Abstract

Land-titling programs in low-income nations have provided the opportunity to leverage the application of geospatial technology to support low-cost titling and expedite implementation. The spatial data acquired and managed in land administration is often a cornerstone of a broader spatial data infrastructure (SDI) in a country. Geospatial technology use in land titling is often viewed narrowly in scope; consequently the benefits associated with its application are not adequately examined. This is reflected in the economic models used in evaluating the feasibility of land administration programs, typically through metrics such as Economic Rate of Return (ERR). After first describing the multipurpose nature of geospatial technology and examining the key attributes of spatial data infrastructure, this paper will examine qualitatively the benefits often considered in the economic models used for evaluation of land-administration programs by multilateral development banks. The goal is to convey the multipurpose nature of geospatial technology and why it should be given greater consideration when evaluating land-administration projects.

Key Words

geospatial, land titling, spatial data infrastructure (SDI), cadastre, economic rate of return (ERR), geodetic, continuously operating reference stations (CORS), global navigation satellite system (GNSS), geographical information system (GIS), computable growth equilibrium framework

Introduction

In this paper, we will highlight the multipurpose nature and economic value of a modern spatial data infrastructure (SDI). In addition, we will review the metrics by which investment decisions are made
regarding the use of spatial technology in land-registry projects, and discuss an alternative approach of measuring the enormous benefits of geospatial technology that may be taken when assessing the economic viability of land-registration projects. We will look specifically at how organizations that provide development funding for land projects, such as the World Bank and the Millennium Challenge Corporation (MCC), evaluate potential investments. We focus on development organizations because they offer a record of well-documented, land-administration projects and use rigorous conceptual frameworks that evaluate both the direct financial impact as well as economic externalities that are likely to occur.

A critical component of the land-registration process is the efficiency with which the geometric data that define the extents of adjudicated boundaries of land are captured, processed and stored for easy retrieval and management. In land registration, spatial technology plays the critical role of defining physical characteristics of land parcels in an accurate and discernible manner. Indeed, without this physical definition, title to land has little economic value because it lacks the fundamental information needed to define its value both to the owner and to others. The World Bank’s recently published Land Governance Assessment Framework (LGAF), which examines the land tenure systems in five distinct developing countries, establishes that, while initial land registry may take place without significant attention paid to the spatial characteristics of land, lack of a geometric definition of parcels in land-title registration has detrimental long-term effects that carry high economic and social costs. It is unsurprising that 12 of the LGAF’s 21 Land Governance Indicators suggest a strong need for spatial data infrastructure. While not limited to land registry, the need for spatial data centers around registries, because assets are defined and owners and occupants are aligned with them when land is registered. Registry information feeds a multitude of other land-management functions such as property taxation, land-use planning, administrative and infrastructure planning, and more (Deininger, Selod, Burns, 2012).

When incorporated into a land registry system, high-quality spatial data facilitates greater efficiencies in land markets by helping to define property boundaries, area, and location to an extent that a parcel’s physical features are not disputed. In areas where the demand for land is high, the demand for accurate spatial data typically is also high. This dynamic between land markets and varying spatial data accuracy is well-understood and well-documented and has long since justified the development and management of cadastral systems. The cadastre is a database that combines many different forms of spatial data for land management, including land parcels, administrative boundaries, and so on. Importantly, the cadastre provides fundamental spatial data to the land registry system, which in turn feeds physical and non-physical parcel data back into the cadastre. This continuous exchange of data between the cadastre and
the land registry system highlights the fact that cadastres are dynamic systems that are constantly evolving and incorporating new information. As a source of spatial data that is current, the cadastre is therefore also a valuable resource for other segments of society and ultimately serves as a catalyst for greater spatial data use. A country’s SDI, which contains many types of spatial data and technology, is heavily reliant on cadastral systems. It is this relationship between land data and the broader SDI that begins to expose the multipurpose nature of spatial data.

Adoption of cadastral systems and realization of the benefits they provide may not be easily achieved in the developing world due to myriad challenges. Many developing countries may not have legacy institutions; even if they do, the institutions often lack the necessary technical capacity and resources to deploy modern, cost-effective spatial data capture and management techniques. In some instances, spatial data legitimacy has suffered due to regime change or radical ideological shifts in a country. While these reasons are of concern and should not be ignored, developing countries are in fact in a fortunate position. Just as cellular technology has enabled most of the developing world to bypass fixed-line telecommunications infrastructure, SDI, of which the cadastre is a fundamental component, helps developing nations avoid years of gradual, costly technology adoption similar to what has taken place in the developed world. More importantly, the cost of this kind of technological leap-frogging is insignificant in comparison to the tremendous economic and social benefits to be accrued. Although land registry is often first in line to benefit from such technological change, the benefits of a well-designed investment in modern SDI can permeate through to agriculture, transportation, utilities, construction, mining, forestry, hydrocarbons, meteorology, seismology, and water management.

Multilateral development institutions such as the World Bank, United Nations Development Programme (UNDP), and others have long recognized the role of land in stimulating and sustaining economic development. The critical role of enhanced land tenure security and its role in poverty reduction have been at the core of recent land-reform projects, mainly in the developing world. Many bottlenecks in the efficient delivery of land administration can be traced to inadequate technology use in the process of securing title to land and its long-term management. Geospatial technology in particular has been increasingly popular with land administrators due to, among other things, the power of spatial data to define the physical characteristics of land. Not surprisingly, spatial data holds tremendous value outside the land sector as it is utilized by other government, civil society, and private-sector entities in a multitude of functions. Despite its growing popularity, investment in geospatial technology is often made within the parameters of only one or a few uses, and thus may be inadequate to ensure that the benefits of spatial data can be realized by greater society. This paper will first outline the components of a modern SDI and
its benefits to society. We will also discuss the role SDI plays in land administration, and provide a qualitative examination of the metrics used in evaluating land administration projects by development institutions. Our examination is intended to encourage the use of geospatial technology by shedding light on the potential benefits to be realized by investing in SDI, not simply within the parochial scope of land registration projects, but holistically. As a key metric of evaluation, we focus on Economic Rate of Return (ERR) calculations, which are often used as the criteria for the assessment of the economic viability of projects.

**What Constitutes Modern SDI? What is its Value?**

There is no benchmark that defines what a modern SDI is or is not, but it is useful to consider the inherent characteristics of a modern SDI that provide benefits to society:

- system interoperability (openness);
- integration of old and new technologies; and
- system accessibility for multiple stakeholders, such as government entities, private individuals and companies, and civil society.

A Booz Allen Hamilton (2005) study of interoperability of geospatial technology found that, through examination of the savings-to-investment ratio, projects that adopt interoperability standards experience overall costs that are 30% lower on a comparative basis. In general, implementation costs are higher when interoperability is a central component of the project, but this higher initial investment brings up to 26% savings in operation and maintenance costs. This dynamic is reflected in the long-term risk profile of a project, which is found to be higher where interoperability is ignored, because investment decision-making is supported by mutually accepted data and procedural norms. Continuous operating reference stations (CORS), which provide the basis for the use of a common reference frame (or common coordinate system), add significantly to the interoperability of an SDI because of the ease of ubiquitous collection of spatial data. A 2009 study funded by the National Geodetic Society of the USA estimates the value of the national spatial reference frame, of which CORS is a significant part, is approximately $US2.4 billion per year. While not assuming that the use of CORS in the USA is similar to that in the developing world, the study highlights the benefits that may be achieved (Leveson, 2009). Geographic information systems (GIS) also facilitate interoperability by providing a platform for analysis of multiple spatial datasets, as well as by allowing for spatial and non-spatial data to be combined into a dynamic functional geographic database.
Modern SDI also supports the integration of the old and the new. In many countries there are legacy technologies and institutions that are responsible for spatial data acquisition and analysis. While SDI development today requires the adoption of new technology such as surveying using global navigation satellite systems (GNSS) or real-time networks (RTN), it supports integration of data collected using conventional surveying techniques as well. The latter provides a framework that supports adoption of new surveying techniques by practicing professionals over a period of time. This possibility of integration of technologies reduces the adverse impact of radically changing data-collection methods while improving productivity and capacity (Lemmon, Wetherbee, 2005; Rizos, 2007). Often in land titling initiatives, time constraints for completing the titling process drive the use of more efficient technologies. Traditionally, the learning curve in adopting new technologies acts as a disincentive for its acceptance by practicing professionals. However, the possibility of integrating a number of data sources irrespective of the methodology that underpins the data collection in modern SDI provides a relief to professionals who are slow to adopt new techniques.

Accessibility of data to multiple stakeholders is an absolute necessity for any functional SDI. SDI is not simply a tool for land-administration professionals, but a dynamic resource that provides spatial data to public and private entities in numerous sectors for a wide range of tasks. It is therefore imperative for us to examine the critical components of a functional SDI.

The Role of Geodetic Infrastructure in SDI Development

Before discussing further its multiple functions, the term “modern spatial data infrastructure” requires better clarification. Modern SDI is a combination of hardware, software, education, training, and regenerating capacity for the acquisition, analysis and maintenance of spatial information. In an ideal world, SDIs are entirely interoperable, accessible, and contain dynamic geo-referenced data acquired from a variety of sources. A cadastre contains a large portion of this data and acts as a primary spatial database. The efficiency achieved by using SDI does not only justify its cost, but also facilitates the increased adoption of spatial technology that generates greater economic benefit. Under these circumstances, SDI affects the use of spatial data in a repetitive manner, encouraging spatial data users to continue to leverage the infrastructure.

In reality there exists great variation across markets from SDIs that take full advantage of cutting-edge geospatial technology to fragile systems void of modern technology and technical capacity among users. The inclusion of GNSS technology in cadastral development has brought profound changes to surveying
Spatial technology professionals are transitioning from heavy reliance on optical instruments towards an integrated approach that combines optical instruments, GNSS, remote sensing, GIS, and other technologies. Combining technologies allows an increase in spatial data coverage, and provides alternatives for professionals collecting data in variable, diverse environments where one data-collection technology may perform better than others (Dale, 1999; Acharya, 2009). Importantly, modern cadastral systems utilizing CORS that provide real-time positioning have benefitted the most from GNSS technology. CORS improves productivity for surveyors and mappers, increases the speed at which projects are executed, and improves the accessibility and collectability of spatial data for non-survey professionals (Stanaway & Roberts, 2010; Allen Consulting, 2008). CORS networks, which are a series of GNSS stations distributed over space and tied together with software and communications technology, allow for real-time geodetic monitoring as well. This reduces costs to authorities responsible for maintaining geodetic data, which previously required significant time and manpower to monitor widely dispersed static control points. This improved method of geodetic control provides the critical common reference frame for all other spatial data in the market and provides a common framework for collection of data (Levenson, 2009; Federal Geographic Data Committee, 2008).

In the context of land registry and titling systems, CORS networks have increased the speed and reduced the cost with which land parcels can be surveyed, which has brought greater efficiency to the critical early phases of systematic titling. Work flows for titling lands are improved due to rapid production of parcel maps and greater overall transparency of the physical attributes of parcels. Adjudication remains a process which is affected by many variables unassociated with spatial information. However, the ability to demarcate boundaries when disputes arise is streamlined and made more efficient because of the use of CORS, which may improve the dispute resolution process following systematic land registration. Perhaps more important is how CORS improves the sustainability of dynamic land records by providing a geospatial framework that enhances the ubiquitous determination of location; this facilitates and reduces the cost of updating land records with new geometric data and attributes following transactions. (Rizos, 2007, 2008).

It is helpful to understand how CORS can help land-administration systems (and other spatial data systems) remain current as land markets change. Dynamic land markets are prevalent in developing and developed nations alike; changes in land use, zoning, urban expansion, agricultural technology, and many other factors can change the value of land and transaction volume in a short time. As the value of land increases, so does the demand for a highly accurate geometric definition of land. Such accuracy is unattainable using orthophotos, and traditional survey methods are simply too slow to conduct large-scale
parcel mapping. CORS provides a ground-solution technique of positioning determination that is appropriate for the collection of data delineating the boundaries of parcels directly in the field, and is faster than remote sensing technology that requires for the boundaries of parcels to be clearly visible to allow for ease of identification. Remote sensing technology as the basis of data collection has been observed to be ideal from an economy-of-scales perspective but is technically not appropriate (Dale, 1999). CORS networks provide a backbone for effective parcel data collection on a common reference frame, which allows for integration of affordable, high-accuracy data into a modern SDI. Therefore, in an environment where land markets are extremely volatile, geospatial technology can facilitate effective land transactions through improving field data collection solutions to reflect changes in boundaries and ownership information.

The “Multipurpose-ness” of Geospatial Technology and the Role of SDI

Rapid advancements in information and communication technology and in the science of positioning determination have increased the traditional use of spatial data and spawned new applications. The upsurge in the demand and utilization of spatial information has given rise to an increase in the size of the geospatial technology industry. Daratech (2006) estimates that, on a global scale, the geospatial industry grew by 27% per annum over the period 2002 to 2004. The economic value of the British Geological Survey alone to the United Kingdom’s economy is estimated at £GB40 million per annum (Roger Tym & Partners, 2003). The total output of China’s geographic information industry was estimated to be worth over $US10 billion in 2010, with an estimated direct value to other industries in excess of US$63 billion at the close of 2010. Oxera (1999) estimates the value of the geographic information industry in Europe in terms of the amount of investment as €10 billion annually. While there is a lack of data on the aggregate value of the global geospatial industry, it is clear that the industry is growing and is providing tremendous value to society. Meanwhile, steady growth among the industry’s private sector over the past decade is highlighted by a rapid increase in the number of users, both inside and outside traditional fields of surveying and mapping. Technical advancements have facilitated the growth of new and diverse applications for spatial data, increasing productivity in many sectors previously unconnected to the geospatial industry.

The increase in the adoption of geospatial technology has occurred globally, but mainly in the developed world. The increase in the use of geospatial technology has been underpinned by a considerable investment in spatial-data infrastructure, along with the recognition by a large number of public and private sector stakeholders that spatial data can improve efficiency, productivity, reduce risk, and improve the decision-making process. Alongside the land management community, generic infrastructure such as
roads and rail, precision agriculture, mobile tracking, mining, utilities, and many other industries are already making heavy use of spatial data. Another critical component in the rapid adoption of spatial information for greater economic activity is the remarkable progress in information communication infrastructure, which encompasses the management and sharing of data across different platforms and in different interoperable formats.

Activities that are predicated on spatial information have leveraged the technology mainly for productivity gains. Spatial information has contributed greatly to the major gains in agriculture, fisheries, and forestry sectors. It has assisted the agricultural industry in improving production while reducing cost, and enabled governments to use the technique to control and minimize the impact of pest and disease (ACIL-Tasman, 2008) Controlled-traffic farming, soil and salinity mapping, improved climate and weather forecasting, whole farming, and more-efficient water management have contributed significantly to the agriculture industry. The adverse impact of the expected growth in global population on food security calls for innovative ways of improving global food production and security, making the effective use of spatial information technology of crucial importance in agriculture. (Roberts, 2009)

In forestry, innovative airborne technology such as light detection and ranging (LIDAR), amongst others, advancement in satellite imagery processing, and customized use of GIS software have enhanced more-effective management of forests, both for commercial use as well as environmental preservation. Spatial information is utilized for yield estimation, managing harvesting plans, and ensuring regulatory compliance, all of which improve the efficiency of commercial forestry. Meanwhile, the role the world’s dwindling forest cover plays in combating the adverse effects of climate change on the global economy, underscores the relevance of spatial technology in facilitating a more sustainable management of already scarce forestry resources. Multilateral programs such as Reduction of Emissions in Deforestation and Forest Degradation (REDD) and other forest carbon projects rely heavily on a multitude of spatial technologies as well as large amounts of spatial data.

Spatial technology has been deployed to enhance maritime monitoring, which has increased safety, improved port logistics, aided emergency response, and facilitated protection of ocean resources from over-exploitation. Developments in mapping have allowed for precise management of marine habitats and more granular biodiversity surveys. The latter have produced more information on marine species and proved invaluable in enhancing both ocean-resource exploitation and protection of marine resources. In the fisheries sub-sector, more effective mapping of fishing grounds has accounted for major improvements in production and facilitated a more sustainable management of our globally declining fishery stock.
In mining, spatial technology has permitted detection and more-effective exploitation of mineral resources by assisting in precise location and modeling of ore caches. Heavy machinery guided by GNSS solutions, coupled with more-effective 3D modeling of the location of ores, have resulted in improved efficiency in ore excavation with a direct impact on production. Today mining entities run systems that manage all the site resources in real-time, allowing for effective use of all available resources to assure more-efficient production and effective cost control. The positive economic impact of spatial technology in mining has generally been regarded as the cost savings in production and the value of ores that would have gone undetected without the use of spatial technology.

Because of the multitude of engineering and management challenges in large civil projects, the construction sector has been an aggressive adopter of spatial technology. From site surveys to stakeless construction to corridor modeling, spatial technology use in the construction industry is driving cost reduction and increasing productivity. Faster, feature-based collection of field data, using a combination of GNSS, optical instruments, inertial and airborne sensors along with robust project management software, facilitates effective management, reduces inputs, and shrinks the carbon footprint of projects. Spatially precise 3D data directs GNSS-guided heavy machinery to reduce inputs, construct higher-quality assets, and manage assets in real time. Developments in spatial technology have allowed for more-effective modeling of route corridors to assist in determining the optimum alignment of rail, road and pipeline routes, which in turn has a significant impact on the cost of the resulting construction projects. From an economic perspective, all of these benefits to the construction industry result in faster completion of better-quality assets, meaning that the economic benefits to be gained through early completion of projects reach society faster and remain over a longer period.

Today, utilities companies have field teams equipped with technology that enables them to capture the location, status, and other attributes that allow for more effective management of their assets to assure improved performance, customer satisfaction, growth in client base and revenue. Asset tracking has also been leveraged by communication companies, which tend to have a great amount of their resources fixed at locations that require constant management in order to ensure adequate service provision.

The transport industry is essentially spatial in nature and has relied on maps and geographic information for its efficient operation over the ages. Advancements in mapping and GIS have made it feasible for more-effective management of transport systems, facilitating efficiency in the movement of goods and services. From road- to air-traffic management, geospatial information is reducing cost, improving safety and delivering production levels hitherto inconceivable. The location-services industry has evolved with
advancements in mobile resource tracking that allow for more-effective deployment and routing of resources.

Spatial information also finds application in the building of disaster early-warning systems, management of response to natural disasters, and effective administration of public safety. Today new applications in spatial technology are enhancing both conventional and internet retailing and making the impact of advertising more pronounced. On-going research will underpin the emerging trend in the use of geospatial technology by the mainstream consumer market.

CORS infrastructure provides the fundamental framework which enables the effective application of geospatial data as outlined above. The seamless acquisition and exchange of data that an active, real-time CORS infrastructure provides enhances rapid acquisition and leverage of spatial data for an ever-increasing variety of applications. The benefit to this common association is not simply an overall reduction in costly data acquisition and processing, but also the increased speed at which decision-makers can act effectively. Supported by CORS, the purposes and uses of spatial data infrastructure are many and are a central part of all land-based activities.

**Sustainable Land Management and Geospatial Technology**

Advancements in spatial data infrastructure, brought about by utilization of information communication technology and positioning determination, have made a tremendous impact on sustainable land management. From creation of land use plans to management of cadastral records, the impact has been an overall reduction in the cost of spatial-data acquisition and efficiency in data storage, retrieval and management.

Land records prior to the evolution and adaption of information technology were literally held in huge piles of paper documents that occupied copious amounts of space in land registries around the world, often described as a mausoleum of parchment (Dale, 1999). Retrieval of records for clients seeking information was not only cumbersome but additionally an extremely lengthy process. Today, cadastral management software solutions support conversion of existing records into electronic format to facilitate integration of existing records with new ones and provide a more-effective means of managing the data and generating reports.

A combination of GNSS technology, optical instruments, photogrammetry and remote sensing are providing more cost-effective ways of gathering geometric data on the boundary of parcels and associated attribute information to establish the ownership of the parcels in a cadaster. Remote sensing and photogrammetry provide economies of scale in the collection of cadastral data, but only in situations
where the delineated boundary can be identified clearly with accurate spatial characteristics in the captured imagery. As a result, traditional or conventional methods of ground survey still tend to meet the accuracy and statutory requirements of surveying adjudicated boundaries of parcels for cadastral purposes.

GNSS survey provides remarkable advantages over the traditional optical methods of ground survey by reducing both the time and cost of data acquisition. Utilizing independent GNSS surveys or geodetic network solutions permits ubiquitous positioning determination at varying degrees of accuracy depending on the type of network. Geodetic networks provide services that allow for the adoption of positioning beyond the requirements of cadastral survey and indeed a fundamental infrastructure that enhances a myriad of economic activities.

Office applications that allow efficient processing, management and sharing of the collected data have enabled the use of cadastral systems for multiple purposes. Today, the reduction in cost and increased benefits of advancements in technology are making formalization of land rights for the poor in the developing world more feasible than before. The World Bank figures on recent major, land-right formalization projects show that the costs of projects vary between US$20 million to US$250 million (Dale & McLaughlin, 1999). Most of these projects involve a substantial amount of mapping, adjudication and parcel surveying and registration. All these activities are now heavily dependent on spatial technology for efficiency and productivity. Sustainable land management from will continue to rely on spatial technology for both efficiency and the sheer range of services that can be offered to clients.

**Conventional Assessment of the Economic Return on Land Reform Projects**

Feder & Feeny’s 1991 review of land reform projects funded by multilateral development banks in recent times reveals that often the objectives and the benefits anticipated have revolved around three main outcomes of conventional titling, namely:

- Increased tenure security, which can incentivize investment in land improvements;
- Enhanced access to credit, thanks to the use of documented land as collateral;
- Stimulate and facilitate functional land markets required to drive economic activity.

Permutations of the objectives outlined above have often underpinned recent efforts of leveraging land reform to address poverty reduction and to trigger and sustain economic growth in the developing world. Multilateral development organizations have recognized that land-tenure projects can be a catalyst for development in both urban and rural areas, and have been financing land-registration and titling projects for some time now. Development banks use both quantitative and qualitative metrics in vetting potential
land projects, the most common of which are net present value (NPV) estimations, financial internal rate of return (FIRR), and economic rate of return (ERR). Of these, ERR seems to hold the most weight in the evaluation process, as ERR incorporates not only the rate of return the project itself achieves, which is essentially the FIRR, but also all of the expected positive and negative externalities associated with the project. Calculated as shown below, ERR is essentially the cost of capital ($r$) that would be needed for society to gain zero benefit from the project as given by Shinnar, Dressler and Feng (1989) and also in Massimo (1999).

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ERR = r \text{ where } \sum_{t=1}^{n} \left( \frac{(Economic\ Benefits_t - Economic\ Costs_t)}{(1+r)^t} \right) = 0
\]

Thus, high ERR values suggest a project will have a substantial economic return. For many development finance institutions, the baseline for cost of capital is 10 percent, which represents the opportunity cost of the investment. Therefore an ERR of 10 percent or more suggests that a project is worthy of investment.

Supposing multiple potential projects are investment-worthy from the standpoint of ERR calculation, the discussion shifts to resource allocation. Here, critically, is where the benefits of spatial data infrastructure have by and large failed to be conveyed. Economic externalities modeled in ERR calculations tend to remain narrow in scope, linking externalities brought on by investment closely to the theme of the project. In land-titling projects, for example, seldom is there mention of economic impacts of spatial data infrastructure outside the land sector. Because of this, investment in spatial technology in land-titling projects may be constricted so that technology chosen to complete the project is not robust enough to support other societal functions, both public and private. Table 1 below provides a short list of examples of positive externalities modeled in land projects conducted by the World Bank and the Millennium Challenge Corporation (MCC).

<<INSERT TABLE 1: Land Project ERs and Positive Externalities Modeled>>

Externalities often modeled in land-titling projects do, rightly, include important changes such as incremental increases in land value, positive changes to the financial sector, agricultural yield, and lower transaction costs. However, land-management-system sustainability brought about by the availability of spatial data is not always captured in the models, nor is the benefits of spatial technology used in land projects to the non-land sector. The fear for spatial technology professionals and industry experts, therefore, is that investment in spatial technology will be insufficient to support a long-term, sustainable land-management system that can simultaneously support broader spatial data needs across society. In short, spatial technology use is not currently at the forefront of the project evaluation process, and
therefore the multitude of benefits that could be realized from investment in spatial-data infrastructure are sometimes left out of the evaluation.

A Non-Conventional Approach to Evaluating Land Projects

Pohl and Mihaljek (1992), in a review of 1,015 World Bank projects worldwide and across a number of sectors, found that there was a noticeable divergence between pre-project appraisal estimates and actual post-project benefits. They attributed the variation to the inability of the Little and Mirrless (1968, 1974) methodology used by the World Bank and other multilateral development banks to capture variations of critical parameters of the investment model. The 1992 study underscores the need to develop other approaches of estimating investment return that incorporate the full range of variables that underpin projects in general. The economic benefits of SDI are far-reaching, as revealed by the spectrum of applications of spatial data.

However, attempts at developing a rigorous conceptual framework for measuring these benefits have proved daunting. This is partly due to the multipurpose and ubiquitous nature of SDI in almost every part of the economic and social sphere.

It is in view of the above that the work of the Allen Consulting Group (2008) among others, which aimed at evaluating the economic impact of SDI on certain sub-sectors of the Australian economy, was pioneering as well as educative. The ACIL Tasman (2008) study of the value of spatial technology to the Australian economy was ground-breaking as the first known attempt of establishing the aggregate economic impact of spatial technology in an economy. The approach determined the aggregate economic impact of investment in geospatial technology by capturing its footprint throughout the Australian economy in terms of its impact on GDP, using the computable general equilibrium framework (CGE).

The ACIL Tasman (2008) study offers an empirical model of the economy-wide impacts of geospatial technology, focusing on 22 key sectors of the economy. While the study is supported by Australian data, the model incorporates potential impacts on segments of the economy that are critical to almost every country and particularly to developing countries rich in natural resources. Most notably, agriculture, natural resources, construction, transportation, utilities, communications, and, importantly, government productivity are closely scrutinized. Due to the fact that an SDI is founded on robust modern geodetic infrastructure, it is important to note that the ACIL Tasman (2008) study focuses heavily on the provision of real-time spatial data. In terms of achieving both real-time data acquisition and data accessibility, geodetic infrastructure is a requisite investment, particularly in providing these services on a national scale. Adoption of the approach will provide a good measure of the economic benefits to be accrued from
investments in geospatial technology, which is at the foundation of modern land administration systems. It is anticipated that the existence of a more comprehensive estimate of the benefits to be derived from SDI will significantly alter the outcomes of conventional models adopted in the determination of the viability of land projects by multilateral development banks.

One of the drawbacks to the CGE framework, however, is its colossal data requirement, which may prove a constraint in many developing countries where data is not readily available. In the absence of data in Ghana, the World Bank instead applied the empirical results of the ACIL Tasman (2008) study in estimating the economic return on investment in Phase 2 of the Ghana Land Administration Project for a period of 20 years. The project investment over the implementation period of five years is US$75 million, followed by a recurrent operation cost of US$1 million annually for the remaining 15 years. Project benefits are not expected to occur until the investment phase is complete, allowing for 15 years of benefits to be realized. Starting with a very conservative impact on GDP of 0.08%, the project ERR was estimated at 15% using the standard project opportunity cost of 10%. Increases in the impact on GDP from 0.08% to 0.1% and 0.4% generate ERRs of 21% and 49%, respectively, were estimated.\(^1\) One notable aspect of the World Bank estimate is that even the most aggressive assumptions of impact on GDP in Ghana fall short of the lowest estimated impact of spatial technology on Australian GDP given in the ACIL Tasman (2008) study. Given this conservative application, the results of a post-implementation evaluation and how it compares to the pre-project assessment will be revealing and informative at the end of the project.

While Ghana’s SDI is developing, it has active mining and agriculture sectors and a generic infrastructure deficit, so the expectation is that the economic impact of the investment in a nationwide geodetic infrastructure will be much more pronounced than in the case of Australia. Furthermore, Ghana’s economy is heavily reliant on land, from agriculture to forestry to mining. This reliance on land, as well as rapid land-price inflation spurred by speculation and urbanization, highlights the need within land-governance institutions to leverage spatial data to streamline land management, improve delivery of title, and continue to develop Ghana’s SDI. This can be done by updating and actively managing and sustaining land market activity. Recognizing the broader importance of SDI economy-wide, Phase 2 investment by the World Bank in Ghana’s SDI goes beyond the scope of land administration and facilitates investment for a broad user base. There are linkages between a robust SDI and the proliferation of spatial data throughout society. The Phase 2 approach is a welcome advancement in thinking holistically about investment in spatial technology.

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\(^1\) Similarly, cost-benefit ratios for the same three GDP impact scenarios were 1.45 (0.08%), 2.09 (0.1%), and 8.37 (0.4%).
Conclusion

We discussed the importance of modern spatial data infrastructure, highlighted its components, its functionality across much of society, and examined its use in the administration of land. We outlined that a modern SDI, while difficult to define holistically, allows for system interoperability, facilitates the integration of old and new technologies, and, importantly, is accessible to multiple stakeholders. We showed that an integral part of modern SDI is a strong geodetic infrastructure that serves as the backbone of the entire system. Through a ubiquitous positioning framework, data can be collected in a cost-effective and efficient manner and leveraged in a variety of applications hitherto inconceivable. We further explained how spatial data is no longer confined to a cadre of surveyors and mapping professionals, but rather is used in huge volumes by many different actors in industry, government, and social sectors.

Secondly, an analysis of economic return on investment brought about by land-administration projects funded by multilateral development organizations looked at the role spatial technology plays in evaluating the viability of a project. Our main objective in this evaluation was to highlight the need for greater consideration of the inclusion of benefits and costs of spatial technology when modeling economic externalities. Through comparing the methodology used in the ERR calculation for Phase 2 of the Ghana Land Administration Project with other conventional ERR calculations, we exposed the possibility of using an evaluation approach which allows for the incorporation of the broader benefits to society brought about by investment in geospatial technology in land projects.

The use of ERR to determine the viability of projects has both strengths and limitations. Like most financial and economic modeling techniques, ERR is flexible and therefore requires sound and objective controls to be applied so that the externalities associated with a project do not become too numerous or too few. While we accept that the externalities applied by multilateral development organizations to land-project evaluation are justified and supported by economic research, our suggestion is to further examine the possible benefits of technology used in these projects. The ERR comparison made in this paper is largely qualitative in nature, and, as indicated by the Project Appraisal Document provided by the World Bank for Phase 2 in Ghana, quantitative studies of the value of spatial data infrastructure in the developing world are limited because of the unavailability of data. We recognize that the computable general equilibrium framework is data-demanding. However, it is an approach that can be refined to capture the many benefits of geospatial technology to a myriad of sectors of the economy and assist in modeling the real economic impact of projects that involve investment in geospatial technology. Where CGE is deemed inappropriate for use and conventional modeling prevails, we suggest that additional
benefits of geospatial technology be considered to support the appropriate amount of investment that will facilitate sustainable land management and strengthen a country’s SDI. It is certain that the ease of adoption of geospatial technology will continue to increase as result of advancements in technology and an increasing demand for spatial data across society. The provision of appropriate geospatial technology is therefore of paramount importance in enabling and sustaining land-reform projects. In addition, it is our hope that this paper will spark further dialogue between industry, government, and development organizations, and hopefully get us closer to understanding how we as the development community can use geospatial technology to eliminate poverty and improve the quality of life for all.
Table 1: Land Project ERRs and Positive Externalities Modeled

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>ERR (Modeled)</th>
<th>Positive Externalities Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>MCC</td>
<td>20%</td>
<td>Lower transaction costs&lt;br&gt;Land value increase&lt;br&gt;Increase in agricultural productivity</td>
</tr>
<tr>
<td>Madagascar</td>
<td>MCC</td>
<td>31%</td>
<td>Leveraging land to raise capital&lt;br&gt;Financial sector improvements&lt;br&gt;Increased investment in land&lt;br&gt;Improvements in land management</td>
</tr>
<tr>
<td>Mongolia</td>
<td>MCC</td>
<td>38.5%</td>
<td>Improved access to land financing&lt;br&gt;Land value and rental price increase&lt;br&gt;Increase in return on land investment</td>
</tr>
<tr>
<td>Mozambique</td>
<td>MCC</td>
<td>13%</td>
<td>Land value increase&lt;br&gt;Lower transaction costs&lt;br&gt;Improved access to land</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>MCC</td>
<td>29%</td>
<td>Land value increase&lt;br&gt;Lower transaction costs</td>
</tr>
<tr>
<td>Croatia</td>
<td>World Bank</td>
<td>31%, 77% *</td>
<td>Lower transaction costs&lt;br&gt;Improved access to spatial data</td>
</tr>
<tr>
<td>Honduras</td>
<td>World Bank</td>
<td>18.6%</td>
<td>Land value increase&lt;br&gt;Improvements in land taxation&lt;br&gt;Reduction in land conflicts</td>
</tr>
<tr>
<td>Vietnam</td>
<td>World Bank</td>
<td>38% (FIRR) **</td>
<td>Increased investment in land&lt;br&gt;Improvements in land taxation&lt;br&gt;Financial sector improvements&lt;br&gt;Land use/planning efficiencies&lt;br&gt;Eliminating redundant government functions</td>
</tr>
<tr>
<td>Ukraine</td>
<td>World Bank</td>
<td>**</td>
<td>Increased investment in land&lt;br&gt;Increase in financial liquidity&lt;br&gt;Improvements in rights protection&lt;br&gt;Land use/planning efficiencies&lt;br&gt;Improved rental markets&lt;br&gt;Increase in agricultural productivity</td>
</tr>
<tr>
<td>Philippines</td>
<td>World Bank</td>
<td>24%, 36% ***</td>
<td>Increase in agricultural productivity&lt;br&gt;Land value increase</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>World Bank</td>
<td>17%</td>
<td>Increase in agricultural productivity&lt;br&gt;Improvement in soil conservation&lt;br&gt;Land use efficiencies</td>
</tr>
</tbody>
</table>

* 31% over 4 years, 77% over a 10-year period ;  ** No ERR calculation done
*** 24% in the first project, LAMP, and 36% in the second project, LAMP II
References


