

GIS for Urban Resilience: The Case of Naryn, Kyrgyzstan

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Corresponding Author:

chynarkan.saparova@ucentralasia.org

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Chynarkan Saparova¹, Madina Junussova², Azamat Karypov³

¹University of Central Asia, Kyrgyz Republic

²University of Central Asia, Kazakhstan

³State Agency for Land Resources, Cadastre, Geodesy and Cartography, Bishkek, Kyrgyz Republic

Abstract

Amid growing climate, environmental, and governance challenges, strengthening urban resilience has emerged as a global priority. Scholars worldwide recognise the potential of digital tools such as Geographic Information Systems (GIS) to enhance local governments' adaptive planning, risk management, and service delivery. However, technological sophistication alone does not guarantee a positive impact—particularly in low-capacity, resource-constrained municipal settings such as aid-dependent Central Asian (CA) countries. The paper contributes to the ongoing debate by shifting analytical focus from GIS as a technical solution to its institutional embedding within local governance processes. It addresses a theoretical gap in the literature regarding the role of institutional absorption and readiness in shaping the sustainability of digital tools. Drawing on the Naryn town case, the study examines how digital governance interventions unfold when tailored to local capacity constraints. Methodologically, the research integrates stakeholder consultations, semi-structured interviews with civil servants, technical system reviews, and field observations of GIS usage and training. Findings reveal that institutional fit, targeted training, and iterative stakeholder engagement were more decisive for the practical uptake of GIS than the system's technical design. The study concludes that adaptive, context-sensitive GIS implementation can serve as a practical decision-support system and a catalyst for institutional transformation, offering lessons for urban resilience in similar governance contexts.

Keywords:

geographic information systems, urban resilience

1 Introduction

Mountain regions of Kyrgyzstan, such as Naryn, face persistent development challenges due to recurrent natural hazards and environmental degradation. Mountain towns remain highly vulnerable to landslides, debris flows, and floods, exacerbated by overgrazing and deforestation, which undermine slope stability and increase exposure to cascading risks (Roy,

2025; Sidle et al., 2025). Addressing these vulnerabilities requires more than physical infrastructure; it demands adaptive, locally led governance strategies that integrate spatial data into urban planning and management. Strengthening the institutional capacity of local governments through modern tools such as Geographic Information Systems (GIS) is therefore central to building long-term adaptive resilience. Digital technologies such as GIS offer transformative potential for enhancing local governance, but their impact depends on how effectively they align with on-the-ground institutional capacity. GIS can support hazard mapping, asset inventories and climate-sensitive spatial planning, yet without adequate readiness, these tools often remain underutilised and unsustainable.

Post-Soviet CA countries such as Kyrgyzstan offer a compelling example of how GIS can strengthen urban resilience, particularly as many municipalities still rely on manual or basic digital record-keeping systems that limit their ability to integrate geospatial data into policy and planning processes. The Kyrgyz case could contribute to understanding of a broader governance challenge experienced by developing countries: the mismatch between the delivery capacity of technological systems and the receiving capacity of local institutions. The history of GIS in Kyrgyzstan illustrates both progress and the persistence of this capacity gap. GIS was introduced in the mid-1990s through donor-supported projects focused on land and environmental management. Early milestones included the Kyrgyz–Swiss Cadastre Project¹ (1997–2003) and Japan-supported regional planning initiatives². GIS is widely used in Kyrgyzstan by research and academic institutions, including the Central Asian Institute for Applied Geodesy (CAIAG), the University of Central Asia (UCA), and the Austria-Central Asia Centre for GIScience (ACA-GIScience). While these efforts laid the foundation for spatial data infrastructure, high technology costs, limited human capital, and inadequate institutionalisation became obstacles for the proper introduction of GIS in urban management. The sustainable digital transformation in Kyrgyzstan still requires adaptive institutions capable of embedding new technologies into routine governance, not just one-off deployments.

Recent national reforms have created enabling conditions for bridging the opportunity to decrease the absorption capacity divide. The *Digital Kyrgyzstan 2019–2023* programme improved digital infrastructure across sectors, while the adoption of the *Concept on Digital Transformation 2024–2028* introduced a strategic focus on spatial data through the development of a National Spatial Data Infrastructure (NSDI) (GoKR, 2019 & 2024). These policy reforms

¹ GIS were first introduced in Kyrgyzstan in the mid-1990s, following the country's independence from the Soviet Union in 1991. The initial adoption was part of a broader effort to modernise spatial data management and land administration systems. The Kyrgyz–Swiss GIS/Cadastre project was implemented from 1997 to 2003 as a pilot initiative to introduce modern GIS technologies in land management. This project laid the groundwork for developing a national cadastral system and improving the spatial data infrastructure.

² In the early 2000s, collaboration with Japan led to the development of a Master Plan for Issyk-Kul, further advancing the application of GIS for regional planning and environmental management. By the mid-2000s, the systematic teaching of GIS technologies began in Kyrgyz universities, incorporating international best practices. However, early adopters faced challenges such as high costs for computer hardware and software, a shortage of skilled professionals, and an underestimation of GIS capabilities.

shift digitalisation from fragmented efforts to a more coherent national government-led agenda. However, the success of policy implementation still depends on whether local governments possess the institutional capacity to use digitalisation to produce actionable resilience strategies. Local self-governments (LSGs) play a vital role in the digital transformation, yet they remain structurally constrained despite formal mandates. The Constitution of the Kyrgyz Republic (2021) and the Budget Code (MJKR, 2025) empower LSGs to manage local affairs and generate revenue through land, resources and local taxation. In practice, however, LSGs remain reliant on central transfers and lack the expertise to mobilise locally available assets effectively. Recently, the government launched a pilot project in 2024—the *Automated Cadastral GIS Land Management System (Land Cadastre)*—in Naryn and Sokuluk municipalities. The initiative aims to enhance spatial data management and improve municipalities' capacity to manage land assets and local revenue systems through an integrated digital platform. Naryn is also the site for the Naryn Urban Resilience Programme (NURP)³ that aims to strengthen municipal capacities by engaging them in evidence-based urban planning and management, including the use of integrated GIS-based decision-making systems.

Given Kyrgyzstan's digitalisation agenda and the growing emphasis on GIS for urban management, the study examines two ongoing initiatives—NURP and Land Cadastre in Naryn—that aim to build municipal capacity and institutionalise digital decision-support systems. Rather than evaluating technology in isolation, the research explores how adaptive institutional practices emerge when digital solutions are matched with local absorptive capacity. The study examines how such an approach can close the gap between technological potential and institutional reality. By analysing the implementation of GIS through the donor funded NURP and the government funded Land Cadastre, it explores how adaptive institutions emerge when digital tools are integrated through participatory, context-sensitive processes. The findings aim to inform scalable models for embedding GIS into municipal governance in Kyrgyzstan and similarly situated mountain regions, with the broader goal of advancing resilient and inclusive urban development.

2 Literature review and analytical claim

Urban resilience is a concept for planning and managing urban development in the face of climate, economic, and social risks. Urban resilience refers to a city's ability to absorb and recover from shocks, and to adapt to future risks while maintaining essential services and social

³ NURP is a five-year (2022-2026) planning and proof-of-concept initiative aimed at transforming Naryn into a model resilient town, fostering sustainable economic growth and investment. Implemented by the Aga Khan Foundation (AKF) and the University of Central Asia (UCA) and funded by the Swiss State Secretariat for Economic Affairs with co-funding from agencies of the AKDN. Designed as an integrated model for climate-resilient urban development, the NURP blends technical assistance, capacity building, applied research, and infrastructure upgrades to foster a safe, inclusive, and sustainable mountain town that could serve as a benchmark for similar settlements in Kyrgyzstan and Central Asia.

functions (UNDRR, 2017). Local governments' capacity to effectively manage urban development is widely recognised as a cornerstone of urban resilience, particularly amid growing environmental, economic, and social risks (UNDRR, 2020; UN-Habitat, 2022). However, in Kyrgyzstan, the concept of urban resilience is inconsistently interpreted, often conflated with "sustainability," and lacks clear operationalisation in municipal governance frameworks (Saparova, 2024). This gap underscores the need for institutional strategies that extend beyond infrastructure and engage with governance and planning systems.

Building such resilience requires not only physical assets but also robust institutions capable of adaptive governance—particularly in transitioning and low-capacity settings. Originally rooted in engineering, the concept of resilience has expanded to describe the ability of socio-technical systems to absorb and adapt to shocks, including those arising from pandemics and climate change (Meerow et al., 2016). Urban resilience thinking, now embedded in SDG 11, highlights the importance of institutional adaptability, inclusiveness, and planning foresight. However, in practice, especially in countries like Kyrgyzstan, realising these goals requires overcoming persistent barriers related to institutional inertia, resource deficits, and limited planning tools (ADB, 2023). Similar obstacles are evident across other developing countries pursuing digital resilience agendas. For example, in South Africa, GIS-based planning systems introduced for flood risk reduction were underutilised due to weak municipal capacity and lack of cross-departmental coordination (Coetzee et al., 2016). Studies in Indonesia and the Philippines have shown that while GIS systems were deployed for disaster risk reduction, institutional limitations—including staff turnover, low technical literacy, and donor dependence—undermined their long-term sustainability (Leitner et al., 2008). These cases highlight that without context-sensitive institutional strengthening, digital tools such as GIS risk becoming underused or unsustainable, reinforcing the need for integrated frameworks that account for both technological delivery and institutional absorption.

Digital governance tools, particularly GIS-based decision-support systems, have emerged as critical instruments for building institutional capacities for urban resilience. GIS supports evidence-based policymaking by enabling local governments to visualise risk zones, track infrastructure, manage land assets, and foster transparency through interactive, spatially enabled data platforms (Jha et al., 2013; World Bank, 2021). In Vietnam, GIS-based flood risk mapping that combined local knowledge with spatial analysis has helped improve disaster risk assessment and participatory disaster risk management — though challenges remain in institutional uptake and sustainable data management (Tran et al., 2009). However, some case studies also highlight a persistent caveat: mapping efforts led by NGOs or community organisations may not always transition into formal municipal planning or public service delivery due to a lack of institutional ownership (Panek & Sobotova, 2015). Although donor-initiated GIS projects provide local actors with disaster-risk mapping tools, sustaining their long-term use depends on local governments' commitment to integrating spatial data into decision cycles and on stable funding and training mechanisms (Ullah & Zhang, 2020). The international cases underline that GIS is not merely a technical solution, but a governance mechanism—whose success depends on aligning digital tools with institutional processes,

human capacity, and political will. As such, the transformative potential of GIS in resilience planning lies not in its sophistication but in its embeddedness within local systems of decision-making.

Despite a promising change in the policy landscape, the institutionalisation of GIS remains uneven in many developing countries, including Kyrgyzstan, due to fragmented initiatives and a lack of systemic alignment with governance practices. Most GIS-related projects in Kyrgyzstan have been externally funded and narrowly technical, with limited integration into local planning systems or municipal workflows (Evtimov et al., 2014; Ismailova et al., 2023). Municipalities often face challenges such as poor ICT infrastructure, a lack of trained personnel, and limited coordination between agencies, all of which constrain the use of geospatial data for decision-making. Moreover, geospatial datasets are often outdated, unavailable, or locked in central repositories—limiting local governments' capacity to generate actionable insights (ADB, 2023; UN Habitat, 2022). Urban studies using GIS and remote sensing have documented land-use change and urban expansion in cities such as Bishkek, revealing patterns of green-space loss and impervious-surface growth (Ormukov et al., 2023). However, such studies primarily emphasise technical or environmental applications, with little analysis of how GIS is institutionalised in municipal governance or used as a long-term decision-support system for resilience and service planning. The literature review findings affirm the importance of shifting research focus from GIS functionality to institutional fit and long-term absorptive capacity. Addressing this literature gap requires theoretical tools that move beyond technological determinism to account for adaptive, iterative capacity-building.

To help close the identified literature gap, the research contributes to theory by conceptualising GIS adoption as a dynamic process of institutional absorption rather than technological insertion. The study draws specifically on the capacity-building tradition, which asserts that institutional change occurs through cycles of learning, engagement, and adaptation—not through linear technology transfer (Andrews et al., 2017; Tan & Taeihagh, 2020). The study challenges deterministic views of GIS implementation and instead explores how local governments in Kyrgyzstan adopt, adapt, and sustain digital tools despite real-world constraints. The study focuses on how municipalities navigate trade-offs between system complexity and usability, and how capacity-building processes shape the institutionalisation of spatial data systems. In practice, this perspective is critical for understanding why many GIS systems in low-capacity environments fail to produce sustainable impacts. Accordingly, the study does not evaluate GIS tools in isolation but examines how they interact with existing administrative routines, institutional incentives, and political commitments.

This study advances a theoretical claim that GIS-based urban resilience initiatives are unlikely to be sustained unless digital tools are aligned with existing urban governance processes and supported by the development of institutional capacity. Rather than proposing a fully specified theoretical framework or testing a generalisable model, the article uses the case of Naryn to examine how this claim unfolds in a low-capacity municipal setting. The analysis therefore shifts attention from technological implementation to institutional absorption, suggesting that the critical determinant of GIS success is not system sophistication but fit-for-purpose

integration into local administrative routines, mandates, and decision-making processes. The research question is: what institutional conditions shape the early use and uptake of GIS in ways that may strengthen urban resilience? Using the case of Naryn, the study illustrates how limited resources, weak infrastructure, and fragmented workflows can undermine GIS potential unless digital tools are adapted to municipal institutions' capacities.

3 The Background Information: Case Studies

The town of Naryn is situated in the south-eastern part of Kyrgyzstan, bordering China to the south (Figure 1). Serving as the administrative centre of the Naryn Region, the town covers approximately 84 square kilometres. According to the National Statistical Committee of the Kyrgyz Republic (2024) and its report for 2022 Population and Housing Census of the Kyrgyz Republic, Naryn has an estimated population of 41,681 people. Established in 1868 as a fortress along the historic Silk Road, Naryn has evolved into a key regional hub. Naryn is a linear town located between a mountain chain and the Naryn River—one of the Syr Darya's primary headwaters—which flows through a dramatic gorge, contributing to both the town's natural beauty and its strategic geographic significance.

Within the NURP, GIS have emerged as a key enabler of evidence-based governance. Initial expert support came from the Aga Khan Agency for Habitat (AKAH), which conducted an Integrated Habitat Assessment (IHA), and UN-Habitat, which developed the Naryn Strategic Spatial Plan (UN-Habitat, 2025). However, the municipality lacked the institutional capacity to operationalise these outputs. In response, UCA initiated targeted capacity-building efforts to promote the practical use of GIS tools by civil servants. These efforts aimed to strengthen local authority capacity in asset management, hazard identification, and the planning of climate-sensitive interventions, such as expanding green infrastructure. The process began with the development of a public asset inventory using open-source GIS platforms and evolved into the co-development of GIS-based decision support systems. NURP specifically targets municipal enterprises responsible for urban greening, waste management, and hazard mitigation. To support this integration, it combined QGIS training with the provision of GIS-enabled laptops, enabling municipal staff to conduct spatial risk assessments, map hazard-prone areas, and prioritise resilience-building measures.

The Land Cadastre, launched in 2024 by the Government of Kyrgyzstan, aims to improve land and property management in Naryn by automating and integrating municipal land administration processes, providing local governments with a powerful decision-support tool for effective spatial planning, land-use regulation, and asset management. The Municipal Property and Service Management Department is the primary administrator and user of the Land Cadastre, serving as a resource-supplying institution that maintains the geodatabase in ArcGIS. Key functionalities of the system will include i) digital cadastral mapping with parcel-level accuracy, enabling real-time visualization of land ownership, lease status, and land categories; ii) integration with national registers and systems such as the State Land Cadastre,

Unified Address Register, and Land Balance Information System; iii) interactive tools for updating and editing spatial layers, allowing municipalities to manage data on leased plots, municipal properties, utility infrastructure, and environmental assets.



Figure 1: Location of the Naryn town, created by UCA team in December 2025

4 Methodology

This study employed a qualitative case study methodology to examine the institutional, technical, and behavioural dynamics associated with the adoption and implementation of GIS in urban governance in Kyrgyzstan. The research focused specifically on the NURP and Land Cadastre initiatives, both implemented during late 2024 and 2025. These complementary interventions aimed to strengthen spatial data infrastructure and decision-making capacity at the municipal level. By integrating multi-level stakeholder engagement with practical capacity assessments, the methodology enabled a comprehensive and context-sensitive understanding of the conditions for digital innovation in local self-government.

The Land Cadastre survey was conducted from December 2024 to January 2025. Initial stakeholder consultations, held primarily at the national level, were followed by localised needs assessments in the target municipalities of Naryn town and Sokuluk village. Data collection and process analysis within Land Cadastre were led by a subcontracted firm based in Bishkek.

The research team also reviewed existing automated platforms, notably ‘Sanarip Aimak’, developed in 2022 by the public enterprise Infocom under the Ministry of Digital Development. This system supports inter-municipal and state–municipal interactions through digital engagement tools. As part of the local-level assessment, the project team conducted field visits to Naryn to conduct an in-depth analysis of the digital and institutional needs of municipal actors involved in spatial data governance.

The NURP needs assessment, conducted in January 2025, followed a three-stage qualitative data collection process. The first stage involved stakeholder consultations through a one-day workshop with the Naryn Mayor’s Office, municipal enterprises, and relevant government agencies. This consultation was designed to capture institutional perceptions of opportunities and challenges in GIS adoption, as well as to identify key actors and spatial data gaps. The second stage consisted of semi-structured interviews with heads and technical staff from municipal entities involved in spatial data management. These interviews examined current practices, assessed IT infrastructure, and evaluated institutional readiness for GIS integration. The third stage involved observation of GIS training sessions under NURP, where participants were introduced to open-source GIS software (QGIS) for developing a municipal geodatabase, including an inventory of public assets. This practical engagement yielded insights into skill-building outcomes and the potential integration of GIS tools into routine municipal functions.

5 The needs assessment results

The NURP needs assessment findings highlight a systemic gap in institutional readiness, with no formal spatial data workflows or internal protocols existing for data editing, storage, or geodatabase governance. Digital tools, particularly GIS, are not yet embedded in urban governance, thereby limiting their potential to support spatial planning and service delivery. The data management practices across municipal entities in Naryn remain largely rudimentary and fragmented (Table 1). According to the NURP team survey, six out of seven organisations continue to rely on manual record-keeping systems, with 83% of respondents reporting relying on paper-based tracking systems such as journals or logbooks (printed document created in Microsoft Word and Excel), 11% indicated the use of combined paper and digital tools, and only 6% work in a digital space. The Land Cadastre team identified the underdevelopment of the municipal archive system with over 1,200 paper-based lease records, many of which lacked geospatial referencing or contained inconsistencies in parcel descriptions. Field validation further identified that 32% of the land ownership records had discrepancies between physical and administrative boundaries—an issue compounded by historically weak cadastral systems in Kyrgyzstan municipalities.

Kyrgyzstani municipalities are in the early stages of digitalisation and remain constrained by weak human resources and limited IT infrastructure. The NURP team found that Zelenkhoz, Taza-Naryn, and the Department for Emergency Situations operate without integrated GIS platforms, often citing insufficient staffing or IT resources: 73% of respondents indicated "lack

of knowledge and skills" as a key barrier to GIS adoption, followed by 60% who cited "lack of suitable software or access to necessary data". Only 2 of 15 respondents participated in a GIS training course in the past, highlighting a significant skills deficit. The Land Cadastre survey showed that 15 out of 18 employees reported limited digital literacy. Approximately 78% of respondents had no prior experience with GIS platforms, and 61% relied exclusively on Microsoft Excel or handwritten ledgers for data management.

Municipal civil servants have uneven capacities to use GIS, which results in its inconsistent application across municipal institutions. From the 7 surveyed local institutions by the NURP team, only 3 - Taza-Naryn, Vodokanal, and the Municipal Property Management Department- reported on the periodic use of GIS. Among them, only Vodokanal has implemented a functioning GIS-based system, under EBRD support, that includes GPS surveying, orthophotography, and web-based mapping. The municipal GIS does not form part of standard operational practice but is associated with donor-supported temporary projects delivered by external GIS experts with limited local capacity building support. The Land Cadastre assessment of the national municipal information system, Sanarip Aimak, highlighted significant underutilisation and functional limitations. Although 14 staff members were registered users in the Naryn municipality, only 5 had accessed the system in the previous 6 months. The use of Sanarip Aimak is primarily limited to administrative reporting rather than geospatial functions. The Land Cadastre team's interviews indicated that initial training by the system developers lasted less than one hour, with no supporting documentation, user manuals, or helpdesk support available. Moreover, the system lacked error-reporting functionality and lacked GIS modules, rendering it unsuitable for spatial data workflows.

A significant structural barrier to institutionalising GIS is the absence of dedicated GIS units within municipal entities. The GIS Centre, established at the Naryn Mayor's Office with donor funding, is no longer operational, underscoring the institutional fragility and lack of sustained capacity. None of the NURP team surveyed organisations reported having full-time GIS specialists on staff. Instead, GIS tasks are either outsourced to consultants or performed ad hoc by existing staff. Over 85% of respondents confirmed that they lack job descriptions or institutional mandates that include GIS responsibilities. Annual digitalisation budgets were capped at 150,000 KGS (~1,700 USD), insufficient to cover licensing, system updates, or technical staffing. Due to budget constraints, these entities are unable to allocate dedicated resources to establish GIS positions or invest in necessary equipment upgrades. The assessment also revealed that many municipal offices rely on ageing computers that cannot run modern GIS software. The average computer age across departments exceeded eight years, and some offices lacked stable internet connectivity. Only four offices had computers that met the technical requirements for installing and running QGIS, and only 2 had stable internet connections sufficient for web-based GIS tools.

The Naryn case study findings empirically support the study's theoretical claim that institutional fit and adaptive capacity-building are more determinative of GIS success than technology transfer alone, especially in low-capacity urban governance contexts like Kyrgyzstan. The NURP and Land Cadastre assessments demonstrate that the primary barriers

lie not in the availability of technology but in institutional capacity for absorption. Despite national digitalisation agendas, GIS remains peripheral to municipal governance because internal protocols, spatial data workflows, and designated roles for geodata management are largely absent. The evidence of institutional fragility is the unsustainability of donor-driven GIS adoption, where externally delivered systems and training are introduced in isolation from organisational structures, resulting in limited ownership, weak integration, and ultimately system abandonment, as illustrated by the non-operational GIS Centre at the Mayor's Office.

Fragmented and outdated data systems undermine the municipality's capacity for adaptive, data-informed planning, thereby constraining Naryn's urban resilience. The majority of municipal entities continue to rely on paper-based archives or on rudimentary digital formats such as Word and Excel, thereby impeding their ability to perform spatial analysis or to respond systematically to urban risks. This limited data infrastructure inhibits timely decision-making and hinders cross-sectoral coordination—core components of resilient urban governance. Furthermore, the use of digital tools, particularly GIS, remains marginal and unintegrated. Among the seven institutions surveyed, only one reported the operational use of GIS, and even this application was project-based rather than embedded within institutional routines. These findings confirm that the mere availability of digital tools is insufficient; without formal integration into governance structures, mandates, and workflows, these tools fail to become routine instruments for planning and decision-making.

Systemic resource and capacity constraints undermine the sustainability of GIS adoption for digital governance in Naryn. The digitalisation budget is too modest to support system maintenance, software updates, or the recruitment of technical personnel. The lack of predictable financing, coupled with outdated hardware and unstable internet connectivity, prevents municipal entities from scaling digital solutions or integrating them into core operations. Additionally, the institutional capacity gaps are profound: across surveyed entities, there are no dedicated GIS roles, and spatial data responsibilities are neither formally assigned nor supported by internal protocols. These structural limitations indicate a low level of organisational readiness, with most GIS-related tasks performed informally by staff lacking the necessary qualifications. However, the findings also point to a viable pathway forward—targeted training and appropriate tool selection. Respondents consistently identified training gaps as a key barrier, suggesting that well-designed, iterative capacity-building programmes aligned with local workflows could play a pivotal role in enabling GIS to function as a practical, sustainable decision-support system in low-capacity environments.

6 The NURP tailored capacity building and local stakeholder's engagement

Earlier GIS initiatives in Naryn showed that introducing digital tools is unlikely to be sustained unless municipal staff can use them in routine administrative tasks. The NURP's emphasis on institutional capacity-building, participatory engagement, and immediately actionable GIS outputs was therefore a deliberate response to weak staffing, fragmented data practices, and limited municipal ownership of externally introduced systems. In this sense, NURP was distinctive not because it introduced more sophisticated technology, but because it prioritised institutional absorption, practical usability, and local ownership, which rarely occur in donor-funded projects. Following the suggestion by UCA research team, NURP tailored its intervention strategy in direct response to the institutional, technical, and human capacity challenges identified during the 2024–2025 needs assessment. Recognising that technology deployment alone would not suffice, NURP adopted a capacity-building model centred on institutional absorption, iterative training, and sustained local engagement. To address technical and infrastructure limitations, NURP supplied GIS-ready laptops to key municipal departments, including those responsible for land cadastre, waste management, and urban landscaping. The training sessions, tailored to local needs, were delivered offline and online via Zoom and focused on the practical application of QGIS for asset inventory and fundamental spatial analysis. The training reflected real municipal needs, facilitating immediate use by municipal departments to solve their daily responsibilities. Staff who previously lacked GIS experience contributed to the development of high-resolution maps (1:4000 scale), in use by municipal and emergency service offices for daily reference and operational decision-making (Figure 2).

In parallel, NURP facilitated a series of targeted stakeholder engagements, ranging from technical workshops with municipal departments to strategic discussions with the Naryn Oblast Administration. These engagements ensured alignment between GIS-based tools and policy priorities. Notably, the participatory process helped catalyse a broader digitalisation agenda. Building on the demonstrated utility of spatial data during the pilot phase, the NURP team collaborated with the regional government to draft a Memorandum of Understanding with the UCA. The public-private cooperation aims to develop a long-term digital governance platform that integrates urban mobility monitoring (e.g., bus route tracking) and climate-sensitive GIS-based planning of the Green Naryn 5-year plan.

The NURP team's applied alignment, initiated by UCA team, illustrates an opportunity to shift from donor and external-experts-led, project-based GIS usage to a more embedded, locally owned model of spatial governance. Rather than prioritising the sophistication of the GIS tools, the intervention focused on their fit-for-purpose integration within local routines and their capacity to generate actionable insights. The experience in Naryn thus reinforces the central argument of this study: that sustainable GIS adoption in low-capacity municipalities depends not solely on access to digital tools, but on the presence of institutional structures, training, and incentives that enable their meaningful and continuous use.

7 Conclusion

The case study findings suggest that the foundations for a more resilient and digitally enabled model of municipal governance are emerging in CA. The Naryn cases analysis presents a compelling illustration of the practical challenges and opportunities associated with introducing GIS-based tools within local governance systems in Kyrgyzstan. National digital strategies signal strong political commitment, but translating these ambitions into functional municipal reforms remains constrained by local capacity deficits. There is a promising window of opportunity to integrate spatial data tools with broader digitalisation and urban policy frameworks. To maximise the ongoing digitalisation potential, future research must focus not only on expanding digital infrastructures but also on promptly updating institutional ecosystems capable of absorbing, adapting to, and sustaining technical innovations over time. The analysis of the Naryn case illustrates how context-specific GIS implementation using open access software and data can still meaningfully contribute to strengthening urban resilience, even in low-capacity municipal settings. There is a need for simple, inexpensive GIS operational tools to support routine decision-making processes. The GIS applications in developing countries should not create additional dependence on donor resources or expertise from developed countries.



The current reliance on donor-driven pilots underscores the urgent need for a national financing framework, legal mandates, and mechanisms to institutionalise GIS responsibilities within the local government structures of developing countries. When properly institutionalised, GIS can enable municipalities to identify spatial development priorities, address service delivery gaps, and plan more resilient urban futures, transforming how local governments engage with their communities and manage their territories. Initiatives such as NURP have begun to lay the groundwork by providing essential hardware and skills development, demonstrating that even modest interventions can catalyse broader institutional change when embedded within coherent reform agendas. The adaptation of activities based on the research not only improved the institutional readiness of municipal actors but also enabled the practical application of externally developed intellectual products. When GIS tools are delivered with attention to context, embedded in existing governance structures, and supported by continued investment and training, they can serve as practical decision-support systems that significantly enhance urban resilience.

As a single-case study, the Naryn analysis cannot prove a general model of sustainable GIS adoption in local government. Rather, it illustrates a set of conditions that appear important for early uptake in low-capacity municipal settings: alignment with existing governance routines, task-based training, accessible technologies, local ownership, and continued institutional support. Further comparative research across municipalities in Kyrgyzstan and other developing countries is needed to examine whether these conditions are sufficient for long-term, sustainable GIS implementation. This approach offers an instructive model for other municipalities in Kyrgyzstan and beyond, highlighting that transformative urban governance is achievable not solely through technology, but through deliberate, grounded, and inclusive institution-building.

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Annex 1: Questionnaire for Municipal Management (Heads of Entities)

- Q1. How does your institution currently locate or browse assets to fulfil its key responsibilities? (Select all that apply)
- a. Using available maps
 - b. Via browsing systems or electronic databases
 - c. Manual search or physical inspection
- Q2. Does your institution maintain an asset inventory or asset registration book (in any format—paper or electronic)?
- a. Yes
 - b. No
 - c. I don't know
- Q3. How do you keep track of assets on your institution's balance sheet?
- a. Paper-based records (journals, books)
 - b. Electronic format
 - c. Combination of paper and electronic records
 - d. Other method (please specify): _____
- Q4. Which software or tools are used to manage the institution's asset records?
- a. 1C
 - b. Microsoft Word
 - c. Microsoft Excel
 - d. Other (please specify): _____
- Q5. Who is responsible for maintaining asset records and entering data into your institution's database? (Select all that apply)
- a. Accountant
 - b. IT specialist
 - c. Department managers
 - d. Other (please specify): _____
- Q6. How would you rate the performance of employees responsible for asset inventory and data entry (in terms of accuracy, speed, and task quality)?
- a. Very effective
 - b. Effective
 - c. Satisfactory
 - d. Ineffective
 - e. Cannot assess
- Q7. Does your department work with digital maps (for analysis or inventory purposes)?
- a. Yes
 - b. No
 - c. Partially (please provide examples): _____
- Q8. Are you personally familiar with GIS technologies (e.g., QGIS, ArcGIS, satellite maps, mobile apps, drones)?
- a. Yes, very familiar

- b. Partially familiar (please specify): _____
c. No
- Q9. Are there staff members in your institution who have received GIS-related training?
- a. I have
 - b. Staff from my department
 - c. No one
 - d. Don't know
- Q10. How do you assess the need for GIS training among your employees?
- a. Very high
 - b. High
 - c. Average
 - d. Low
 - e. No need (please state the reason): _____
- Q11. What forms of training would be most convenient for your staff? (Select all that apply)
- a. Online courses
 - b. Practical seminars or hands-on training
 - c. Internal seminars or workshops at your institution
 - d. Other (please specify): _____
- Q12. Have you been involved in past or current GIS-related projects that included data sharing or active participation?
- a. Yes
 - b. No
- Q13. [If Yes] When was this project implemented and what outcomes were achieved?
- Q14. Open Question: If the GIS project is ongoing, how are you supporting its implementation?
- Q15. Open Question: Do you have any questions, issues, or suggestions regarding GIS in your institution?

Annex 2: Questionnaire for Municipal Employees (Technical Staff)

- Q1. Do you currently use GIS programs in your work?
- Yes
No
- Q2. [If Yes] What tasks do you solve using GIS in your work? (Select all that apply)
- a. Land use planning
 - b. Visualisation and analysis of infrastructure or facilities
 - c. Development of urban infrastructure projects
 - d. Inventory of municipal or public assets
 - e. Other (please specify): _____
- Q3. What difficulties do you experience when using GIS in your work? (Select all that apply)
- a. Lack of knowledge and skills
 - b. Lack of access to necessary spatial or attribute data
 - c. Uncertainty about how to apply GIS to specific tasks
 - d. Other (please specify): _____
- Q4. [If No to Q1] What are the main reasons for not using GIS? (Select all that apply)
- a. No need for GIS in my current role
 - b. Lack of knowledge and skills
 - c. Lack of appropriate software
 - d. High implementation or maintenance costs
 - e. Other (please specify): _____
- Q5. How do you rate your individual need for GIS training in relation to your work?
- a. Very high
 - b. High
 - c. Average
 - d. Low
 - e. No need for training (please state reason): _____
- Q6. Which GIS features do you think are most useful for improving current or future processes in your organisation? (Select all that apply)

- a. GIS for asset or land inventory
- b. Spatial analysis
- c. Data visualisation on maps
- d. Database management and reporting
- e. Don't know

f. Other (please specify): _____

Q7. Do you have access to a personal computer for work purposes?

- a. Yes, I have a desktop computer provided by the institution
- b. Yes, I have a laptop provided by the institution
- c. I use my personal computer/laptop
- d. No, I do not have a computer/laptop for work

Q8. Which training format is most convenient for learning GIS?

- a. Online courses
- b. Practical seminars or hands-on training
- c. Internal seminars at the institution

d. Other (please specify): _____

e. I do not need training

Q9. How many days per month could you realistically dedicate to learning GIS?

- a. 3 days
- b. 5 days
- c. 10 days

d. Other (please specify): _____

Q10. How many hours per day could you devote to GIS training?

- a. 2 hours
- b. 4 hours
- c. 6 hours

d. Other (please specify): _____

Q11. Would you be able to combine your main work responsibilities with additional GIS-related tasks?

- a. Yes
- b. No (please state the reason): _____
- c. I don't know (please specify what might affect your workload): _____

d. Other (please specify): _____

Q12. Are you willing to conduct data collection in the field as part of GIS-related activities?

- a. Yes
- b. No
- c. I don't know

d. Other (please specify): _____

Q13. Open Question:

Do you have any questions, comments, or suggestions about GIS implementation or training?

Table 1: Analysis of the Application of GIS and Current Data Maintenance

#	Municipal Enterprise	Key Responsibilities	Application of GIS	Data Maintenance Mode
1	Naryn Municipal Enterprise for Landscaping (Zelenkhoz) – 39 employees	Carries out landscaping activities in the city, including planting of trees, shrubs and flowers, as well as maintenance of parks, playgrounds, squares and other public areas.	Not used due to a lack of staff and poor IT infrastructure	Combined: Keeps recording manually in the logs; also, electronically in MS Word and Excel
2	Naryn Municipal Enterprise "Taza-Naryn" – 91 employees	Maintenance of the traffic lights, street lighting, trash removal, as well as maintenance of bridges and road signs.	Through a donor-funded project, a GIS database was created; the system was not further deployed due to the loss of institutional knowledge.	Combined: Manual logs and electronic documents in Word and Excel formats
3	Naryn Municipal Enterprise "Vodokanal" 65 employees	Collection, treatment, and distribution of drinking water to the entire town; as well as maintenance of water supply networks	There is a GIS-based system with an interactive water supply and sewerage map that allows editing of network items and topographic layers.	GIS-based asset inventory, GPS surveying, creation of orthophotography and vector layers, and development of local and web versions of the system
4	Department for Emergency Situations in Naryn town under the Ministry of Emergency Situations of the Kyrgyz Republic	Ensuring safety in emergencies on the territory of Naryn city and Naryn district	Not used due to weak IT infrastructure and staffing within the entity	Combined: Using both paper media (monitoring books) and electronic documents in Excel formats.
5	Naryn Regional Office of the Ministry of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic – 38 employees	Monitoring, protection, and technical oversight over the natural resources, including water, forests, and land soil.	Occasionally used. Temporarily sub-contracts a GIS specialist to create a database using an open-source programme (QGIS).	Used to keep recordings manually in Word and Excel

#	Municipal Enterprise	Key Responsibilities	Application of GIS	Data Maintenance Mode
6	Naryn Municipal Enterprise for Management of Municipal Property and Provision of Services to the Population – 17 employees	Registration and control over the condition of municipal assets, their lease, sale or transfer, as well as compliance with legislation and property transactions. Also develops a strategy for the effective utilisation and preservation of municipal assets.	Participates in the pilot project on Public Order for Automated GIS-based Cadastral Web-Portal	Keeps recording manually in Excel
7	GIS Center established in 2015 through donor support at the Naryn City Hall.	At the moment this GIS centre is not functioning, and GIS data collection is not carried out.	NO	Database created in 2015-2017 project