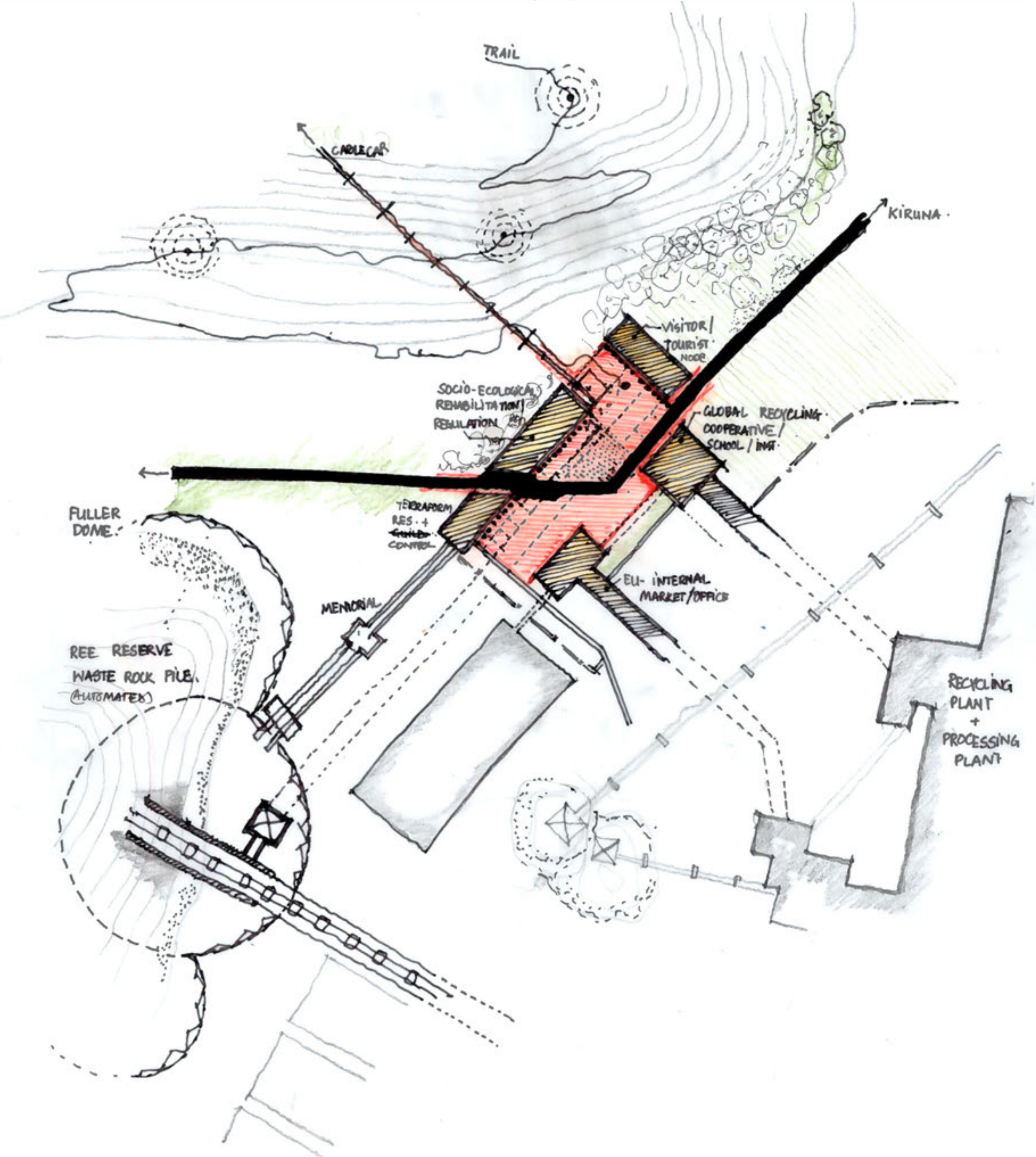
Visitor . Tourist Centre

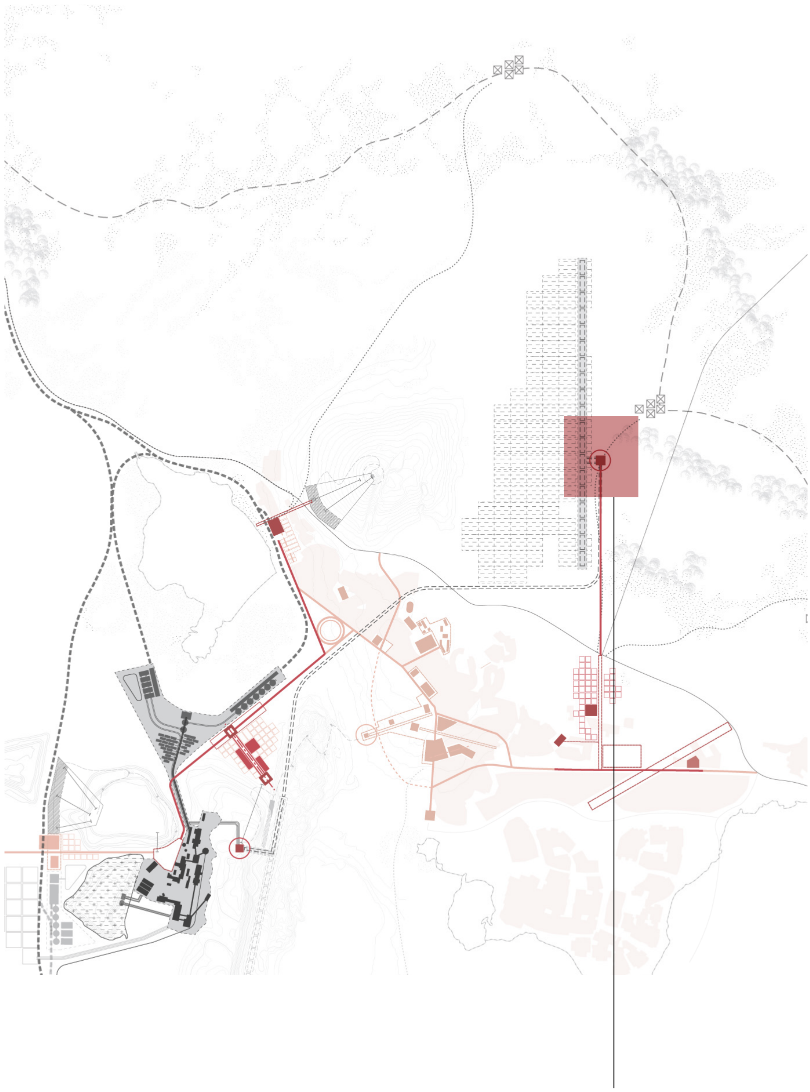
Funicualr / Hiking Trail

Phytoremediationabove toxic containment stabilisation

Schematic section and plan of the resulting public space


PROTECTION SHIELD
DRONE
MEMORIAL
AUTOMATED
SOCIO ECOLOGICAL REHAB + REGULATION
TERRAFORM RESEARCH + CONTROL


TRAIL
CABLECAR
KIRUNA
VISITOR / TOURIST NODE
SOCIO-ECOLOGICAL REHABILITATION / REGULATION
GLOBAL RECYCLING COOPERATIVE / SCHOOL / INST.
FULLER DOME
TERRAFORM RES. + CONTROL
EU-INTERNAL MARKET / OFFICE
MEMORIAL
REE RESERVE WASTE ROCK PILE (AUTOMATED)
RECYCLING PLANT + PROCESSING PLANT



Interface for demonstration

Interface for Stakeholders

Restoration Scientists

EU Internal Market

Gabna Sameby

Ecologists

Kiruna Kommun

Kiruna Lapland Economic Association

Swedish Environmental Agency

Miners Co- operative guild

inhabitants

Students / vocational trainees

Tourists

Swedish Tourist Association

Sport enthusiasts

Reindeers

individual *local* *national* *EU* *global*

Interface for Spatial Program

Per Geijer Miners Co-operative

Mining School - Skill Development / Vocational Training

Restoration Centre + Point / Wetland / Forest / Deformation

Safety Control /Regualtor

Sámi Interpretation Centre

Handicrafts emporium

Knowledge Exchanage and Archival

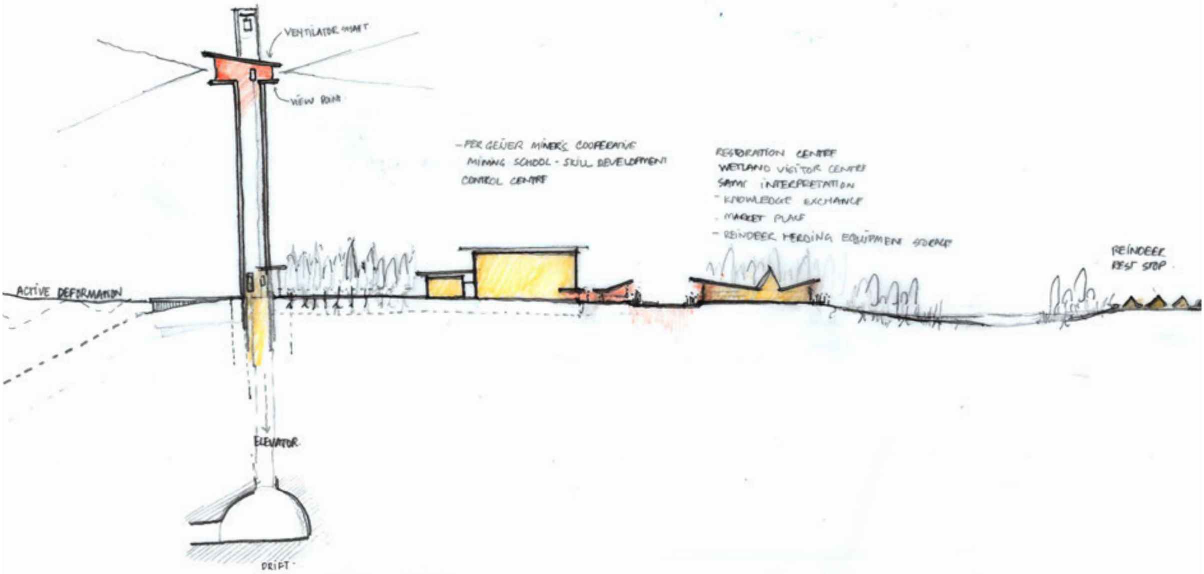
Shared Reindeer Herding Equipment Temporary Storage

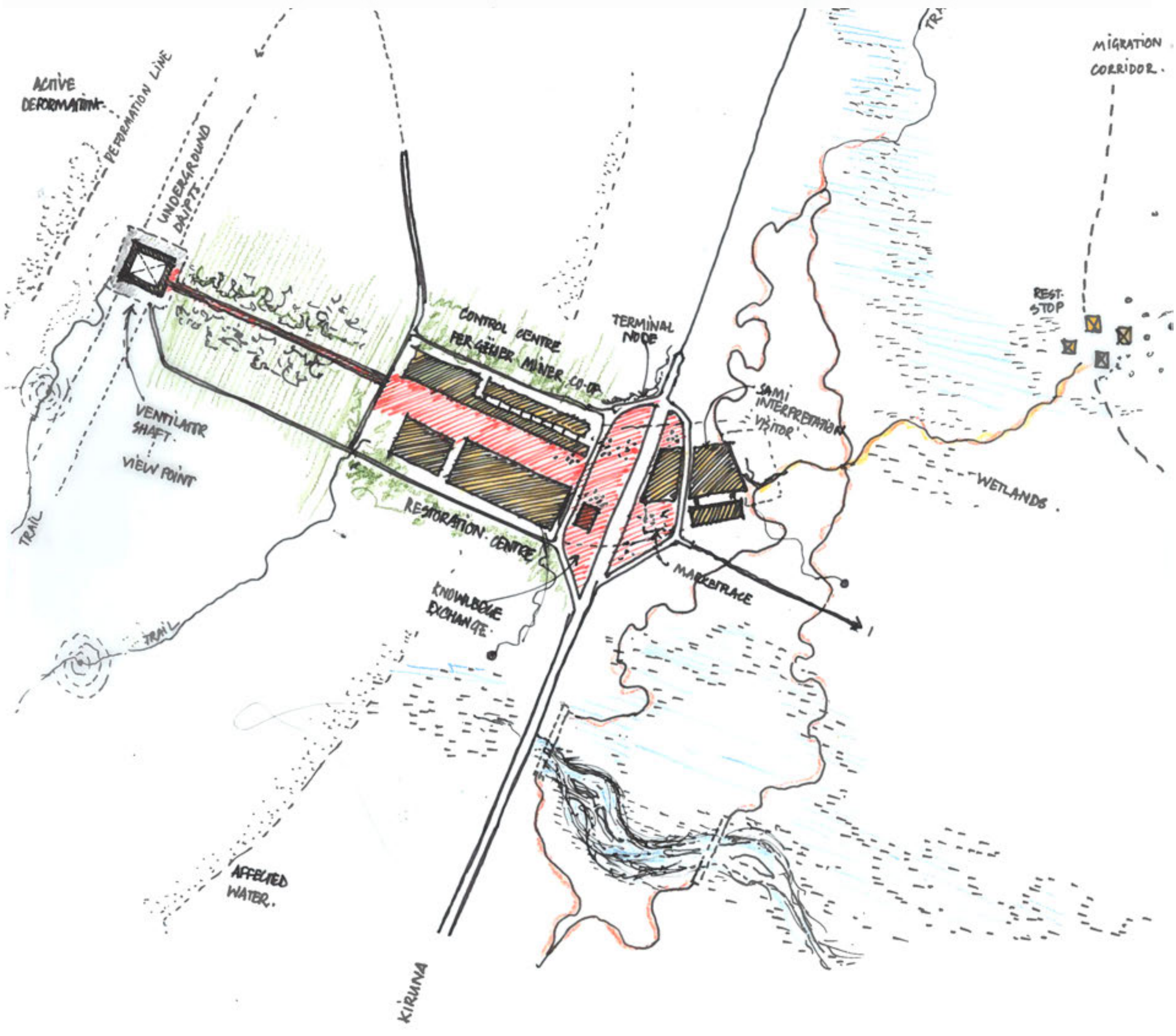
Public Utilities - Transit Node

Tourist centre

Restaurant / Food

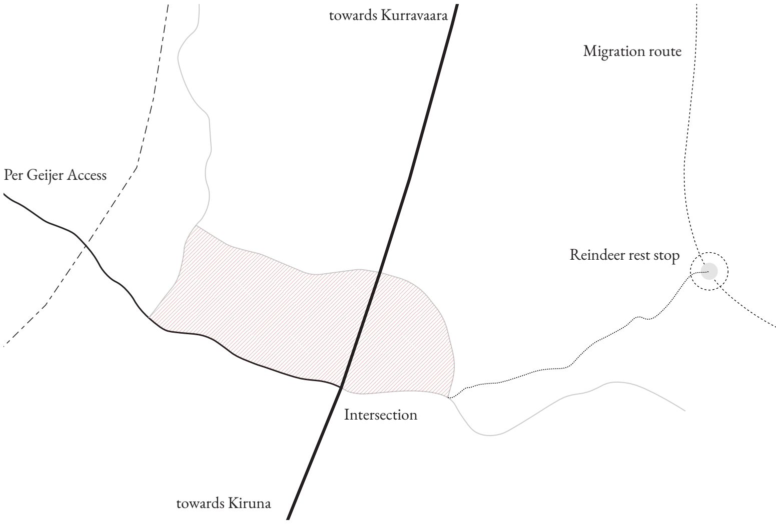
Schematic plan and section of the anticipated public space


VENTILATOR SHAFT
VIEW POINT
- PER GEIJER MINER'S COOPERATIVE
MINING SCHOOL - SKILL DEVELOPMENT
CONTROL CENTRE
RESTORATION CENTRE
WETLAND VISITOR CENTRE
SAMI INTERPRETATION
- KNOWLEDGE EXCHANGE
. MARKET PLACE
- REINDEER HERDING EQUIPMENT STORAGE
REINDEER REST STOP
ACTIVE DEFORMATION
ELEVATOR
DRIFT


ACTIVE DEFORMATION
DEFORMATION LINE
UNDERGROUND DRIFTS
MIGRATION CORRIDOR
CONTROL CENTRE
PER GEIJER MINER CO-OP
TERMINAL NODE
SAMI INTERPRETATION VISITOR
REST STOP
VENTILATOR SHAFT
VIEW POINT
WETLANDS
TRAIL
RESTORATION CENTRE
KNOWLEDGE EXCHANGE
MARKETPLACE
TRAIL
AFFECTED WATER.
KIRUNA

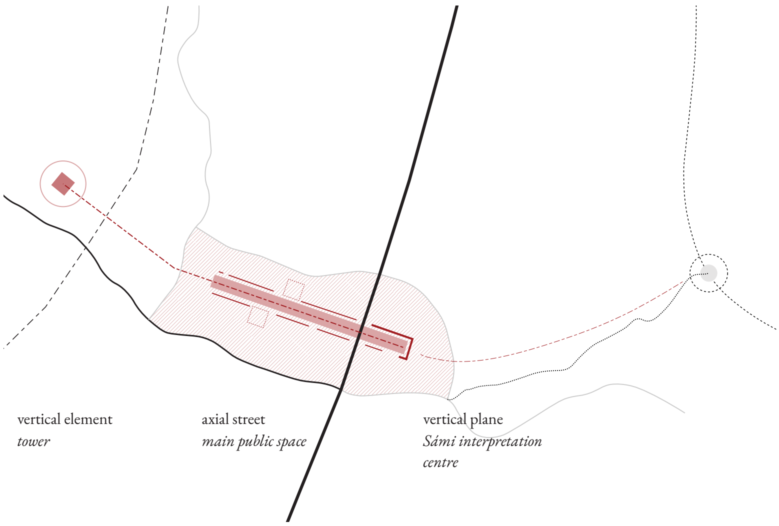
SUITABLE LOCATION

Intersection on the main road towards Per Geijer deposit and the wetlands with reindeer herding on the east creates an ideal site for the public space



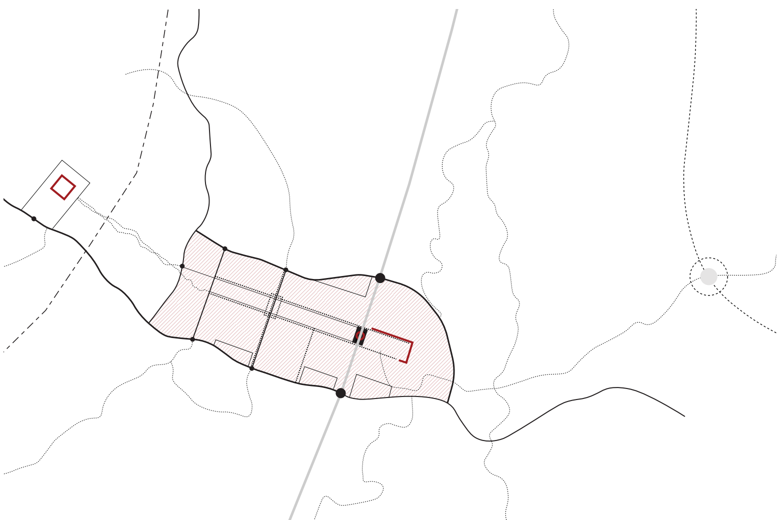
AXIAL CONDITION

The exsiting fragmentation patches allows for creating a main axis with the terminals defined by architectural and programmatic elements



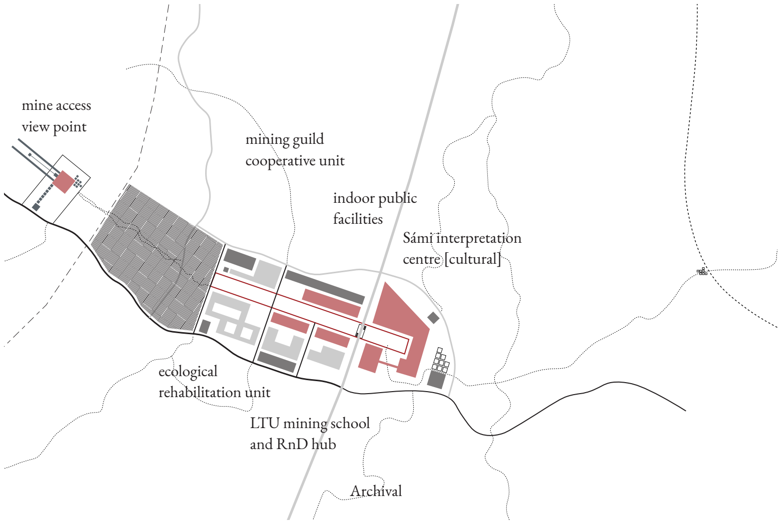
CIRCULATION

The current access roads create conditions for heavy traffic in the periphery allowing for the central space organise the series of public spaces.



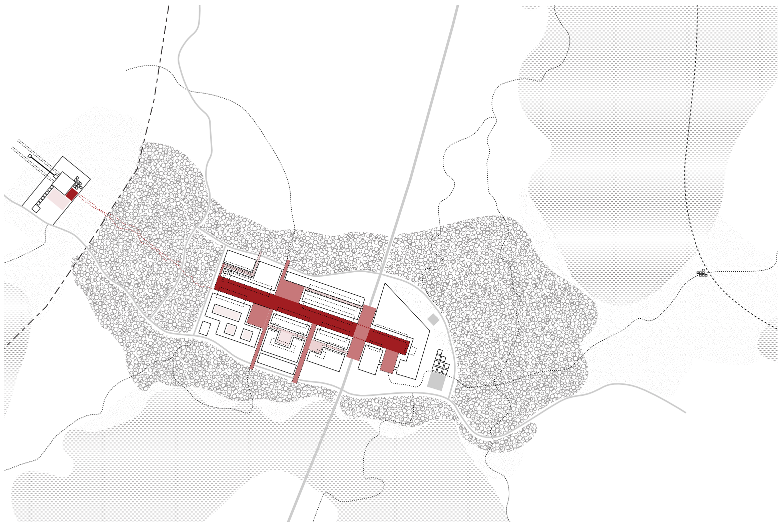
PROGRAM

The central shared public space allow for the zoning of the different programmatic elements - cultural, industrial, research and regulatory



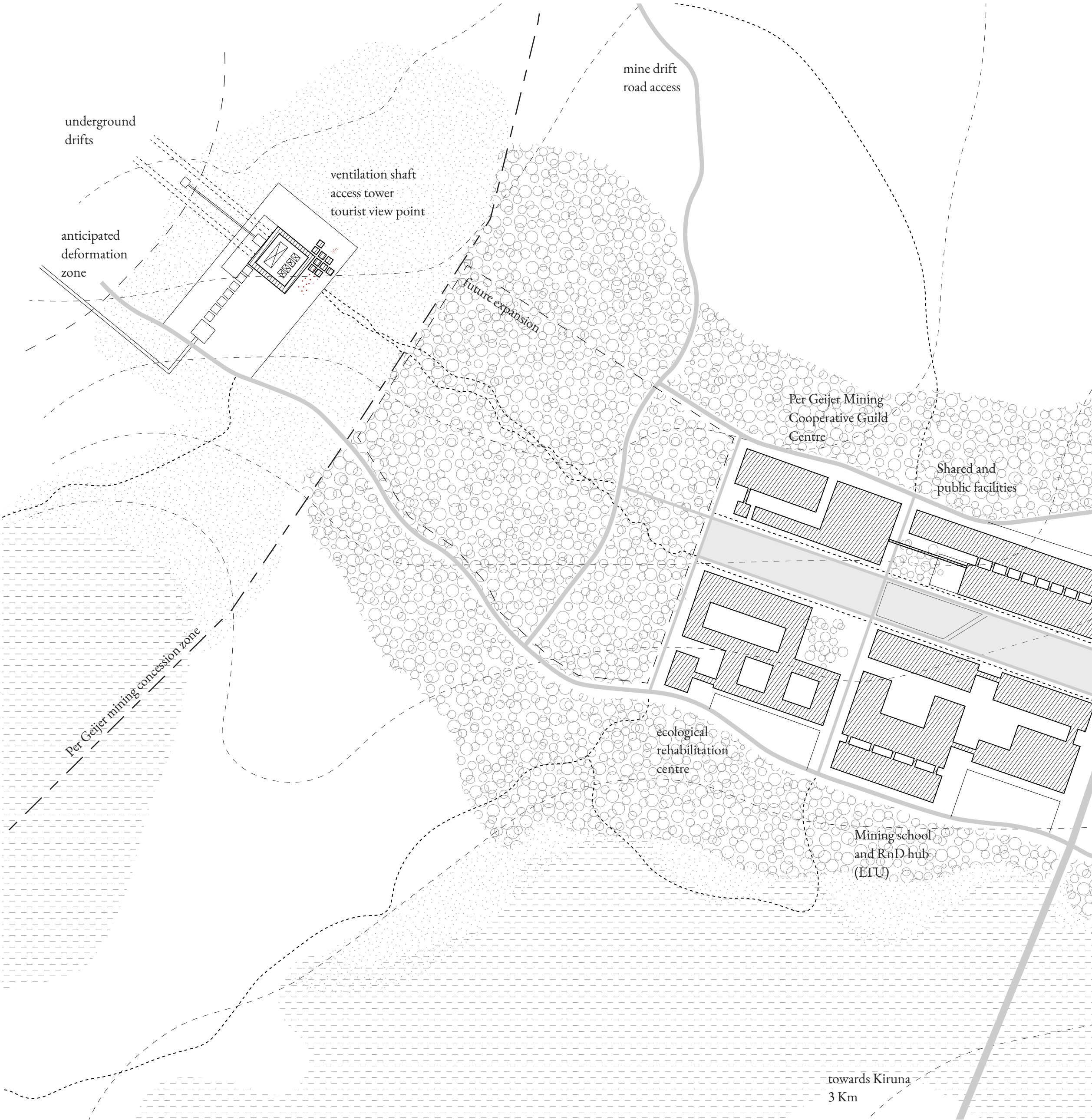
DEPTH OF SPACE

The spatial organisation is designed to accommodate various levels of spatial depth from public through private forming a gradient allowing for shared spaces between different levels of stakeholders

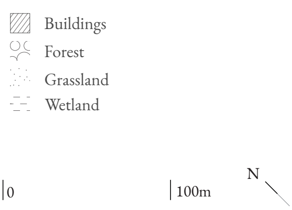


BUILT CONNECTIONS

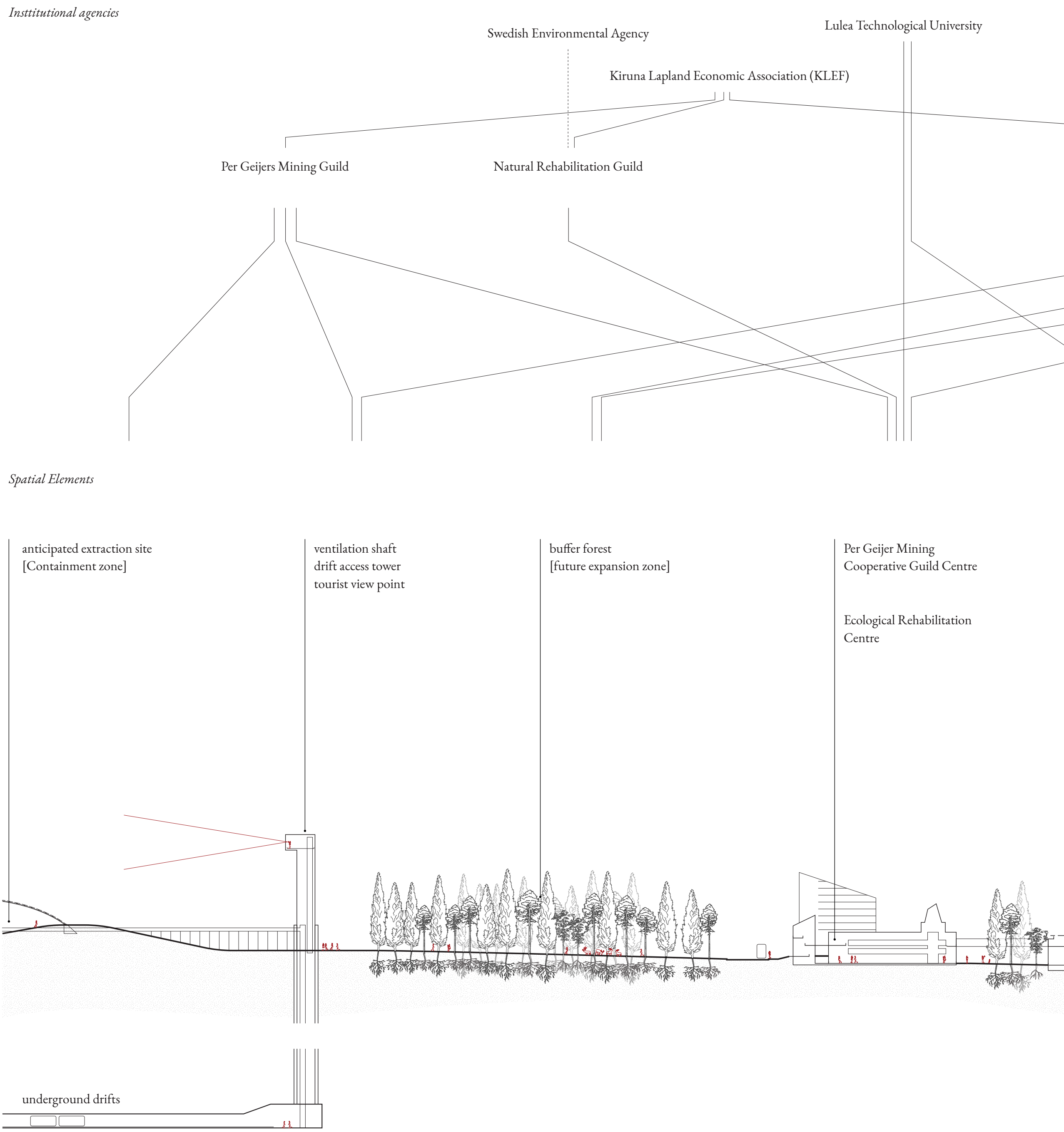
Considering the harsh climatic condition the blocks are concentrated and have built connections for internal circulation. This also allows for creating a dense fabric which can be extended for future programmatic additions



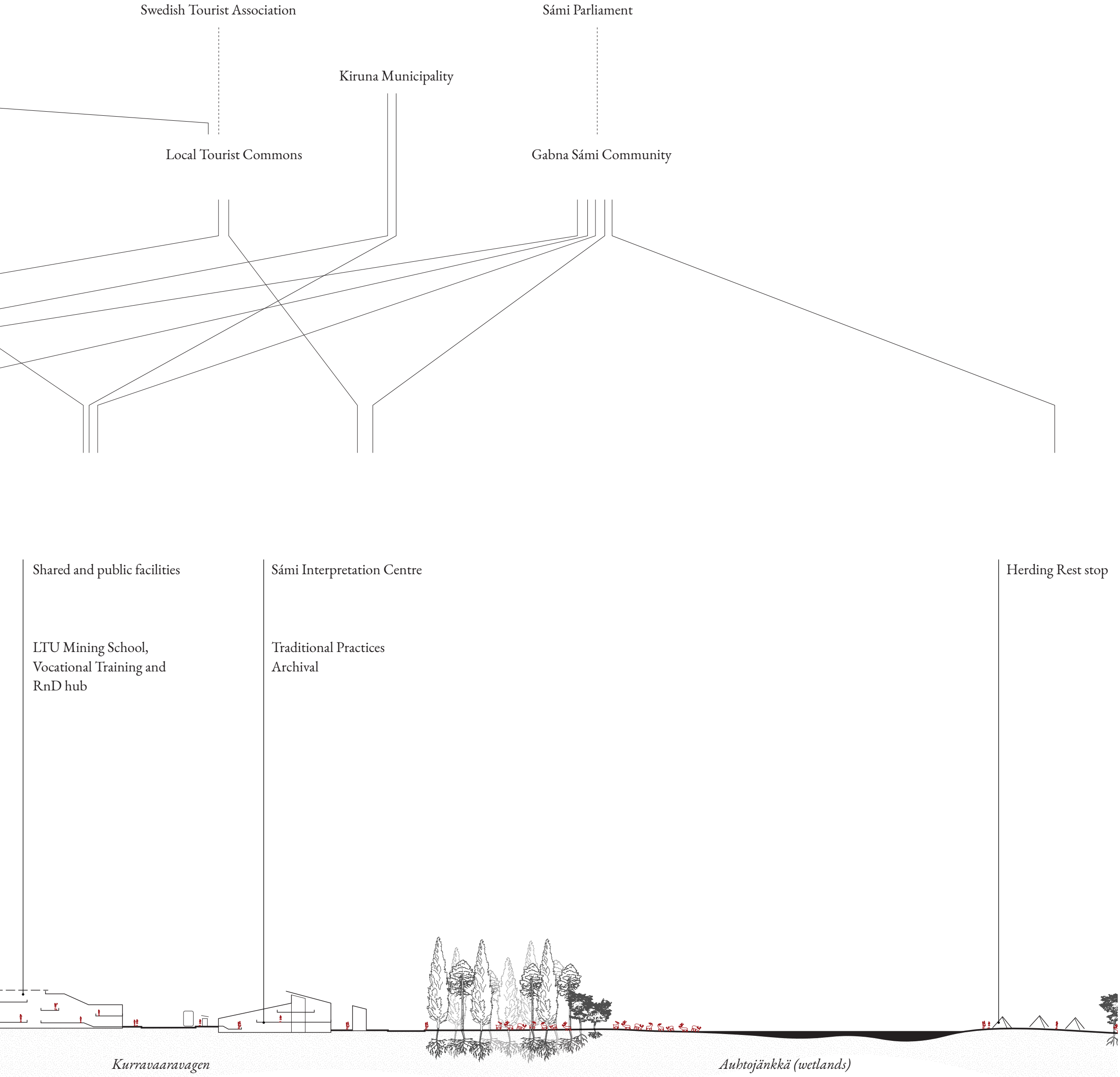
Synthetic Plan of the Interface

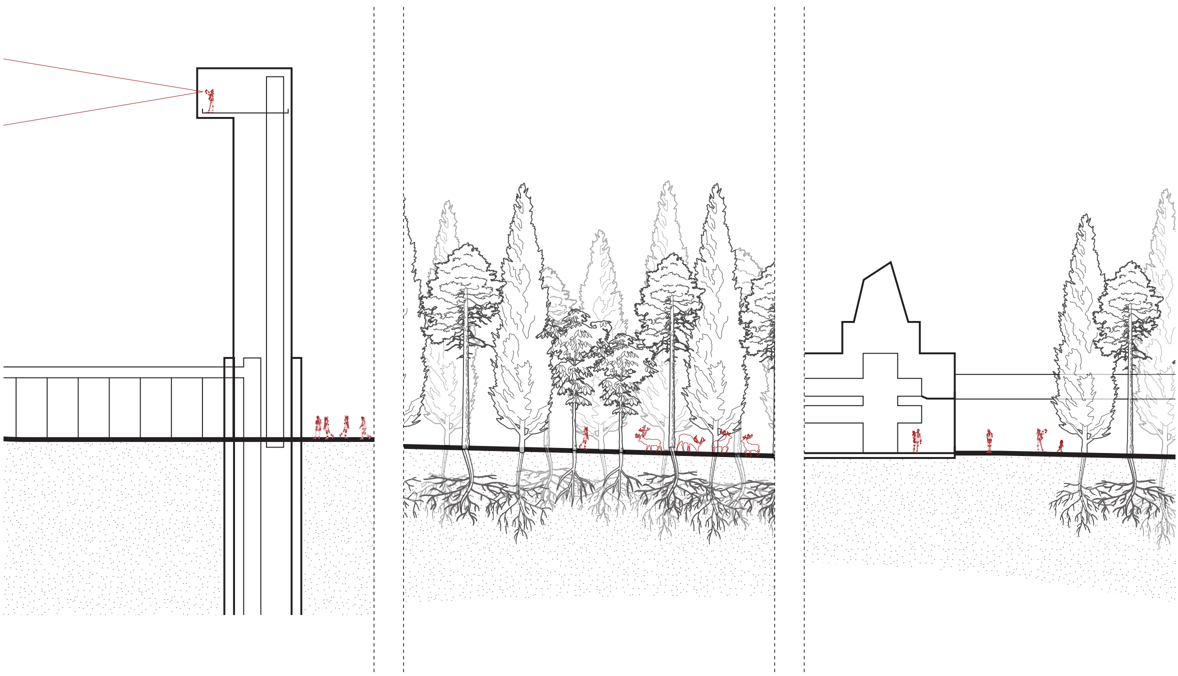



towards Kurravaara
reindeer
migration
corridor
Sámi
interpretation
centre
rest stop
bus stop
Archival
Common
herding
equipment
storage



Longitudinal Section


Swedish Tourist Association
Sámi Parliament
Kiruna Municipality
Local Tourist Commons
Gabna Sámi Community
Shared and public facilities
LTU Mining School,
Vocational Training and
RnD hub
Sámi Interpretation Centre
Traditional Practices
Archival
Herding Rest stop
Kurravaararavagen
Auhtojänkkä (wetlands)

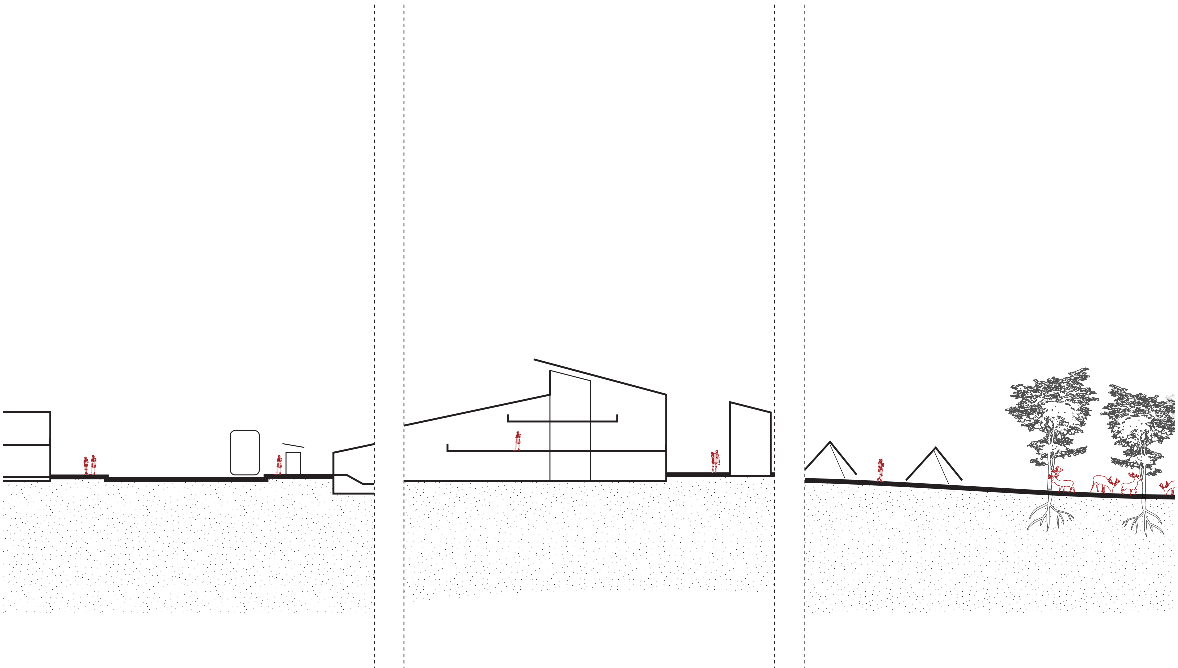


Ventialtion Tower functioning public access to point to the underground drifts and a view tower with observation decks

A forest the fucntions as a buffer between the mining fucntions and the interface, This buffer also allows for expansion of the built fabric with programmatic additions through time.

The buildings function as units for the different guild operations since the guilds are subjected to change along time, it is recommented that the architecture allows for the flexibility. The climatic conditions and the potential of devolution to decentralise and establish interdependencies require for shared indoor spaces in addition to the outdoor spaces operated by the municipality.

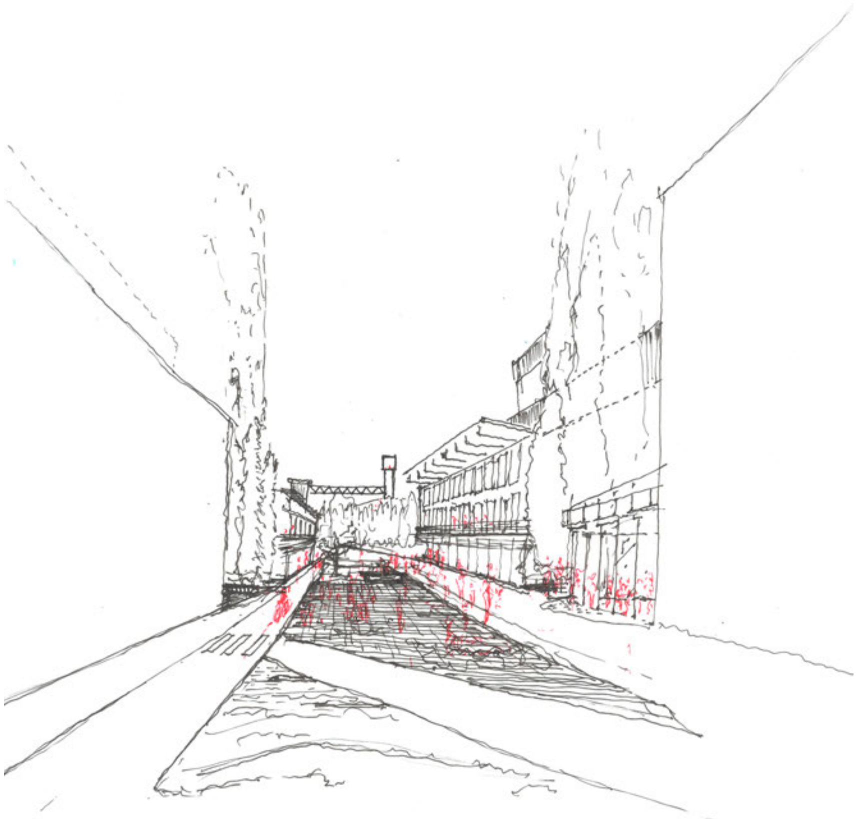
Emergent Spaces



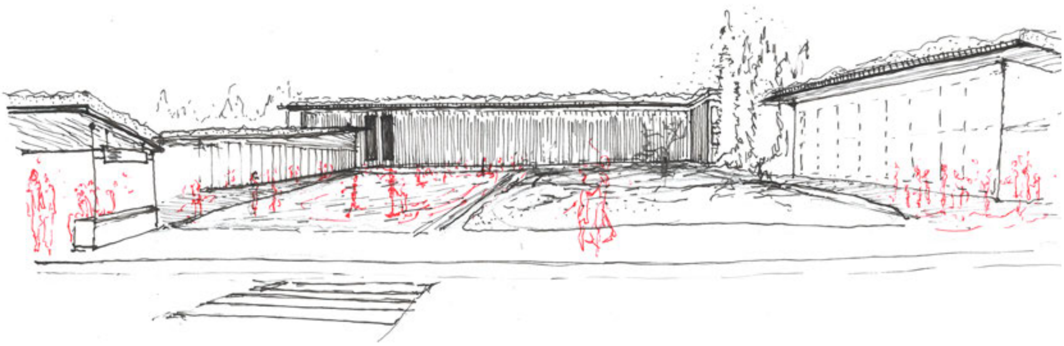
The intersection of the axial public space and the main street creates a centrality for transit point.

The Sámi interpretation centre, archival and the resulting spillover spaces increases the indeterminacy of the resulting patch by overlapping stakeholders, creating conditions for learning and archiving traditional knowledge of land practicies, restoration and opportunities for material and knowledge exchange. It is coupled with the reindeer herding equipment storage which allows for shared resources in additon to knowledge.

The herding rest stops which are active during spring and autumn would require for the extraction activities to cease to protect the interests of the reindeers and introducing the rhythms into the annual extraction cycles.



[left] Impression of the axial sreet with the main public space towards the anticipated Per Geijer mine in summer.
[right] Impression of the Sámi interpretation centre with the public common public space in winter.



Territories of Devolution

[Meta-Project]

This chapter attempts to upscale the spatial logic of devolution to the scale of the Norrbotten Technological Megasystem. It looks into transferring and replication of the project ideas along to different conditions defined by the territorial organisation. This is done by defining the spatial actions the synthetic maps and the institutional mechanisms. Finally the spatial implications of upscaling the concept of indeterminate interfaces is elaborated through selected paradigmatic examples.

The actions of devolution can be scaled up to transform the Technological Megasystem. The historically produced spatial organisation defined by the accumulation of fixed capital and human settlements can guide the decentralisation for degrowth to reorganise other economies in the fabric of extended urbanisation and to create conditions for coexistence and exchange of material and knowledge.

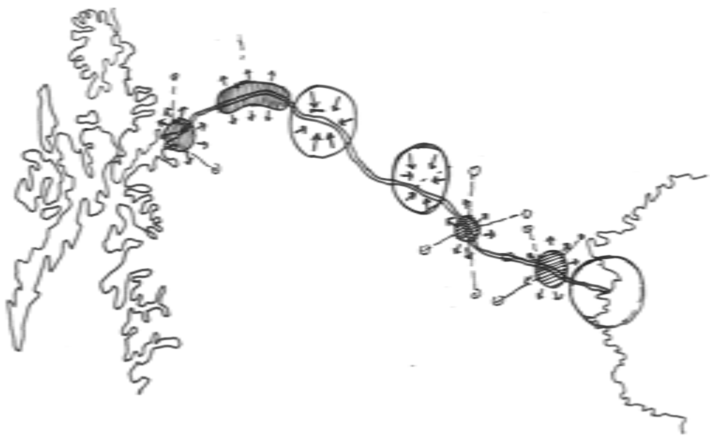
The diversification of economies contests monofunctionality and the economic dominance of mining. Efforts to shift to biobased economies for a greener transition will be data driven. These economies are reindeer husbandry, forestry, Arctic permaculture, food production, recycling, and knowledge which are organised along the transect with the spatial logic of the geographical position (latitudes), accumulated capital for transformaiton. Building on synergies, they are based on interdependencies with each other and ecodependencies with the natural systems.

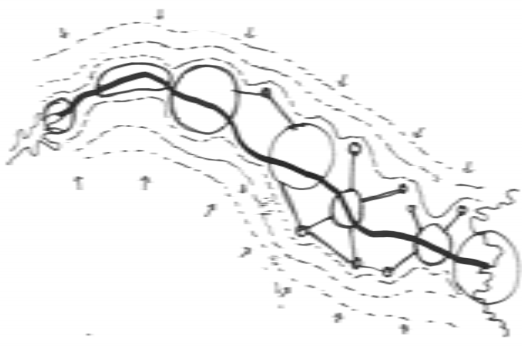
Secondly, to contest the sacrificial landscape by transforming the infrastructural system, which can be used to operationalise repair, the spatial organisation can shape the landscape of degrowth to concentration along the infrastructural corridor and retreat from the fringes to allow for a freer migration movement and reduced landscape fragmentation. The conflict with the reindeer migration movement are varied based on the practice of mountain grazing, migration and forest grazing. The transformation thus need to accommodate for repair based on the capacities and the situated conflicts.

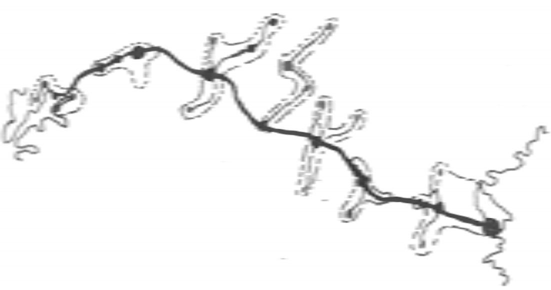
Lastly, to contest the determinate landscape, the cities fucntion as indeterminate interfaces between different economies, regulating them, and they also form interfaces between global and local production and indigenous appropriation of land, the connected and disconnected states. These interfaces at the territorial scale and create conditions to uncertainties like climate change, population fluctuation, etc., in the longue durée.

Spatial actions at the territorial scale

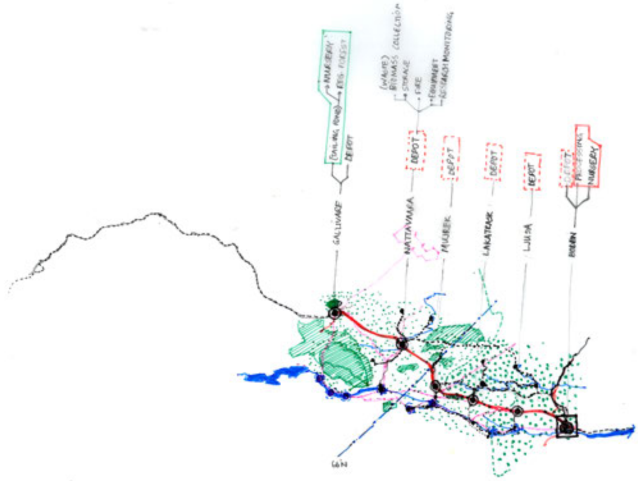
- acculumated state of fixed capital - infrastructures and settlements
- diversification of saptial hierarchy along the transect
- concentration along the transect to reduce fragmentatinpressure in the periphery
- existing human settlements as upscaled indeterminate interfaces



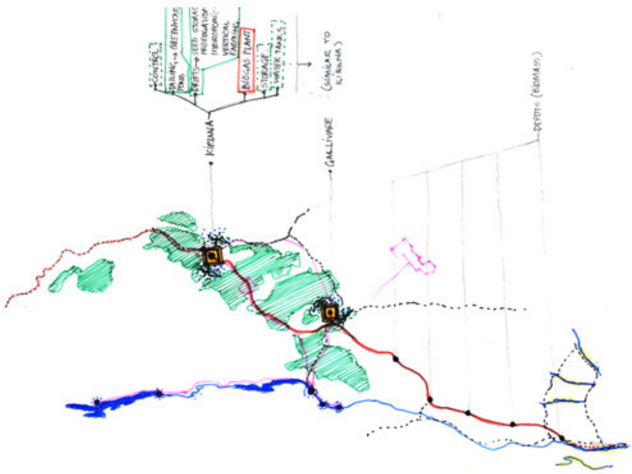




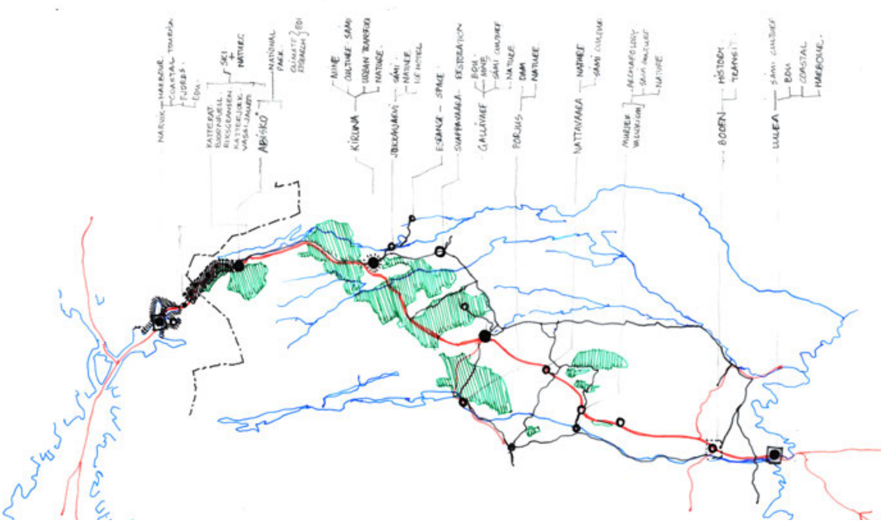
FORESTRY



AGRICULTURE



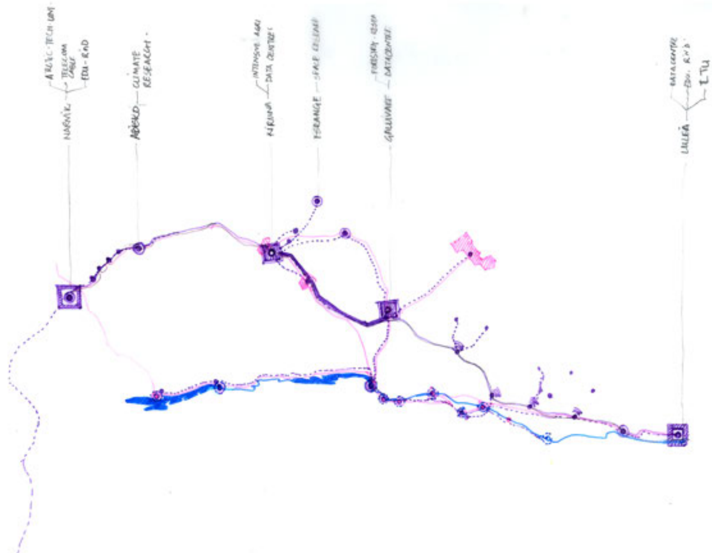
TOURISM



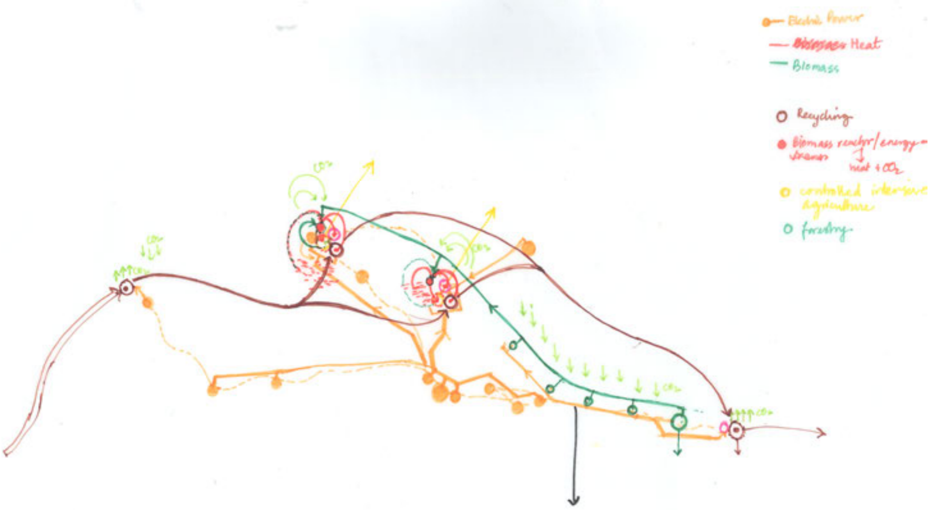
Diversifying industrial ecologies along the NTM transect

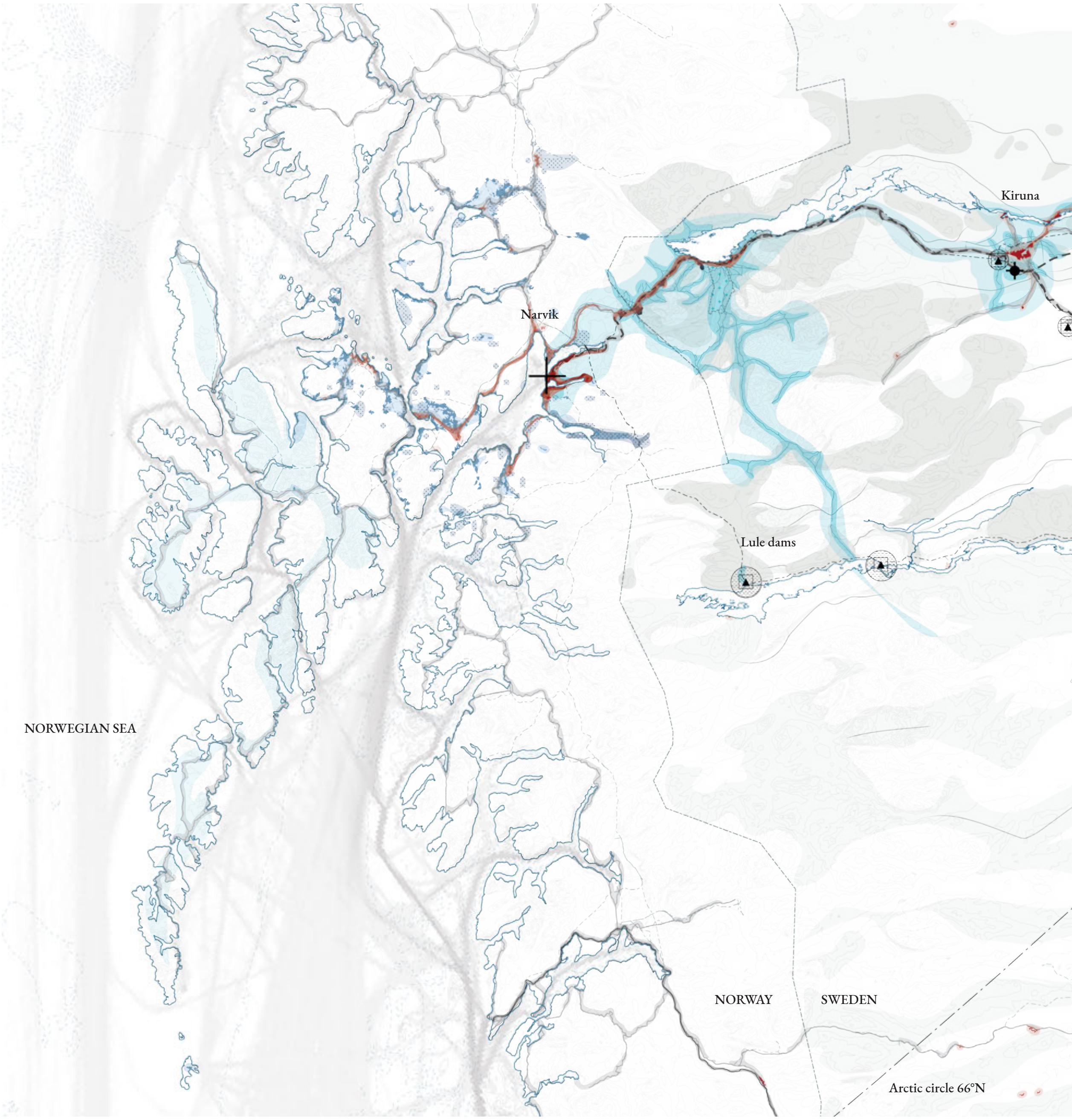
RECYCLING INDUSTRY

INFORMATION TECHNOLOGY



SYNERGIES

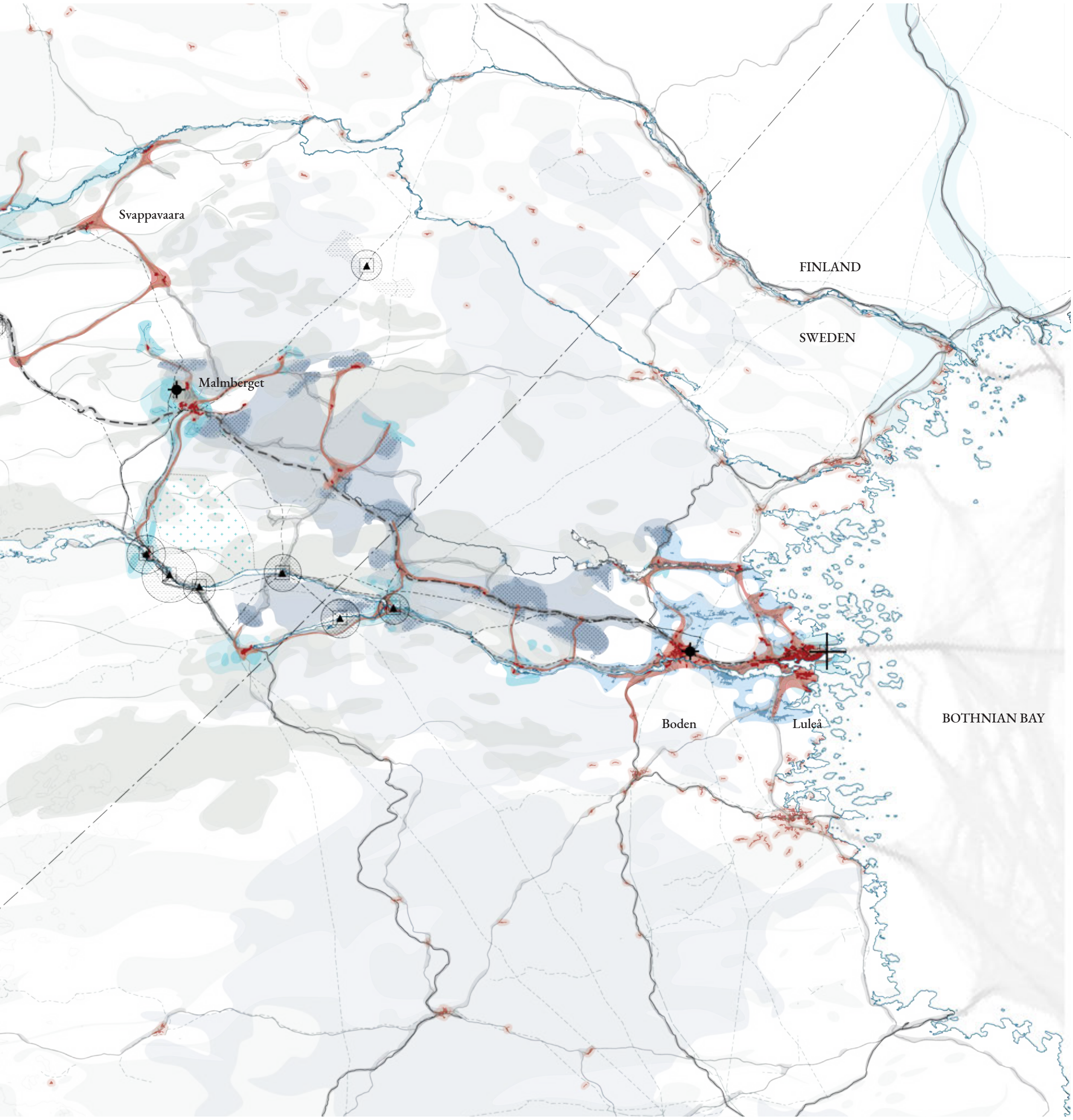


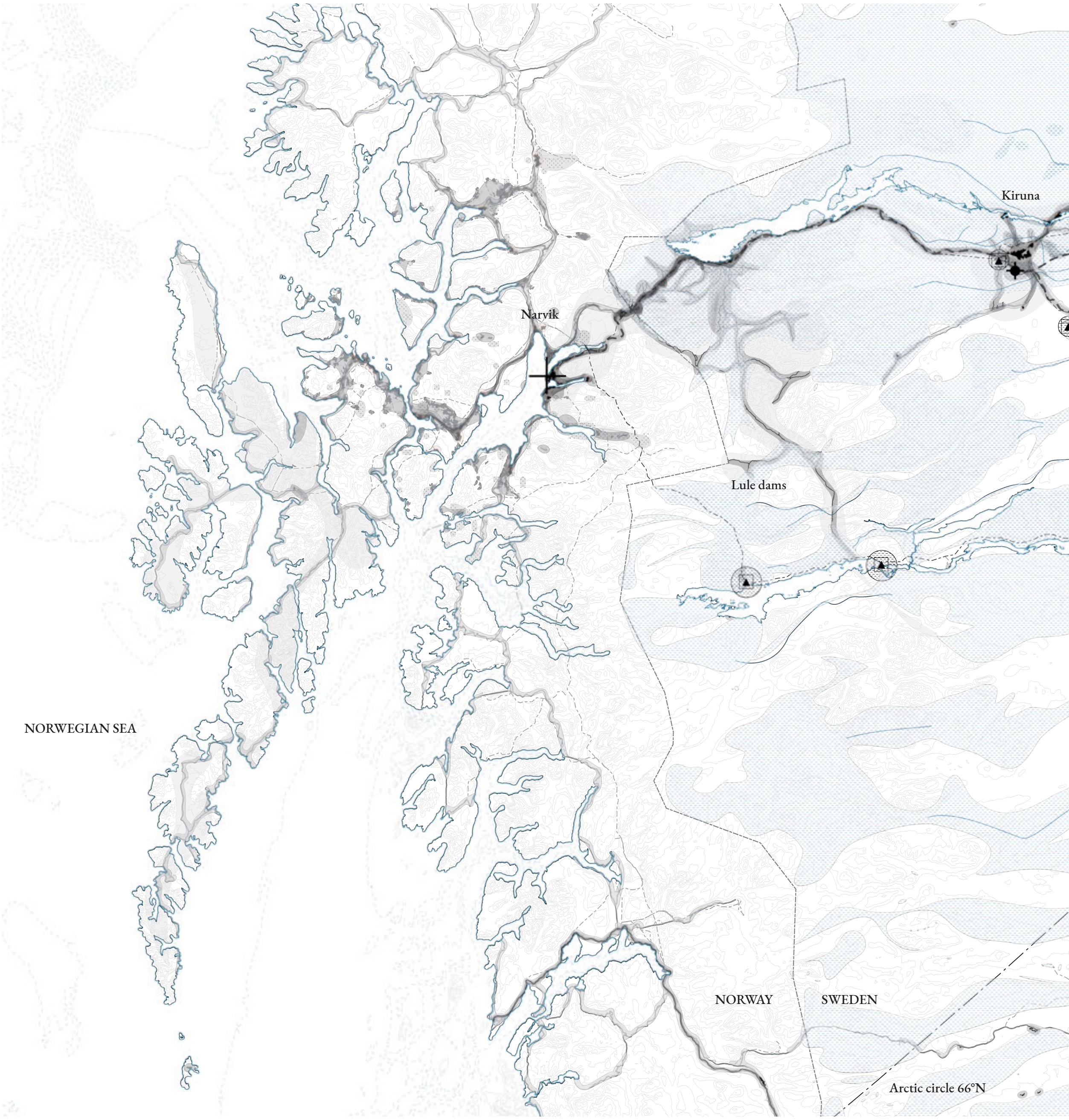


Multifunctional Landscape - Decentralisation and Diversification

- Urban
- Productive Foresty
- Agriculture
- Tourism - Ski parks, hiking trail

0 50 km N

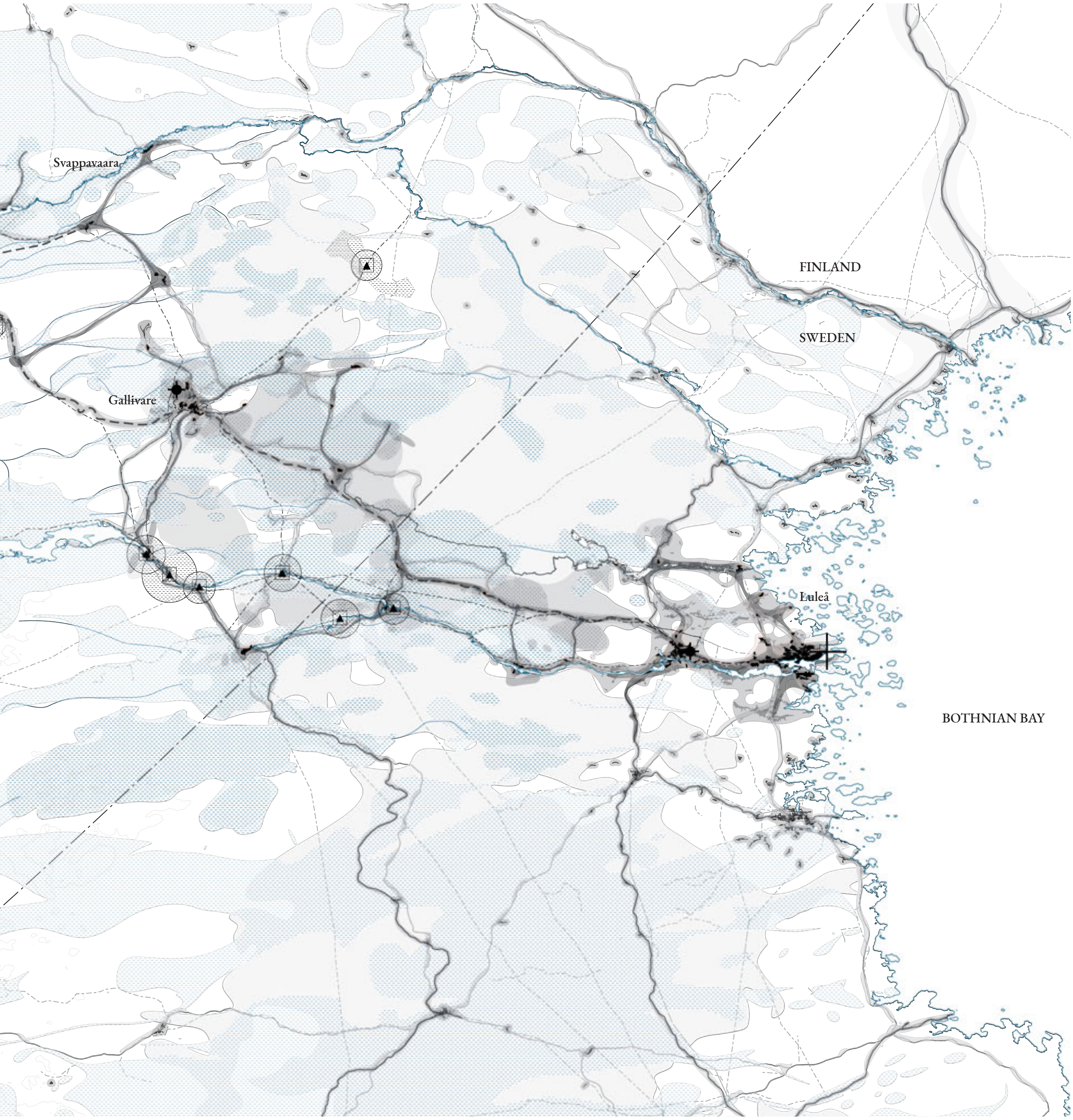

Svappavaara
FINLAND
SWEDEN
Malmberget
Boden
Luleå
BOTHNIAN BAY

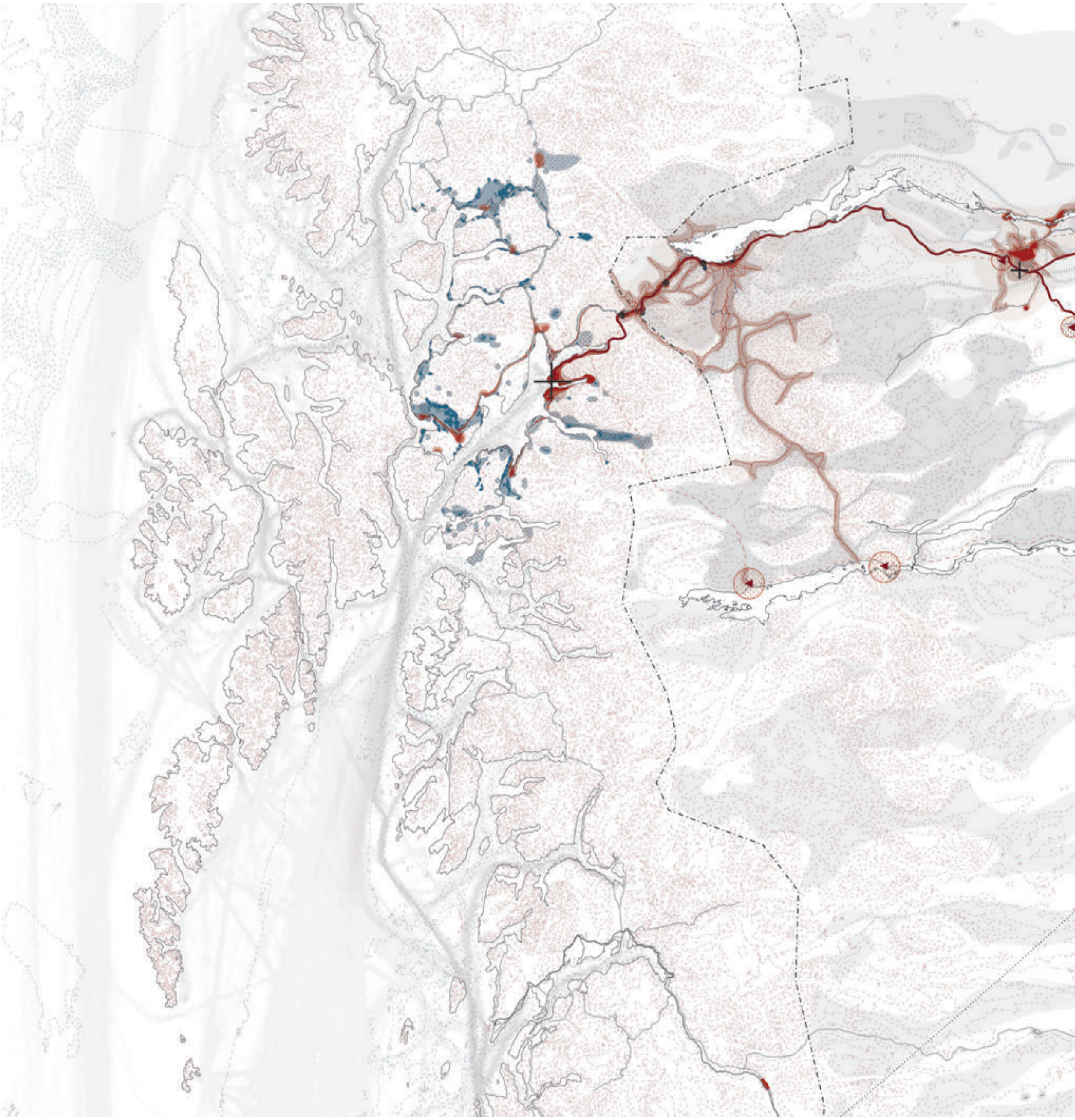


Degrowing Landscape

Urban
Concentration pattern
Reindeer pastures
Reindeer migration corridors

0
50 km
N


Svappavaara
FINLAND
SWEDEN
Gallivare
Luleå
BOTHNIAN BAY

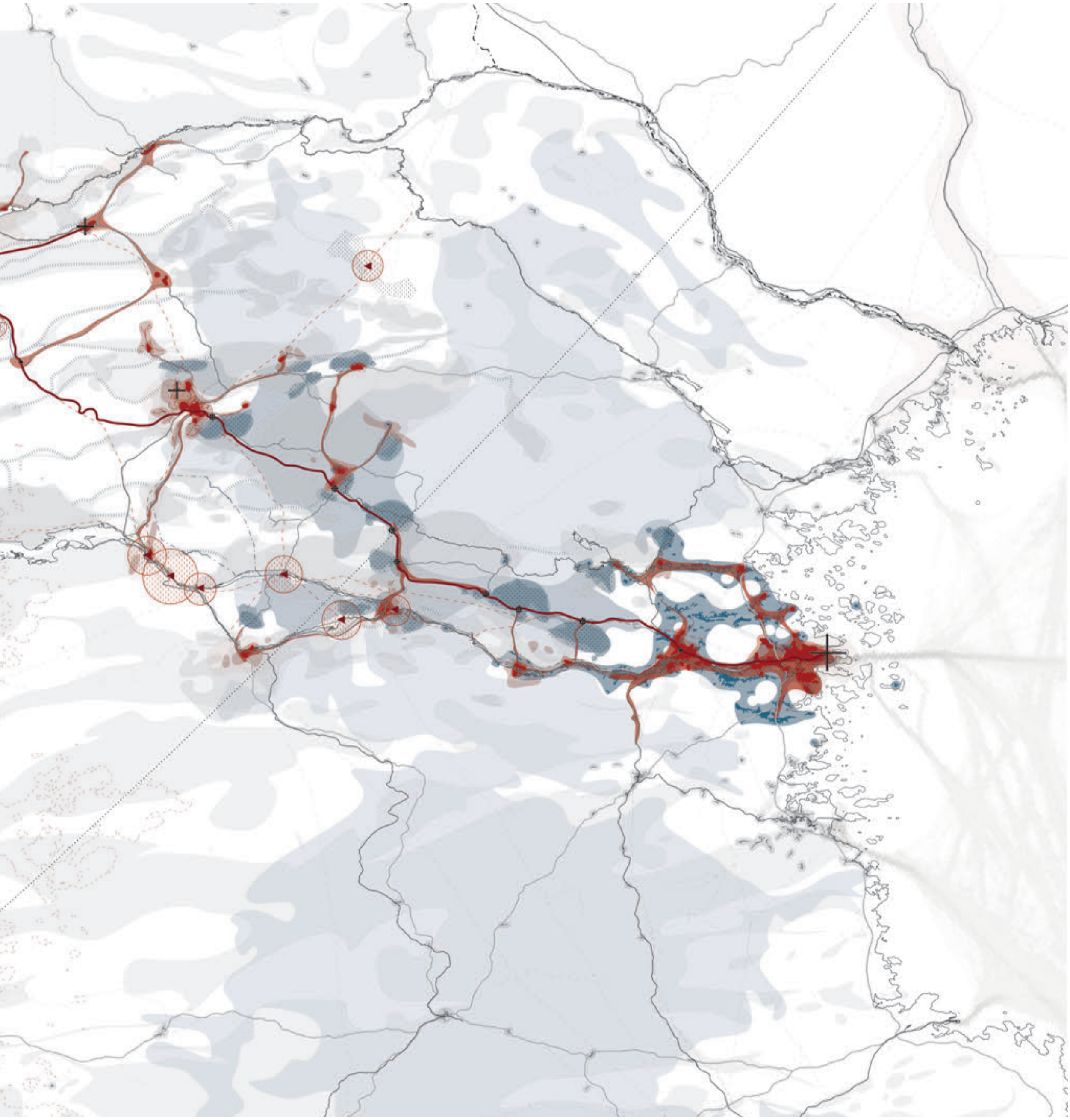


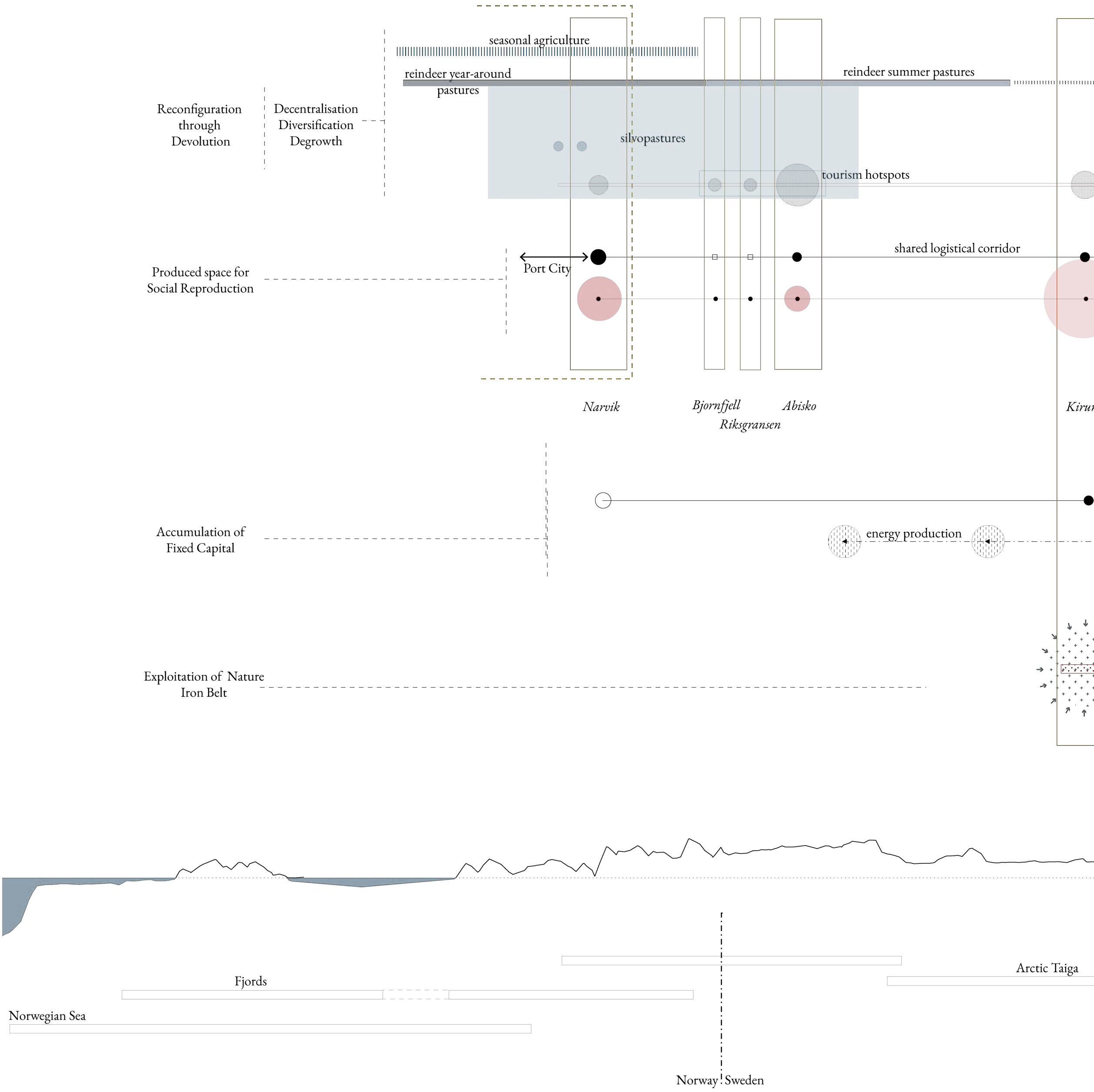
Synthetic Plan with the Settlements as Interfaces

- Settlements
- Projection-Network
- Forestry
- Reindeer herding
- Seasonal agriculture
- Tourism
- Energy production
- Power lines
- Malm rail
- National parks
- Post-mines
- Forestry depots
- Ports

0 | 50 km

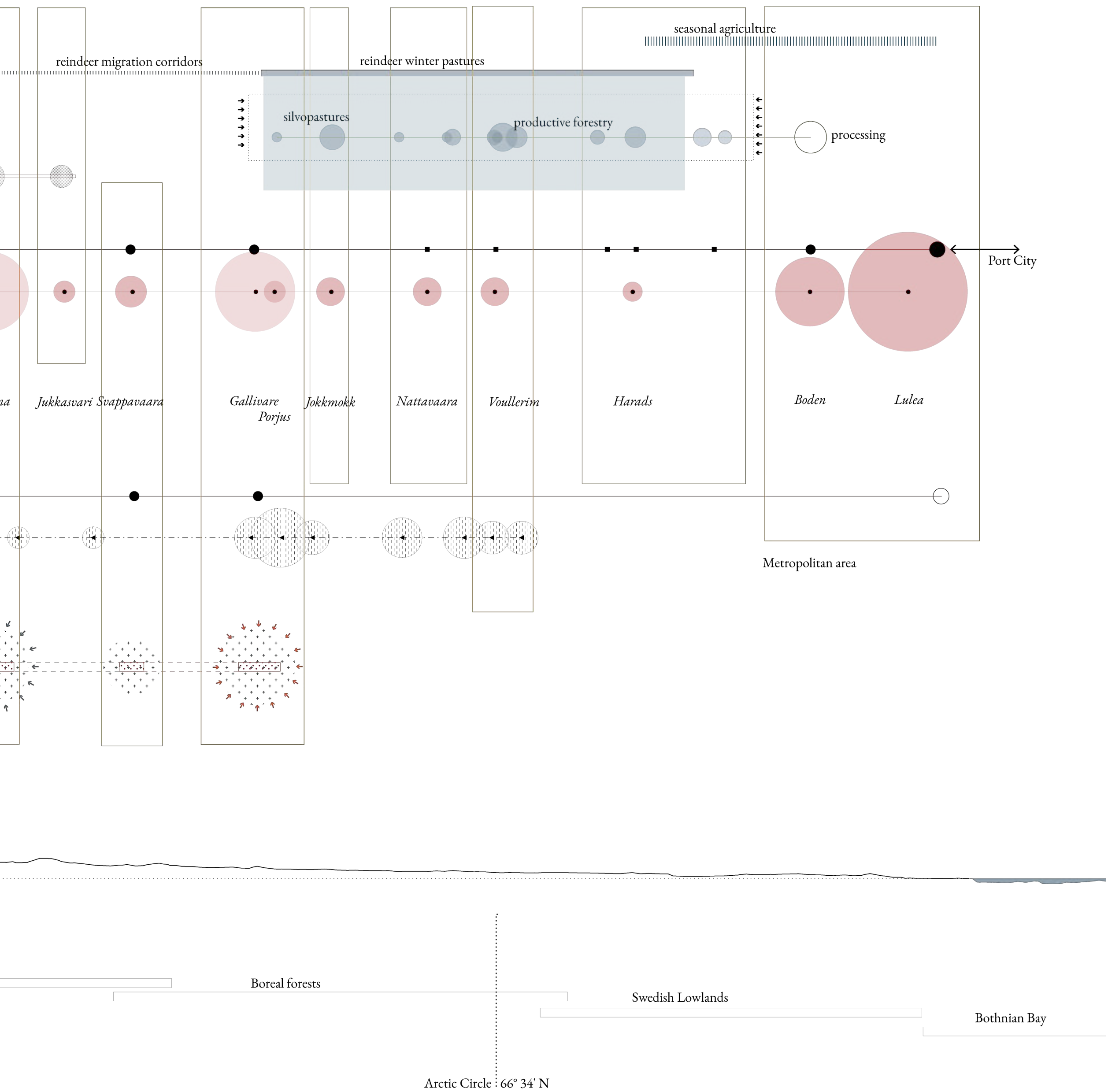
N





Synthetic diagram with the Settlements as Interfaces

|0 |50 km


seasonal agriculture
reindeer migration corridors
reindeer winter pastures
silvopastures
productive forestry
processing
Port City
Jukkasvari Svappavaara
Gallivare
Porjus
Jokkmokk
Nattavaara
Voullerim
Harads
Boden
Lulea
Metropolitan area
Boreal forests
Swedish Lowlands
Bothnian Bay
Arctic Circle 66° 34' N

Institutional Mechanism

Like extraction, which is managed by LKAB, other land uses such as extensive forestry are also managed by the state-owned company Sveaskog, and steel production is handled by SSAB. When the action of devolution is upscaled to the territorial scale, these companies are decentralized, and the operations are taken over by established local cooperatives of the guilds. These diversely operating guilds are regulated by the local economic association. The transfer of control from centralized state-owned corporations to local cooperatives and guilds represents a significant shift towards decentralization. This empowers local communities and ensures that resource management is more contextually appropriate and responsive to local needs.

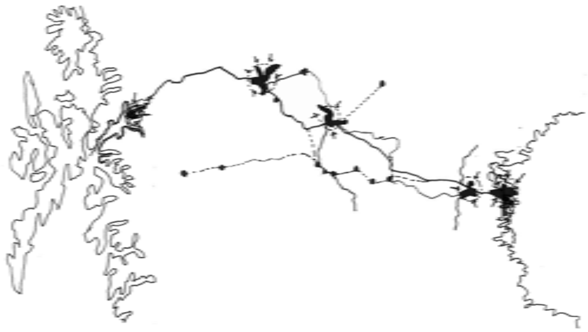
The national parks, nature reserves, and waterbodies, which were state-owned land, are now deemed commons, and the Sámi parliament is given collective stewardship of the commons. The local Samebys manage the land. The role of the local municipal bodies—the Kommuns—is to function as regualtors and the interfaces between the cooperatives and the commons. By involving the Sámi Parliament and local Samebys in the management of commons, the methodology respects and integrates indigenous knowledge and practices, promoting sustainability and cultural preservation.

Similar to the self-organization of the Sámi Parliament by the local Samebys, the local economic cooperatives form self-organized networks with similar economic guilds at the territorial scale. These networks stimulate material exchanges among and across the economies and enhance synergies at the territorial scale, although the primary agency is at the level of the municipality. The emphasis on self-organized networks of economic guilds fosters a bottom-up approach to resource management, enhancing resilience and adaptability. These networks can stimulate economic diversification and create new opportunities for local communities.

The proposed institutional model consists of diverse guilds with their own agencies, as opposed to the current hierarchical ones of state-owned corporations that give more control to the state. The primary scale of operation of the guilds, regulations, and management is at the level of the municipality and the settlements. This model allows for decisions, negotiations, and interactions to be shifted to the lower levels between the guild cooperatives—forestry, mining guild, recycling, herding, restoration, tourism, etc.—and the local economic associations, which are moderated by the municipality.

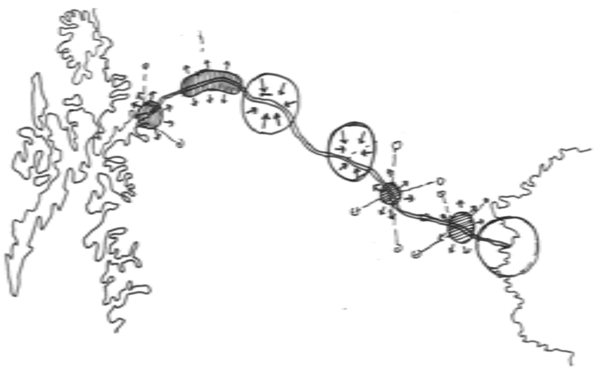
Accumulated State

Infrastructure and agencies



Decentralisation

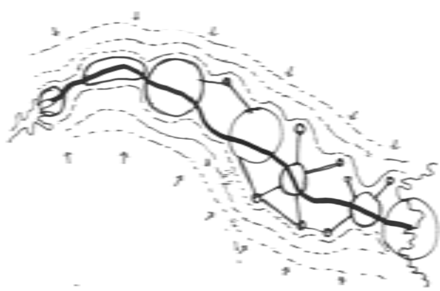
Diversification



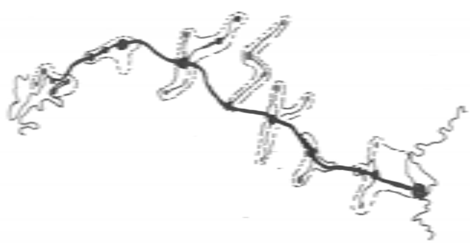
Self organisation

concentration and Retreat

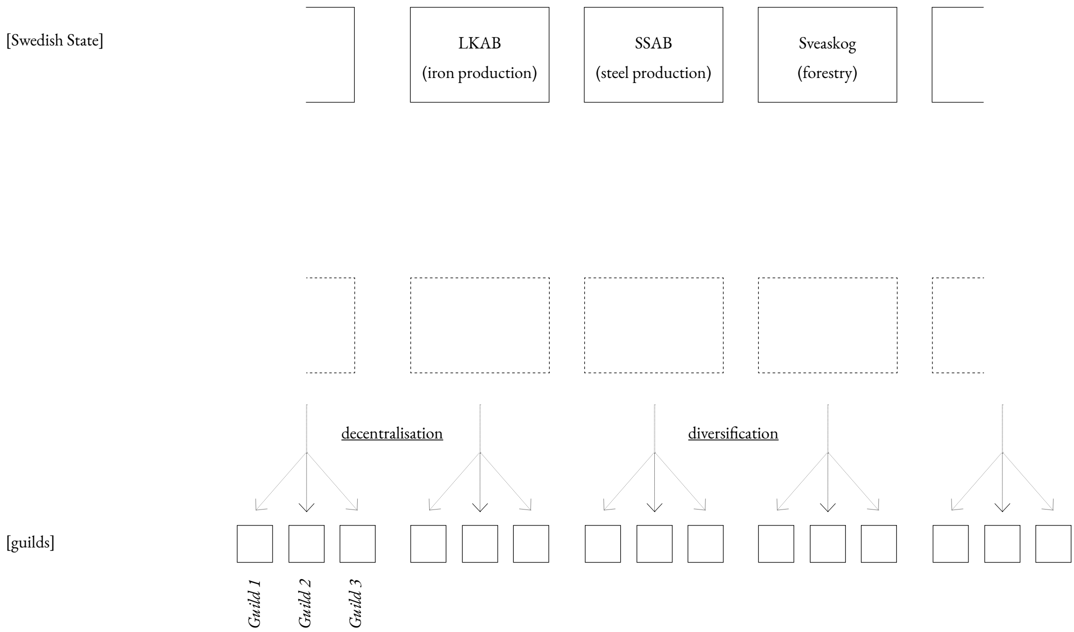
stewardship

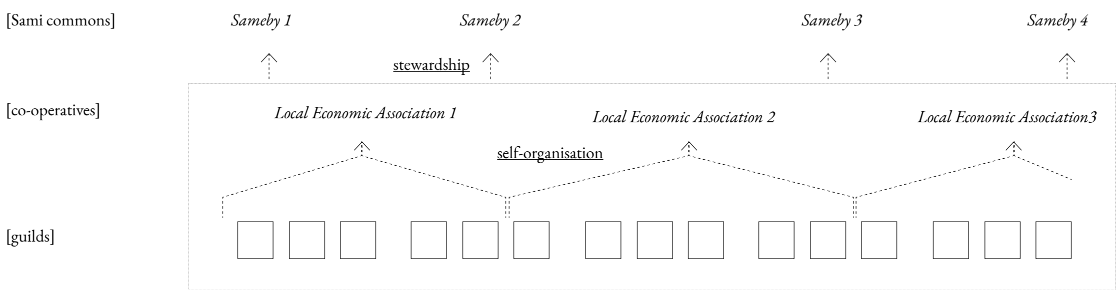


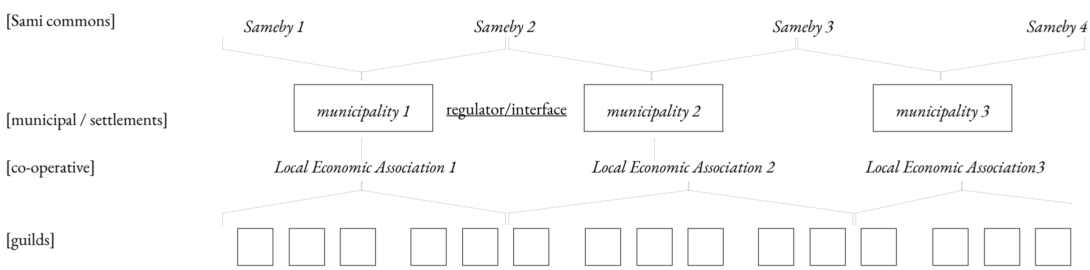
Settlements as interfaces



Institutional Mechanism


[Swedish State]
LKAB
(iron production)
SSAB
(steel production)
Sveaskog
(forestry)
decentralisation
diversification
[guilds]
Guild 1
Guild 2
Guild 3


[Sami commons]
Sameby 1
Sameby 2
Sameby 3
Sameby 4
stewardship
[co-operatives]
Local Economic Association 1
Local Economic Association 2
Local Economic Association3
self-organisation
[guilds]


[Sami commons]
Sameby 1
Sameby 2
Sameby 3
Sameby 4
[municipal / settlements]
municipality 1
regulator/interface
municipality 2
municipality 3
[co-operative]
Local Economic Association 1
Local Economic Association 2
Local Economic Association3
[guilds]

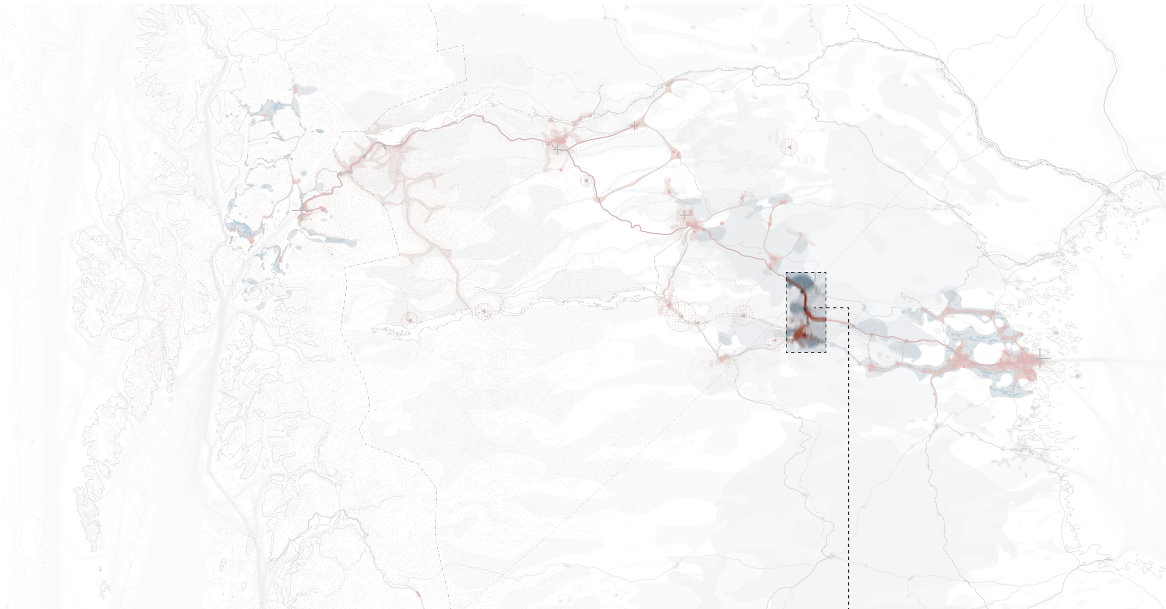
Elaborating on the indeterminacy concept, at the scale of the territory, the human settlements representing social reproduction become the interfaces that inform spatial organisation and temporal regulation. These settlements function as spatial nodes which function as

- Interface between conflicting economic activities with the same land cover
    [case: silvopasture and productive forests]
- Interface between conflicting land uses in the same season
    [case:tourism and herding in summer]
- Interface between different scales of operation
    [case: port city]

Interface between economic activities with the same land cover

Eg: Voullerim and Murjek

The town here creates the interface for the same land-cover conflict: productive forestry and silvopastures—forest grazing. In addition to productive facilities like timber depots near the railway line, the infrastructural line with added station transforms into the interface for negotiation, exchange of material and knowledge, and migration equipment storage facilities.



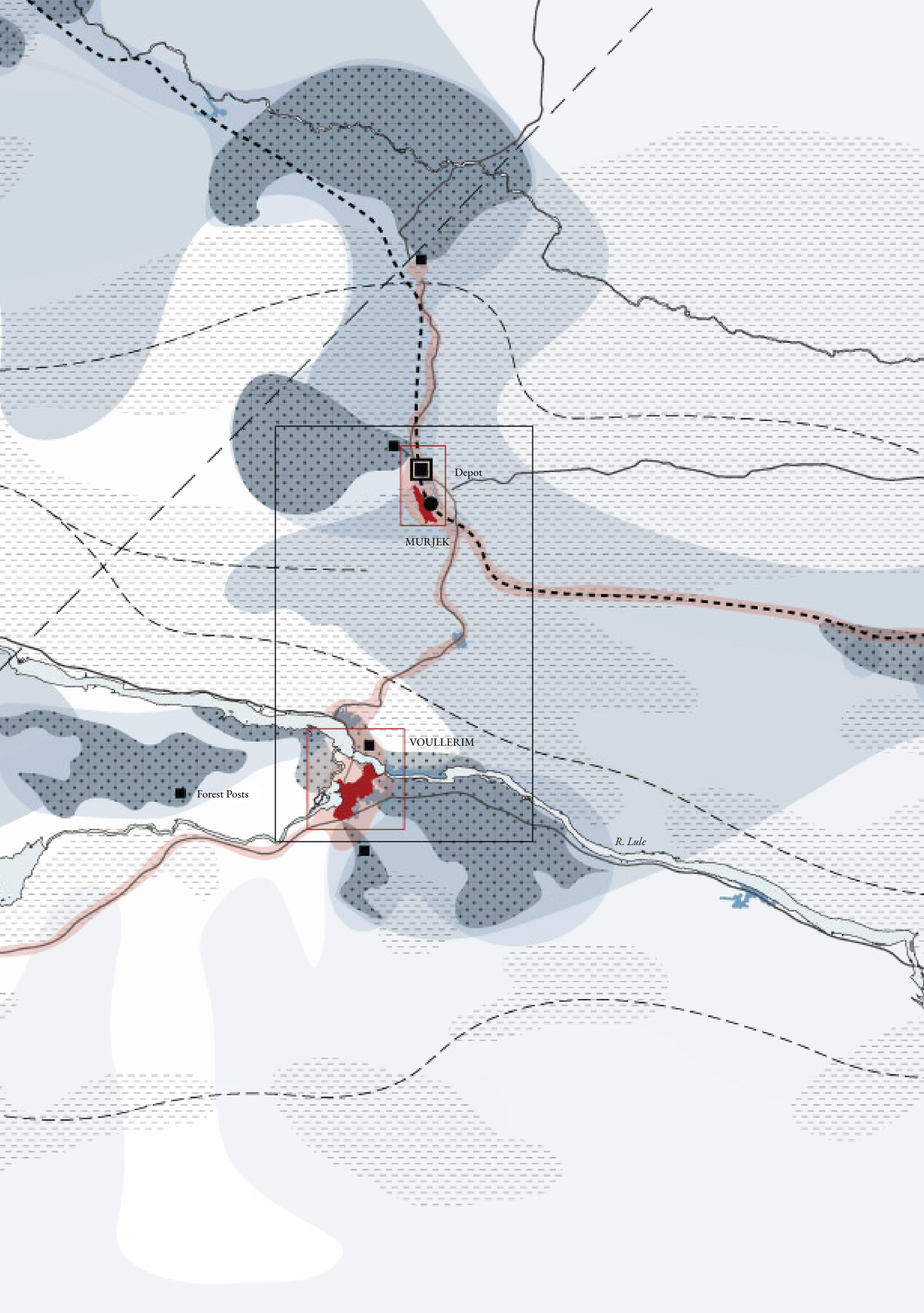
Murjek
[satellite image from ESRI]

Synthetic Map - Voullerim-Murjek

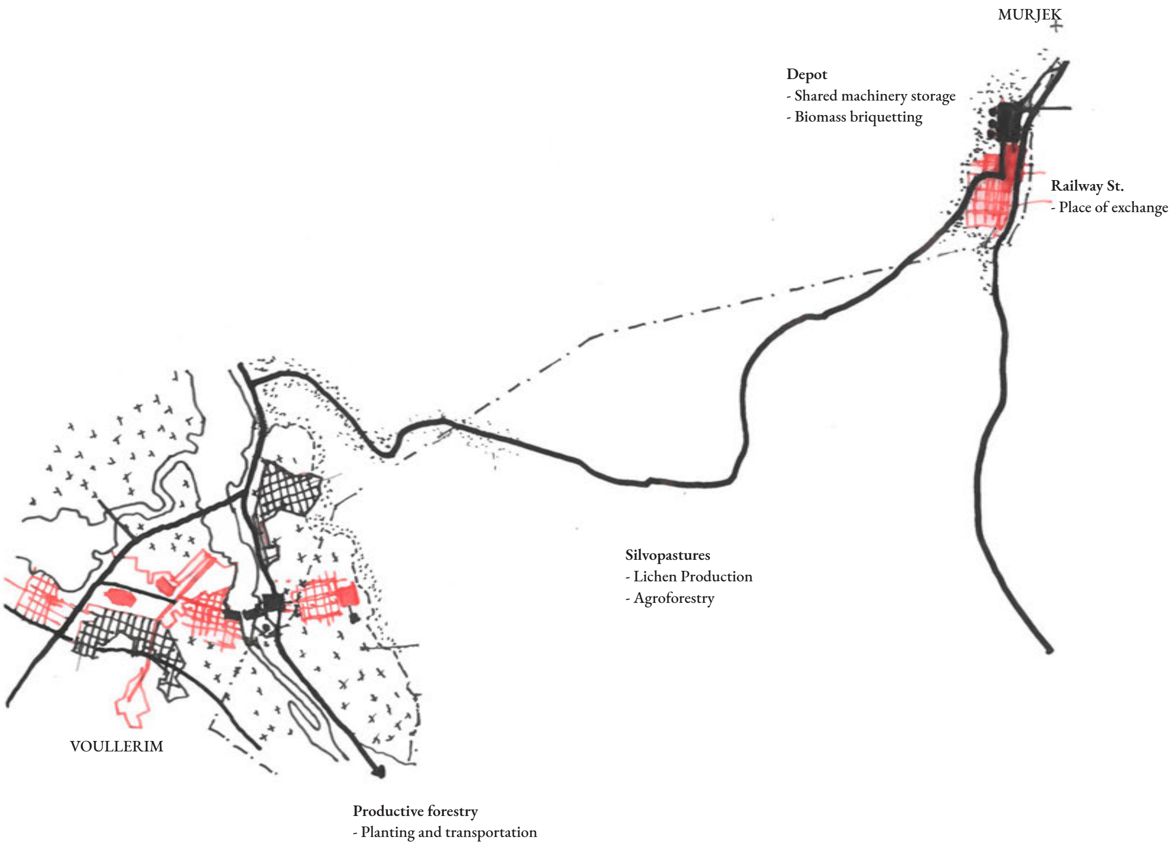
The synthetic map shows the design actions of concentrating forestry along the infrastructurally dense corridor and the building and retreating from the forest pastrures . The spatial elements of the depots and the decentralised forest posts also condition and moderate conflicts arising between the forestry industry and the silvopastures.

Urban
Productive Foresty
Agriculture
Winter Pastures
Reindeer migration corridors
Railway line
Railway Station
Depot
ForestPost

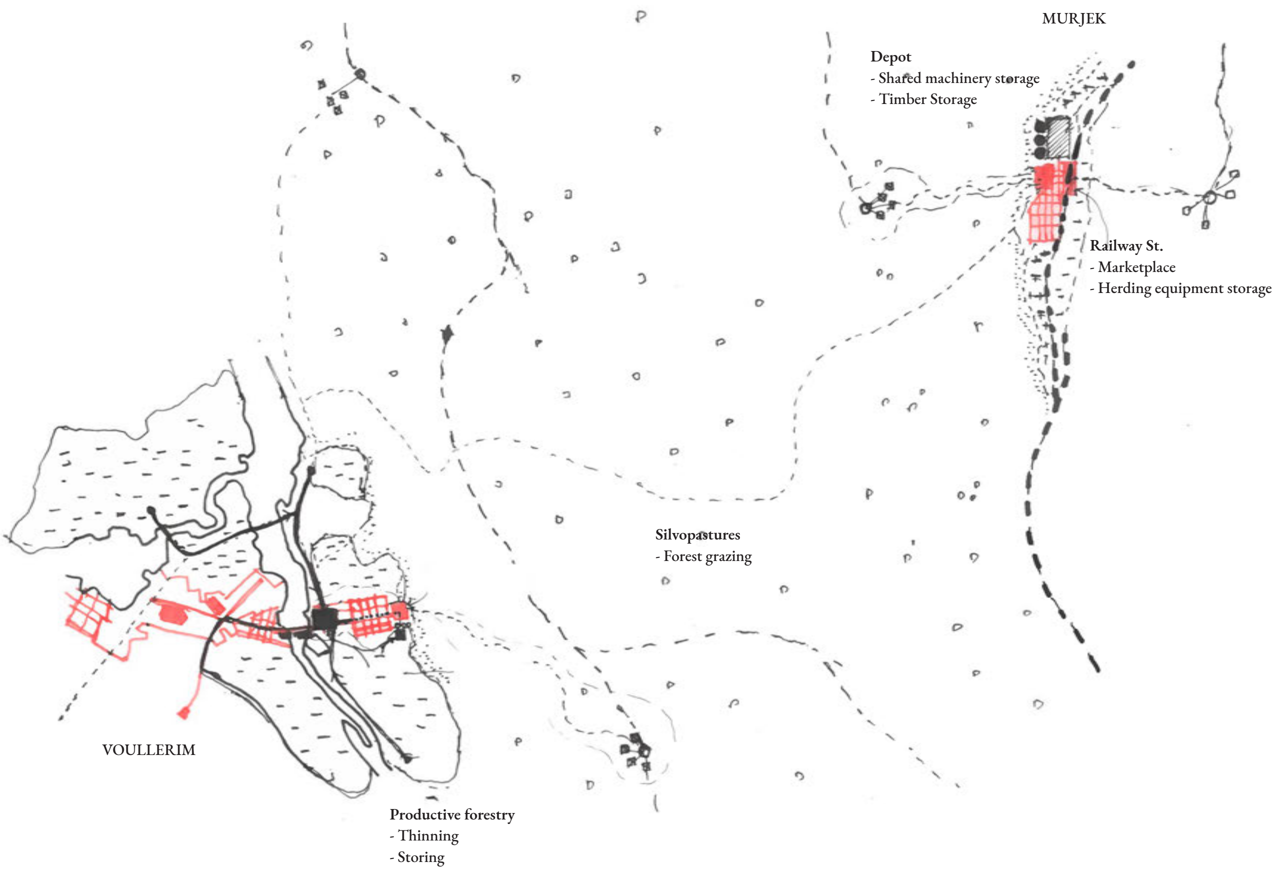
0 5 km N



Depot
MURJEK
VOULLERIM
Forest Posts
R. Lule



Connected State - Summer / Winter

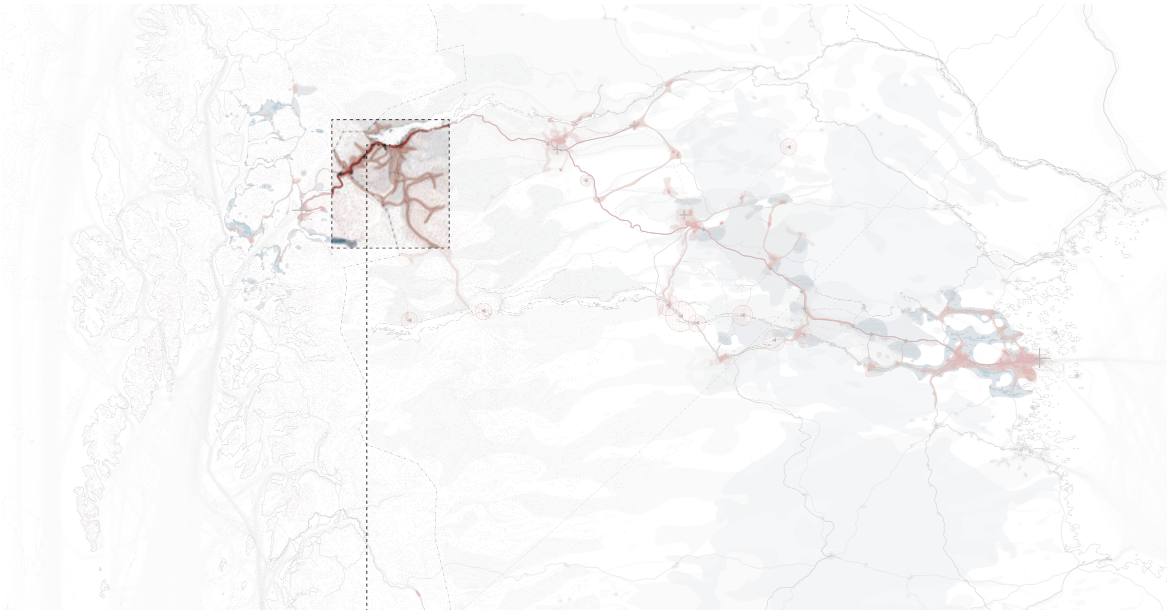


Disconnected State - Autumn / Spring

Interface between conflicting land uses in the same season

Eg: Abisko

The town here creates the interface between land-uses with same season conflict. Along with the midnight sun in the summer, which boosts tourism and the location of the Arctic Climate Research Institute, the reindeer at this time graze in the mountains. The city then creates an interface between the Sámi communities and the tourists to increase awareness and exchange of material, cultural, and knowledge.

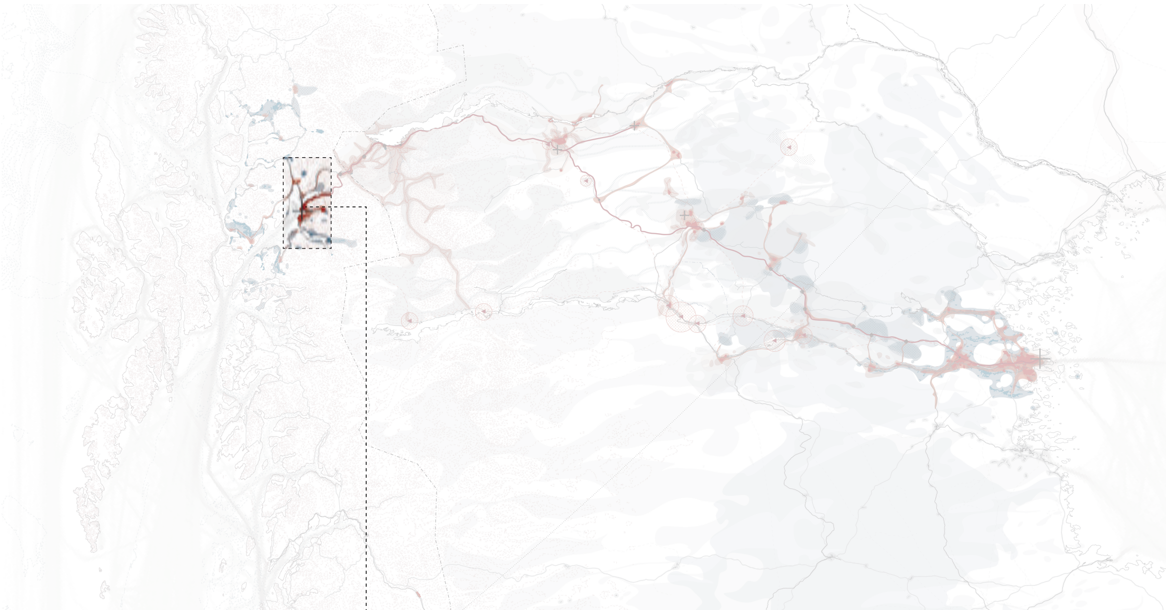


Abikso
[satellite image from ESRI]

Interface between different scales of operation

Eg: Narvik

The port city creates the interface between the planetary material flows and the technological megasystem. With the increasing rate of sea-ice melting and the development of transpolar sea routes that strengthen the connection between the Pacific and the Atlantic, Narvik creates the ideal condition that allows the transport of bioaccumulated waste material from the planetary mine for its recycling in Kiruna and Gallivare. Narvik is then programmed with the port housing sorting stations, storage areas, and cruise terminals, in addition to the diversified economies of aquaculture, forestry, agriculture, and reindeer husbandry in the fjordscape.



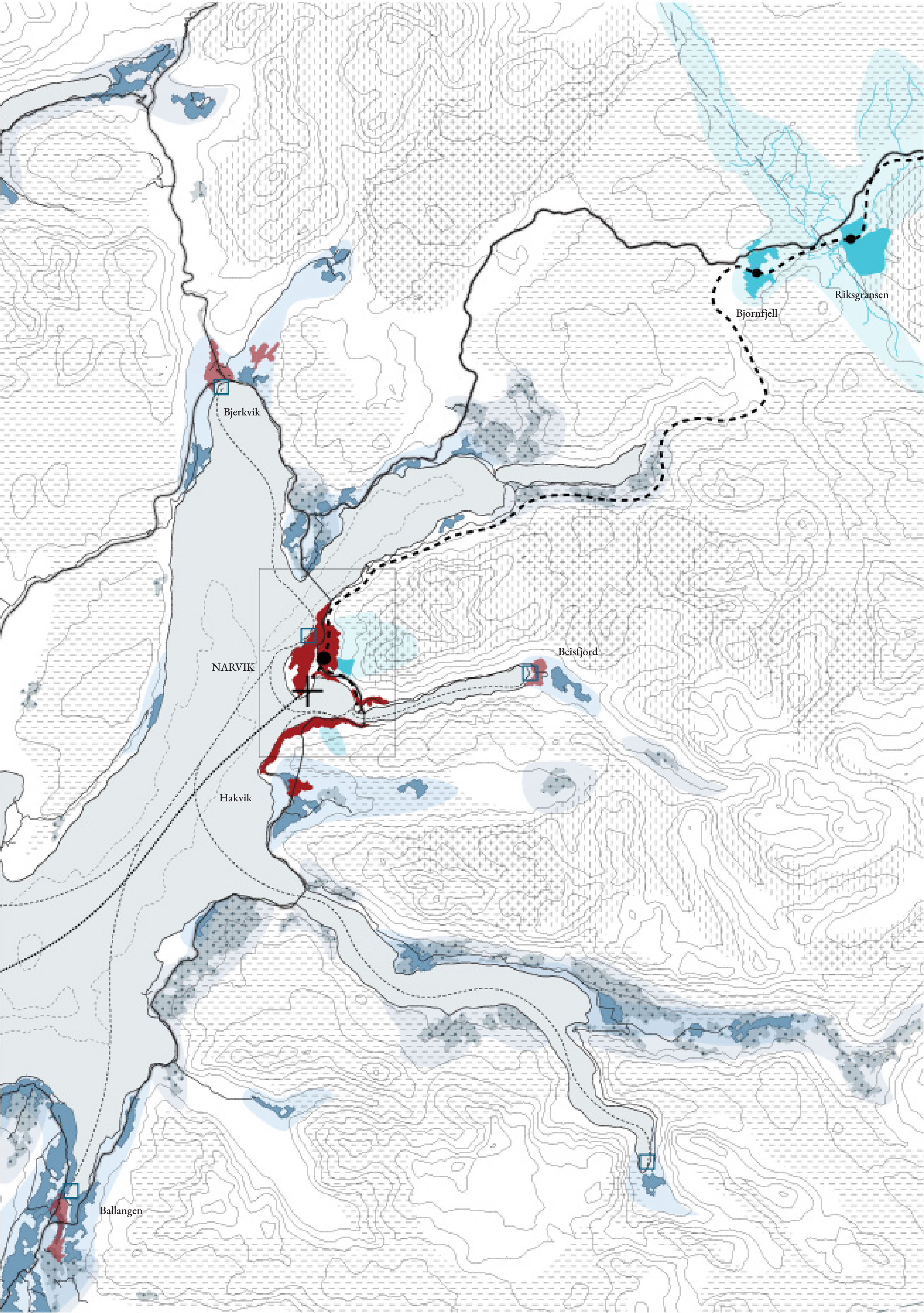
Narvik
[satellite image from ESRI]

Synthetic Map - Narvik

The synthetic map shows the design actions of diversifying economies in the fjord landscapes.

Urban
Productive Foresty
Agriculture
Tourism - Ski parks, hiking trail
Pastures - Summer, winter, all year
Roads
Railway
Water Transport
Raw material shipping
Aquaculture farms
Port
Railway Station

0 5 km N

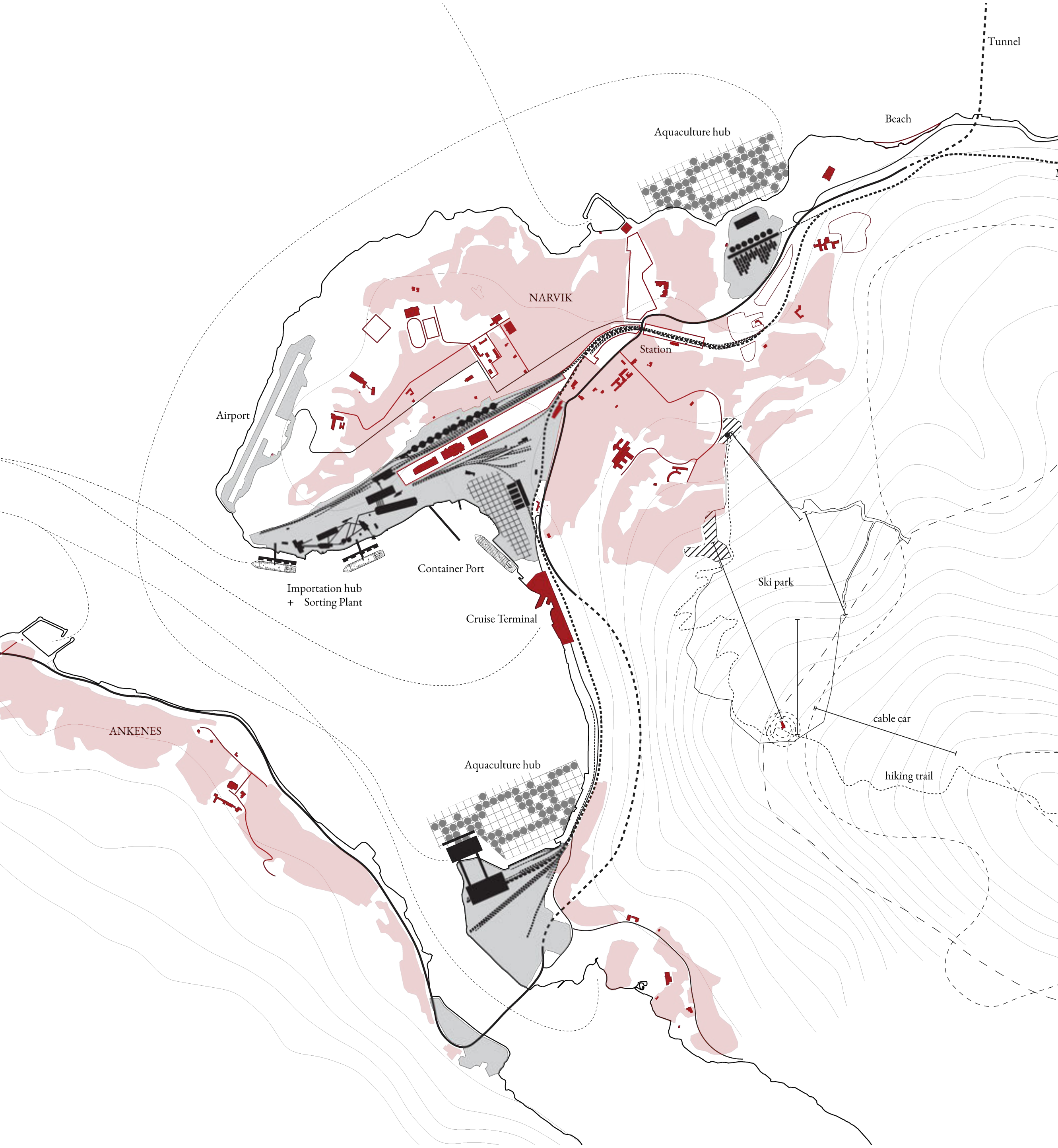

Riksgransen
Bjornfjell
Bjerkvik
Beisfjord
NARVIK
Hakvik
Ballangen

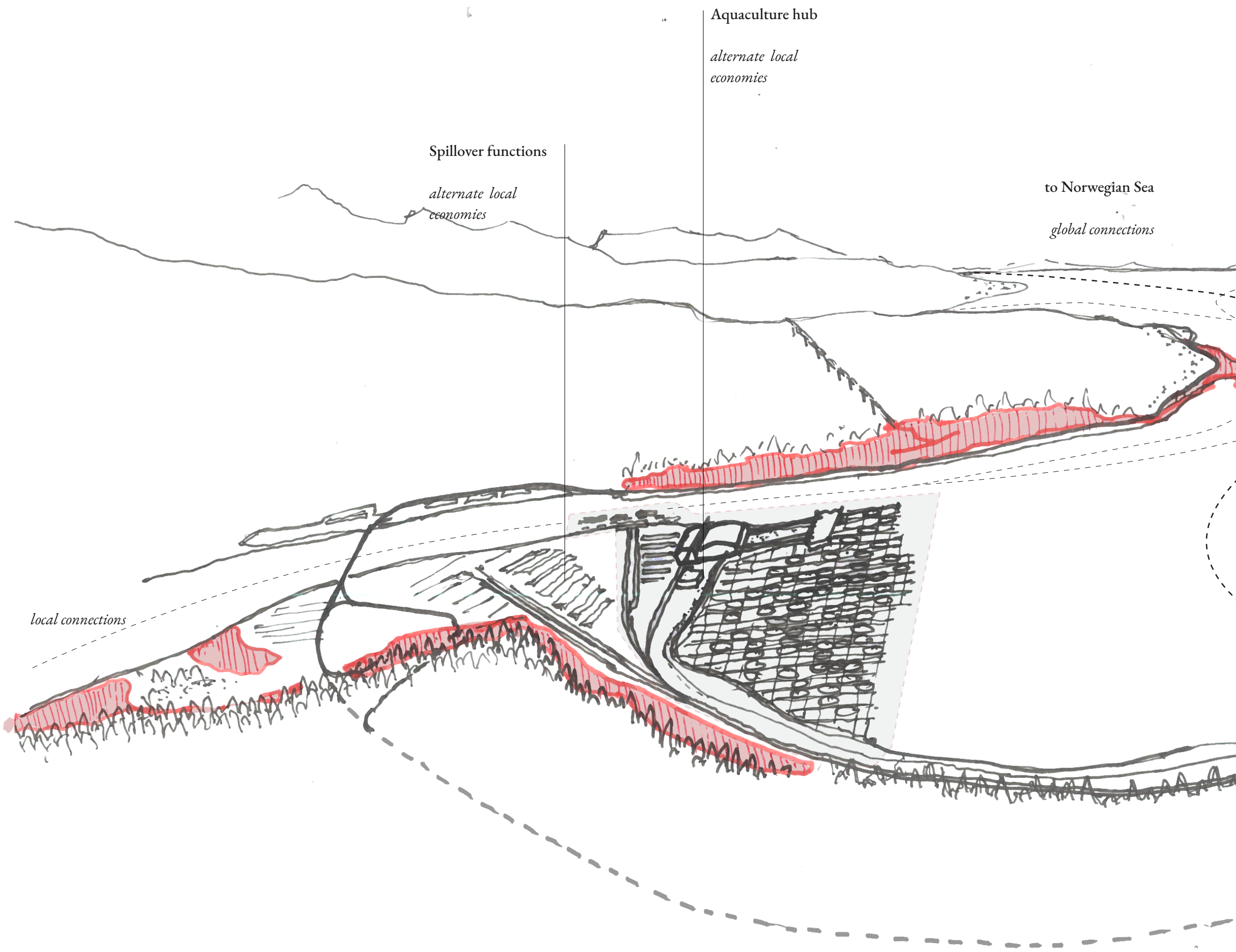
Programming the terminal end

The synthetic map shows the various programme of the coastline which allow for Narvik to function as the interface with the industrial economies at the higher scale such as the importation and sorting plant, container port , aquaculture hub etc. and the inland as the social core.

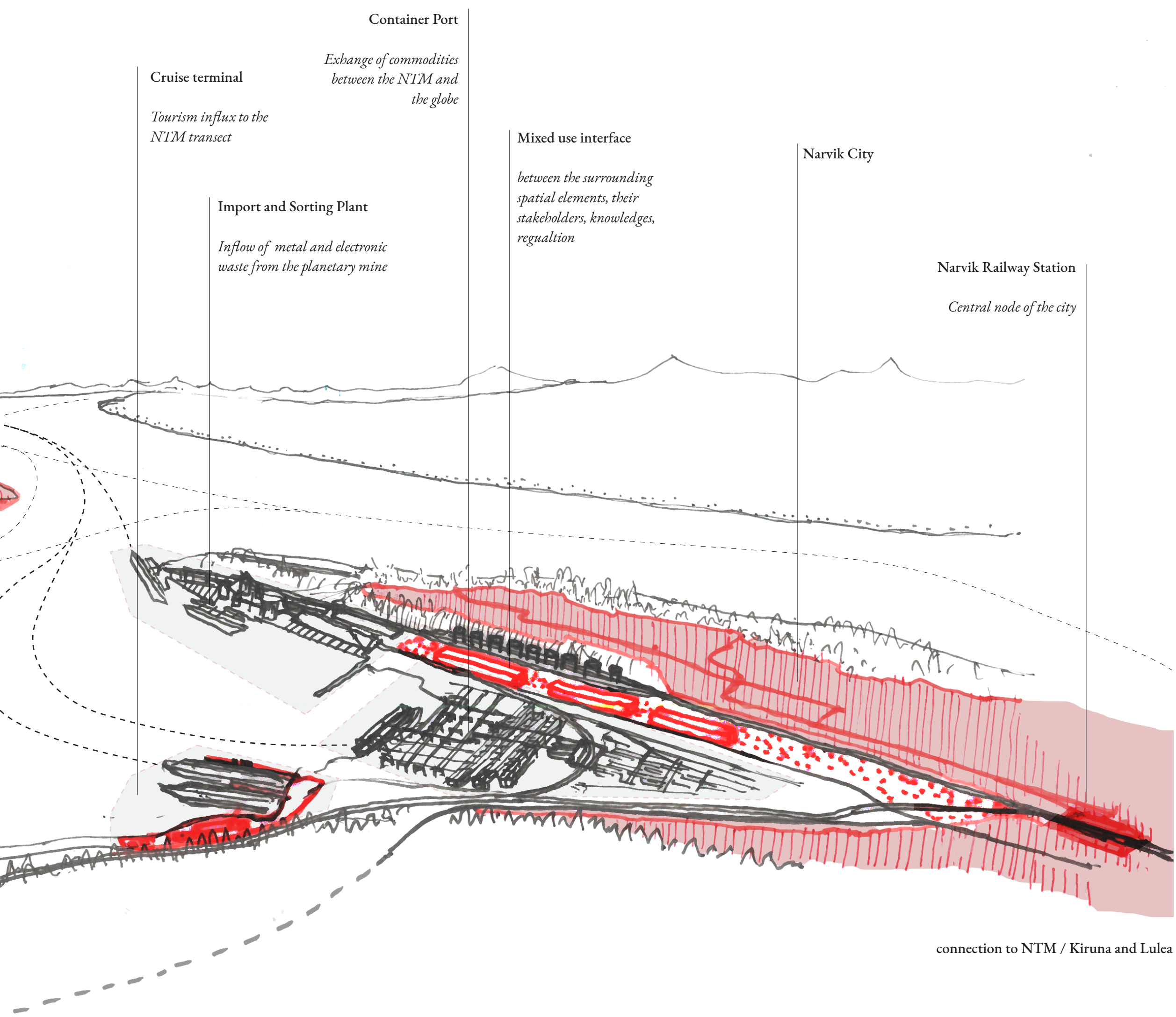
city - social core
extended city - infrastructurally dense
- - - water transport
····· railway transport
— road transport

|0 |5 km N


Tunnel
Beach
Aquaculture hub
NARVIK
Station
Airport
Importation hub
+ Sorting Plant
Container Port
Cruise Terminal
Ski park
cable car
hiking trail
ANKENES
Aquaculture hub



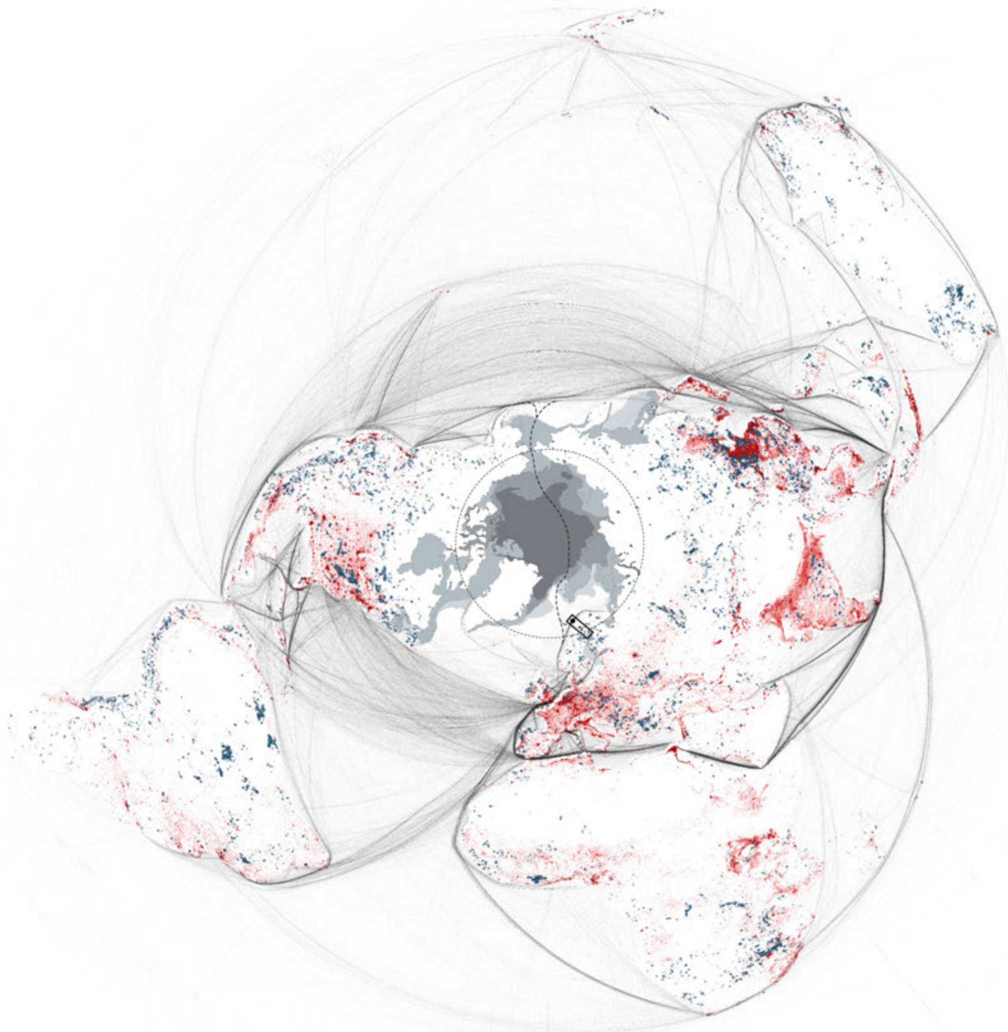
Impression of the emerging landscape


Container Port
Exhange of commodities between the NTM and the globe
Cruise terminal
Tourism influx to the NTM transect
Mixed use interface
between the surrounding spatial elements, their stakeholders, knowledges, regualtion
Narvik City
Import and Sorting Plant
Inflow of metal and electronic waste from the planetary mine
Narvik Railway Station
Central node of the city
connection to NTM / Kiruna and Lulea

Connection to the planetary fabric

The synthetic map shows the connection of the Norrbotten Technological Megasystem with the anticipated transpolar sea route and the retreting sea ice through Narvik. This enables for the use of the megasystem to process waste material accumulted in the planetrary mine. (in the cities)

- Norrbotten Technological Megasystem
- Human Influence Index - Planetary Mine
- Marine transport
- Geological mines
- Sea ice retreat - Sept-Mar
- Arctic Circle
- Transpolar Sea Route



Conclusion

To summarise, extraction landscapes create territories that are monofunctional, sacrificial, and determinate at different scales. These landscapes are devoid of social integration and controlled by state agencies. In these territories, fixed capitals are accumulated in the form of infrastructures which are premised on the social construction of scarcities. It is essential to approach the design of these landscapes through their post-extraction transformation potential. This thesis uses Kiruna and the Norrbotten Technological Megasystem as a paradigmatic example to propose new approaches to extraction landscapes through devolution—decentralizing agencies and their spatial implications. This is methodologically approached through three design projects.

Firstly, the Post-Project concludes that post-extraction transformation potential can contest these characteristics by [i] fragmenting and diversifying the program and decentralizing the agencies; [ii] coupling sacrifice and repair through terraforming and remediative actions for degrowth and social integration; and [iii] integrating indeterminate interfaces that act as catalysts for establishing interdependencies and eco-dependencies among human and more-than-human actors. These three conditions form the spatial logic to devolve the mining infrastructure in Kiruna and the agencies that control post-extraction transformations, mainly by decentralizing the state-owned mining company LKAB. The introduction of public indeterminate interfaces as public spaces in extraction landscapes would catalyse ecological regeneration, facilitating social integration into these landscapes.

Secondly, the Anti-Project transfers the design outcomes from the Post-Project to propose new ways of approaching the design of future mines. It emphasises proactive rehabilitation and pre-emptive considerations of socio-ecological conflicts. By learning from the current mine's transformation, new spatial and institutional mechanisms can be established that require mining companies to incorporate ecological and social considerations into the planning stages. Engaging local and indigenous communities in the planning and operational phases ensures their needs and traditional practices are respected and integrated into the spatial logic. The public space design with this intent suggests that the approach can promote harmonious coexistence, represented through indeterminate interfaces that increase the scope of negotiation.

Lastly, the Meta-Project upscales the spatial and institutional mechanisms of devolution to the territorial scale. This involves utilizing the spatial production of the extraction megasystem to reorganize the spatial structure to support decentralized economies and their agencies. The spatial logic decentralizes and diversifies economic and spatial production across the NTM transect, creating conditions for retreat and concentration along it. Institutionally, indigenous communities are deemed the stewards of the common land, and different economic activities are managed by networks of guild cooperatives. The role of settlement/municipal bodies is to act as a spatial and institutional interface between the cooperatives and indigenous communities, creating a landscape of coexistence. These settlements serve as interfaces between global markets, chains, networks, and local systems. This indeterminacy allows for responses to future uncertainties while moving away from the capitalistic nature of creative destruction.

The thesis attempts a systemic understanding and transformation of the territory, using design simultaneously as a method of analysis. This calls for both process-based and space-based design, which cannot be separated. This approach gives spatial design agency in rethinking extraction landscapes towards a post-capitalist future of coexistence with the dialectic approach of nature-cultures.

The thesis does not propose a definitive proposal as a solution because the spatial and institutional conditions are subjected to various multi-layered uncertainties. Instead the thesis looks into the agency of spatial design and the embedded methodologies that can propose indeterminate conditions that can allow for the holistic approach to the complex urban issues.

The project reflects on the discourse of post-capitalism by critically analysing its implications on Arctic infrastructural landscapes, mainly where extraction industries dominate. It focuses on trying to move away from the capitalistic process of creative destruction in the making of the landscape of co-existance, contesting 'antivisuality' and 'exceptional statuses' (Nesbit & Waldheim, 2022). This not only contests the capitalist model of resource exploitation but also promotes a resilient and multifunctional economic base for the territory. The inclusion of local and indigenous perspectives in planning and decision-making processes would ensure that the transformations are culturally sensitive, socially inclusive, and ecologically careful.

The success of many proposed interventions relies heavily on advancements in technology and radical changes in regulatory frameworks. It is accepted that these advancements may not materialise as expected, which could impede the practical implementation of the thesis's recommendations. Secondly, designing in indigenous and is a sensitive topic, and the role of this research here is to understand how cities can be interfaces for exchange, negotiation, and coexistence and how they can form conditions for continuous ongoingness. Since the governance structure in the extraction landscapes in indigenous territories is complex with the multiscalar economic actors and stakeholders. Design proposals specifically at spatial quality need a high degree of input and involvement of the local Sámi community. This calls for interdisciplinary design and participatory design strategies which were not considered in the thesis.

Rethinking the spatial implications of extraction landscapes from a post-extraction perspective can help in generating ideas that allow for longer strategies, not just for extraction landscapes but also industrial ones. This will help in considering and owning to the damage the critical processes tend to have on human and more-than-human environments. While some global regions are on the verge of post-industrial thinking, there are nations that are still industrialising, mainly in the global south. The idea of indeterminacy can help in integrating the social dimension into otherwise merely technical landscapes.

The social responsibility to clarify and return from human and nature as a dual concept to human and nature as a dialectic is embedded in the intent of the thesis. The adaptations for this are multi-scalar, ranging from the systemic planetary conditions of extraction, logistics, and production to the local scale of socio-ecological shifts and justice for indigenous communities to the object-scale consumption of the technologies composed of these resources, all with their own temporal scales. There is a need to create new imaginaries in the form of radical transformations in reflecting on the future of socially and ecologically vulnerable territories towards post-capitalism to acknowledge the socio-environmental implications—mostly uncertain—with a holistic approach to nature-cultures.

On Process and Method

It all started with the idea of the presence of human footprints in what we consider wild with an example of Arctic urbanisation. It was ambitious to explore the scale. Sections and drawing the ecological surplus in the Scandinavian Arctic transect helped me identify three frames exploring different interplays of conditions: geographical, geopolitical, and cultural, which were Svalbard, Tromso, and Kiruna. At this time, I had to focus my scope considering the scale of the master's thesis, and Kiruna had all the aspects of the extractivism paradigm I wanted to challenge. In the initial stages of the thesis formulation, my position in the thesis was not clear. But the design thinking and understanding of the different criticalities of resource urbanism challenged me to clarify my position in extractivism and the perception of nature-cultures. The critical cartography exercises of the Transitional Territories Studio Intensive and the Geographical Urbanism Intensive helped me gain a focus on the theoretical bodies I had to focus on and their overlaps with urban design and morphology. Critiquing the current paradigm of extraction and understanding the transformation potential of the production of spatial conditions through literature and mapping was extensive. Many theoretical readings were complementary, but it was difficult to synthesise and translate the concepts of political ecology and environmental humanities into spatial terms. Every step of the thesis required new abstract concepts that needed to be translated into space. In reflection, I wish to have reduced the amount of theoretical readings and focused on the theoretical production of knowledge. Although, to an extent, there were critical theory constructions, it was challenging for the graphical representation of the abstractions. Due to the complexity of the different spatio-temporal layers, the construction of the post-project, the anti-project, and the meta-project helped in structuring them and creating a narrative. Constant guidance by mentors and discussion with peers strengthened the focus on the monofunctional, sacrificial, and determinate nature of extraction landscapes and the design actions to contest them. Although the concept of devolution was introduced during the last stages, it helped narrow my focus on the concepts of indeterminacy to contest the current paradigms of extraction territories. In an integrated manner, it was also necessary to learn the concepts of spatial production and appropriations from the economic geography perspective to explore the implications of the devolution at the territorial scale through the concept of indeterminacy. Although the three projects—Post, Anti, and Meta—could be projects of their own, the research question required insights into all of them to understand the paradigm of extraction and, moreover, rethink it towards post-capitalism through the dialectic thinking of nature-cultures.

On Research and Design

The thesis required the method of simultaneous and repetitive analysis and synthesis because of the scope of the three subprojects. The interpretation of the continuous literature and the field observations had a constant influence on the sub-projects, and each of them had feedback loops, some of which were exciting but intensive. Here, design is a method of research itself. The innovativeness in the methodology of the Post, Anti, and Meta project could be a framework I will continue using for the critical understanding of the environments—the historical construction, in anticipation, and the spatio-temporal limits. The interdisciplinarity of the project was in the process of gaining knowledge from economic geography, political ecology, environmental history, and the humanities and contributing to the discourse of landscape urbanism. Environmental history was interpreted through historical land use and the palimpsests, indigenous histories, and evolution of environmental policies; environmental humanities through the narratives of how extractivism is represented, ethical and moral considerations, and the perspective of the dialectic thinking of nature-cultures. Political ecology was reflected in the thesis through the power structures, environmental justice, and spatial regulations, and lastly, economic geography through the spatial socio-economic processes discussing global economic processes in local environments and the use of spatial production to reorganise the territorial fabric. Spatial production is a resource.

Relation to the Transitional Territories Studio

The focus of the thesis is on the sacrificial nature of the extraction landscapes and the spatial accumulation of capital and reproductions. This is complimentary to the studio theme of Altered Nature—the poetics of change. Semantic exploration and creating a lexicon of infrastructures, their characteristics, and their alterations in the physical and chemical processes of space are integral to the argumentation of the thesis. A deeper understanding of the scarcity of resources allows for the exploration of more complex systems embedded in the geological, geographical, and geopolitical frameworks. The primary relation of the project is to the studio principle, based on the premise of understanding and deconstructing the notions of extended urbanisation and the spatial production of territories. In addition to the theoretical and syntactic understanding of the formation of the territories, it also uses methods such as critical cartography, palimpsest, and design as a method of inquiry. My project tries to understand the production of extraction territories, and here the primary focus is not on providing solutions but using design to understand different ontologies and epistemologies in the spatial process in inquiry. In this process, my project, in the framework of the studio, tries to identify the relation of design to political ecology and economic geography.

Relation to Urbanism Master Track

The resource potential, climate crises, and geopolitical tensions in these wild territories are under increasing pressure and pose a threat that is not eminent today but will only amplify in the future. This calls for the agency of design to form conditions to analyse future forms of extraction and their implications for space and matter. This required the design knowledge gained from MSc1 and MSc2 in developing the methodology for the graduation project. The critical thinking and urban morphological explorations in designing for uncertainties from Q1; engineering of urban systems and material ecologies from Q2; system thinking, agencies, and urban metabolism from Q3; and infrastructural and territorial design of extractivism from Q4 can be seen in the framing of the project.

Relation to the MSc AUBS Master Programme

Having a background in architecture and the practical experience of designing on a very small scale, I knew I wanted to study design on a larger scale—to explore the various aspects that form the foundation of architectural design. While that was my motivation to study urban design, I never thought I would be exploring a larger territorial scale of design. But during the Urbanism Masters, I realised that to synthesise sensitive design processes even at the architectural scale, it is necessary to have a systemic understanding of the various ecologies that are altered or proposed. Design, therefore, as in architecture, building technology, and urbanism, is not applied knowledge, but design itself is a form of knowledge production. This perspective shifts the perception of the master's programme and re-evaluates my position as a designer.

Avenues for further research

The research allows for deepening the focus in different critical environments formed by the extraction practices, each of which approaches the structure of the post, anti, and meta projects. Further in the devolution of the territories defined by technocratic thinking, the framework of the policies and the regulations as a product can create another trajectory for research towards the governance of these territories. But the most interesting of all would be to explore different extended urbanisation uses of historically produced spatial organisations, strengthening the link between urban geography and spatial morphology.

Transferability of Projects

The concepts of capital and social productions and appropriations are relevant in urban environments like the Dutch productive landscapes. The concept of devolution is multiscalar and abstract enough that it can create space for the indeterminacy and negotiation that are missing in landscapes that are dominated by a set of powerful economic actors and regulations. The proactive holistic approach not just restricted to extraction environments, but can relevant also in industrialising countries.

Evaluation

The methods of evaluation the case where design itself is the research is difficult and this is one of the limitations of the thesis. In this thesis I feel that Anti-project is evaluative of Post-Project and the Meta-Project is evaluative of the Anti-Project. Although not elaborated, the design is a method of evaluation in the thesis. The position in this thesis was to not create a definitive solution.

Limitations and scope

The scope of the research was to think about how transformation potentials could inform design agency in reshaping extraction landscapes. The question was more about design methodologies than the technical feasibility of the transformations themselves. The proposal was based on form, organisation, and systemic thinking. But the absence of expertise in civil engineering, geosciences, industrial ecologies, and biotechnology would be necessary for feasible design solutions. Secondly, although indegenous aspects were introduced, better engagement and participatory models would have given the project much more grounding.

Professional and Ethical Relevance

The mapping of the Arctic's ecological surplus and the appropriation shifts that result in various conditions for the creative destruction of ecological and spatial formations make this project one of disclosure. Along with causing climate crises and processes, these changes also constantly modify the ecologies of matter and space. The idea that changed ecologies are constantly creating and reshaping landscapes has to do with how earth systems are designed and how that design is expressed spatially. I think architects and urbanists have an ethical role in rethinking the futures of vulnerable territories through their direct and indirect manipulations and motives of architecture and the fabrics of urbanisation on the altered landscapes. Understanding the Anthropocene doesn’t mean that we don’t extract from the deep-sea surface or these extreme territories. But it is important to take a critical position in understanding at what cost we are enabling urban processes that accumulate capital and form conditions for continuous ongoingness that respect the human and more-than-human notions of the sensitive areas without looking for colonising solutions. It is necessary to take a position on what is green and reflect on the current trends of green colonisation. The need for curation in the design profession through creative media is very much necessary in today's society to disclose the extent of the ramifications that spatial processes have and the agency of design in them—what are the spatial and temporal limits of the space we are designing, how sensitive and sensible are the details we propose, and thus the responsibility of professional spatial practice towards Mother Earth.

Scientific and Academic Relevance

The project investigates the architecture of these altered landscapes and their material implications—formation and reformation—through the lens of different theoretical bodies. The project would contribute to the discipline of landscape urbanism at the intersection of landscape infrastructure and landscape ecology. It supports the shift in the current paradigm from viewing nature-society dualism to nature-society dialectic. It follows the current discourses on the Anthropocene and the Capitalocene, which necessitate frameworks to assess how global socio-economic upscaling offers opportunities to rethink the ways we associate with nature: on nature and through nature. As explained earlier, the use of design as a process of research is fundamental to the graduation project’s process, and it looks at design as not applied knowledge or science but as a form of knowledge production.

References

André, J.-B., & Baumard, N. (2020). Cultural evolution by capital accumulation. Evolutionary Human Sciences, 2, e18. https://doi.org/DOI: 10.1017/ehs.2020.19

Bai, J., Xu, X., Duan, Y., Zhang, G., Wang, Z., Wang, L., & Zheng, C. (2022). Evaluation of resource and environmental carrying capacity in rare earth mining areas in China. Nature. https://doi.org/10.1038/s41598-022-10105-2

Balaram, V. (2019). Rare earth elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact. Geoscience Frontiers, 10(4), 1285–1303. https://doi.org/10.1016/J.GSF.2018.12.005

Batty, M. (2007). Editorial: The creative destruction of cities. In Environment and Planning B: Planning and Design (Vol. 34, Issue 1). https://doi.org/10.1068/b3401ed

Bélanger, P. (2013). Landscape infrastructure : urbanism beyond engineering.

Bélanger, P. (2016). Landscape as infrastructure: A base primer. In Landscape as Infrastructure: A Base Primer. https://doi.org/10.4324/9781315629155

Bhatia, N., & Casper, M. (2013). The Petropolis of Tomorrow (N. Bhatia & M. Casper, Eds.). ACTAR.

Boyd, W., Prudham, W. S., & Schurman, R. A. (2001). Industrial Dynamics and the Problem of Nature. In Society and Natural Resources (Vol. 14).

Braudel, F. (1980). History and the Social Sciences: The Longue Durée. On History.

Brenner, N., & Katsikis, N. (2020). Operational Landscapes: Hinterlands of the Capitalocene. Architectural Design, 90(1), 22–31. https://doi.org/10.1002/ad.2521

Brenner, N., & Schmid, C. (2011). Planetary Urbanisation. In M. Gandy (Ed.), Urban Constellations (pp. 11–13). Jovis.

Brenner, N., & Schmid, C. (2015). Towards a new epistemology of the urban? City, 19. https://doi.org/10.1080/13604813.2015.1014712

Carrasco, C. M. (2020). Kiruna forever. ARQ, 2020(105). https://doi.org/10.4067/S0717-69962020000200070

Ellis, E. C. (2014). Ecologies of the Anthropocene: Global upscaling of social-ecological infrastructures. In D. Ibañez & N. Katsikis (Eds.), New Geographies (Vol. 6, pp. 20–27). Harvard University Press. https://doi.org/10.13140/2.1.2427.4729

European Critical Raw Materials Act, Pub. L. No. IP/23/1661 (2023).

Gabrielsen, G. (2005). The Arctic Paradox. Nature, 436, 177–178.

Gallison, P. (2022). What are Technical lands? In Jeffery. S. Nesbit & C. Waldheim (Eds.), Technical Lands: A Critical Primer. JOVIS.

García, A. C., Latifi, M., Amini, A., & Chaouki, J. (2020). Separation of Radioactive Elements from Rare Earth Element-Bearing Minerals. Metals, 10(11). https://doi.org/10.3390/met10111524

Graham, S. (2022). Vertical Imperialism: The Technical Lands of Mining Extraction. In Jeffery. S. Nesbit & C. Waldheim (Eds.), Technical Lands: A Critical Primer (pp. 156–171). JOVIS.

Gudynas, E. (2013). Transitions to post-extractivism: directions, options, areas of action. In Beyond development. Alternative visions from Latin America.

Gudynas, E. (2021). Extractivisms: Politics, Economy and Ecology. PRACTICAL ACTION PUBLISHING. https://doi.org/10.3362/9781788530668

Haetta, S. (2022). 'The crows take everything' - Kunstkritikk. Kunstkrittikk - Nordic Art Review. https://kunstkritikk.com/the-crows-take-everything/

Harraway, D. (2008). When Species Meet. In When Species Meet. University of Minnesota Press.

Harvey, D. (2014). Uneven Geogrpahical Developments and the Production of Space. Seventeen Contradictions and the End of Capitalism.

Heringman, N. (2015). Deep Time at the Dawn of the Anthropocene. Representations, 129(1), 56–85. https://doi.org/10.1525/rep.2015.129.1.56

Hutton, J. (2020). Reciprocal Landscapes; Stories of Material Movements. Routledge.

Katsikis, N. (2023). Social Construction of Scarcity. Dlft University of Technology.

Labban, M. (2014). Deterritorializing Extraction: Bioaccumulation and the Planetary Mine. Annals of the Association of American Geographers, 104(3), 560–576. https://doi.org/10.1080/00045608.2014.892360

Latour, B. (2017). Facing Gaia: Eight Lectures on the New Climatic Regime. Polity.

Lefebvre, H. (1968). The Right to the City (E. Kofman & E. Lebas, Eds.). Blackwell.

LKAB. (2022). LKAB 2022 Mineral Resource Summary Report. https://lkab.mediaflowportal.com/documents/folder/446946/

LKAB. (2023a). A Summary Technical Report on the MIneral Resources and Mineral Reserved of LKAB - Kiruna Mine. https://lkab.mediaflowportal.com/documents/folder/446946/

LKAB. (2023b). A Summary Technical Report on the Mineral Resources of LKAB Sweden - Per Geijer Iron Ore Apatite Deposit. https://lkab.mediaflowportal.com/documents/folder/446946/

LKAB. (2023c, January 12). Europe's largest deposit of rare earth metals is located in the Kiruna area. LKAB Press Release. https://lkab.com/en/press/europes-largest-deposit-of-rare-earth-metals-is-located-in-the-kiruna-area/

MDO. (2023). Major Mines & Projects: Kiruna Mine. Mining Data Solutions. https://miningdataonline.com/property/493/Kiruna-Mine.aspx#Overview

Meredith, M., Sommercoe, M., Cassotta, S., Derksen, C., Ekaykin, A., Hollowed, A., Kofinas, G., Mackintosh, A., Melbourne-Thomas, J., Muelbert, M. M. C., Ottersen, G., Pritchard, H., & Schuur, E. A. G. (2022). Polar Regions. In The Ocean and Cryosphere in a Changing Climate (pp. 203–320). Cambridge University Press. https://doi.org/10.1017/9781009157964.005

Min Odda Giron. (2023). De hedrade och mindes förlorade betesmarker i Kiruna - Min Ođđa Giron. https://www.minoddagiron.se/de-hedrade-och-mindes-forlorade-betesmarker-i-kiruna/

Moore, J. (2006). Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism. PM Press. https://

www.researchgate.net/publication/301301869

Moore, J. (2010a). “Amsterdam is standing on norway” part I: The alchemy of capital, empire and nature in the diaspora of silver, 1545-1648. Journal of Agrarian Change, 10(1), 33–68. https://doi.org/10.1111/j.1471-0366.2009.00256.x

Moore, J. (2010b). “Amsterdam is standing on Norway” part II: The global North Atlantic in the ecological revolution of the long seventeenth century. Journal of Agrarian Change, 10(2), 188–227. https://doi.org/10.1111/j.1471-0366.2009.00262.x

Moore, J. (2014). Toward a Singular Metabolism: Epistemic Rifts and Environment-Making in the Capitalist World-Ecology. In D. Ibañez & N. Katsikis (Eds.), New Geographies (pp. 10–19). Harvard University Press.

Morata, B. (2023). Urbanization as Socionatures’ Reproduction: from Territories of Extraction [PhD Thesis]. Luleå University of Technology.

Morata, B., Cavalieri, C., Rizzo, A., & Luciani, A. (2020). Territories of Extraction: Mapping Palimpsests of Appropriation. Urban Planning, 5(2), 132–151. https://doi.org/10.17645/up.v5i2.2901

Nesbit, J. S., & Waldheim, C. (2022). Technical Lands: A Critical Primer. JOVIS.

Nkrumah, P. N., Erskine, P. D., Erskine, J. D., & van der Ent, A. (2021). Rare earth elements (REE) in soils and plants of a uranium-REE mine site and exploration target in Central Queensland, Australia. Plant and Soil, 464(1–2). https://doi.org/10.1007/s11104-021-04956-3

Schumpeter, J. a. (1943). The Process of Creative Destruction. In Capitalism, Socialism and Democracy (5th ed., pp. 81–87).

Sjöholm, J., & Luciani, A. (2019). Norrbotten’s Technological Megasystem as a heritage discourse: paradoxes and controversies. AMPS Proceedings Series, 2(15), 292–300.

Skorstad, B. (2023). Sacrifice Zones: A Conceptual Framework for Arctic Justice Studies? In Arctic Justice. https://doi.org/10.56687/9781529224832-012

Sörlin, S. (2023). Resource extraction and Arctic communities : the new extractivist paradigm. Cambridge University Press. https://doi.org/10.1017/9781009110044

Sotoca, A. (2020). More Than One City: Kiruna and the Technological Megasystem of Sweden’s North. In D. Golling & C. Carrasco (Eds.), Kiruna Forever. Arkdes.

Stormcrow. (2020). Rare Earths 2020 Report - Things are not Great, but The Will Get Better.

Swedish Environmental Agency. (2022). Swedish - Pollution Release and Transfer Register .

Swedish Sámi Parliament. (2014). Minerals and mines in Sapmi: The viewpoint of the Swedish Sámi Parliament.

Swyngedouw, E. A. (1992). Territorial Organization and the Space/Technology Nexus. Transactions of the Institute of British Geographers, 17(4), 417. https://doi.org/10.2307/622708

WCS, W. C. S., & CIESIN, C. for I. E. S. I. N. (2009). Last of the Wild Project. https://doi.org/10.7927/H4ZC80SS.

Appendix

Reciprocal

A documentary about Kiruna

by Polis - TU Delft Student Platform for Urbanism and Landscape Architecture

Contributors:
Anmol Bhargava
Bas Kramer
Evgenia Vamvakousi
Jan Osusky
Jiheng Li
Kirthan Shekar
Nancy Nguyen
Preksha Rautela
Vera Vince
Willemijn Hoogland
Yi-an Lu

The documentary explores the complex relationships that are sometimes obscured by economic growth between the production of steel, harm to the environment, and indigenous rights. Beginning wiht the shots of Tata Steel Plant, the film is mainly set with the idea of going one step deeper to explore Kiruna as a hinterland of Ijmuiden. As the story shifts to Kiruna in the Arctic, where indigenous Sámi populations have lived, paractically forever, it explores the history and cultural landscape of the area. The film confronts viewers with the harsh realities hidden by technology growth as it moves through the layers of intricacy present in our modern society through the narrative. As the story develops, it reveals the hidden costs associated with the production of iron by Swedish state owned company LKAB, exposing the negative effects industrialisation has had on society and the environment. The conflict between tradition and modernity is brought to light by the encroachment of mining activities into areas that are surrounded by pristine landscapes and ancestral traditions. The documentary explores the ethical ramifications of switching to renewable energy sources while challenging the concept of sustainability in the context of the worldwide push for green technologies. The movie asks viewers to reconsider our relationship with nature and the true cost of progress through imagery and interviews. The intention is to remind of our shared responsibility to protect the environment, respect the rights of indigenous people. The calls for action confronting environmental issues, urging us to rethink our objectives and work towards harmony and critically reflect on 'What is truly green?'


POLIS - PLATFORM FOR URBANISM AND LANDSCAPE ARCHITECTURE
PRESENTS
RECIPROCAL
A DOCUMENTARY ABOUT KIRUNA AS A PRODUCT OF BIG TRIP 2024 - SWEDEN
WITH THE SUPPORT OF EFL STICHTING, PHILIP SPANGENBERG TRAVEL GRANT, FAST
AND TU DELFT DEPARTMENT OF URBANISM
POLISTUDELFT.NL

Which landscape?

Material traces of an integrated design and research approach in Kiruna

Working Paper

Valeria Federighi
Department of Architecture and Design, Politecnico di Torino

Taneha Kuzniecow Bacchin
Faculty of Architecture and the Built Environment, TU Delft

Kirthan Shekar
TU Delft

This appendix is redacted as it is still a unpublished working paper to avoid plagiarsim

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Transitional Territories

TU Delft / Urbanism

Transitional Territories

TU Delft / Urbanism