National Spatial Data Infrastructure vs Cadastre System for Economic Development: Evidence from Pakistan

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Abstract: The growth of Pakistan's agriculture-based economy depends on elevating agriculture production and raising the per-capita income of rural communities. This paper evaluates the value of two simultaneous initiatives for the economic development of Pakistan, i.e., (i) reforming and modernization of the cadastre system, and (ii) the implementation of national spatial data infrastructure (NSDI). Both can provide crucial frameworks to assemble geographic information necessary for effective agriculture policies in the country. Their execution at the national level requires substantial technical, human, and finical resources. These mega initiatives may become highly challenging, due to the already shrinking economy of the country from COVID-19. The study makes use of an evaluation framework, official documents, such as project proposals, minutes of meetings, in addition to data collected through questionnaire and from ministries, such as the ministry of planning, development, and reforms (commonly known as planning commission), as well as Pakistan bureau of statistics. Our findings indicate that both the projects share some commonalities in terms of benefits, problems, and resources. However, the economic benefits of the NSDI project are high compared to the cadastre for the country, especially for effective agricultural policy-making. The results output will help practitioners from both systems to reduce the overlapping value, cost, and scope of the work involved.

Keywords: land; NSDI; cadastre; economic development; agricultural policy-making

1. Introduction

Spatial data (also referred to as geospatial, geographic, or location-based data) relate objects to a location on the Earth [1]. Geospatial information has substantial value for the economy and society [2,3]. Land can generate income, and therefore, is "also a key economic resource inextricably linked to access to, use of and control over other economic and productive resources" [4]. Integrated geospatial frameworks, such as cadastre and national spatial data infrastructure (NSDI), improve efficiency (e.g., time and cost savings) and effectivity of geographic information about the land for economic development. The agriculture sector in Pakistan contributes almost 23.4% to its GDP, is directly associated with 70% of rural livelihood, and engages 45% of the national workforce [5]. For such an agriculture-based economy, efficient and effective geospatial information is necessary for evidence-based policy-making to increase agricultural production and the national GDP. For instance, with the Infrastructure for Spatial Information in Europe (INSPIRE) framework, the Ministry of Agriculture of the Republic of Lithuania saved 20,000 working days gaining 1.2 million Euro indirect socio-economic benefits and 1.8 million Euro direct saving [6].

A cadastre is an up-to-date land information system (LIS) containing a parcel-based record of land interests (e.g., rights, restrictions, and responsibilities). It usually includes the geometric description of a land parcel linked to other thematic attributes regarding the ownership or control of the parcel interests and its value and improvements. It may

establish fiscal (e.g., valuation and equitable taxation) and legal purposes (conveyancing) to assisting the management of land and land use (e.g., for planning and other administrative purposes) and to enabling sustainable economic development or environmental protection [7]. Williamson [8] argues the LIS developed with accurate land cadastre and integrated with GIS technology is the fundamental infrastructure for economic development. It is well established that a well-organized and standardized LIS promotes trust for public investments and wealth accumulation, a crucial ingredient for digital business and sustainable economic development. On the other hand, an NSDI initiative is generally concerned with policy, technology, (technical) standards, people (including partnerships), and geospatial data [1]. The possible benefits of implementing the NSDI could refer to costs and time savings (efficiency gains), more effective policy-making, collaboration improvement, workflow modernization, economic development [3], better service delivery, and production of new products and services for a wide range of stakeholders. Masser [9] and Williamson [10] discussed three common objectives of most NSDIs about promoting economic development, stimulating better government, and fostering environmental sustainability. Geospatial information is widely considered one of the crucial parameters for any economic development model [11]. However, without NSDIs implementation, it is impossible to harvest full socio-economic benefits of geospatial data for national to regional development [12,13].

As compared to most developed countries, however, Pakistan is quite late in recognizing the economic potential of land-related geospatial data and their contribution towards the agriculture sector. Because the geographic information systems were relatively new to the policy-makers, who historically underestimated the socio-economic value of systematic acquiring, maintaining, and disseminating geospatial data [14]. Therefore, there had been a lack of political will to regard geospatial information as a national asset [15]. Consequently, the development of policies regarding institutional and legal issues of geospatial data always gets the least priority at higher levels [14]. However, recently Government of Pakistan (GoP) has made available a large number of public funds for 631 projects relevant to land and spatial data in the country during the fiscal year 2020-21.

The objective of the present study is to evaluate the simultaneous developments of two projects: (i) Reforming and modernization of the cadastre system and (ii) establishment of NSDI in Pakistan, to set pivotal organizational characteristics (in terms of type, size, level, roles, and resources), usage, demands/needs, motivations, and relationships with other stakeholders. To accomplish this, the study designed a framework that includes the following sub-steps. The first step is to identify the relevant key stakeholders. They include public authorities, private companies, NGOs, and academic institutions from federal to provincial public and private sector organizations. These entities produce, provide, store, manage, and use geospatial data or services or demand such resources. The second step is a survey based on official documents, such as project proposals, minutes of meetings, in addition to data collected through a questionnaire and from key stakeholders identified in the first step. Questions were formulated to determine the organization's characteristics. The third step refers to survey data analysis and some stratification analysis. The research output will help policy-makers better plan and run both megaprojects and avoid duplication of state resources (e.g., time and cost savings).

The paper is organized as follows. Section 2 describes issues and actions for the modernization of the cadastre system of Pakistan. Thus, it sets the cadastre background, identifies shortcomings and implications of the existing cadastre system. Finally, it describes the project stakeholders, their roles, and responsibilities. Section 3 provides the background and importance of NSDI for Pakistan and its key stakeholders. Section 4 describes the materials and methods used for the study, and Section 5 presents results. Section 6 draws discussions and policy guidelines for the implementation of both the NSDI and Cadastre system in Pakistan.

2. Reforming and Modernization of Cadastre System of Pakistan

2.1. Background

The Prime Minister (PM) office of Pakistan held a high-level meeting in October 2019. It was identified in the meeting that the ancient, manual, and paper-based cadastre system is the major impediment in the economic development, planning, and construction activities. Survey of Pakistan (SoP), being the national mapping agency, was given the task of modernization of the current cadastre system. Regarding this, SoP will conduct the demarcation/digitization of all state/government land and cadastral mapping of Karachi, Lahore, and Islamabad with a one-year pilot project as the phase-1 of the initiative.

The SoP submitted a detailed proposal to the PM office, knowing the project urgency, which complimented all the objectives earlier identified by the office. Additionally, the project proposal included two more project objectives identified during the document preparation phase. Thus, the final proposal set the following project objectives:

(i) To ensure standardization, uniformity, and integration for efficient management and planning of land data resources of the country;

(ii) to develop a digital cadastre (through identification and demarcation of private and state-owned land in federal and provincial governments of the country) to integrate with the land record management system of all the country provinces;

(iii) to accurately record the geographical position of land parcels, and to correctly link those parcels to land ownership, interests, and control; and,

(iv) to implement an IT-based land record management system in Pakistan.

GoP wants to start the project on a priority basis as many recent government initiatives for economic development are depending on its completion, for instance, national housing programs and the construction of industrial and agricultural zones under the mega-project of Pak-China Economic Corridor (CPEC). However, the rigidity of conventional cadastral systems is largely hampering cadastral modernization.

2.2. Shortcomings of Existing Cadastre System

The existing cadastral maps are hand-drawn lines without adopting any cartographic standards for inaccuracy [16]. These maps contain no information about the coordinate system, datum, projection, or related topographic details. Therefore, it becomes difficult to identify and locate land parcels on the ground. Moreover, it is impossible to link attribute data for land parcels to paper maps (name of the owner, area, value). The information, such as ownership, land rights, land type, and land measurement for a single land parcel, known as Khasra, is often scattered across multiple record registers, and is, therefore, difficult to retrieve and update. It often results in wastage of precious time and resources. 'Karam' / 'Chain' used to measure land parcels are always approximate and inaccurate. Land records are inaccessible to owners, and therefore, insecure being vulnerable to illegal manipulations. Trijunction pillars/Burji reference system used for existing cadastre paper maps don't exist anymore on the ground, due to natural disasters and human interventions. Therefore, the measurements based on tentative locations of these pillars/control points introduce inaccuracies.

Despite the shortcomings described above from a surveying and technical point of view, there are administrative issues in the existing cadastre system, which are generally related to the provincial board of revenues (BoRs). BoRs have a mandate to see matters concerning the land administration, collection of land revenue. Land records are not updated regularly and systematically by BoRs. It usually takes months to complete a land transaction. Consequently, land ownership rights as recorded in land registers are seldom found on the ground, and the situation causes land disputes and violence. Moreover, there is no uniformity of land data and land record management system amongst the provincial BoRs. It makes the situation verse without a federal land commission in the country, which should function under the ministry of inter-provincial coordination.

There exist redundant and overlapping efforts for setting up cadastre systems in the country. Provinces tend to implement those systems in their jurisdiction areas without

adopting uniform standards and practices. For example, the government of Sindh has recently invited consultancy services for the implementation of the cadastre system in Hyderabad [17], one of its districts. Table 1 shows the details of scope, specifications, and quantum of work.

Table 1. Phases, the scope of work, budget, and timelines for national spatial data infrastructure (NSDI) Pakistan.

Initiative	Phase	Scope of Work	Budget	Timeline
NSDI	1-Feasibility study		Rs.90 Million	One year
		i. Background Research (socio-economic impacts)		
		ii. Need analysis		
		iii. Stakeholder analysis		
		iv. Identification of critical prerequisites.		
		v. Phase-wise development plan		
		vi. Development of NSDI secretariat		
		vii. Proposed features/services offered in the NSDI.		
		vii. Success indicators and risk factors		
		ix. Management structure of NSDI		
		x. Human resource requirement and induction plan.		
		xi. Energy-efficient NSDI architecture		
		xii. Environmental impact assessment		
		xiii. Financing/investment options		
		xiv. Business model for sustainability		
		xv. Investment and operating cost		
		xvi. Governance structure of NSDI (rules, roles, and responsibilities)		
		xvii. NSDI viability (Technically, financially).		
		xviii. Preparation of PC-I		
	2-Implementation	It will be determined after phase-1	Not yet decided	Not yet decided

The provincial government of Sindh has provided more useful details (i.e., specifications for the cadastral work of approximately 50,000 acres) than the federal government department, i.e., SoP. The reason is provincial governments have local knowledge when compared with the federal government. The Sindh government identified the scope and specifications for the cadastre system, including:

(i) Measurement of the area of interest with the help of computer-oriented gadgets coordinates,

(ii) To prepare GIS/GPS mapping,

(iii)　To process Survey data in GIS environment for the development of Deh map, land register, field book, survey Bandi, F.A Yadast (in the case where old survey numbers exist), and others allied documents,

(iv)　To fix stones (line stones of Sonda) on the corner of each survey number, and

(v)　To formulate block number of 16-00 acres each ad provided under rectangulation survey manual.

2.3. Policy Implications of Existing Cadastre System

The existing cadastre system has several policy implications. For example, the absence of updated and accurate land records seriously impedes the development planning process. The planning process involves efforts, resources, and time for collecting data. No government can run without collecting taxes, such as property tax. The cadastre systems support the core framework for tax collection [18–20]. According to the World Bank report [21], Pakistan is continuously lagging in realizing its tax revenue potential. The report further suggests focusing on strengthening access to land data. However, the existing outdated and inaccurate cadastre system lacks land information. Moreover, tax collection is not guaranteed, and the country's governance system is becoming challenging. Like every government, the GoP is responsible for providing utility services. For example, clean drinking water, sewerage, telephone, and electric supply services to the public. But due to the lack of detailed land information, policy-makers face difficulties in identifying and setting the right priorities for the provision of such services.

The inaccurate and modifiable land records lead to disputes and protracted litigations by landowners, resulting in wastage of effort, money, and even life losses. Presently, around 50% of court cases are land disputes. Consequently, many development projects delay, due to ambiguous land records owing to litigations. Similarly, there is no optimal planning for land use. Some parts of the state land are illegally encroached, causing the loss of precious state revenue. Moreover, a large part of the state land, leased out to private individuals for agriculture and industries, is partially utilized for the stated purposes.

GoP is also in the process of implementing NSDI in the country. Land data is a fundamental and vital data layer for NSDI. The existing paper-based land data cannot be part of the NSDI.

3. National Spatial Data Infrastructure (NSDI) for Pakistan

3.1. Background

The GoP mandated SoP to develop NSDI to collaborate with the relevant stakeholders for the country in 2014 [22]. However, the SoP is still awaiting funds allocation by the government to start the implementation, divided into two phases for establishing NSDI in Pakistan. Table 1 shows the scope, budget, and timeline details of the NSDI project in Pakistan.

In addition to the provision of funds for the NSDI, GoP also provided funds for 1022 projects. The data collected from the planning commission indicates that out of 1023 projects completed in all 34 ministries, 62% of the total projects (i.e., 631) are related to geospatial data. Figure 1 shows the sector-wise distribution of these projects.

From Figure 1, about 84% of projects are physical infrastructure. Almost all the infrastructure development projects belong to the construction industry, a vital sector of every economy [23]. Some extensive projects include the construction of Burhan to Dera Ismail Khan motorway, approach roads to the new Islamabad international airport, and construction of a fish landing jetty and allied harbor facilities at Pishukan, Gwadar. Some major land sector projects include sustainable land management programs to combat desertification, land acquisition for Swat motorway, relocation of utilities to new Islamabad international airport, and land acquisition for CPEC. Some landmark projects in the water sector are water conservation in the rainfed area of Khyber Pakhtunkhwa province, monitoring the sea-level rise in Sindh, provision of groundwater for the industrial sector in Gwadar and Balochistan, and rehabilitating the irrigation system in Punjab. Significant projects under

the climate change set up the Geomatic center for climate change in Islamabad and the installation of radars for weather surveillance in Karachi and Multan. The overwhelming projects in food security targeted enhancement of wheat, rice, sugarcane, and pulses production. More projects established information systems for the food security of the country. They improved the production and supply of quality seed to farming communities. In the IT sector, the major projects aimed at establishing the IT industry standards, IT infrastructure for E-Offices, and NSDI for the country. Notable projects in the energy sector projects installed solar energy units in district Chaghi of Balochistan, solar lights in Nawabshah, Mirpurkhas, and Sukkur districts of Sindh province, and 20 MW hydropower project in Gilgit.
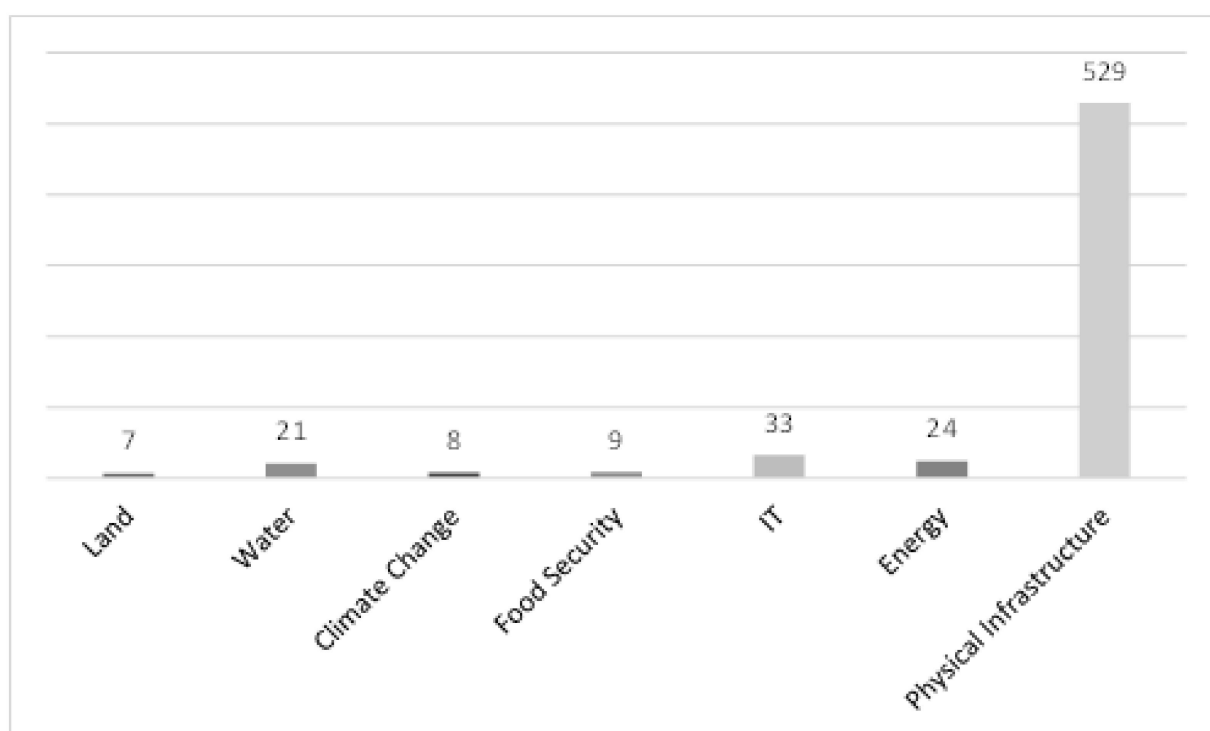

Figure 1. Sector-wise distribution of geospatial projects.

Figure 2 shows the distribution of 102 geospatial projects apart from physical infrastructure development implemented in 27 ministries. Some important geospatial data projects include the establishment of the national center of excellence in Big data, data-driven smart decision platform for increased agriculture productivity, establishment of national spatial data infrastructure (NSDI), geospatial monitoring of major and high-value crops, sustainable land management program to combat desertification, the establishment of the national center for the Internet of Things and mapping of historical and religious sites in Pakistan. Table 2 shows the details of the most significant geospatial projects in terms of budget and impact.

An enormous amount of geospatial data will be used and generated by the 631 projects implemented in 34 ministries and 43 divisions. To facilitate the efficient sharing and reuse of geospatial data for economic development, evidence-based decision making, and overcoming duplication of efforts and resources, the data needs to be standardized and managed properly through coordination, legal and institutional arrangements [14]. For these reasons, most of the countries are implementing NSDIs. In the absence of NSDI in Pakistan, sharing geospatial data, mostly produced by the public sector organizations, will remain an issue [15,24].
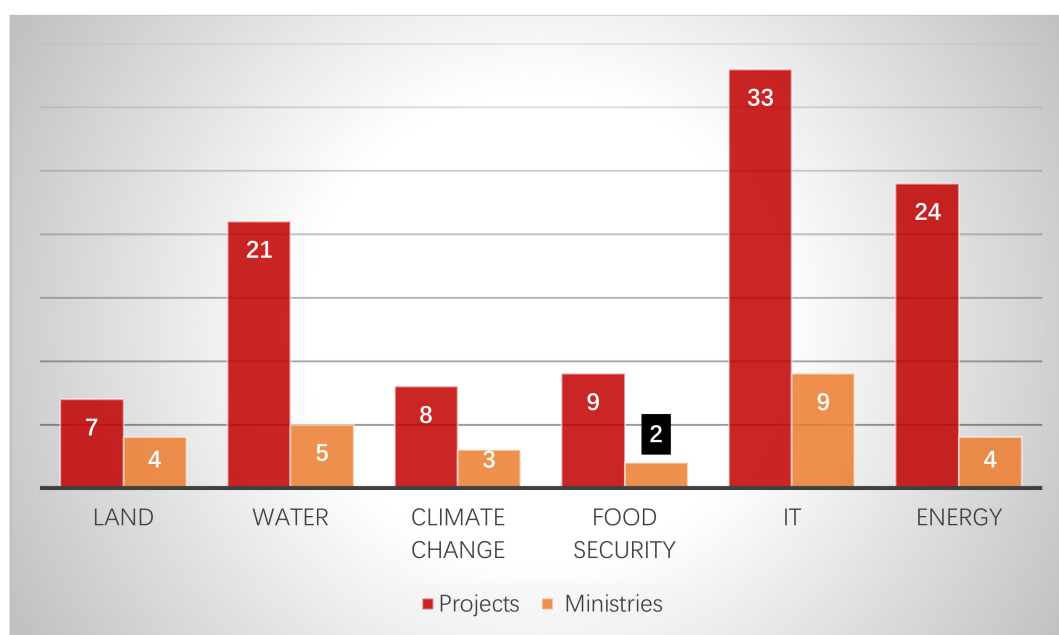
Figure 2. The number of ministries and geospatial projects in different themes in terms of budget and impact.

Table 2. The details of the most significant geospatial projects in terms of budget and impact.

Project Name	Concerned Ministry
Updating Agro Ecological Zones of Pakistan through Satellite and In-situ Data Mapping	National Food Security and Research
Establishment of National Spatial Data Infrastructure	Defense
Geospatial Monitoring of Major and High Value Crops	National Food Security and Research
Mapping of Historical and Religious Sites in Pakistan	National heritage and Culture
Geological Mapping of 50 Topo sheets of Balochistan	Petroleum
Cadastral Mapping	Planning, Development, and Special Initiatives
Pakistan Satellite Navigation Program	SUPARCO
Sustainable Land Management Program to Combat Desertification of Pakistan	Climate Change
Ten Billion Trees Tsunami Program	Climate Change
Relocation of Utilities to New Islamabad International Airport	Communications
Land Acquisition and Resettlement for China-Pak Economic Corridor	Communications
Relocation of Utilities to Lahore Ring Road	Communications
Pilot Project DTMB-A-Digitization of Terrestrial Network of PTV (Chinese Grant in Aid)	Higher Education Commission
Land Revenue Records Management System in Rural Area of ICT Phase-II, Islamabad	Science and Technological Research
National Center for Internet of Things	Information Technology and Telecom
Enterprise Resource Planning System	Power
Irrigation System Rehabilitation Project Punjab	Water Resources
National Pesticide Residue Monitoring System in Pakistan	National Food Security and Research
Establishment of Food Security Information System	National Food Security and Research
Pakistan Single Window	Revenue

3.2. Implementation Issues of NSDI in Pakistan

Survey of Pakistan constituted a coordination committee on 30th June this year during a meeting held at SoP headquarter as the first step for coordinating the NSDI implementation efforts to collaborate with the various stakeholders being the right direction according to SDI literature [1,15,24–27]. The committee comprises 16 representatives of various federal ministries, government departments, and private companies, including SoP. During the meeting, SoP also presented salient features of the prepared terms of reference (TORs) for hiring a consultancy firm to conduct a feasibility study for the establishment of NSDI for Pakistan. Then all the participants were asked to discuss and give input regarding the TORs. The representative of private surveying and mapping companies criticized the evaluation criteria prepared by SoP and highlighted the need to enrich the criteria giving

more weightage to the technical capacity of the bidding firms. The academic institutions' representatives pointed out that the bidding firms having SDI professionals as permanent staff should be given due consideration in TORs. They also mentioned that institutional aspects are more challenging than technical, while implementing SDIs. Therefore, TORs need appropriate attention to these aspects. The representative of federal government departments stated that a legal framework is essential for the NSDI.

After much effort, the finalized TORs were published on the Public Procurement Regulatory Authority (PPRA) and the SoP websites, advertised in the national newspapers, and shared on social media. Later the SoP noticed the deadline of 34 days is not enough for submitting proposals, especially for international firms. Some foreign firms reported the unavailability of any suitable and reliable local firm for the association. Consequently, the local firms, being inexperienced in the field of SDI, could not technically qualify, due to the lack of capacity required for such studies. We concluded the most impeding factors for the NSDI establishment in Pakistan include a relatively short time duration for proposal submission, capacity issues of foreign and local firms, and risks involved, due to the ongoing COVID-19 pandemic.

4. Materials and Methods

The study designed a framework that includes the following sub-steps. The first step is to identify the relevant key stakeholders. Among the government of Pakistan and national and international firms, SoP has a pivot role as the executing agency of both the initiatives, i.e., NSDI and cadastre system. With this role, SoP faces a difficult situation, due to several limitations pertaining to the technical and organizational capacities of the organization. Therefore, it is essential to decide which project should get priority or any possibility to work on both projects simultaneously, and in doing so, what are the overlapping areas between the two projects.

The second step is a survey based on official documents, such as project proposals, minutes of meetings, in addition to data collected through a questionnaire and from key stakeholders identified in the first. Questions were formulated to determine the organization's characteristics (in terms of type, size, level, roles, and resources), usage, demands/needs, motivations, and relationships with other stakeholders. To analyze this, we adapted the evaluation framework developed by Hansen et. al [28] (see Table 3 for details). It identifies decision criteria based on a systematic review of the literature. We performed a systemic literature review and identified 34 decision criteria for infrastructure projects. We organized the criteria into five groups: (Group-I) strategic fit, (Group-II) owner philosophies, (Group-III) project funding and timing, (Group-IV) project requirements, and (Group-V) value engineering. After critical examination, only 29 criteria were included being relevant in the context of this study. For instance, from group-II, the decision criteria "maintenance philosophy" was not considered to be too specific to civil engineering projects. Similarly, from group IV, criteria "determination of utility impacts" and from group V, criteria "value engineering procedures", "material alternatives", and "constructability procedures" were not considered. Therefore, these criteria were marked as "not considered". We formulated a questionnaire to take input from stakeholders on items in Table 3.

The third step refers to a survey data analysis to compare the cadastre system and the NSDI projects through the adapted evaluation framework. For data acquisition, the questionnaire was distributed among the respondents to assign a score from 0 (least important) to 2 (most important) to each decision criterion. To accomplish the survey campaigns, SoP frequently organized meetings where representatives from the public and private organizations were invited to give feedback for the NSDI establishment and Cadastre system in Pakistan. The sampling scheme consists of 100 federal government and provincial government organizations engaged in spatial data production, academia, and private surveying and mapping companies. The respondents were representatives from the key organizations, including 5% from SoP as the executors, 15% represent various

federal government departments, 30% representatives from provincial governments, 28% represent academia, and 22% representatives from private companies.

Table 3. Decision criteria identified by Hansen et. al [28] for infrastructure projects. The criteria are organized into five groups: (Group-I) strategic fit, (Group-II) owner philosophies, (Group-III) project funding and timing, (Group-IV) project requirements, and (Group-V) value engineering.

Group	Decision Criteria	Cadastre System	NSDI
Group-I Strategic Fit (SF) This group comprises ten criteria and focuses on project issues.	1. Needs and Purposes criterion analyzes the needs and purpose of a project in the light of its importance.	Economic development, to solve ongoing land disputes between people, and to stop and reclaim state land encroachment.	Economic development saves spatial data collection and management cost, and overcome duplication efforts for spatial data.
	2. Consistency criterion analyses the alignment of the project with national development goals and strategic defense aims.	The project perfectly aligns with SDGs adopted by the GoP. And large-scale data for security forces is also required for precise counter-terrorism activities.	The project is in accordance with e-Government initiative being implemented since 2005.
	3. Government Priority criterion analyses the project's importance regarding the national economy at national and regional levels.	The project is the priority of GoP.	It is important, but is not a priority of GoP.
	4. Investment Studies criterion is related to the feasibility and other investment studies required during a project planning process.	Detailed and high resolution data of the project is extremely needed for "precision agriculture" [29] and economic development in Pakistan.	For evidence-based development planning, multiple spatio-temporal datasets are required, which can only be available through NSDI.
	5. Economic Issues and Impacts: This criterion is concerned with examining the issues and effects of a project in relation to the economy.	The project would boost the construction industry of the country, and therefore, positively impact economic development.	The project would reduce duplication of financial resources, and therefore, would have a positive impact on the economy.
	6. Social issues and impacts of the project.	Food security, poverty alleviation, and better housing facilities are all social issues faced by the country. The detailed project data would help to overcome these issues.	Social issues, such as clean drinking water, better housing, and health facilities require multiple datasets presently not accessible would become available through NSDI.
	7. Environmental Issues and Impacts criterion focuses on the issues and impacts of the project concerning the environment.	This project will be partially useful to overcome environmental issues, such as the loss of green areas.	Pakistan faces various environmental issues, such as air pollution, loss of biodiversity, solid waste management, and climate change. Climate change is a crucial threat to Pakistan [30]. Twenty-two datasets were identified by [31] to combat climate change. NSDI would have a positive impact being a data-sharing initiative.
	8. Team and Stakeholder Coordination criterion analyzes the coordination among the team members and stakeholders of the project.	Poor coordination has been observed among the stakeholders.	There is lack of coordination for NSDI development in Pakistan [32].
	9. Public Involvement criterion is concerned with the fact that how much the public is involved with the project and what is their attitude regarding the project.	Although the public is not involved in the project. Moreover, resistance from local governments does exist.	No direct involvement of the public, however, the representatives of various sectors are on board [33].
	10. Good Governance: This criterion analyzes the contribution of the project towards good governance.	The project outcome will contribute to achieving good governance as illegal land occupation is one of the critical causes of corruption in Pakistan.	The project outcome will contribute to achieving good governance.
Group-II Owner Philosophies This group consists of seven criteria and focuses on the necessary information, which is needed to understand the project from the owner's perspective.	11. Design Philosophy criterion focuses on the design of the project to ensure its success.	The project is not well designed so far, due to the urgency of the GoP.	The project is well designed and in accordance with set norms of the planning commission.
	12. Operating Philosophy criterion examines the level of service, which is required at a sufficient capacity over an extended period.	SoP does not possess sufficient capacity to complete the project within one year.	SoP does possess sufficient capacity to carry out a feasibility study, but as per GoP's rules, it has to be carried out by a third party.
	13. Maintenance Philosophy criterion focuses on the maintenance of the project.	Not considered	Not considered
	14. Future Expansion criterion is concerned with any possibility regarding the alteration or expansion of the project in the future.	The project is likely to expand after a successful pilot project.	No further expansion.
	15. Innovation criterion assesses the innovation of the project.	The outcome will contribute to bringing innovation to the land market.	The outcome will contribute to bringing innovation to not only the land market, but also in many other sectors.
	16. Risk criterion assesses the level of risk, which is involved with the project.	The highest risk is the limitation of time, i.e. one year.	No risk of time, however, being a long term project, changing priorities of the coming governments may hamper the project.
	17. Contractual Conditions and Procurement criterion examines the conditions and models which the project takes into consideration.	Finalized, but guidelines to check the quality of outsourced work not yet ready.	Bit tough contractual conditions, such as at least one year of experience does exist in the ToRs.

Table 3. *Cont*.

Group	Decision Criteria	Cadastre System	NSDI
Group-IIIProject Funding and Timing This group comprises of three criteria dealing with the objectives of the project, which are related to the funding and timing constraints.	18. Funding and Programming criterion deals with the funding and programming sources of the project.	No issue of funding as GoP is providing funds.	No issue of funding as GoP is providing funds.
	19. Preliminary Project Schedule criterion deals with the schedule of the project	Despite having a preliminary project schedule, achieving the set milestones could not be possible in the planned time frame.	Well planned schedule does exist; however, COVID-19 may impede achieving the set milestone.
	20. Contingencies criterion is concerned with the contingencies in order to calculate the risks of the project.	No contingency plan to mitigate the project's risks.	No contingency plan to mitigate the project's risks.
Group-IV Project Requirements This group comprises of ten criteria, which are concerned, with the requirements of the project.	21. Project Objectives Statement criterion is concerned with the objectives of the project.	The project objectives are difficult to achieve, due to quite a short time period.	Almost all the objectives are achievable.
	22. Functional Classification and Use criterion is concerned with the functionality of the project, which would be either public or private.	The project is for public welfare and use.	The project is for public welfare and use.
	23. Evaluation of Compliance criterion is used for analyzing the requirements of the project according to the existing plans, standards, and regulations.	The project will complement the existing plan of NSDI-Pakistan and Naya Pakistan Housing Program [34].	Among others, the project will support the existing plan of E-Government, SDGs, and Pakistan single window [35].
	24. Existing Environmental Conditions criterion is concerned with examining the existing environmental conditions for the sake of making better decisions.	Poor existing environmental conditions.	Good existing environmental conditions.
	25. Site Characteristics criterion analyzes the difference between the existing characteristics and required characteristics.	The site is good enough for the project.	There is a discrepancy between the available site characteristics and the required site characteristics. However, a separate office will be constructed.
	26. Dismantling and Demolition criterion is concerned with the requirements, which are related to the dismantling and demolition of the project.	No such issue of dismantling and demolition.	Presently no issue, but the implementation stage may be problematic.
	27. Determination of Utility Impacts criterion analyzes the adjustment of the utilities for the designing and construction of the project.	Not considered	Not considered
	28. Work Force criterion analyzes the work force needed for the project.	Not sufficient work force is available in the department.	Not sufficient trained work force is available in the department.
	29. Resource Handling and Utilization criterion is concerned with the handling and utilizing the resources for the project.	The available human and technical resources are being utilized properly.	The available human and technical resources are being utilized properly.
	30. Scope of Work criterion examines the scope of work of the project.	Well defined scope of work.	Well defined scope of work.
Group-V Value Engineering This group consists of four criteria, which examine the function of the project to enhance its value.	31. Value Engineering Procedures criterion analyzes the project for consisting of value engineering procedures.	Not considered	Not considered
	32. Design Simplification criterion focuses on simplifying the design of the project.	The specifications of the project design could not be well defined, due to time limitations.	Will be determined after a feasibility study.
	33. Material Alternatives criterion focuses on alternatives materials to use in the project.	Not considered	Not considered
	34. Constructability Procedures criterion is concerned with the construction constraints of the project.	Not considered	Not considered

5. Results

5.1. Stakeholders Analyses for Cadastre System

The study identified high-level stakeholders from the federal and provincial governments. These governments further consist of ministries, divisions, sub-divisions, departments, and authorities running several projects initiated by the current government. For instance, Naya Pakistan Housing and Development Authority (NAPHDA) is running under the ministry of planning, development, and special initiatives, known as the planning commission of Pakistan, Billions Tree Tsunami initiative is running under the climate change ministry, SoP is working under the ministry of defense. Other relevant ministries include Finance and Revenue, Industries and Production, National Food Security and Research, Water Resources, Forests, and Rangelands, among 34 ministries. The planning

commission of Pakistan is an apex federal body led by the Prime Minister. It has a mandate (i) to release all funds to other departments, (ii) to manage Pakistan's socio-economic development strategically and sustainably, and (iii) to providing state land data. NAPHDA is a newly established corporation to deals with planning, development, construction, and management of real-estate schemes and housing projects of the current government. SoP is responsible for the on-ground execution of land-related projects, including surveying land, collecting attribute data, preparing digital cadastral maps, and integrating these maps with land record management systems of provincial boards of revenues. The PM Office, however, identified the NAPHDA, SoP, and the planning commission as the major stakeholders of the cadastre system.

5.2. Stakeholders Analyses for NSDI

There are 34 ministries under which 43 divisions administratively function at the federal level in Pakistan (http://www.pakistan.gov.pk/index.html, accessed on 23 November 2020). Hundreds of departments are working under the 43 divisions. Similarly, there is a long list of private companies dealing with surveying and mapping activities. Although, it is mandatory for these companies to register with SoP according to the surveying and mapping act, 2014 [22], but, so far, only 62 companies have registered as mentioned on the website of SoP (http://sop.gov.pk/, accessed on 23 November 2020). The purpose of registering these companies is to regulate the geospatial industry and also to determine the size of the industry of Pakistan. Many NGOs and academic institutions are also dealing with geospatial data. In principle, these all are stakeholders of the NSDI.

5.3. Survey Data Analysis

After receiving scores from all, Figure 3 shows the average calculated scores. Out of the total 58 points, the obtained scores for the cadastre and the NSDI was 43.5 (75%) and 45 (77.6%), respectively. Figure 3 indicates the weak areas of the cadastre project spread almost evenly over all groups. The weak areas include needs and purposes, investment studies, environmental issues and impact, public involvement, design, and operating philosophy, innovation, contractual conditions, and procurement model, preliminary project schedule, functional classification, and use, and environmental conditions. The NSDI initiative proved weak in some criteria. The main impediments for the NSDI project include lack of consistency, government priority, social issues and impacts, team members and stakeholder coordination, good governance, future expansion, risk, unclear and wide objectives, evaluation of compliance, and site characteristics.
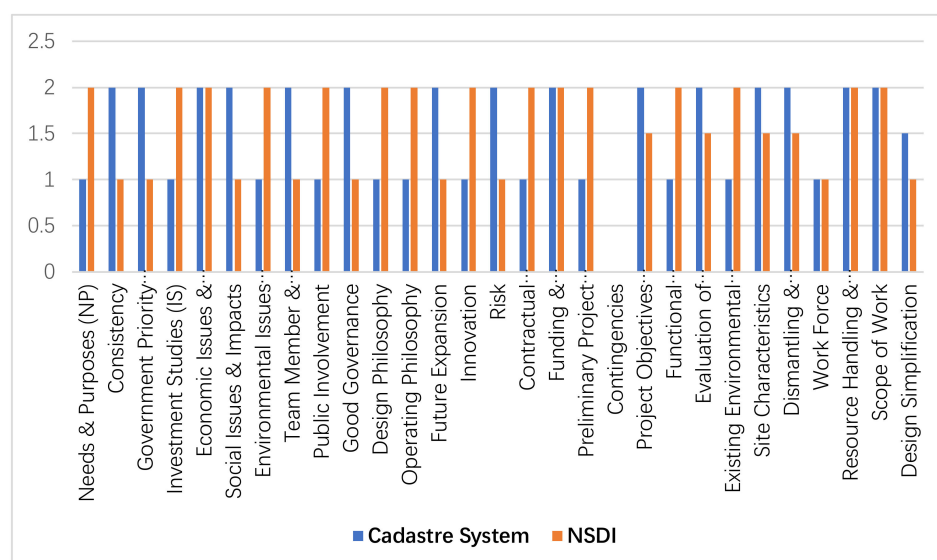

Figure 3. Average calculated scores for each Cadastre and NSDI criterion.

6. Discussions

This study evaluated the two national-level mega-projects recently initiated by the SoP, i.e., NSDI and the national cadastre system. To do so, it adopted a framework developed by Hansen et. al [28] and compared the two projects on 29 criteria ranking to a total of 58 points. The overall comparison shows the NSDI is relatively more important for the Pakistan government. Similarly, the alignment of the NSDI with national development and defense goals is well established. However, compared to NSDI, the cadastre project is a priority for the Pakistan government, which is of utmost importance for authorities to achieve their political objectives. The prime minister personally monitors the progress of the cadastre project. It shows the government's keen interest in the project. Besides, we analyzed the NSDI is more effective in addressing social issues and good governance. However, NSDI has several risks being a long-term project spreading over 6-10 years, and the too broad objectives of the NSDI. On the other hand, the objectives of the cadastre system are clear, short-term, and of political nature. For example, the cadastre system is a prerequisite for the NAPHDA program announced by the government. ToRs for the NSDI establishment available on the SoP website (http://sop.gov.pk/, accessed on 23 November 2020) shows the implementation of the project would require establishing a new secretariat. Presently, the design specifications for the NSDI are not explicit and would be available after the completion of phase-I of the project, i.e., feasibility study.

Both the initiatives (i.e., reforming and modernization of the cadastre system and establishment of NSDI) follow a top-down approach. The cadastre project started with the PM directive, and the NSDI started following Surveying and Mapping Act 2014 [22] passed by the federal government. The provincial governments maintain cadastre records through their boards of revenues. The forest departments in all the provinces hold records for most of the state land. Moreover, the Auqaf departments in all provinces are the custodian of land records of religious sites in the country. The key stakeholders are the province governments, boards of revenues, forest, housing, and Auqaf departments of all provinces. Private stakeholders from the housing sector include only housing societies and the defense housing authority. Almost all the stakeholders are provincial government departments, whereas the project executing agency (i.e., SoP) is a federal government department. It creates a vertical hierarchy of state power, and therefore, provincial government departments are reluctant to give access to their land record. Thus, the project progress suffers, due to the lack of coordination between the federal and the provincial governments.

The scores for both the cadastre and the NSDI projects are similar, i.e., 43.5 (75%) vs. 45 (77.6%), respectively. It is because about 87% of respondents perceive that through establishing NSDI, GoP can eliminate redundancies and duplication of data collection and promote the harmonization, dissemination, and use of spatial data. However, the cadastre data serves as one of the core data sets required for the successful implementation of NSDI, including topography, hydrology, administrative boundaries, geographic names, and geodetic framework. Therefore, the survey respondents perceive that the cadastre development (i.e., parcel-level geospatial data) will ultimately be a part of the NSDI implementation.

Policy guidelines for Cadastre system development in Pakistan

The present study found several findings based on which the following suggestions can be incorporated for the proper implementation of Cadastre system development in Pakistan.

- The survey respondents from SoP Peshawar raised the issue of the definition of state and government land. They believed the state land and government land are two different concepts, whereas GoP has used the two terminologies interchangeably with the same meaning. The issue was well taken by the SoP top officials who emphasized to resolve it for the proper implementation of Cadastre system development in Pakistan.
- The survey respondents from the federal organizations noticed the list of identified stakeholders is highly shallow for the cadastre system development in Pakistan. For

instance, the list excludes the provincial forest departments being the prime custodian of state land in all provinces. Similarly, the Auqaf departments were missing, which are the custodian of religious sites, e.g., mosques, temples, and shrines in all the country provinces. Therefore, SoP was not able to access land records possessed by these departments. Similarly, private housing schemes, defense housing authorities, and military land cantonments were missing from the stakeholders' list.

- During survey campaigns, a political issue highlighted by the respondents is provincial organizations in Sindh and Balochistan, being non-allies of the ruling party, should be aligned with the federal organizations to fasten the project's progress. The BoRs should give access to land records in these provinces for the smooth implementation of the project.

- A technical issue highlighted by the respondents is the obsolete spatial reference system used in paper maps. It demands the definition of a new, unified, and standard reference system for the project to overcome data integration issues. Accuracy is questionable, due to centuries-old maps and distorted relevant paper records.

- Due to limited human resources, SoP is hiring consultancy firms for cadastral mapping. However, it requires setting up a monitoring and evaluation (M&E) office to ensure data integration from all the consultancy firms.

- Cadastral mapping demands a dense geodetic control network of very high accuracy. Such a network does not exist so far. It will seriously affect the accuracy of cadastral maps. Moreover, the integration of the cadastre data will be problematic.

- The survey respondents from all public and private organizations highlighted a standard data model is crucial to the cadastre system development in Pakistan. Since there is no national cadastral system in Pakistan, all the provinces implement different data models and often do not give access. Therefore, a single data model may not be sufficient to integrate existing land records from all the provinces. No study conducted so far to analyze the issue of harmonizing different data models at the provincial level.

Policy guidelines for NSDI development in Pakistan

The present study findings recommend the following policy guidelines for the proper NSDI establishment in Pakistan.

- During the survey campaigns, the respondents from public departments at the provincial level showed reluctance to the NSDI establishment, since most of the stakeholders for the NSDI project are public sector organizations at the federal government level. However, the private sector organizations and academia showed immense interest in the NSDI establishment, which is a healthy sign for the long-term implementation of the initiative [24]. For the successful NSDI implementation in Pakistan, we suggest increasing the stakeholders from both public and private organizations at the provincial level.

- About 78% of the survey respondents found the NSDI project faces the limited capacity of national and international firms besides that of SoP, tough ToRs for hiring consultancy firms, the time duration for proposal submission, and the prevailing COVID-19 situation around the globe. While the cadastre project faces main constraints from the limited access to land records, distorted and paper-based records, different data models, lack of coordination, political conflicts of stakeholders, lack of trained staff, and the SoP's limited human resource capacity.

- About 98% of respondents from the private sector organizations raised issues of national data sharing policy. Presently, the survey of Pakistan, the custodian of core data sets, poses strict restrictions on their share and reuse. To fulfill the spirit of both the Cadastre system and NSDI, they suggested the SoP should revisit their policies regarding data sharing and reuse. Decision-makers, civil servants, researchers, professionals, and even civil society should be able to access spatial datasets through standard web services for better policy-making. It requires revisiting national spatial

data policy for disseminating geospatial data, and achieving it, develops practical tools (e.g., national geoportal).

- About 90% of the survey respondents from federal organizations suggested systematically assessing the SoP's present and future needs regarding the necessary resources required for the successful development/implementation of Pakistan NSDI. Such assessments should analyze the SoP (institutional) capacity: (i) To undertaking and managing the NSDI, (ii) to delivering the necessary services to its potential users, and (iii) to proposing the optimal arrangement, and structure to ensure the seamless provision of such services. It means that a thorough assessment of the ground situation at SoP needs to take place based on a checklist derived from SDI Components [36], CO-BIT [37], and IGIF (https://ggim.un.org/) pathways. Such detailed assessments are only possible by organizing in-depth interviews/discussions with key stakeholders (particularly with the SoP staff members).

- Some respondents suggested enhancing the capability of SoP in leadership, someone who promotes and coordinates the NSDI development. Because leadership remains one of the challenges and risks considered critical in the execution of mega-projects like NSDI and the national cadastre system. Therefore, investigations are required to analyze the capability of stakeholders for outreach and capacity building activities, which specifically lead to political support for NSDI. According to the previous works and the literature, in the stand-alone stage of organizational development, the individual organizations do not consider the NSDI as such, and as a result, NSDI leadership is lacking. It is widely considered a risk factor for failure of NSDI, which should be addressed by planning for the awareness of the importance of coordination and increasing the likelihood of introducing potential leaders. This process would result in the accepted leadership of one or a limited number of entities. Such a leadership should satisfy the geospatial community.

- Management of information and good governance are the two important elements that must work together to form the bases of effective decision-making. There must be a synergistic relationship between good governance and information whereby good governance creates a healthy legal, institutional, and socio-political-economic framework for information to flow, and the information flow, in turn, facilitates sound decision-making for good governance. Therefore, decision-making requires the support of legal, institutional, and technological frameworks that enable equitable access to information and transparency of decision-making across government, private sector, and the community. The NSDI development is, thus, vital to good governance.

- Agriculture plays a key role in the economic development of Pakistan [38]. However, its contribution to the gross demotic product GDP is declining for the last decade. The country is in dire need to promote digital and precision agriculture to increase agriculture production and reduce costs. These initiatives might take advantage of the NSDI development and availability of geospatial data in the process of digital transformation to become more efficient (and to cut costs) to deliver improved and new services to innovate.

One limitation of the study might be the stakeholders of both the cadastre and the NSDI projects belong to national federal, and provisional organizations. It is partially due to both projects are in the initial stage. Future studies should focus on identifying international donor organizations that often support developing countries in these projects. For instance, the World Bank often finances the developing countries for national Geoportal and NSDI standards, building up institutional capacities, improving technical infrastructure (e.g., communication networks, WEBGIS). Future studies may identify international donors like Food and Agricultural Organization (FAO), USAID, Swedish International Development Cooperation Agency (SIDA), State Secretariat for Economic Affairs (SECO), and German Agency for Technical Cooperation (GTZ) as potential stakeholders.

7. Conclusions

This study evaluated the value of two development initiatives for the National Spatial Data Infrastructure (NSDI) and the cadastre system in Pakistan using the 29 evaluation criteria.

Results show, out of the total 58 points, the obtained scores for the cadastre and the NSDI was 43.5 (75%) and 45 (77.6%), respectively. There are overlapping areas between the two projects; however, both projects are not the same in terms of scope and volume. Cadastre remains a core data set in NSDIs, including orthophotomaps, topography, hydrology, administrative boundaries, geographic names, and geodetic framework. Whereas the dissemination of geographic information in NSDIs is not only limited to land parcels, but also other geospatial and thematic data sets, e.g., satellite imagery, transport networks. Therefore, about 87% of respondents perceive that through establishing NSDI, GoP can eliminate redundancies and duplication of data collection and promote the harmonization, dissemination, and use of geospatial data. Thus, the study concludes that the cadastre development (i.e., parcel-level geospatial data) should be a part of the NSDI project.

For an agriculture-based economy like Pakistan, efficient and effective geospatial information is necessary for evidence-based policy-making to increase agricultural production and the national GDP. The study concludes that the NSDI development will return more economic benefits to the governments at the provincial and federal levels. For this, however, SoP has a limited capacity of human and technical resources. Therefore, we recommend the continuation of NSDI feasibility for one year through hiring experienced consultancy services. Besides, we urge to resolve the political conflicts between the governments at different levels. The provincial organizations in Sindh and Balochistan, being non-allies of the ruling party, should be aligned with the federal organizations to fasten the project's progress.

Both projects are significant for the country in terms of value, cost, and scope. Policy guidelines from this research output will help policy-makers better plan and run both megaprojects and set key organization characteristics, such as priority, type, level, and role.

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