Article

Indigenous Knowledge for Sustainable Communications and Mobility: Perspectives from the Kolyma Road, Northeast Russia

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Abstract: In northeast Russia, the famous historic Kolyma Road spans two thousand kilometers across two federal subjects of the Russian Federation: the Sakha Republic (Yakutia) and Magadan Oblast. Thousands of people live along and in close proximity to the road, depending on it for communication, mobility, goods, and life support. As the major transportation infrastructure in the entire region, it should be reliable and stable for local communities' well-being. One strategic approach to ensure its reliability is to acknowledge the role of Indigenous knowledge, which has been neglected despite being established long before the emergence of existing formal systems of communication. Based on data collected through fieldwork, personal observations, and conversations, this paper aims to demonstrate that Indigenous knowledge regarding ways of living, moving, and communicating along and on the road is the key to sustainability in the region. As a result, we claim that this realization should be manifested in designing and implementing communication and mobility systems based on the principles of diversity, equity, and inclusion. In the long term, it is necessary to develop a sustainable road management system for the Kolyma Road to ensure the security and well-being of local communities and for everyone visiting and working on the road.

Keywords: Indigenous and local knowledge; communications; mobility; Siberia; Arctic; Kolyma Road; sustainable development

1. Introduction

In northeast Russia, the renowned historical route, the Kolyma Road, spans two thousand kilometers across federal subjects of the Russian Federation: the Sakha Republic (Yakutia) and Magadan Oblast. Initially constructed by labor camp prisoners, today it serves as a vital lifeline for thousands of residents in the region, catering to their transportation, goods, and life support needs. Functioning as the primary mode of communication for the entire northeast region, the Kolyma Road plays a crucial role in ensuring the well-being of the local residents. To achieve this, it is imperative for the road to remain reliable and stable throughout the year. One strategic approach for fostering future sustainability in the region involves acknowledging and integrating Indigenous and local knowledge and experiences, which have been historically overlooked despite their establishment in these lands long before the road's existence.

The main research question is how Indigenous and local knowledge intersect with questions of mobilities and communication in the context of the Kolyma Road. To answer

this question, we explore the following: what are the characteristics of mobility, communication, territory, and transport in the study region? How do these characteristics differ across Indigenous and non-Indigenous communities, gender, and occupation?

Indigenous knowledge systems are intricate networks comprising knowledge, skills, practices, and representations that steer human societies through myriad interactions with the natural environment: agriculture and animal husbandry; hunting, fishing, and gathering; struggles against disease and injury; naming and explaining natural phenomena; and strategies for coping with changing environments and climate [1,2]. Indigenous knowledge contributes to biodiversity conservation efforts [3]; sustainable and resilient food systems [4]; physical health, mental, and spiritual well-being [5]; climate change adaptation and resilience [6]; language and culture preservation [7]; responsible natural resource use with ecological balance, disaster risk reduction, and preparedness [8]; among others. In essence, transformative changes are needed in the application of Indigenous knowledge alongside science for environmental decision making in the Arctic [9].

Indigenous and local knowledge are integral components of the world's cultural diversity, laying the groundwork for locally appropriate sustainable development [4,10,11]. Although it was previously largely ignored in the fields of development and conservation, Indigenous knowledge receives wider recognition as a necessary part of sustainability transitions [12], and its incorporation into development projects is seen as essential for ensuring their sustainability and justice [11]. In several Arctic states, there is a growing trend of incorporating Indigenous knowledge into development plans and policies [13]. These initiatives stress the significance of consulting and collaborating with Indigenous communities, considered a preferred strategy for future development in the study area.

Indigenous knowledge represents a dynamic process rather than a static outcome. It encompasses not only knowledge associated with rural or nomadic lifestyles but also experiences shaped by urbanization and social transformations. Outdated perspectives of Indigenous as primitive and inferior [14,15] have become obsolete. However, ongoing discourse on integrating, incorporating, or bridging Indigenous knowledge with other ways of knowing [16,17] persists in both academic and policy realms.

Our analysis is rooted in an interdisciplinary approach to studies of mobility, territory, communication, and transport [18]. This involves various forms of mobility, including information, people, and commodities. According to Morley, this approach incorporates notions of virtual and embodied mobility, network geographies, deterritorialization, sedentarism, nomadology, connectivity, containment, and exclusion [18]. This perspective allows us to comprehend the complex systems that encompass vital aspects of life in remote and marginalized areas in the North.

Previous studies have delineated the specificities of mobility, territory, communication, and transport experienced by Indigenous communities globally. Historically, Indigenous people's mobility has served diverse purposes, from community and individual economic well-being to cultural exchange and knowledge gathering, or as a means to escape colonial intrusion [19]. Mobility has been crucial in the lives of Indigenous communities, facilitating relationships with environment and kin. Indigenous relationships with lands and waters are characterized by connections rather than ownership, necessitating free access to natural resources for herding, fishing, and hunting [20]. Also, these relationships keep adapting and changing, and engaging in new forms of mobilities as well [21].

Another challenge arises with connecting mobility with future prospects for Indigenous-led tourism, which is growingly becoming a driver for sustainable economic development. In the western Arctic, stakeholders in the tourism industry acknowledge the pivotal role of Indigenous people, presenting both challenges and opportunities [22]. This becomes especially relevant in Russia's Arctic where tourism development puts even more pressure on limited infrastructures, including communication. Therefore, challenges remain in finding the balance between tourism and traditional ways of life and mobility.

Internet and communication technologies play a significant role in Indigenous lives in the Arctic, integrating into nomadic culture [23]. Although the spread of information and

communication technologies, along with global interconnectedness, holds the potential for human progress [24], there are serious concerns about their impact on Indigenous cultures, which are often minority groups in their respective countries. However, it is important to recognize that people not only consume information but also produce it. The emergence of Indigenous content creators and social media influencers demonstrates that Indigenous individuals should not merely be seen as passive subjects in these processes but also as active participants and creators.

There is a substantial and growing body of theoretical and practical research on the anthropological aspects of nomadism and mobility of Indigenous people in Siberia and the Arctic [25,26]. Researchers have approached communications and mobility in Sakha (Yakutia) from different angles: in relation to Indigenous mobility and migration [27–30], gender aspects of mobility [31,32], roads in Indigenous livelihoods and cultures [33–35], transport mobility and life quality [36], transport connectivity and winter ice roads [37], among others. Despite this, there remains a lack of integrated approach to communications and mobility, encompassing all forms of mobility, namely information, people, and commodities. In recent years, local and Indigenous knowledge has emerged as a new and increasingly influential contribution to the global science–policy interface [38]. Although recognized as a basis for sustainable practice, integrating Indigenous knowledge into research, scientific analysis, and practical applications, especially within context let alone used in practice, in real projects and plans, especially within the context of highly centralized systems like Russia, remains challenging.

Current systems fail to incorporate Indigenous and local knowledge for the promotion of sustainable communications and mobility. Our objective is to delineate potential solutions to long-standing and persistent problems in the study area, emphasizing the inclusion and implementation of Indigenous knowledge. Our contribution is to help advance informed policy decisions for the well-being and sustainable future of the study area. The paper sheds light on the complexities and challenges faced by the diverse communities along the Kolyma Road, challenging stereotypes and offering a more nuanced understanding of this historically significant region.

2. Materials and Methods

The study relies on data gathered during fieldwork conducted in two adjacent administrative regions along the Kolyma Road, with a particular emphasis on the Indigenous community. A seventeen-day-long journey traced the path of the new Kolyma Road (Figure 1), intersecting at points with the old historic route, which is now officially closed for travel. Nevertheless, particularly during the summer, tourists continue to traverse the historic route, attracted by its scenic views and the opportunity to witness the history embedded along the road. Given our focus on present-day life along the road and in the settlements where people reside year-round, we opted to follow the new route.

The field trip took place from 4 July to 20 July 2022, primarily centered in the Oymyakon district of the Republic of Sakha (Yakutia). The team visited settlements including Tomtor, Oymyakon, Sordonnookh, Uchugey, Bereg-Yurdya in Yakutia, and Seymchan in Magadan Oblast. Within these communities, the lives of Indigenous people are typically shaped by traditional activities such as hunting, fishing, reindeer herding, and cattle and horse breeding. During the preliminary stage, efforts were made to establish local contacts and collect relevant data. This involved defining objectives, arranging accommodations, and packing necessary equipment. Throughout the trip, the team observed, documented, and collected data, concentrating on aspects related to mobility, communications, territory, and transport. Subsequently, the studies were enriched with additional data and observations obtained during the first author's visit to the Tomtor community in July 2023.

Defining the researcher's positionality [39] becomes crucial in contexts such as these, particularly when engaging in research within Indigenous communities. This significance is heightened when research is carried out by individuals who share many similar experiences with the informants, thus potentially being labelled as 'native anthropologists' [40], a

term that itself sparks considerable debate. Although our project is Indigenous-led, it conforms to formal frameworks and does not explicitly align itself with an Indigenous perspective or paradigm [41]. However, it is important to recognize that our identities still influence our perspectives, biases, and interpretations of data. This encompasses various elements, including the researcher's background, identity, experiences, and values, all of which can shape how they approach a research topic and interact with participants or subjects. The acknowledgement of one's positionality is critical for conducting reflexive and ethical research, offering insight into how it may impact the study's outcome. This awareness enables a more comprehensive understanding of the potential implications of the researcher's standpoint on the research process and findings.
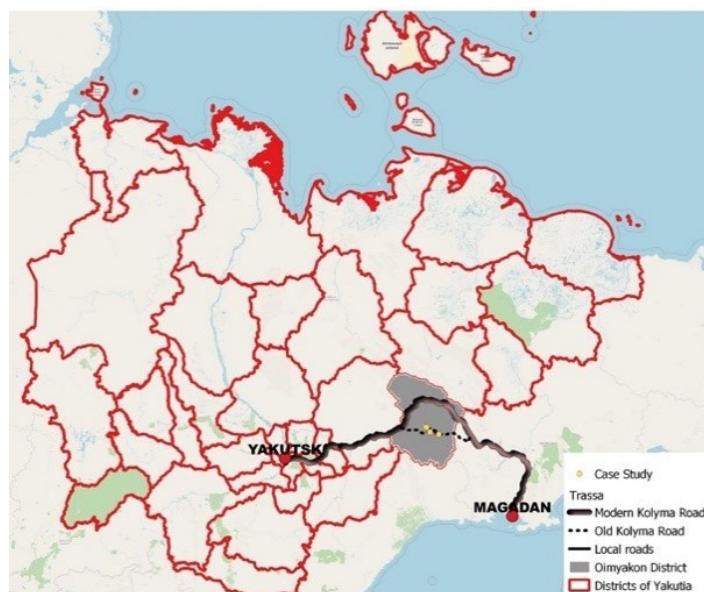

Figure 1. The new Kolyma Road. Yellow dots are case study communities.

The studies were spearheaded by a team of female researchers with backgrounds in social geography and cultural studies, affiliated with research and educational institutions in Yakutsk and Irkutsk. Despite being ethnic minorities in Russia, specifically Sakha and Buryat, none of the team members falls under the classification outlined in Russian legislation as "small-numbered indigenous peoples of the North"–"korennye malochislennye narody Severa" [42], which is the primary focus of the project. Despite this, even though the research project targeted the category of "small-numbered Indigenous peoples of the North", encompassing groups such as the Even and Yukaghir, it is important to note that Sakha and other individuals of various ethnic or mixed ancestries also played significant roles in contributing to the study. This complexity underscores the challenges associated with identification, definitions, and the diverse array of identities within Russia's Arctic.

In this paper, we present data collected through observation and the conversational method [43], complemented by the use of mental maps—a valuable tool for gaining insights into place and attachment dynamics [44]. The conversation participants were identified through the snowball method, leveraging personal contacts, recommendations, and consulting recognized experts such as elders and community leaders.

These conversations unfolded in public spaces and, in many cases, at the participants' workplaces, including rural administration offices, community centers, municipal libraries, hospitals, schools, local museums, and other community hubs. This paper draws from ten conversations conducted in the communities of Oymyakon district of the Republic of Sakha (Yakutia) and two conversations in Seymchan of Magadan Oblast. The participants represented diverse backgrounds and formal sectors, including administration, education, healthcare, culture, and the animal husbandry sector, which includes reindeer herding, cattle, and horse breeding. It is crucial to acknowledge the diversity of human experiences

and bear in mind that engagement in one sector does not preclude involvement in another. Many of the participants held multiple roles and positions, simultaneously serving as official community workers and engaging in activities such as reindeer herding.

In each community, we invited residents to participate in a community mind-mapping project (refer to Figure 2a–c). Throughout our conversations, we explored the population's opinion on access to areas of traditional environmental management, their attitudes towards various forms of communication, and the local perception of the surrounding space using mental maps. A particular focus was placed on the method of creating a mental map, reflecting the respondents' interactions with the outside world. This method allows for an assessment of the overall state of communications within and between regions, as well as determination of a respondent's spatial orientation boundaries.
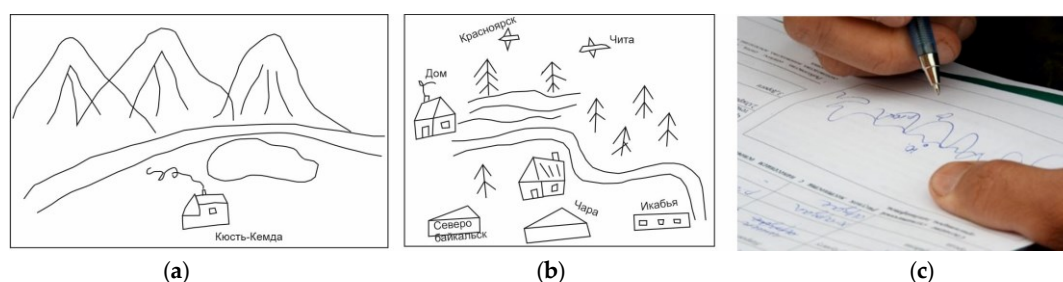

Figure 2. Examples from community mind-mapping project. (**a**) Landscape surrounding the community of Kyust'-Kemda. (**b**) Map of the community drawn by its resident showing the location of major areas. (**c**) Residents drawing maps.

During our study, respondents were requested to identify areas significant for hunting various animals, fishing, berry and plant gathering, sacred sites, historical locations, campsites, hunting lodges, and official and unofficial roads. Mapping with local communities involved using a 1:200,000 scale topographic base map coupled with a semi-structured interview process with community members' perspectives on their areas. Respondents marked specific icons on the topographic maps at a 1:200,000 scale. While these maps may not provide a comprehensive overview of the current use of traditional resources, they highlight areas of importance to communities. The mapping of traditional knowledge was conducted with the participation of elders, members of nomadic tribal communities, and rural residents, including reindeer herders, hunters, fishers.

An analysis of information and communication infrastructure provision was conducted using the public register of communications and television and radio broadcasting infrastructure of the Russian Federation [45]. Data from reports on the activities of executive bodies of state power in the ulus (districts) of the Republic of Sakha (Yakutia) for 2022 [46] were also included in the analysis. Data were collected for settlements along the Kolyma Road, considering postal services, local telephone communications, long-distance and international communications, data transmission, telematic communication services, mobile communications (GSM, UMTS, LTE, NMT-450, and IMT-MC-450 (CDMA)), TV and radio broadcasting, cable television, payphones, and public access points.

3. Study Area

The Kolyma Road, historically a dark symbol of the Soviet totalitarian era, has been described as "the most frigid and deadly outpost of Stalin's Gulag" [47]. Despite its ominous reputation, it is a place that local Indigenous people and some Russian settlers call home [48]. Unfortunately, colonial narratives have dominated outsider views of the Kolyma, overshadowing its past and present, including the lives of those who inhabited the region before and after the prison camps. Pushed aside by outsiders' views and narratives, these stories remain untold to broader audiences (a few exceptions include [49,50]) and can challenge the prevailing image of Kolyma as an abandoned, dark, and fearsome place, revealing a history of human adaptation and resilience.

The Federal Highway P504, known as the "Kolyma Road", connects Magadan on the Sea of Okhotsk with the gold fields of Kolyma, serving as a critical lifeline for the gold-producing areas in the north. Originating from a 19th-century postal route linking Yakutsk, Verkhoyansk, and Srednekolymsk, this modern motor road links Yakutsk and Magadan and has historical significance as the only regular post road in the Siberian Arctic [51]. Initially constructed to support the Russian imperial postal system in the mid-19th century, the road later played a role in transporting Soviet exiles during the political upheavals of the late 19th and early 20th centuries [52].

The construction of the motor road aimed to provide access to valuable mineral resources such as gold, tin, silver, and coal. However, the challenging terrain, extreme climate, and permafrost posed significant obstacles, earning the route the nickname "road of bones" due to the extensive involvement of Gulag camps and deceased prisoners in its construction. From 1932 to 1953, the Kolyma camps received 740,434 people, with approximately 120–130 thousand considered dead and around 10 thousand of them shot [52].

The highway spans two regions, crossing five territorial-administrative entities in the Republic of Sakha (Yakutia) and three in the Magadan Oblast. The total length of the route is 2032 km, with approximately 1197 km in Yakutia and 825 km in Magadan Oblast. As of 1 January 2023, the entire territory housed around 110 thousand people, with a uniform decrease in population observed along the route.

According to scholarly sources, two distinct categories of cultural and social traditions have been recognized in relation to the two successive waves of Arctic colonization: Indigenous peoples who migrated there millennia ago and Europeans who arrived more recently [53]. In the study area, these waves have formed areas with predominantly Indigenous and settler populations, where the first is mainly engaged in agriculture, while the settler-dominated areas rely more on industry. Infrastructural and socioeconomic inequality has developed along these lines. The Oymyakon district of Yakutia serves as an example of two contrasting realities. Divided into two parts, with the center in the town of Ust-Nera, the first part is an industrial zone (gold mining) with developed infrastructure. The second part, centered in the village of Tomtor, focuses on agriculture, including cattle breeding, and the village of Yuchyugey engaging in reindeer husbandry. In contrast, the town of Seymchan in Magadan Oblast exemplifies the loss of traditional Indigenous Even reindeer husbandry traditions.

4. Results

We conducted an examination of the characteristics of communication and mobility in the study region, considering four key aspects: mobility, territory, communication, and transport. Our research revealed a notable disparity between formal and informal systems in the study area. Formal systems, it appears, do not adequately consider Indigenous livelihoods, traditions, kinship, and relations. Conversely, informal systems, which encompass those essential aspects of life crucial for identity and people's determination, should be equally regarded in planning and development programs implemented in the regions. The distinctions between the two systems are presented in Table 1 below.

4.1. Nomadic Reindeer Herding in the Kolyma Road Area

To gain a comprehensive understanding of communications and mobility within the context of nomadic reindeer herding, we delve into the traditional activities prevalent among Indigenous communities in the study area. The primary branches of the traditional economy are reindeer husbandry, hunting, and fishing. The history of reindeer husbandry in the northeast of Russia reveals three distinct periods, each characterized by a specific method of environmental management, a form of animal ownership, and the role of reindeer husbandry in the overall economic structure [54].

Table 1. Characteristics of formal (public) and informal (Indigenous and local) systems of communications and mobility.

	Formal	Informal
Mobility	Sedentary lifestyle, formal jobs, vertical career growth, women at home and in settlements, men more mobile out in the lands	Nomadic lifestyle, multiple and horizontal careers, both men and women are mobile with different patterns of mobility
Territory	Defined and limited by administrative borders, written regulations, defined by municipalities, highly centralized	Defined and limited by natural borders, defined by relations, kin networks, oral agreements, shared knowledge, less centralized
Communication	Limited by cable networks, networks focus on connecting sedentary communities and their administrations	Provided by satellite to connect nomads in the lands, information is transmitted non-formally, storytelling is part of communicative practices
Transport	Focus on local public transport, companies, freight, road is perceived as a job, main users are professional long-haul drivers and shift workers, mostly male, outsider, non-Indigenous	Need for private transport and public transport between communities, focus on people, passengers, tourists, road used by Indigenous and local residents, mostly women, elders, children

The 20th century witnessed all three periods: traditional herding, nomadism within the collective and state farm system, and nomadism in a market economy. Throughout this time, whether on collective farms, state farms, or nomadic tribal communities, reindeer husbandry remained the primary traditional economic activity. Notably, among the Yukaghirs, reindeer herding served as a means of transportation, with an average of up to ten reindeer per farm. Some affluent families possessed 100–150 reindeer. Fishing and fur hunting were integral components of the economy, and before their Sovietization in the mid-1950s, the total number of reindeer among the Evens ranged from five to six thousand [54].

The Dalstroy trust, the primary organization overseeing construction, engaged not only prisoners but also local representatives of Indigenous peoples. Reindeer herding collective farms and later state farms were established under Dalstroy's jurisdiction, employing the Evens and Yukaghirs in cargo transportation. While the demand for horse-drawn transportation diminished after the completion of the Kolyma Route in 1938, reindeer transport remained vital until the advent of helicopters and snowmobiles in the 1970s and 1980s. During this time, reindeer served as essential means to deliver goods and products to the herds and transport children to and from boarding schools [54].

Between 1964 and 1975, under the pressure of the Soviet sedentarization and extractive industrial development, reindeer husbandry among the Yukaghirs was lost, while among the Evens, it is currently preserved only among those who live on the territory of Yakutia, in the communities of Yuchyugey and Berezovsky, and in Khabarovskiy krai. In Yakutia, policies aimed at supporting small Indigenous groups were more targeted and considerate of Indigenous principles of animal husbandry. Conversely, in the adjacent Srednekansky district in Magadan Oblast, prioritization of industrial development has visibly impacted the traditional settlement system. Indigenous people's places of residence have vanished from administrative maps, and pastures have been seized for mining enterprises. The shift from traditional settlements to villages resulted in isolation from traditional activities and loss of skills in conducting traditional farming [54].

Currently, reindeer are still in demand as a means of transportation in places where there are no roads. During an expedition to the community of Yuchyugey, we were told about seasonal migrations of Even reindeer herders from the neighboring Khabarovskiy krai. This transregional travel is associated with meeting with relatives and purchasing food in villages in Yakutia, the distance to which from the herds is much closer than to the settlements in Khabarovskiy krai. An interesting fact is that Khabarovsk reindeer herders also come to the Oymyakon region to earn money as the local entrepreneurs hire them for tourist services, because local reindeer herders already have other sources of income, while in the Khabarosvkiy krai, income opportunities for reindeer herders are limited.

4.2. Mobility and Territory

The formal system is designed for a sedentary lifestyle, assuming that women primarily stay at home and in settlements, while men tend to be more mobile, spending a significant amount of time outdoors. This system emphasizes formal jobs and vertical career growth, operating within administrative borders and written regulations in a highly centralized context. However, our research indicates that the characteristic features of life in the study area are non-centralized and nomadic. Contrary to the formal system's assumptions, both men and women exhibit mobility, albeit following different patterns. The lifestyle is not limited by administrative borders but may be influenced by socio-cultural ones, defined by relationships, kin networks, oral agreements, and shared knowledge.

In reality, people in the study area engage in multiple and horizontal careers. This aspect encompasses traditional land use; intra-regional and local communications focused on the location of traditional activities such as hunting, fishing, and reindeer herding; and medicinal plant collection. Additionally, the location of cultural and archaeological sites is considered, highlighting the importance of a non-centralized, holistic understanding of the community's dynamics.

Areas where people actively engage in hunting, fishing, and reindeer herding may not always align with the official boundaries depicted on officially issued maps. All cartographic information obtained from the mind maps was entered into a GIS database for spatial analysis. These data were used to create GIS information layers that include traditional land use, interregional and local communications infrastructure, and more. Given the spatial nature of traditional cultural and environmental knowledge, GIS technology can facilitate the integration of Indigenous knowledge into decision-making processes. At the same time, GIS technologies play a vital role in mapping and studying areas of traditional resource use. This raises serious concerns about land rights and conservation, as GIS is used to manage and exploit the natural resources on these territories.

The example illustrates the developed space through the lens of traditional farming practices, such as haymaking near the community of Yuchyugey, fishing and hunting hare on the Agayakan River, and mountain sheep hunting on the Suntar River. While women also engage in hunting and fishing, there remains a division of labor. Notably, several women marked areas on their maps where they pick berries. In exploring the developed space and its distinctions between women and men, it is intriguing to note that women are more likely than men to indicate the location of their homes on the mental map (refer to Figures 1 and 2). The absence of a home for men does not diminish its importance; rather, it underscores the traditional understanding of mobility. Men, who generally spend more time outside the home, have a broader spatial perspective, while women, who often remain in villages due to education and stable jobs, play key roles in caring for homes, children, and elderly relatives.

The maps clearly depict hunting and berry picking as two activities that constitute essential components of seasonal mobility patterns [55,56]. (See Figure 3). A distinct gender aspect of space development through traditional activities is evident here, with men engaging in hunting, fishing, and haymaking, while women predominantly focus on berry picking. Notably, women overwhelmingly identified berry picking as their main traditional activity, while men indicate hunting. These distinctions underscore the significant differences in traditional activities. Both activities contribute crucial food products to households, playing a vital role in diets and food security. Furthermore, they serve as important means of socialization and contribute to mental and emotional well-being [55]. Both hunting and berry picking symbolize stability, seasonal change, and cultural identity, and simultaneously function as "important traditional food, traditional activity, and social fabric" [57]. The variety in activities acts as a determining factor for differences in mobility characteristics and communications within and between regions. For instance, berry picking typically does not involve extensive and challenging travel, unlike fishing or hunting. Additionally, berry picking is limited by late summer months, while fishing and

hunting last almost an entire year depending on the season. This aspect impacts the nature of communications.
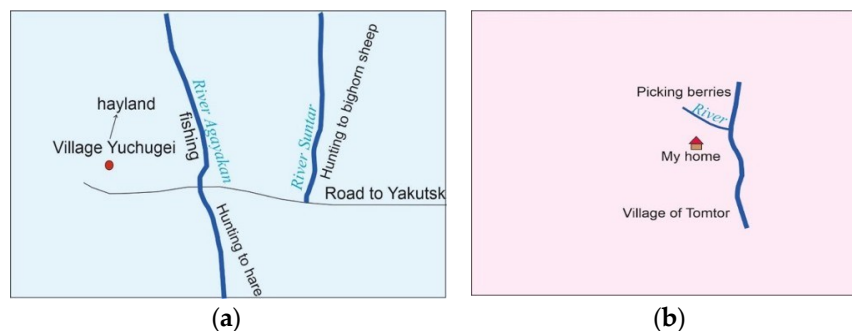

Figure 3. Examples of mental maps. (**a**) Mental map drawn by male respondent. (**b**) Mental map drawn by female respondent.

Finally, it is essential to highlight the findings regarding social mobility and careers. Employing a competency-based perspective on careers [58], we delve into the implications for "boundaryless careers", considering changing organizational, occupational, and industry community contexts. These contexts are perceived as potential catalysts for promoting boundaryless career behaviors.

In reindeer herding families, both women and men establish non-commercial organizations to apply for government grants. The obschina (from Russian, suggesting a participatory tribal community) is an organizational structure to assert their rights to natural resource use, hunting, fishing quotas, etc. Individuals assume various roles within these diverse organizational forms. Women, in addition to engaging in formal civil jobs in healthcare, culture, education, and social care within settlements, take on additional responsibilities. Having a higher level of education, women usually handle tasks such as accounting, resource management, filing annual reports, taxes, and other related functions.

4.3. Communication and Transport

The formal system, with its emphasis on a sedentary lifestyle, significantly influences communication and transport systems. The formal system relies on cable networks that primarily connect sedentary communities and their respective administrations. In contrast, nomads in the lands are connected by satellite, with information transmitted informally, often through storytelling as a communicative practice. The formal system places a focus on local public transport, mainly for freight, where roads are perceived as fundamental to their job, predominantly used by professional long-haul drivers and shift workers, most of whom are male and non-Indigenous, often outsiders. In contrast, there is a need for private and public transport to travel between communities, emphasizing the importance of focusing on people and passenger needs. The road should also cater to civil use, including infrastructure for tourists.

At the World Summit on the Information Society (WSIS) in 2003, Indigenous Peoples called for their active involvement in the Information Age on their own terms. While progress has been made since then, fully realizing this objective is still ongoing. The COVID-19 pandemic has underscored the need to accelerate digital inclusion, particularly in the study area. It emphasized the crucial role of ICTs in sustaining societal functions but also brought attention to significant disparities between and within countries, particularly for Indigenous communities [24].

Local and intrazonal telephone communications are primarily handled by Rostelecom PJSC in almost all localities, except for a few other operators in the city of Magadan. Internet data transmission, in most settlements, is carried out by Rostelecom PJSC, with data transfer speeds ranging from 32–56 Kb/s in small settlements to maximum values of 15–100 Mb/s in the town of Susuman. Additionally, in almost half of the settlements along the Kolyma Road, internet data transmission is managed by Vympel-Communications

PJSC and Mobile TeleSystems PJSC. The analysis revealed that not all settlements have the opportunity to access digital television, with analogue television still being broadcast in many remote settlements.

In three settlements of the Oymyakonsky district, namely Oymyakon, Bereg-Yurdya, and Yuchyugey, there are no branches of the Russian Post. These communities are served by the nearest post office located in the village of Tomtor. The analysis indicates that the development of information and communication infrastructure in many rural settlements along the Kolyma Road does not align with the national level of development of information and telecommunication technologies. Despite the presence of mobile operators and internet providers, the research reveals dissatisfaction among residents with the quality of communication, which became particularly crucial during the COVID-19 pandemic when reliance on technology for information, work, education, health services, and social connections increased. This underscores the global issue of Indigenous communities remaining underserved [24], a concern highly relevant to our study area.

Access to communication services becomes especially crucial when transport infrastructure is insufficient. The research unveiled gendered aspects of transportation and mobility, highlighting at least two distinct dimensions. Firstly, data confirmed that women in the study area utilize public transport more frequently than men, often due to limited access to personal transportation resulting from ownership structures or a lack of driving skills or licenses.

Interestingly, women show a higher tendency to travel by plane, often for work or family obligations. This is linked to their higher education level and employment in positions requiring travel responsibilities. Unsurprisingly, traveling by personal vehicle remains the most popular mode of mobility, reflecting the underdevelopment of public transport in the North, coupled with low population density and infrastructure challenges. For men, mobility and communication are characterized by movements with, on average, similar extents in time and space, involving visits to places within a region (traditional activities). In contrast, women's movements indicate either short distances within a populated area or long distances through airplane flights. Women's movements are either frequent and short (daily work commute) or infrequent but extended, including tourism and recreation outside the community (often simultaneously involving caretaking).

While traveling outside the region poses challenges due to its difficulty and cost, the Kolyma Road attracts both domestic and international tourists. The route's complexity, remoteness, and natural diversity make it particularly popular among extreme auto, bicycle, and motorcycle tourists [59], evidenced by ongoing motorcycle races and biker festival in Magadan, attracting participants from across Russia and various countries. Recent improvements and reconstructions efforts on the road, along with repairs, expansions, and the construction of additional structures, hint at a potential gradual increase in tourist flow and the development of less extreme types of tourism in the future.

Tour operators in areas along the Kolyma Road offer a diverse range of experiences, including car tours, visiting museums, natural sites, and attractions, trips to mines and camps of the Dalstroy era, rafting and fishing excursions, ecological tours for photo hunting and animal observation, excursions around Yakutsk and Magadan, extreme and active tours for record-setting, gold washing, and visits to mineral water resorts. Visits to former camps on the Kolyma Road fall under the category of "dark tourism", identified as a type of cultural tourism [60]. Efforts have been made to develop the Great Kolyma Trail, a network of ecological trails catering to various activities such as cycling, hiking, and skiing.

Indigenous people are playing an increasingly prominent role in the region's tourism industry. In the Oymyakon district, known for its extreme cold, the Pole of Cold festival, initiated and led by Indigenous people, has been held annually since 2001. The festival includes elements of rural tourism, offering visits to farms with the Sakha aboriginal breed of cows and horses, insights into the lives of Even reindeer herders and Sakha horse breeders, horseback riding, reindeer rides, and more. Social media coverage and media attention contribute to the growth of tourism along the Kolyma Road.

In Magadan, alongside popular festivals like the Gold Festival and Cool Kolyma, visitors can partake in traditional Even celebrations such as the beginning of the fishing season Bakaldydyak, the Even beginning of the year Hebdenek, and Reindeer Herder Day (a professional holiday established in Soviet period). However, compared to the neighboring region, these events in Magadan may not fully serve the communities culturally, socially, and economically. Unlike Oymyakon, souvenir production in Magadan is often managed by non-Indigenous individuals unfamiliar with traditional ornaments and their meanings, resulting in confusion or the creation of entirely new items. Indigenous craftsmen have voiced concern, but lack the local support and resources needed for necessary changes. Unfortunately, tourism development along the Kolyma Road appears chaotic and driven by individual initiatives, often neglecting the recognition and fair compensation of local talents. In Magadan, this is conducted without proper understanding and necessary respect to Indigenous cultural heritage.

5. Discussion and Conclusions

The primary objective of this paper is to delineate potential solutions to the long-standing and persistent problems in the study area, emphasizing the inclusion and implementation of Indigenous knowledge. The current systems fail to meet the needs of local residents and therefore should take into consideration existing knowledge and experiences for the promotion of sustainable communications and mobility.

There are common limitations of our analysis. The sample size may not be representative of the population, leading to limited generalizability of findings, while time constraints may prevent thorough exploration of the data or consideration of alternative approaches. However, using the gathered data, we were able to identify current disadvantages of the existing communication and mobility systems in the study area. Based on this knowledge, we lay a foundation for a future framework that provides better understanding, analysis, and addressing of specific problems related to mobility, territory, communication, and transport in the study area. Our findings can help guide the development of a more sustainable future where Indigenous residents of the study area can thrive in their established relationships to lands, waters, and kin.

The results of research indicate that the social structure in the study communities is more complicated than it seems. While Soviet politics of de-nomadization bound women to the settlements, leaving men in tundra [48], the present-day dynamics are more intricate [61,62]. We argue that viewing traditional activities like reindeer herding as "primitive" overlooks the formal professional criteria established in Western paradigms of social careers. Despite being seemingly confined to "primitive activity" characteristics of a hunter–gatherer society, modern reindeer herder communities demonstrate extensive knowledge in crafting their career paths. This involves not only traditional vertical growth but, more importantly, horizontal development that demands a broader range of competencies, including both general and specific professional skills. Our objective has been to illustrate that the complex system of the modern reindeer herding economy in Russia should not be misconstrued as a primitive activity, but rather as a manifestation of high adaptivity, creativity, and competence.

The existing systems are tailored for sedentary communities with formal jobs, anchoring them to specific localities and promoting vertical careers with traditional upward growth. In these systems, Indigenous communities are regarded as firmly situated on territories without significant contact between them. The movements of these communities across the land and their interdependence with the environment are not adequately considered. Their connection to nature extends beyond mere food security; it influences their identity and overall well-being. The current systems treat Indigenous communities as if they are bound to their homes and herds, and as if they do not require modern ICTs and other technologies. The reliance on roads for travel, driven by the prohibitively high costs of airfares and the absence of infrastructure, further underscores the inadequacy of the present approach. (See Table 2).

Table 2. Reaching sustainable communications and mobility system.

	Conversing with Respondents	Identifying the Problem	Solving the Problem
Mobility	"There is no reindeer herding anymore, there is no one in the woods! There were planes, the barges used to go to [from Seymchan in Magadan Oblast to Zyrianka in Yakutia] . . .but because of the [Srednekanskaya] dam the water level is low and it is only possible to travel after rains during the autumn flood. . .Also it is hard to fish on the river now. . ." (female, administration worker, Seymchan)	Challenges exist for travelling between communities and settlements in neighboring region due to a lack of infrastructure	Facilitating opportunities for communities to travel between them using both public transport and private—enhancing mobility within and between the regions
Territory	"It infuriates me that, for example in Alaska [they get support from mining companies] are doing something for the residents. But we don't have this [. . .] let them allocate equipment, let them renovate houses, or let them do something according to a social program" (female, shop owner, Magadan)	Neglect of reindeer movement and migration routes, along with overlooking hunting and fishing activities	Fostering nomadic lifestyles and supporting traditional activities to enable people to preserve their traditions and practices along with sedentary lifestyles
Communication	"I bought those two French satellite Iridium SIM-cards in Ufa for 60 thousand roubles, in Yakutsk it would be 200 thousand. . .The bank security even assumed money fraud and blocked my bank account" (male, businessman, Tomtor)	Lack of opportunities for nomadic communities to engage in communication with each other due to the high cost of satellite-provided networks	Establishing and developing the satellite network and internet services for enhanced connectivity between and within the communities
Transport	"The airplane costs more than 10 thousand, it is very expensive, taxi is 7 thousand to Yakutsk. . . it is becoming harder to travel with age, the cars are not comfortable even considering better road conditions recent year [we used] to drive in UAZ, it is hard, especially with no air conditioner [in summer]" (male, administration worker, Tomtor)	Lack of infrastructure on the road posing challenges for the well-being of people, children, women, elders, disabled individuals, as well as hindering comfortable mass transit and tourism	Establishing infrastructure for passenger transportation and relevant services on the highway, encompassing tourism and hospitality services—improving transportation infrastructure to cater both the movement of goods and people

The current situation leads to a loss of contact and relations with relatives in neighboring regions, as people lack access to transport and roads connecting communities in different regions. The existing system neglects careers that span formal, non-commercial, non-governmental, and private sectors, requiring a diverse set of competences. Lack of roads to ancestral places and shortage of fuel for private transport further exacerbate the problem, preventing connection with family and friends in nomadic and remote camps, and hindering access to help during serious events. This systemic inequality highlights the urgent need for solutions.

In order to overcome this problem, planning and development should be changed to fit the interests of Indigenous people by including them in decision-making processes. In particular, based on our experience, communications and mobility systems should be inclusive of different ways of life, conforming to both sedentary and nomadic lifestyles, movements both within and between the regions, ensuring connectivity via both cable and wireless systems, building infrastructure for both commercial and private activities, and movement of both goods and people. There are of course limitations to the proposed solutions such as resource constraints in the context of current economic difficulties, which further exacerbate institutional barriers and lack of stakeholder involvement. However, only by consulting with communities and working together on each stage of the infrastruc-

ture planning, development, and maintenance can we ensure sustainability of infrastructure and the region in general.

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