UN·IGIF
INTEGRATED GEOSPATIAL
INFORMATION FRAMEWORK

UNITED NATIONS INTEGRATED GEOSPATIAL INFORMATION FRAMEWORK

FUNDING GUIDE

December 2024

Audience:

The intended audience for this Funding Guide is any person or organisation that is involved in developing geospatial information management strategies and Country Level Action Plans (CAPs) to support UN-IGIF implementation.

Acknowledgement:

The preparation of this Funding Guide has been led and supported both financially and in kind by the General Authority for Survey and Geospatial Information (GEOSA) of the Kingdom of Saudi Arabia.

Disclaimer:

This document has been prepared based on the information available at the time of its creation. While every effort has been made to ensure accuracy, readers should exercise their judgment and consider additional sources or advice as needed.

Contents

Citation: UN-IGIF, 2024, Funding Guide for Implementation of the UN-IGIF, United Nations, New York

Foreword

Geospatial information is a vital national resource for achieving social, economic, and environmental progress, yet securing financial support for geospatial programs and initiatives is often a challenge. In 2018, the United Nations Integrated Geospatial Information Framework (UN-IGIF) was adopted by the United Nations to provide comprehensive guidance to Member States on developing and strengthening geospatial information management and related infrastructure to drive sustainable development. While numerous Member States utilized the UN-IGIF to realize substantial benefits and positive outcomes, for some, securing funding for this initiative continues to be an obstacle.

Recognizing the challenges in obtaining financial support for geospatial initiatives, the United Nations created a High-level Group of geospatial experts to provide strategic leadership and guidance, and as Co-Chairs of this High-level Group, we are committed to helping Member States advocate for resourcing. As geospatial executives, we have firsthand experience advocating for funding within our respective governments – the United States and Cameroon. We understand that despite the clear benefits of geospatial initiatives like the UN-IGIF, securing financial backing can be challenging amidst competing priorities and economic uncertainty.

To assist Member States in overcoming these challenges, the High-level Group formed a Sustainable Funding Work Group, comprised of geospatial and financial experts from Member States, Academia, and the Private Sector. Following extensive research and targeted consultations with Member States, financial institutions, and donors, the group created this comprehensive Sustainable Funding Guide. The guide provides practical guidance on identifying potential funding sources, estimating budget, and performing cost/benefit analysis. It also shares resources and experiences from other Member States.

We encourage you and your stakeholders to carefully review the information and resources presented in this guide. It is our hope that the guide will provide you with the necessary information to develop a sustainable funding plan for the UN-IGIF that best suits the needs and financial circumstances of your country.

Most sincerely,

Deirdre Dalpiaz Bishop
U.S. Census Bureau, Chief of Geography Division
Co-Chair, High-level Group of the UN-IGIF

Fernand Guy Isseri
Assistant Director, Cameroon National Mapping Institute
Co-Chair, High-level Group of the UN-IGIF

July 2024

Message from the Co-Leads of the UN-IGIF Sustainable Funding Work Group

The Sustainable Funding Work Group is pleased to present this Funding Guide as a contribution to assist Member States in achieving sustainable funding for the UN-IGIF.

The UN-IGIF is a framework to help coordinate, develop, strengthen and modernize approaches to geospatial information management strategies and Country Level Action Plans. The UN-IGIF supports the establishment of national spatial data infrastructures and implementation of the efficient and effective use and sharing of geospatial information for policy formulation, decision-making and innovation. The framework facilitates the integration of geospatial information across all sectors to advance national and global development priorities.

The Funding Guide aims to set the scene for Member States to formulate the actions and investments required, to identify domestic and external funding sources and engage with economists and ministries of finance (or equivalent), financial institutions, and potential donors. The chapters on economic methods will serve as reference material on economic terms, techniques and methodologies.

In the course of our work over the past eighteen months, three things have become evident. The first is the need in many Member States to progress the plans, policies, and investments to realize the goals of the UN-GIF. The second is that there will be significant benefits for Member States in doing so. The third is the importance of being able to make the economic case for investment to policy makers and funders.

The Work Group Members believe that this Funding Guide should be a living document and updated from time to time as experience with implementation accumulates.

We would like to thank all the consultation participants, including Member States from each of the UN-GGIM Regions and their respective Ministry of Finance, Financial Institutions, and Donor Agencies for their valuable insights.

We would like to thank the Work Group members for their contribution to this work. We also thank Maroale Chauke and Simone Lloyd for their previous work as Co-Leads of the Work Group.

Finally, we thank H.E. Dr. Eng. Mohammed Yahya Alsayel, President, General Authority for Survey and Geospatial Information (GEOSA) & Chair of the UN-GGIM Arab States, Kingdom of Saudi Arabia for providing the funding and in-kind support in the preparation of this report.

Mohammad Almabrook

Executive Director for International Cooperation & Partnerships

General Authority for Survey and Geospatial Information (GEOSA)

Kingdom of Saudi Arabia

Odette Semiao

General Manager

Agência Nacional de Desenvolvimento Geo-Espacial

Republic of Mozambique

Co-Leads, UN-IGIF Sustainable Funding Work Group

UN-IGIF Sustainable Funding Work Group and Steering Committee

Eng. Mohammad Almabrook **Chair**	General Authority for Survey and Geospatial Information (GEOSA), Kingdom of Saudi Arabia
Ms. Odete Semiao **Chair**	Agência Nacional de Desenvolvimento Geo-Espacial, Mozambique
Ms. Maroale Chauke **Previous Chair**	Department of Agriculture and Reform and Rural Development, South Africa
Ms. Simone Lloyd **Previous Chair**	Ministry of Economic Growth and Job Creation, Jamaica
Mr. Alan Smart **Author**	General Authority for Survey and Geospatial Information (GEOSA), Kingdom of Saudi Arabia
Dr. Zaffar Sadiq Mohamed-Ghouse **Member**	General Authority for Survey and Geospatial Information (GEOSA), Kingdom of Saudi Arabia
Mr. Syed Nasrullah Zafarullah **Member**	General Authority for Survey and Geospatial Information (GEOSA), Kingdom of Saudi Arabia
Mr. Nisar Ul Haq Syed **Member**	General Authority for Survey and Geospatial Information (GEOSA), Kingdom of Saudi Arabia
Mr. Andrew Coote **Member**	ConsultingWhere, United Kingdom
Ms. Emily Carlson **Member**	U.S. Census Bureau, United States of America
Mr. Johannes Van Geerstom **Member**	Nationaal Geografisch Instituut, Belgium

Consultation Participants

Chile	**Ms. Raffaella Anilio Olguin,** Geospatial Analyst at La Infrastructura de Datos Geospaciales de Chile (IDE-Chile) within the Ministerio de Bienes Nacionales. **Ms. Pamela Castillo Retamales,** Executive Secretary of the UN-GGIM Americas.
Fiji	**Ms. Meizyanne Hicks**, Director of Geospatial Information Management, Ministry of Lands and Mineral Resources
Georgia	**Ms. Mari Khardziani**, National Agency of Public Registry, Ministry of Justice of Georgia
Kingdom of Saudi Arabia	**Eng. Mohammad Almabrook**, Executive Director for International Partnership and cooperation and Advisory, EGEOSA **Eng. Khalid Abdullah AlMazroa**, GEOSA, Assistant to President for Strategic Planning **Dr. Zaffar Sadiq Mohamed-Ghouse**, Chief Advisor to H.E. The President, GEOSA **Mr. Meshal Ali AlOtaibi**, Finance, GEOSA **Mr. Ali Abdullah AlZahrani**, Finance, GEOSA **Eng. Syed Nasrullah Zafrullah**, Consultant, Office of the President, GEOSA
Republic of Indonesia	**Dr. Antonius Wijanarto**, Deputy Director General, Baden Informasi Geospatial, Deputy Chair for Geospatial Information, Chair of UN-GGIM Asia Pacific **Dr. Dheny Trie Wahyu Sampurno,** Integrating Geospatial Information and Statistics **Dr. Tandang Yuliadi Dwi Putra**, Mapping Surveyor, Center for Thematic Mapping and Integration, Geospatial Information Agency of Indonesia (BIG), Indonesia
Republic of Mozambique	**Ms. Odete Semiao**, General Manager, National Geospatial Agency (NGA) (Agência Nacional de Desenvolvimento Geo-Espacial)
Republic of South Africa	**Ms. Maroale Chauke**, Director, National Spatial Information Framework **Ms. Karen Harrison,** National Treasury
United Arab Emirates	**H.E. Eng. Hamed Khamis Al Kaabi**, Director General, UAE Federal Geographic Information Centre
World Bank	**Ms. Kathrine Kelm**, Senior Land Administration Specialist. Global Land and Geospatial Unit
PVLIC Foundation	**Mr. Stephen Keppel**, PVBLIC Foundation President

1 Introduction

The Committee of Experts on Global Geospatial Information Management (UN-GGIM) at its eighth session in August 2018, adopted the Implementation Guide of the United Nations Integrated Geospatial Information Framework (UN-IGIF) as a means of strengthening national geospatial information management arrangements within and across Member States at the institutional level and supporting the implementation of the Sustainable Development Goals, especially in developing countries. The UN-GGIM Committee of Experts formed a High-Level Group (HLG) on the UN-IGIF, tasked with providing the strategic leadership, promotion, coordination, planning and oversight to successfully advance implementation of the UN-IGIF globally. The HLG identified four strategic goals for its workplan for the period 2022-2025, each supported by a Work Group.

This Sustainable Funding Guide was produced by the Sustainable Funding Work Group. It focuses on mobilizing sustainable funding to advance the UN-IGIF. The tasks are outlined in the following table.

Table 1 Goal 4 and its task

Goal 4 – Mobilize sustainable funding		
	Task	**Deliverable**
Task 1	Identify funding sources and modalities to foster and support implementation of the UN-IGIF.	Knowledge of feasible and available funding sources and terms and conditions.
Task 2	Help identify funding sources in Member States.	Help to identify feasible and available funding sources such as in country budgetary allocation/modality.
Task 3	Provide guidance to help identify funding and estimate budget and investment for UN-IGIF Country-Level Action Plan implementation in developing countries. Identify items for dedicated funding. Collate and share best practice cost benefit analysis.	Guidance and methodology for estimating investment and identifying funding sources. Examples of actions and activities that need funding internally or externally. Guidance on best practice cost benefit analysis.
Task 4	Finalize and promote the Sustainable Funding Guide and support tools to broaden knowledge and awareness.	Guidance and examples that will help Member States justify needed investments in geospatial information and the UN-IGIF.

This Funding Guide addresses Tasks 1, 2 and 3. Task 4 is to be addressed by the Work Group separately.

The objective of this guide is to provide information to help any organization involved in implementing the UN-IGIF develop funding strategies and undertake economic impact assessments in support of developing business cases to this end. It discusses the potential funding sources, the types of investment that might be required, the benefits that they deliver, and information on best practice approaches to undertaking cost benefit analysis.

The Guide provides information on cost benefit analysis and valuation techniques to provide users with sufficient background information to support engagement with economists, officials from Finance and Treasury Departments and funding agencies.

This funding guide does not specifically address strategic alignment with broader policy objectives, planning and financial management or development of a business case. These issues are addressed in associated papers produced under the UN-IGIF work program. [1]

The UN-IGIF is a framework of guidance, standards, methods, recommended actions, and best practices to help Member States coordinate, develop, strengthen and modernize approaches to geospatial information management, including aspects relating to geospatial policy and legal strategies, governance, data integration and infrastructure, education, innovation, use, and collaboration.

The Framework promotes the efficient and effective use and sharing of geospatial information for policy formulation, decision-making and innovation and facilitates the integration of geospatial information across all sectors to advance national and global development priorities and agendas.

The primary objective of the UN-IGIF is to develop geospatial information management strategies and Country Level Action Plans that support National Spatial Data Infrastructure (NSDI) development and UN-IGIF implementation.

The research for this report included a literature review of methodologies, and consultation with eight Member States and two development assistance financial organizations, to gain an understanding of the current state of financing and development in selected Member Countries from Arab States, Africa, Asia Pacific, South America, Europe and Western Asia.

[1] Relevant documentation includes the UN-IGIF documents Part 1 – UN-IGIF Overarching Strategy _Second edition (UN-IGIF, 2023), Task 8, Strategic Alignment and Benefits (UN-IGIF, 2023), Task 9 Strategic Alignment and Benefits, And SP3 – Appendices (UN-IGIF, 2023).

This Funding Guide is organized in the following chapters:

- ***Chapter 2*** outlines funding sources and their requirements.
- ***Chapter 3*** identifies items for dedicated funding, typical costs, and benefits.
- ***Chapter 4*** discusses best practice cost benefit analysis to assess the net benefits of investing in the UN-IGIF.
- ***Chapter 5*** outlines accepted approaches to valuing benefits created by implementation of the UN-IGIF. This chapter can be used as a reference document for those who need to engage with economists, finance and budget departments, investment banks, and donors.
- ***Annex A*** describes other economic impact assessment techniques. It is for reference in the event that those involved come across other techniques in their discussions with economists.
- ***Annex B*** provides a summary of definitions of direct and indirect benefits.
- ***Annex C provides*** metrics for assessing an investment or policy change.

2 Funding sources

Main points in this chapter

Significant financing to implement the UN-IGIF is needed globally. Multiple funding sources may be needed for Member Countries to implement the UN-IGIF.

In country sources of funding

Domestic sources of funding include budget appropriation, user charges to local businesses, or setting up special purpose state owned enterprises.

While these are important, budget constraints often mean that they are insufficient to fully finance all of the investments in the UN-IGIF that will be required.

External sources of funding

External funding sources include United Nations organizations such as United Nations Development Program (UNDP), United Nations-Habitat (UN-Habitat) and the United Nations Food and Agricultural Organization (FAO).

They also include multilateral development banks such as the World Bank and the African Development Bank. Multilateral Development Banks offer a range of loans, grants, and technical assistance. Grants are typically directed to less developed member states and are used to fund specific issues such poverty, the environment or regional cooperation.

Official Development Assistance (ODA) is another source of funding. This includes ODA from organizations such as the Japan International Cooperation Agency (JICA), the Korea International Cooperation Agency (KOICA), and the U.S. Agency for International Development (USAID).

Non-government organizations (NGOs) are also potential sources of funding. Active in the geospatial sector are organizations such as the Bill and Melinda Gates, Nippon, W.K. Kellogg and PVBLIC foundations and charities such as the World Wildlife Fund (WWF).

Partnerships within government are also possible sources of finance. For example, mapping agencies and transportation departments have a common interest in developing spatial data infrastructure.

Public-private partnerships have been used to develop infrastructure in many countries. They involve the private sector providing elements of the infrastructure for a limited concession period.

Matching ratios can be used to define the contribution of partners working together to fund an investment. This may suit limited duration collaboration or collaboration where financial commitments are small.

2.1 Introduction

Strategic Pathway 3 of the UN-IGIF notes that sources of funding can include government allocations, development and donor assistance, revenues from geospatial products and services, and private sector investment (UN-IGIF, 2023). Possible financing models could include government funding, donor funding, government owned or state-owned enterprises, outsourcing or partnerships.

Funding approaches within developing countries may be challenging due to lack of local financial resources which means that implementing the UN-IGIF program may not be financially sustainable if it were to depend on time limited development assistance alone. Ongoing funding will be required to sustain investment in the IGIF. Multiple funding sources may be required to initiate and sustain the investment in the UN-IGIF program.

The potential sources of funding are discussed in the following sections.

2.2 Funding from internal country resources

There are three main sources of funding from within the financial resources of a Member State. The first is from government funding, the second is from user charges, and the third is from the operation of state-owned enterprises.

2.2.1 Government funding

Government funding for implementing the objectives of the UN-IGIF could come from central and regional governments (where applicable), or from municipalities or local government. National and regional budgets are framed within overall government policies and priorities and include estimates of expenditure in future years. Local government funding is subject to local priorities.

Funding for the National Land Agency in Jamaica, for example, is included in the budget for the Ministry of Economic Growth and Job Creation. The budget estimates include both capital and recurrent expenditure and include forward estimates of future expenditures (Ministry of Finance and the Public Service, 2024).

In most cases, financing of UN-IGIF activities will be competing with other government expenditure programs. Accordingly, Implementation of UN-IGIF Country-level Action Plans may need additional funding outside of that committed in government budgets.

New projects requiring additional funds will require a robust justification for investment. Most bids for funding of UN-IGIF activities at the national level will involve engagement and oversight from a Ministry of Finance or equivalent body. The UN-IGIF Strategic Pathway 3 document of the Implementation Guide provides further advice on government budgeting processes (UN_IGIF, 2022).

Another approach to funding is through specific taxation, for instance a levy on spatial data related activities channeled into a special fund established to finance Spatial Data Infrastructure (SDI) implementation. This model was used for example, in New Zealand to assist in the implementation and maintenance of their “Land-Online” system.

2.2.2 User charges and open data

National mapping agencies may charge fees for access to their mapping data and services. These fees can be levied on various users, and may vary according to categorization – government agencies, businesses, researchers, and individuals may attract different levels of fees.

User fees help generate revenue to sustain mapping operations and cover the costs of data collection, processing, and dissemination. With the notable exception of the Ordnance Survey Great Britain, few achieve full cost recovery, but such fees can provide a degree of flexibility for investment. Often this is part of what is called a "freemium model" by which basic services may be provided free but premium services are only available for a fee. Basic services may include access to fundamental geospatial data themes as outlined in (UN-GGIM, 2019). Some Member States provide fundamental geospatial data free as a public good (the definition of a public good is provided in the box below).

Box 1 – Definition of a public good

A public good is defined in the economic literature as a good or service that is non-rival (which means that its use by one consumer does not prevent its use by another consumer) and non-excludable (which means that users cannot be excluded from using the data (Samuelson, 1958).

Geospatial data is a quasi-public good. Users can be required to pay for access to the data which means that the "non-excludable" criterion does not apply. However, because the marginal cost of supplying geospatial data to an additional user is close to zero, it can be argued that society is better off if fundamental geospatial data are made available to all at no charge (World Bank, 2020). Such data may include some or all of the fourteen Global Fundamental Data Themes identified by the UN-IGIF (UN-GGIM, 2019).

The European Union issued an Open Data Directive in 2019, that lays down the legal framework for making public sector information more accessible and reusable. The directive obliged the European Commission to adopt a list of high-value datasets which should be made available free of charge, in machine-readable formats, through application programming interfaces and, where relevant, as bulk downloads. The datasets were selected from within six thematic categories which include geospatial data, earth observation and the environment. In such cases, the organization concerned with implementation is required to finance the maintenance and curate these geospatial data sets from public funds (EU, 2019).

State-owned Enterprises[2]

Some countries have created state owned enterprises, that are legal entities that undertake commercial activities on behalf of government, such as managing geospatial information. Their legal status varies from being a government agency to a normal company with the state being the only shareholder or having a controlling position. Although these organizations answer to government, they are generally financially self-sufficient and do not rely on government budget funding for the

[2] Referred to in some countries as government owned corporations.

majority of their activities. A good example is the Ordnance Survey of Great Britain (Ordnance Survey, 2022). Ordnance Survey recovers its costs by charging commercial-level prices for its highest accuracy data and services. Under its government-owned arrangements, it returns part of its profits to the government but can re-invest the remainder in product and service innovations. It is also able to raise money, if required, from commercial banks and can invest in commercial companies.

The advantage of this type of funding model is the reduced (or total lack of) reliance on government finance. One difficulty in many countries of such a funding model is that legislation may not permit or may restrict the operating practices of the entity. For example, this model is unlikely to be viable where legislation requires that all public data must be provided free of charge to all users.

2.3 External funding sources

Development assistance can be provided in many forms from multilateral arrangements, bilateral development assistance and, in many cases, co-funding through partnerships between multilateral, bilateral and public/private sector collaborations. Potential avenues for Member States to seek sustainable funding are discussed below.

2.3.1 United Nations

The United Nations, through its multiple agencies, supplies funding through specialist agencies for specific development programs. Prominent agencies include the United Nations Office for Partnerships, United Nations Statistics Division (UNSD), the United Nations Development Program (UNDP), United Nations Habitat (UN-Habitat) and the United Nations Food and Agriculture Organization (FAO).

2.3.1.1 United Nations Office for Partnerships

The United Nations Office for Partnerships facilitated collaboration on the SDG Data Alliance that was launched in 2021. The SDG Data Alliance is a collaboration between Esri, the W.K. Kellogg Foundation and the PVBLIC foundation. The Alliance had raised funding to work with developing countries to create data hubs where countries can track progress on their Sustainable Development Goals.[3]

2.3.1.2 United Nations Statistical Division (UNSD)

The UNSD itself does not directly fund geospatial information programs. However, it collaborates with other entities to promote geospatial capabilities and is committed to advancing geospatial information systems in member countries. [4]

[3] https://unpartnerships.un.org/sdg-data-alliance accessed on 28 June 2024

[4] (Scott, 2024), (UNSD, 2019)

2.3.1.3 United Nations Development Program (UNDP)

The United Nations Development Program (UNDP) doesn't specifically invest in the UN-IGIF but collaborates with countries to strengthen their capacity in geospatial information management in support of the UN-GGIM.[5]

The UNDP relies on voluntary contributions from UN Member States, multilateral organizations, the private sector and other sources, in the form of unrestricted regular resources (core), and contributions earmarked for a specific theme, program or project.[6] For example, it funded a program in Kiribati to strengthen the use of geospatial information systems for the Ministry of Health and Medical Services with funds from the Global Fund to Fight AIDS, Tuberculosis and Malaria.[7]

The UNDP also supports governments in building institutional, policy, and technical capacity. This may include enhancing regional support for implementing international standards and commitments relating to geospatial data. Through collaboration with the private sector, it promoted implementation of the SDG Geo Data Hub. The GeoHub is a modern web frontend part of an ecosystem of cloud based geospatial data, services and applications supporting the UNDP SDG agenda.[8]

2.3.1.4 World Food Programme

The World Food Programme (WFP) has actively leveraged geospatial technology to enhance its humanitarian efforts. It doesn't have a specific program supporting the implementation of geographical information systems in developing countries.

It has provided project specific funding involving geographical information systems. This includes development of a flood hazard model in Mozambique and mapping facilities to facilitate humanitarian access to risky areas in Afghanistan.[9]

2.3.1.5 United Nations Habitat

UN-Habitat doesn't directly fund geospatial programs, it collaborates with partners and leverages relevant tools to support sustainable urban development.[10] In 2013, the organization produced a Geographic Information System Handbook for municipalities as part of its work program.[11]

2.3.1.6 Potential for funding from United Nations Agencies

Generally, these UN agencies don't specifically fund programs targeting the implementation of the UN-IGIF. However, some fund related programs are consistent with Sustainable Development Goals

---

5 https://sdgs.un.org accessed on 28 June 2024

6 https://www.undp.org/funding accessed on 28 June 2024

7 (UNDP, 2022)

8 https://unstats-undesa.opendata.arcgis.com/ accessed on 28 June 2024

9 (Mendez, 2021)

10 (UN Habitat, 2020)

11 (UN Habitat, 2013)

and there are likely to be opportunities to leverage funding from these programs to implement the UN-IGIF.

In the future the UN-IGIF will underpin the work of these agencies and potentially provide an opportunity to rationalize funding for geographical information systems across UN sponsored programs.

2.3.2 Multilateral development banks.

Multilateral development banks (MDBs) are supranational institutions set up by sovereign states, which are their shareholders. They support programs for sustainable economic development and social progress in line with the priorities of their respective Member Countries (Humphrey, C; Brugger, F, n.d.).

The main multilateral development banks include:

- World Bank.
- African Development Bank.
- Asian Development Bank.
- Asian Infrastructure Investment Bank.
- Development Bank of Latin America and the Caribbean.
- Central American Bank for Economic Integration.
- European Bank for Reconstruction and Development.
- European Investment Bank.
- Inter-American Development Bank Group.
- Islamic Development Bank.
- Eastern and South African Trade and Development Bank.
- International Investment Bank.

Multilateral development banks offer a range of loans and/or grants. Grants are typically directed to less developed countries and are used to address specific issues of concern such as poverty, environment, or regional cooperation. They tend to participate in, or finance, higher-risk projects that may not be otherwise financed by the private sector. They play an important de-risking role and are associated with longer term loan maturities.

There are also sub-regional multilateral development banks such as the Caribbean Development Bank, the East African Development Bank and the Central American Bank for Economic Integration. Membership of these banks generally only includes borrowing nations.

There are also several multilateral financial institutions. These include the International Fund for Agricultural Development and the Arab Bank for Economic Development in Africa. These tend to have more limited membership and focus on specific areas of concern.

The African Development Bank (AfDB) has funded various geospatial information projects across Africa. Geospatial information projects typically involve the use of satellite imagery, GPS data, and geographic information systems (GIS) to support various development initiatives such as urban planning, agriculture, natural resource management, disaster response, and infrastructure development. Box 2 illustrates how geospatial information is already receiving support in Sub-Saharan African regions under the Africa Disaster Risk Financing Initiative.

Box 2 – Africa Disaster Risk Financing Initiative

The African Risk Financing Initiative is a cooperative program that has the overall objective of strengthening the resilience of Sub-Saharan African Regions, countries and communities to the impacts of natural disasters. The program is implemented by several partners including the African Development Bank, the African Union Commission, the United Nations Office for Disaster reduction and the Global Facility for Disaster Reduction and Recovery.

One of the activities supported by the Initiative is establishing the data environment for risk financing, to build an understanding and awareness of disaster and climate risks. Risk data produced under the program has been uploaded to local spatial data platforms in Mozambique and Malawi for example (GFDRR, 2019).

Ongoing funding of such activities is a potential source of support or collaboration for UN-IGIF related activities in the future.

The World Bank has engaged with programs to support the principles and objectives of the UN-IGIF. Box 3 below provides an example of the involvement of the World Bank in collaborative arrangements with countries towards the implementation of the UN-IGIF. A key message from this example is the importance of collaboration with bi-lateral partners for financing activities under the UN-IGIF.

Box 3 – Example - World Bank funding and the UN-IGIF

The World Bank is made up of five institutions: the International Bank for Reconstruction and Development (IBRD); the International Development Association (IDA), the International Finance Corporation, the International Centre for Settlement of Disputes and the Multilateral Investment Guarantee Agency. The World Bank is organized into six regions. These are Africa, East Asia Pacific, Europe & Central Asia, Middle East & North Africa, Latin America and Caribbean, and South Asia.

The World Bank works closely with the UN-GGIM, national governments and other stakeholders to enhance geospatial capabilities in countries. It developed an implementation methodology for the UN-IGIF with the support of the Korea Green Growth Trust Fund. The methodology is designed to help countries develop the case for investment in spatial data infrastructure addressing the socio-economic impact and business case that is required by funding bodies.

The World Bank is usually involved in large-scale capital investments and generally does not pay for recurrent costs. It provides finance through the IDA. Such financing is always allocated through a nation's Ministry of Finance or equivalent body.

Lower income developing countries often use World Bank trust funds to fund economic assessments. This is usually a combination of sourcing grants from other funding sources and trust funds from the Bank. Trust funds are donor financed.

Examples of the World Bank's involvement includes land administration projects in Colombia, Moldova, Georgia, Guyana, Serbia, Nicaragua and Liberia, disaster risk management in the Seychelles, Solid waste management and urban development in Cambodia and digital development in Mongolia. The implementation methodology has been applied in seventeen developing countries to this point.

2.3.3 Official Development Assistance (ODA)

Many nations offer development assistance in the form of both grants and loans. Some of the most active ODAs in the geospatial sector include Japan International Cooperation Agency (JICA), The Korean International Cooperation Agency (KOICA), the United States Agency for International Development (USAID) and the European Union. Two examples are discussed below.

2.3.3.1 United States Agency for International Development (USAID)

USAID supports the development and use of geospatial information systems through its Geospatial Strategy. The Strategy was launched in 2023 and is aimed at leveraging geospatial data and technology to target the delivery of international programs (See Box 3).

USAID has funded a number of programs in the past including:

- Applying geospatial data and analysis to design the Sustainable Landscapes and Biodiversity Project in Peru (USAID, 2017)
- Harnessing the power of Geospatial Data for Rapid Response in Emerging Markets – a case study in identifying the most vulnerable communities in Lagos State for COVID-19 relief efforts (USAID, 2020)
- USAID and the World Bank organized a "crowdsourcing" event in which volunteers mapped Kathmandu's infrastructure. When a massive earthquake struck Nepal in April 2015, USAID was able to upload timely and current data onto GPS devices for disaster response teams. (USAID, 2013)

Box 4 – USAID Geospatial Strategy

The Geospatial Strategy will guide USAID's efforts to institutionalize the use of geospatial technologies to achieve greater efficiency in programs, operations, and development outcomes. Four strategic objectives will help realize the vision of the Strategy:

1. Expand access to geospatial data and tools to strengthen the planning and implementation of USAID programs.
2. Strengthen USAID's capacity to use geospatial data, technology, and expertise for decision-making.
3. Advance USAID policies and practices by applying geospatial information
4. Provide global leadership in applying geospatial solutions for development and humanitarian assistance.

There is limited information on the budget for the Strategy but the Federal Budget for building and expanding digital and cyber programs included $90 million in direct funding for USAID to support Digital Development to meet, in part, the development challenges in the digital age.

2.3.3.2 European Union (EU)

The European Union (EU) provides external development assistance to developing countries and regions.

The European Green Deal is a comprehensive set of policy initiatives aimed at making Europe climate-neutral by 2050. It was launched by the European Commission in December 2019 as the European Union's roadmap to sustainable growth. As part of the program, the EU plans to provide financial assistance to developing countries to help their transition to sustainable practices. Among other things it includes funding for capacity building[12]. The European Green Deal has committed €28.5 billion to developing economies in 2022.

The EU launched the Global Gateway in 2021 to bring together the EU Member States and their financial and development institutions, including the European Investment Bank (EIB) and the European Bank for Reconstruction and development (EBRD), to mobilize the private sector to leverage investment for transformation impacts. [13]

The European Fund for Sustainable Development Plus (EFSD) is one of the financing tools of Global Gateway, promoting sustainable investments in the European Union's (EU) partner countries. The

[12] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en#boosting-global-climate-action accessed on 28 June 2024.

[13] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/stronger-europe-world/global-gateway_en accessed on 28 June 2023

program aims to mobilize €135 billion of public and private financing to help partner countries achieve Sustainable Development Goals. [14]

2.3.4 Non-governmental organizations (NGO)

NGOs are generally defined as non-profit entities that are independent of government, although they may receive government funding. They encompass many different organizations typically established to work toward public or social welfare goals. NGOs can be funded by donations and grants. Active in the geospatial sector are organizations such as the Bill and Melinda Gates, Nippon, W. K. Kellogg and PVBLIC foundations and charities such as the World Wildlife Fund (WWF). The PVLIC Foundation is one of the partners in the SDG Data Alliance discussed below.

2.3.5 Partnerships

Partnerships promote collaboration among the different sectors of society, which usually involves the pooling of resources (financial and non-financial) to efficiently implement the UN-IGIF. Under the umbrella of partnerships, several sub-categories exist, each with its own unique characteristics, described below.

2.3.5.1 SDG Data Alliance

The SDG Data Alliance is a partnership collaboration between Esri, the W.K. Kellogg Foundation and PVBLIC Foundation. The Alliance helps countries develop a UN-IGIF Country-level Action Plan, highlighting the many ways UN-IGIF helps achieve national priorities. The Alliance has not reached the stage of investing in broader UN-IGIF implementation at the time of writing. The role of geospatial information is recognized as being important but the specific approach to funding concepts for the UN-IGIF is yet to be decided. [15]

A key objective of the partnership is to establish the benefits that funding the UN-IGIF would deliver, thereby enhancing Member States' prospects of securing financial support.

2.3.5.2 Korean Green Growth Trust Fund

The Korea Green Growth Trust Fund (KGGTF) is a partnership between the World Bank Group and the Republic of Korea. Since its inception in 2013, the fund has funded over US$98 million for green growth programs. The fund provides grants to support technology innovation, multi-sectoral projects, and pilot projects.

Examples of projects that the fund has supported:

- strengthening Spatial Data Infrastructure in Senegal (US$500,000)
- Use of geospatial information and nature- based infrastructure to build drought resilience in the south of Angola (US$500,000).

[14] https://international-partnerships.ec.europa.eu/funding-and-technical-assistance/funding-instruments/european-fund-sustainable-development-plus_en accessed on 28 June 2023

[15] Consultations for this project

– geospatial information management for Green Growth Operationalization in Lao, Colombia, Mongolia, Cote d'Ivoire (US$588,000).

2.3.5.3 International Platform on Sustainable Finance

The European Union, together with Argentina, Canada, Chile, China, India, Kenya and Morocco, launched the International Platform on Sustainable Finance.[16] The objective of the program is to scale up the mobilization of private capital towards sustainable investments. It offers a multilateral forum of dialogue between policymakers responsible for developing sustainable finance regulatory measures to help investors identify sustainable investment opportunities. It is open to public authorities that are taking action and are willing to promote international cooperation in the area of environmentally sustainable finance.

Such arrangements could lead to sources of funding for the UN-IGIF program.

2.3.5.4 Partnerships within government

Partnerships within government refers to arrangements established between different agencies within a national government or between different levels of government.

This approach has been used, for example, by central governments to fund other national geospatial programs where one agency commits funding to another agency to assist with costs. In cases where different levels of government are involved, financial commitments are made from the different levels to share in costs and ongoing expenses. These arrangements are often governed by a Memorandum of Understanding or Memorandum of Agreement.

2.3.6 Cost-Sharing Partnership

A cost sharing partnership represents collaboration amongst various public and private sector bodies that could be considered in implementing the UN-IGIF. The collaboration can be financial, non-financial or a mixture of both. A good example is Geovekst in Norway.[17] This a joint funding regime for upgrading reference geospatial data. Over 600 stakeholders agreed on long-term cooperation to implement the upgrade. It includes national, regional, and municipal public organizations and some private organizations, with given specific service and infrastructure responsibilities.

A related program is Norway Digital[18]. Under this program participants give access to data sets they own and maintain. Each stakeholder pays an annual fee for the use of the data that has been delivered by all the stakeholders. The "Digital Norway-calculator" is a newly formulated system of stakeholder fees. This is a flexible pricing mechanism that considers the type of datasets needed, their base value, the related interest factor, and other parameters, such as the importance of the dataset to users and the volume of use based on service transactions. This varies somewhat from one year to the next.

---

16 https://finance.ec.europa.eu/sustainable-finance/international-platform-sustainable-finance_en

17 https://www.kartverket.no/geodataarbeid/geovekst

18 https://www.geonorge.no/en/infrastructure/norway-digital/

A key requisite for this model to work is strong collaboration between stakeholders. This can be challenging, where a culture of collaboration between different central and local government agencies is not well established.

The key advantage of such an arrangement is that it is less vulnerable to a reduction of funding by one entity.

2.3.7 Public-Private Partnership (PPP)

A PPP approach involves collaboration between the different levels of public sector organizations and the private sector. In the most common form of PPP, the private sector will provide elements of the construction, financing, operating and maintenance of the infrastructure for a limited concession period[19].

For example, the New South Wales state government in Australia leased the state's land titles registry to a private organization for a 35-year concession (Han, 2017). Similar arrangements have been implemented in parts of Canada, such as in Ontario, where Teranet is currently the exclusive provider of Ontario's online property search and registration. A significant consideration in this case is that Teranet is owned by the infrastructure arm of the Ontario Municipal Employee Retirement pension fund.

The level of sophistication of procurement and contractual oversight may make PPP difficult to implement for many developing countries. Further, fiscal regulations may impose limitations such as the amount of funds directed toward a government sponsored program or time limits on funding an activity. Access to long-term financing of PPPs is challenging, particularly for emerging markets and developing economies.

Pressure on public finances, as well as the quest for better efficiency in projects and programs, has led to an increasing interest in PPPs globally, with efforts to provide the right projects and a strong framework for PPPs.

The World Bank Group has produced an operational framework entitled Country Readiness Diagnostic for Public-Private-Partnerships[20], that diagnoses country PPP gaps and enhances the identification of country tailored solutions. The end goal of the diagnostic is to provide strategic customized advice to client countries, so they can make informed decisions in determining an operational plan for their PPP program.

---

[19] Build–operate–transfer (BOT) or build–own–operate–transfer (BOOT) is a form of financing, wherein a private entity receives a concession from the private or public sector to finance, design, construct, own, and operate a facility stated in the concession contract. The infrastructure and assets can be subject to transfer to Government after a defined period.

[20] https://ppp.worldbank.org/public-private-partnership/library/country-readiness-diagnostic-public-private-partnerships

2.3.8 Matching Ratios

Matching ratios typically involves two or more parties working together to fund an activity nationally. In this model, one partner (e.g., federal, provincial, or local governments, NGOs, companies, or community groups) would match (according to the specified ratio) the amount of funds invested in a UN-IGIF activity by the other partner(s).

This is a simpler approach to partnerships. It requires open book accounting, so that both parties can audit the amounts being spent by each other. It may be suitable for collaborations of limited duration or where financial commitments are small.

2.4 Conclusion

Recent studies of sustainable financing suggest that none of these sources alone will be sufficient for a long-term sustainable model of funding. The risk of reliance on a single source is that if policy or economic conditions change and that single source is either removed or substantially reduced, the viability of the investment is compromised (NAPR, 2022).

What is referred to as a hybrid approach that combines finance from the different sources described above should be considered. Such an approach provides the flexibility across different funding models, for instance, focusing the preparation of proposals for donor funding around capacity building activities and using a cost sharing partnership to fund capital-intensive data theme upgrade or maintenance activities.

Whatever strategy is adopted, a financial plan with an accompanying longer-range budget is important in communicating funding needs for sustainable geospatial services and support. Continuity and collaboration of funding may be more likely if donors are invited, as partners, to take part in the participative process defining the components of a Country-Level Action Plan for implementation of the UN-IGIF.

In addition, the nine strategic pathways offer options for funding decisions based on national priorities and circumstances. Some activities can be funded early in the development phase while funding of others of lesser priority is delayed.

For all donors, the business case for investment must be tailored to fit with the donor's priorities. Climate change, land administration, disaster risk management, economic growth and renewable energy are good alignments for integrated geospatial information management.

One often encountered limitation of donor-funded development assistance is that it is time-limited, and longer-term funding may not be available beyond the end of donor support. This risk can be mitigated by ensuring the project includes specific arrangements for skills transfer and ongoing funding for operations from the recipient country's government.

The awareness of the UN-IGIF program is not high in some donor organizations and the linkage between the program and the Sustainable Development Goals needs to be articulated to maximize the potential source of funding from these donors.

3 Budgeting – estimating costs and benefits

Main points in this chapter

UN-IGIF actions

The UN-IGIF is a framework that recognizes, builds upon, and augments pervious investments and the substantial achievements in planning and implementing Spatial Data Infrastructures (SDIs) and National Spatial Data Infrastructures (NSDIs).

The investments required could include development of policy and institutional arrangements, capacity building, knowledge transfer and development and integration of geospatial management systems.

An important step in implementing the UN-IGIF is identifying the investments required and demonstrating that the benefits justify the costs.

Actions and activities for dedicated funding

Actions that will require dedicated funding include capital and operating costs associated with establishing and operating the geospatial management system required plus the cost of establishing the policies and standards necessary to operate it. Capital costs can vary from as low as US$5 million to US$40 million depending on the state of development in each Member State. Operating costs can vary from between US$1 million to US$5 million. Budget will also be required for development of policies, regulation and standards.

Aligning investment and sources of funding

Given financial constraints, aligning investment categories with funding sources is important.

The optimal model will depend on each country's development needs and budgeting practices as well as the funding policies and preferences of donor organizations.

The potential to recover some costs through user charges is also important and should be considered, where appropriate, as part of sustainable funding strategies

Benefits from geospatial infrastructures

Most areas of government and the private sector benefit from geospatially supported technologies and services. Governments benefit from lower costs of data management as well as in service delivery in areas such as land administration and environmental monitoring. The private sector also stands to benefit, including in sectors such as agriculture, mining, transport, maritime operations, finance, and services. Society can also benefit from time saved, improved access to government services and the use of maps and mapping data.

3.1 Introduction

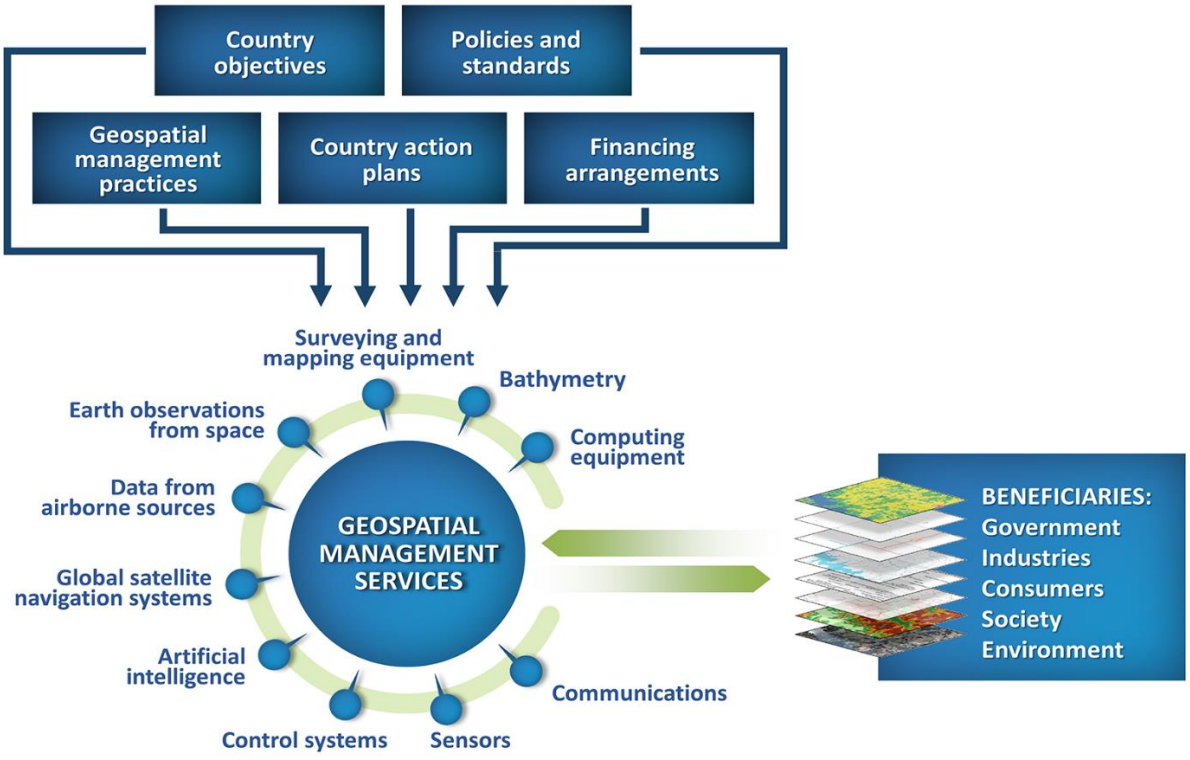
The UN-IGIF is a framework that recognizes, builds upon, and augments pervious investments and the substantial achievements in planning and implementing SDIs and NSDIs. Its goals encompass governance, policy and institutional arrangements to ensure effective geospatial information management, accommodate organizational arrangements and requirements and align with national and regional priorities. This, if executed effectively, offers an economic return on investment (UN-IGIF, 2023).

The investments required could include development of policy and institutional arrangements, capacity building, knowledge transfer and development and integration of geospatial information systems.

National Spatial Data Infrastructures have three components: an institutional framework, a policy framework, and a technical framework. They support the affairs of governments, industry, and society. They are the custodians of fundamental data sets that provide the foundation for all these activities. They provide authoritative data on which value-added services are based.

Spatial Data Infrastructures include surveying and mapping data, Earth Observations from Space (EOS), Position Navigation and Timing (PNT), Airborne Imagery, bathymetry, communications, sensors, and Geographic Information Systems (GIS). When geospatial data are stored and shared under appropriate policies, procedures, and standards, they can be combined with demographic, location, economic and other information to create valuable information to support government, commerce, society and the environment as illustrated in Figure 3.1.

Figure 3.1 Spatial data infrastructures.



Source: ACIL Allen

Geospatial infrastructures and services are fundamental to the achievement of sustainable development goals of governments through improving the effectiveness and performance of governments, industry and supporting society through improved services. They are fundamental to reducing poverty and improving food security.

Examples of how geospatial projects align with national development goals and sustainable development for the Republic of Moldova can be found in (Agentia Relatii Funciare si Cadastru a Republicii Moldova, 2021) and for Georgia in (Natioal Agency of Public Registry, Georgia, 2021).

An important step in implementing the UN-IGIF is identifying the investments required and demonstrating that the benefits that are expected for the economy and society justify the costs.

3.2 Actions and activities for dedicated funding and investment needs

Typical items of expenditure for agencies planning to invest in the UN-IGIF include capital costs, operating costs, training and development of standards, protocols, policies and regulations necessary to support implementation of the UN-IGIF.

Table 2 Typical cost items

Capital costs	Operating costs	Policy and regulation costs
Hardware, IT, storage and communications	Wages and salaries of support and maintenance staff	Costs associated with policy development
Data acquisition	Software license fees and charges	Drafting of legislation and regulation where applicable
Software including data storage protocols, data security and data sharing arrangements	Access and maintenance fees for cloud storage where applicable	Costs associated with development of standards and regulation
Buildings, furniture, facilities, cooling systems and security systems	Maintenance and update charges	Consulting fees
Digitization of topographic and cadastral maps	Professional services	Capacity building in longer term training modules and certification programs.
Periodic upgrades of hardware and software	Rent and insurance	
Intangible assets such as reputation and reliability	Telecommunications	
	Taxes, royalties and other fees	
	Overheads, where charged	

3.2.1 Capital costs.

Capital costs are generally incurred at the beginning of UN-IGIF implementation. They can also occur periodically over the life of an investment in equipment or software upgrades.

Some capital costs may be charged as an organization overhead. Where this occurs, these overheads would be charged on an annual basis as operating costs.

Increasingly however, hardware is not purchased but delivered by cloud hosted services. In this case the charges for access to cloud services are treated as recurrent costs in the organization's accounts and not as a capital charge.

A survey of selected Member States indicated that investment required varies widely, depending on the status of existing spatial data infrastructure, the spatial data infrastructure requirements, and the complexity of organizational arrangements in each country. Estimates generally ranged from US$5 million to US$40 million over five years. In most cases ongoing but lower capital expenditure was expected after 5 years, to further update data, software, and hardware, as a part of ongoing development. This range reflected geographically diverse countries, varying size of programs and in one case a country where there was an existing infrastructure. One country estimated that to fully develop their national spatial data infrastructure including national mapping would cost in the order of US$400 million over five years. This was a geographically large and diverse country with a major program of national mapping and infrastructure development.

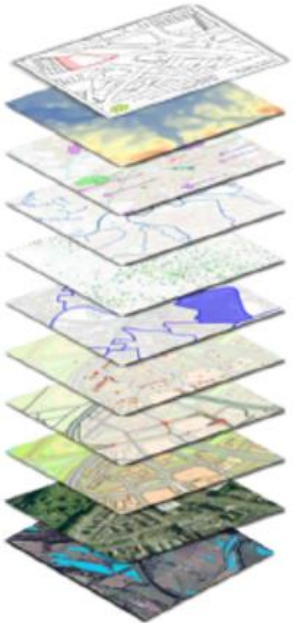
Capital expenditure requirements can occur periodically after the establishment of the initial investment, to cover hardware and software upgrades and sometimes, ongoing development of the infrastructure (Bettinger, P. et al, 2009).

3.2.2 Data acquisition costs

Costs associated with data acquisition also varied across Member States depending on the general state of development.

Data that forms the basis of spatial data infrastructures includes fundamental data themes as defined by the UN-GGIM (UN-GGIM, 2019).

Figure 3.2 Fundamental data themes



Global Geodetic Framework
Geographic Names
Addresses
Functional Areas
Buildings and Settlements
Land Parcels
Transport Networks
Elevation/ Depth
Population Distribution
Land Cover and Land Use
Geology and Soils
Physical Infrastructure
Imagery
Water

Source: (UN-GGIM, 2019)

Costs of data acquisition may include purchase of imagery from Earth Observation Satellites, aerial imagery, digital terrain models, orthophotos and LIDAR capture.

Acquisition of cadastral and property data will, in most cases, be undertaken by municipalities or regional government agencies. However, there may be costs in digitizing analogue data or in developing the software and hardware necessary to share the data with the custodians.

Costs associated with data acquisition may be classified as a capital item if they are included in the cost of setting up the geospatial data infrastructure. However, they may also be classified as operating costs if they are for updating or enhancing data already held in the database.

3.2.3 Operating costs

Operating costs include fixed items, such as routine maintenance, rents and leases and variable operating costs, including delivery of information to beneficiaries. The latter category of costs varies with the level of activity that the responsible organization encounters.

Annual operating costs were reported to be in the range of US$1 million to US$5 million.

3.2.4 Costs associated with development of policy, regulation, and standards

Expenditure is also likely to be required for development of policies, standards, and regulations to govern the ownership, storage and sharing of data, and the standards required to facilitate data maintenance, currency, and security.

Generally, such costs would form part of the annual budget of organizations and would be classified as operating costs for the purpose of an economic evaluation. However, where costs associated with policy, regulation or standards are incurred as part of establishing the UN-IGIF, they may be included as capital costs in the cash flows.

3.2.5 Capacity building, training and certification

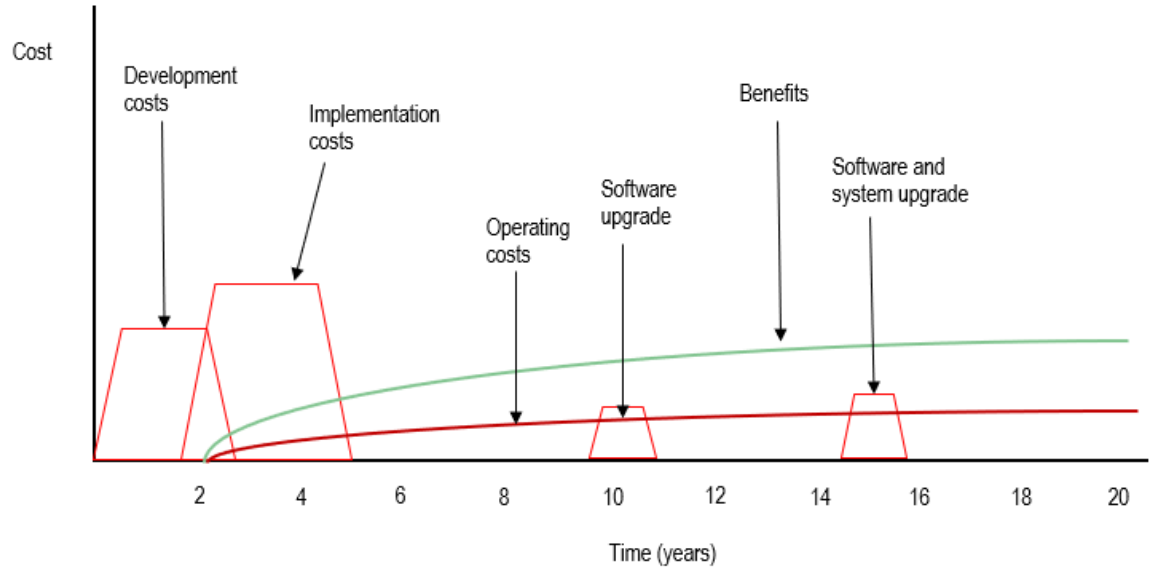
Costs are also likely to be incurred in building capacity in the workforce required to support geospatial data infrastructure, systems and services. This will include costs associated with establishing and sustaining longer-term training programs and the necessary certification programs.

This may also include establishing linkages between the private and public sectors and tertiary training providers and institutions at the technical and professional level.

3.3 Aligning investment with sources of funding

The pattern of investment in spatial data infrastructure is characterized by initial capital outlays for development and implementation activities, followed by periodic investment in software and system upgrades as illustrated figuratively in Figure 3.3. The challenge for those seeking sustainable funding for investment in geospatial infrastructure is to ensure that provision for both capital and operating costs over time is provided in funding arrangements.

Figure 3.3 Hypothetical timeline of costs and benefits associated with implementing spatial data infrastructure



Source: Adapted from (Bettinger, P. et al, 2009)

There are many competing priorities for funding from government budgets. Proponents may need to seek from various sources including domestic budgets, financial institutions, donors and fees and charges for service provided. Some countries prefer to fund all capital and operating costs from domestic budgets. Others seek to fund development and implementation costs from donors while funding operating costs from domestic budgets.

The optimal model will depend on each country's development needs and budgeting practices and the funding policies and preferences of donor organizations.

The potential to recover some costs from usage charges for value added products and services is also important and should be considered in sustainable funding strategies.

3.4 Benefits from investing in UN-IGIF implementation

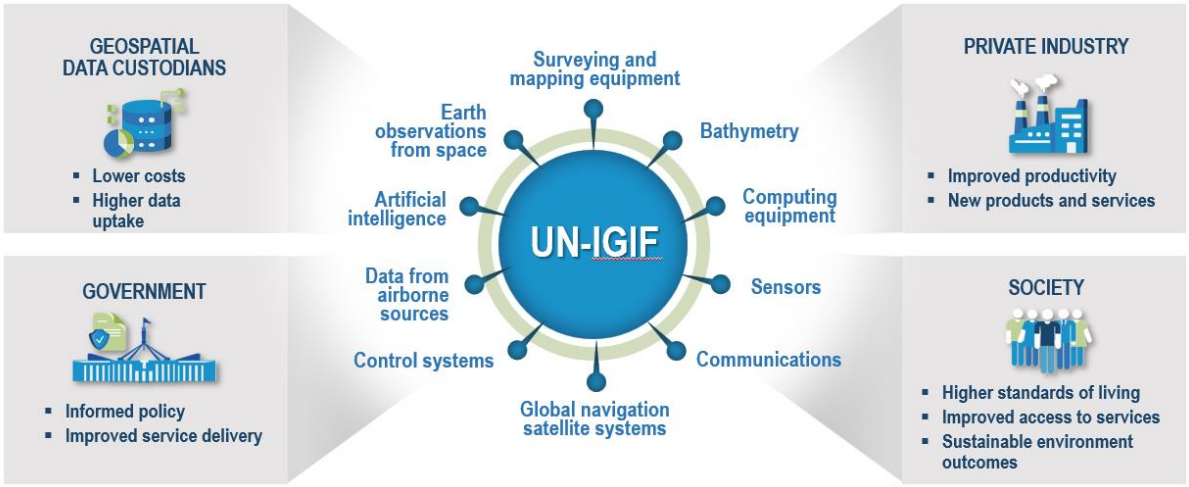
3.4.1 The benefits that can accrue from implementing the UN-IGIF

Geospatial information is an enabling technology where the benefits accrue both along the supply chain and at the end use. These benefits are captured by:

- **Government agencies responsible for implementation** in terms of improved productivity and lower costs
- **Government users of geospatial data** in terms of lower costs for data access, improved productivity and better outcomes for government policy formulation and service delivery
- **Private sector users of geospatial data** through improved productivity and development of new products and services
- **Society** in terms of better economic and social outcomes and greater inclusivity
- **The environment and resources** through tools to manage natural resources and the environment more sustainably.

Potential beneficiaries are illustrated in Figure 3.4.

Figure 3.4 Beneficiaries



Source: ACIL Allen

3.4.2 Identifying and assessing the benefits of geospatial information management

The geospatial value chain involves many transactions and transformations from data capture to storage, access, analysis and ultimately use, as illustrated in Figure 3.5.

Figure 3.5 Geospatial value chain

While each of these transactions involves service providers who benefit from sales of their goods and services, these sales represent transfer payments within the value chain. They cannot therefore be added together to provide an estimate of the total economic impact created by the geospatial data.

The total economic impact of the data held in geospatial infrastructures is only realized when the data is either used by an end user to turn the data into valuable information or when savings along the value chain are realized.

Identifying benefits and costs is also challenging for three reasons:

- Geospatial information infrastructure and services are enabling technologies where the majority of the benefits accrue to those that use the data.
- Many of the benefits are intangible or are not traded in a market, so there is no price that can be observed to calculate value.
- Geospatial data is often provided by Governments as a public good for which there is no user fee.

Estimating the value and benefits of investing in geospatial data infrastructure requires research to identify the ultimate beneficiaries of a geospatial information initiative. This involves consultation with stakeholders and, in some cases, surveys to quantify or otherwise estimate qualitatively, the benefits that accrue to users. These approaches are discussed further in Chapters 4 and 5 below.

3.4.2.1 Potential benefits for government

Most government agencies benefit from access to geospatial infrastructure. For developing countries, the initial beneficiaries are government agencies, who are likely to be the early adopters of geospatial services. Adoption of geospatial services by businesses may take time to eventuate depending on the capacity of small and large businesses to invest in systems enabled by geospatial management services. Examples of the benefits that can be expected to accrue to government follow.

Savings from National Data Infrastructure – Substantial savings can be achieved through establishing a national geospatial data infrastructure. Consultations with a selection of Member States suggested that savings of up to 70 per cent are possible through a coordinated approach to national spatial data infrastructure compared with a scenario where each agency developed its own spatial data infrastructure. In addition, the potential to share data through a national approach improves collaboration on data retention and curation.

Improved integration of government services – Experience has shown that the ability for government agencies to work with common location data, helps coordination of services across government. Examples include improved planning, land development, provision of health and social services, environmental management, delivery of municipal services and many more. Adding location information to national statistics creates opportunities for analysis of demographic change, regional analysis and planning and management of administrative boundaries and land tenure (Crompvoets, J. et al, 2011).

Advancing a digital agenda – Digitizing government data and sharing it across agencies of government offers significant savings in administrative costs. While many developing countries may not be in a position to achieve this goal in the short term, the policies and standards established for sharing geospatial data in National Spatial Data Infrastructure provide a pathway to the digitization of government information across Departments and agencies. This has the potential to deliver significant cost savings for governments and industry (Crompvoets, J. et al, 2011).

Improved asset management – Geospatial information can deliver significant productivity improvements in management of physical assets such as roads, buildings, school facilities, hospital facilities and many other public facilities. This has been shown to deliver significant benefits to government, industry and users.

Protecting the nation's biosecurity – Using geospatially supported technologies can significantly aid in monitoring pest infestations and disease outbreak as well as managing responses to biosecurity threats, thus reducing the costs incurred by countries from incursions of pests and diseases.

Emergency management and disaster response – Using Common Operating Platforms to merge satellite imagery, airborne surveillance with LIDAR and infrared sensors enhances abilities to monitor and map fire hot spots, flooding, coastal inundation, and other disasters, to enhance decision-making and plan effective response strategies.

Improved land management – Fundamental geospatial data and cadastral data provide crucial support for land development and management. Certainty of property rights benefits landowners, while authoritative property boundaries and land titles are essential for financing arrangements for large and small businesses, as well as private citizens. This improves the productivity of businesses both large and small and contributes to economic growth.

Improved coastal zone management – Remote sensing, seabed mapping and positioning services play a crucial role in monitoring changes in the coastal zone, and assessing the impacts of storm surges, coastal erosion, flooding and coastal ecosystem change. Management of coastal zones is critical for many societies located in coastal regions both in terms of safety and economic activity.

Improved monitoring of the marine environment – Modern bathymetry, space-based ocean monitoring, autonomous gliders, and Earth observations from space provide valuable data for assessing water quality and effectively managing marine resources.

Greater efficiency in collecting taxes and charges – With better geocoded data, governments can improve the efficiency of land administration, tax collection and other charges, thereby reducing the administrative time and resources required to support land administration.

Environmental and natural resource management – Satellite and airborne imagery together with satellite positioning, provides essential tools for monitoring land cover, forests, and coastal and marine systems, enhancing the ability too effectively manage and protect vital natural resources.

Management of water resources and water supplies – Earth observations from space, satellite positioning, terrestrial sensors, and weather data provide crucial inputs for the design, construction and development of water supply and distribution networks. Water quality can be monitored from space and geospatial services support flood and coastal inundation mapping, enhancing the overall management of water resources.

Climate change – Satellite and remote sensing play a pivotal role in monitoring emissions sources and sinks, tracking coastal inundation and sea level rise, and supporting carbon trading and similar schemes, all of which are essential for understanding and mitigating the impacts of climate change.

Health care and social assistance - Planning the strategic location of ambulance services and health care facilities is improved with geospatial analysis, ensuring fast response times and critical access to health services.

National security – Geospatial information such as earth imagery from satellite, satellite positioning and communications systems are critical for national security, including managing land and maritime border security and monitoring ships transiting national waters.

More efficient local government – Municipalities and local governments around the world have been rapidly adopting geospatial infrastructure and services to improve delivery of services, including route optimization for rubbish collection, managing development approvals processes, and providing rate payers with more efficient ways of interacting with local government via the internet. Geospatial infrastructure supports local government in delivering better and more responsive services to the benefit of society and the economy.

3.4.2.2 Potential benefits for the economy

While the adoption of geospatial supported technologies may take time, over the longer-term, geospatial services can improve productivity across many sectors important to developing countries.

Agriculture – Precision agriculture can deliver significant productivity improvements to agricultural activities. This includes the use of autonomous farm machinery, variable rate technologies, yield monitoring, and monitoring water and feed conditions for livestock activities.

Mining – Geospatial supported technologies are critical for exploration, production and management of mineral ores and petroleum. They also play a key role in monitoring compliance with environmental conditions and assessing the performance of mining activities, including the integrity of tailings dams and control of leachates. For larger mining operations the development of autonomous vehicles is delivering productivity and safety benefits to mining operations around the world.

Planning the built environment – Geospatial supported technologies have delivered significant productivity improvements to planning and development of the built environment. This includes surveying and mapping, planning and construction, and delivery and management of infrastructure. Three dimensional digital models of the built environment offer the potential for major productivity improvement in the delivery of housing and construction projects and supporting infrastructure.

Infrastructure – Geospatial supported technologies can produce significant savings in asset management, infrastructure, buildings, and energy systems. The emerging use of artificial intelligence in asset management systems offers further potential for productivity improvement in areas such as road and bridge maintenance.

Transport and logistics – The transport and logistics sector can benefit from mapping and positioning data embedded in devices and software to optimize route selection and heavy vehicle operations. Geospatial enabled technologies support logistics for warehousing, shipping, and delivery of goods to customers. Mapping and positioning services support navigation and air traffic control in marine and aviation operations.

The blue economy – Bathymetry and satellite positioning support shipping and port operations. Vessel tracking technologies important to managing operations in national waters are critically dependent on geospatial technologies. Carriage requirements established by the International Maritime Organization, specify that all newly built passenger ships of 500 gross tonnage and upwards, as well as newly built cargo ships of 3,000 gross tonnage and upwards engaged on international voyages, must be fitted with Electronic Chart Display and Information Systems (ECDIS).[21] These systems are also important in port approaches and maneuverings and can provide depth information to avoid groundings in restricted waters.

[21] For existing ships, phased in introduction of ECDIS requirements is being introduced for all ships of a certain size. (IMO, 1980)

Commerce – Geospatial supported technologies enable commercial engagement along value chains as well as between retail operations and customers. Position Navigation and Timing (PNT) is embedded in electronic transactions in the banking sector. GIS systems supported by geospatial information and positioning are embedded in insurance and risk management for both insurance companies and citizens.

Geospatial systems support transactions between small businesses and third parties, efficiently creating opportunities for small businesses to develop and grow their markets.

3.4.2.3 Potential benefits for society

Access to accurate maps and location – Geospatial Information infrastructure services provide citizens with access to accurate mapping and location information via the internet, mobile phones and related devices. These services save time for consumers searching for services from government departments, municipalities, financial and retail organizations, and non-government organizations.

Geospatial information helps citizens and small businesses conduct their personal and business affairs more efficiently. This ultimately leads to improved productivity and social engagement generally.

Optimization of travel arrangements – PNT and geospatial data embedded in GIS software, available through web-based applications on personal computers and devices, is increasingly being applied by local government, businesses and consumers for route optimization, public transport use, and personal navigation. Route optimisation reduces the cost of transport related activities and supports improved services to consumers.

Greater inclusivity – Geospatial information creates the opportunity for greater inclusivity in communities. Geospatial information services provide governments with the potential to use 3D visualization to support community consultation. This supports government engagement with citizens on development plans, including public transport, location of health services, and urban and rural development projects generally.

Delivering opportunities for citizens and small businesses – Geospatial information creates options for national and local governments, large and small businesses, to develop new and innovative products and services. While it is often difficult to predict how new technologies and systems will drive future innovation, the value of the options they create is important to longer term economic growth.

Twenty years ago, it would have been difficult to predict the innovations that have since arisen through the combination of GIS, positioning, sensors, control systems and digitization in applications in almost every area of government and business

endeavor. The rapid emergence of mapping and positioning information being made available to all through computers and personal devices is creating an array of potentially valuable technologies for developing countries.

The emergence of machine learning and artificial intelligence is only just beginning to find applications in services such as in asset management, government services and in delivery of retail options for consumers. While there are numerous policy issues, regulatory approaches and data security and management policies and standards to be settled along the way, the options that they are creating have significant value to developing countries.

3.4.3 Economy wide impacts

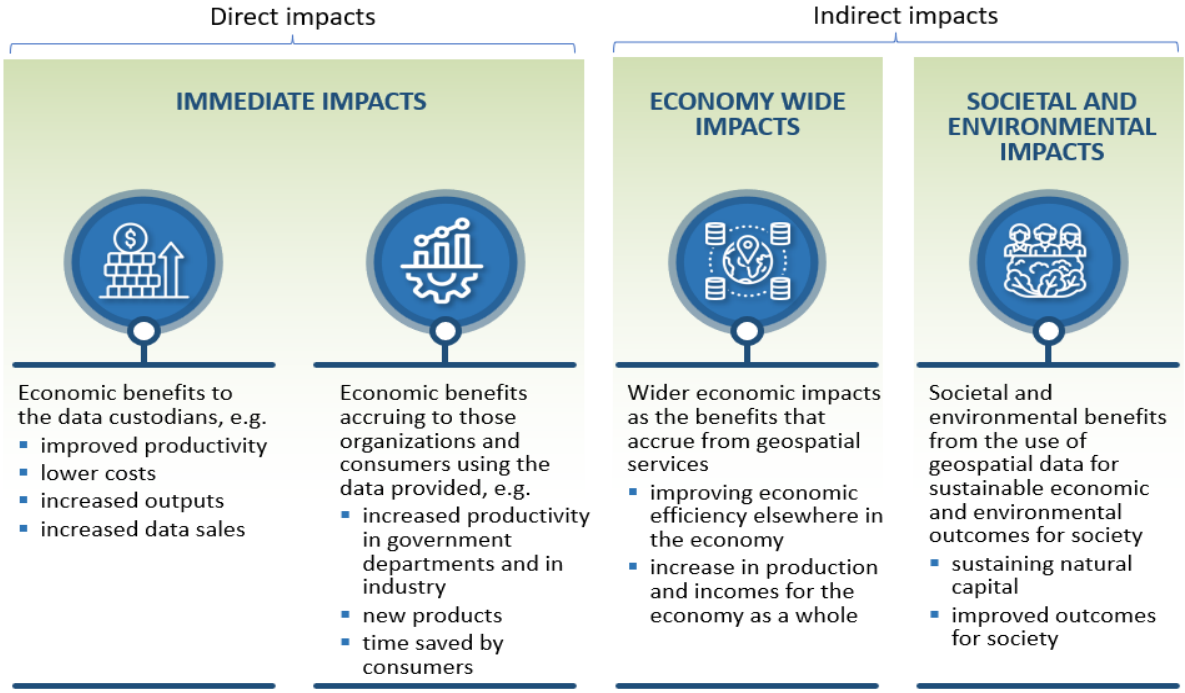
The initial benefits from investment in UN-IGIF activities will ultimately flow on to the wider economy. For example, a productivity improvement resulting from the use of geospatial supported technologies benefits the transport sector initially. This is often referred to as the direct impact. However, an improvement in the productivity of the transport sector will also benefit the users of transport such as freight services and other road users. These are referred to in some literature as indirect impacts (Bower R et al, 2008).

There are also environmental and social benefits that arise. These are also referred to as indirect impacts in the literature (World Bank, 2021). By improving the productivity and effectiveness of government services, industry output and supporting society, geospatial information services support wider national development objectives, including reducing poverty and improving food security. It is important to consider both the direct and indirect impacts when assessing the benefits that arise from investment in geospatial information, services and systems.

A review of selected reports on the value of geospatial information from around the world revealed that many different definitions of direct and indirect impacts arising from geospatial data have been adopted in various studies. A selection of definitions from some recent studies is provided in Annex B.

While there are differences in definitions adopted in past studies, it is important to be clear about what defines direct and indirect impacts. One approach is to define direct impacts as those impacts that are immediately captured by data custodians and by the immediate users of the geospatial data. Indirect impacts on the other hand, are those that accrue to the wider economy, and society as whole. This is illustrated in Figure 3.6 below.

Figure 3.6 Direct, indirect, and societal and environmental impacts



Source: ACIL Allen

This Funding Guide recommends using the definitions illustrated in Figure 3.6. However, Member States should be aware of the different definitions that are contained in reports that they might review as part of undertaking and economic evaluation as part of implementing the UN-IGIF.[22]

3.5 Summary

Geospatial management services involve several technologies and systems including earth observation satellite data, position navigation and timing from satellites, ground stations to transfer the data, software, and hardware to store the data, and policies, standards, and regulations to share and protect the data. It also includes development of capacity, capability and systems for delivery of geospatial information services to users.

Investment in geospatial information services and systems is fundamental to achieving the broader development goals of governments.

Financing investment in geospatial information infrastructure, capabilities and services, faces a challenge in most countries given the competing priorities for funding from government budgets. Sustainable funding is critically important for geospatial infrastructure. The investment does not end with the initial development and implementation costs. It involves periodic upgrades and capital replacement to maintain the performance and value the supporting infrastructure and facilities.

[22] In some cases, the results of a benefits assessment in one country can be used to provide a benefit assessment in another country. This is referred to as benefit transfer and discussed in Chapter 4.

Consideration of funding requirements must also include operating expenses for curation of data as well as maintenance costs for equipment and facilities. There is likely to be ongoing expenditures on data capture and data upgrades as the nature of the data evolves.

The benefits of investment in geospatial data and infrastructure are significant for national and regional economies. They accrue to governments, municipalities, small and large businesses, consumers, the environment, and society. Geospatial information is fundamental to achieving the UN Sustainable Development Goals.

Documenting the quantitative and qualitative benefits that can be expected to accrue from investment in geospatial management services and infrastructure through the UN-IGIF is critical to creating the case for sustainable funding to national governments and donors alike.

The following chapters outline the steps for undertaking cost benefit analysis of such investments and approaches to valuing the benefits.

4 Cost benefit analysis

Main points in this chapter

Cost benefit analysis

Cost benefit analysis considers the full impact of a change for economic, societal, or environmental outcomes from a policy initiative or an investment**.**

Cost benefit analysis is concerned with the allocation of resources and differs from financial evaluation that is concerned with financial factor, revenues, costs, depreciation and tax.

The eight steps in undertaking a cost benefit analysis:

1. **Develop a statement of objectives**
   The objectives should be framed within government policy goals and strategies.
2. **Define the evaluation case and the base case**
   One or more options (evaluation case) are assessed against a base (business as usual) case.
3. **Identify costs and benefits including outputs, outcomes, and rates of adoption**
   Document the inputs, outputs, and outcomes to estimate benefits and costs.
4. **Value the costs and benefits and prepare forecasts over the evaluation period**
   Use market and non-market techniques to estimate benefits. Prepare forecasts of benefits and costs for the options being assessed.
5. **Assess economic performance by estimating Net Present Value (NPV) and Benefit Cost Ratio (BCA) and test sensitivity to key assumptions**
   Prepare cash flows of benefits and costs. Using a cost benefit model, calculate the net present value (NPV) and/or cost benefit ratio (CBA) for each option. Future costs and benefits are discounted by a discount rate that reflects the opportunity cost of funds.
6. **Examine and outline qualitative and distributional impacts**
   Benefits that cannot be monetized should be described in qualitative terms. The distribution of benefits along the supply chain and between different parts of society should be documented where relevant to the analysis.
7. **Analyze risks and sensitivities drawing on the sensitivity analysis**
   Risk and uncertainties associated with the findings are documented. It is also desirable to test the sensitivity of the findings to different assumptions of benefits, costs and discount rates.
8. **Select a preferred option and report the key findings**
   The findings of the analysis are documented in a report. Where options have been assessed a preferred option is identified. The findings should also demonstrate how the project meets the objectives established for the project.

4.1 Socio-economic impact assessment

A socio-economic impact assessment is a systematic process of analysis that aims to measure the full impact of a change in economic, societal, or environmental outcomes from an investment or policy change by government or industry. The most common form of such an assessment is a cost-benefit analysis. Cost benefit analysis is concerned with resource allocation and differs from a financial evaluation that is concerned with financial flows of revenues, costs depreciation and tax and, in most cases, does not capture social or environmental impacts.

The purpose of this chapter is to set out the approach to undertaking a Cost Benefit Analysis to support a business case for investment in activities to implement UN-IGIF Country-Level Action Plans. A more detailed discussion of approaches to quantifying costs and benefits is provided in Chapter 5 and a discussion of other approaches to assessing socioeconomic impacts is provided at Annex A.

4.2 The steps in undertaking a cost benefit analysis

There are generally eight steps in a cost benefit analysis as shown in Figure 4.1. The level of detail, the number of options considered, and the depth of analysis of benefits and costs will vary depending on the circumstance. Generally, policy and investment initiatives are assessed in stages with an initial cost benefit assessment, followed by a more detailed assessment and business case. Regardless of the level of detail, the steps set out in Figure 4.1 apply to any cost benefit analysis.

Figure 4.1 Steps in cost benefit analysis

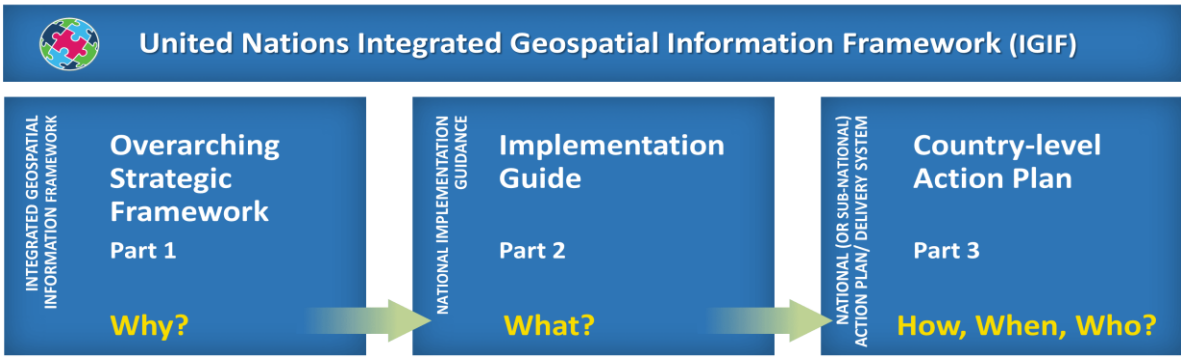
Steps in CBA analysis	Actions and activities	
1 Statement of objectives	Alignment with government policy goals	Intended outcomes of the initiative
2 Define evaluation case and base case	Define activities and, if appropriate, options to realise the intended outcomes	Define the base case scenario that would emerge if the initiative does not proceed.
3 Identify benefits and costs	Identify costs and benefits expected to accrue from the activities and options under evaluation	Estimate the timeframes over which the costs and benefits are expected to occur
4 Value benefits and costs	Value quantifiable benefits and costs for options being assessed	Prepare cash flow of benefits and costs over the evaluation period.
5 Assess the net benefits	Prepare financial model for each option being assessed	Calculate Net Present Value and Benefit Cost ratio for each option
6 Identify qualitative and distributional impacts	Provide qualitative description of environmental and social benefits	Identify major beneficiaries along the supply chain and among user groups
7 Assess risk and test sensitivities	Outline risks associated with each option	Prepare sensitivity tests
8 Select preferred option and report key findings	Select the preferred option considering economic parameters, qualitative and distributional impacts.	Outline the preferred option stating how it meets the economic and social objectives

Source: ACIL Allen drawing on references listed on page 68.

4.2.1 Statement of objectives

A starting point for a Cost-Benefit Analysis (CBA) is to outline the objectives and desired outcomes of the initiative. The United Nations Integrated Geospatial Information Framework (UN-IGIF) Overarching Strategic Framework, Implementation Guide, and Country Level Action Plans, provide the road map for developing objectives and outcomes as set out in Figure 4.2 .

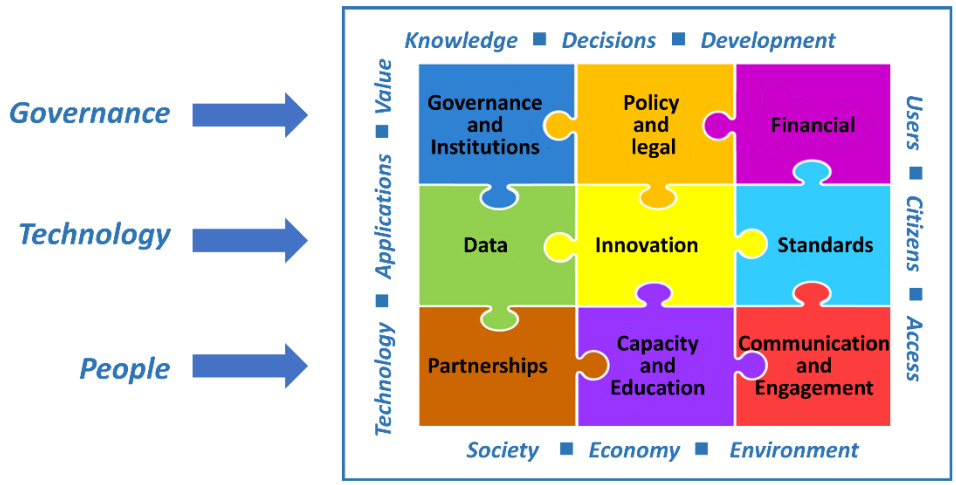
Figure 4.2 UN-IGIF strategic pathway



Source: (UN-IGIF, 2023)

The Overarching Strategic Framework provides the process and protocols within which the stated objectives and outcomes can be developed. There are nine strategic pathways to guide implementation of the UN-IGIF. Strategic Pathway 3 addresses the development of a business model and financing arrangement for implementation of the UN-IGIF (Figure 4.3).

Figure 4.3 UN-IGIF Strategic Framework



Source: (UN-IGIF, 2023)

An important step in this process is development of a business case that sets the objectives of UN-IGIF implementation within the context of wider government policies. UN-IGIF documents provide guidance activities to support the development of the business case including stakeholder engagement, strategic alignment of objectives, gap analysis and needs assessment (UN-IGIF, 2023).

The process and structure of the business case to support implementation of the UN-IGIF depends on the specific circumstances in each country. This may require proponents to consult with central

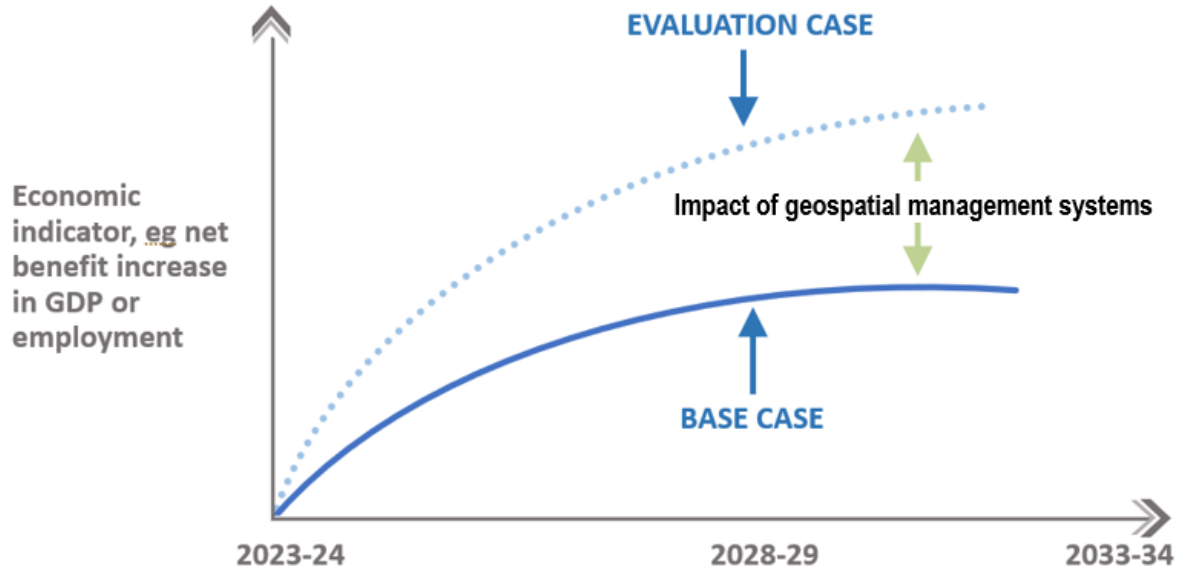
government agencies to achieve alignment with broader strategic objectives and policies. The World Bank has also developed a template to assist countries with geospatial alignment to policy drivers (World Bank, 2023).

Whatever approach is taken, it is important to ensure that the goals and objectives of proposals are strategically aligned with the national strategy and policies of the country.

4.2.2 Defining the evaluation case and the base case

Socio-economic impact is the difference between the socio-economic outcomes that are expected from an initiative (an evaluation case) and a base case (a business-as-usual case). This is represented in Figure 4.4.

Figure 4.4 Comparing the evaluation scenario with the base case scenario



Source: ACIL Allen

4.2.2.1 Base case

The Base Case is defined as the continuation of the current arrangements as if the proposal under consideration is not implemented (HM Treasury, 2022). When establishing a base case, it is important to consider measures or actions that would otherwise occur if the proposal does not proceed.

In some cases, this exercise can be undertaken quickly, as many proponents have a good understanding of the future without the initiative. In other cases, it may require consultation with other government agencies or the private sector to assess the situation under a base case.

The World Bank has developed a baseline assessment template that can be used to survey and assess the existing status across a range of institutional and policy settings. The choice of approach would be up to each country to decide (World Bank, 2020).

4.2.2.2 The evaluation case

The evaluation case is the proposed investment or policy action that is to be assessed. In some cases, it may be necessary to consider different options to achieve the required outcomes. Options could include investment in new hardware and software or upgrading existing hardware and software. The

economic impact of each option is then assessed, and a preferred option selected based on the cost-benefit findings along with other factors to be considered in the business case including financing arrangements and risk management.

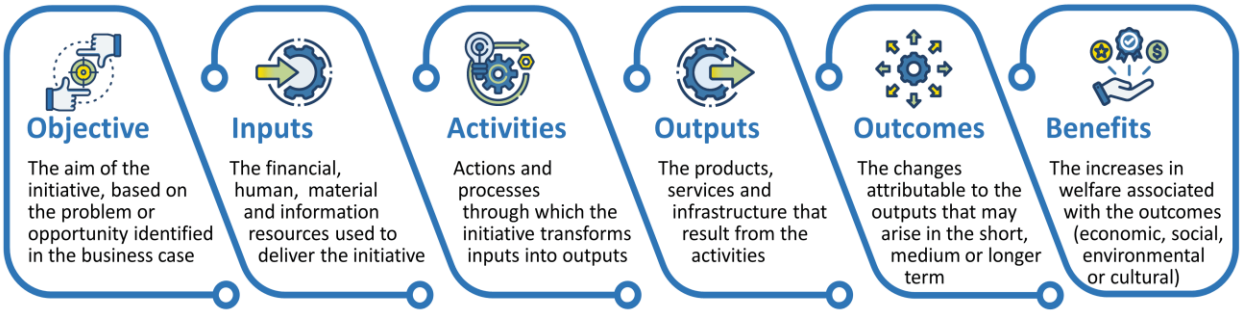
4.3 Identify benefits and costs

Identifying and valuing benefits and costs expected to accrue from implementation of the UN-IGIF requires considerable research and consultation because many sectors of the economy and society can be expected to benefit. In addition, geospatial data tends to generate significant intangible benefits. This requires a systematic approach to documenting the activities, outputs, and outcomes for each option.

4.3.1 Using a logic model

When estimating benefits, it is useful to employ a logic model that describes the links between the proposed investment or policy change, the inputs and activities that will be involved, the outputs that it will produce, and the outcomes that are sought. Logic models can take several forms. A simplified structure is provided in Figure 4.5.

Figure 4.5 Typical logic model



Source: ACIL Allen and (NSW Treasury, 2023)

The outcomes determine the benefits that are expected to be realized from these activities.

The analysis will also require forecasts of the benefits and costs over a defined evaluation period. Research and consultation with stakeholders can provide insights into future benefit streams. Factors to be considered include expected levels of adoption of technologies by users, future economic growth, transformation of government services and industry products and services, uptake by consumers and policy imperatives of government.

Geospatial information can be an agent for change that often leads to transformation of government service provision and industry production processes. This can have a profound impact on economic activity, economic growth, and society's use of geospatial data. Case studies augmented by consultations and research are important to assessing the potential for such developments.

It is also important to record any benefits that cannot be quantified and describe them in qualitative terms. These benefits are reported in parallel to the quantifiable economic benefits.

The logic model is therefore important to a systematic analysis of these benefits.

4.4 Valuing benefits and costs

4.4.1 Valuing benefits

The challenge for analysts placing a value on the benefits of investment in geospatial information management and services, is that while a significant proportion of the benefits can be quantified from market information, some of the benefits are not traded in a market.

There are techniques for valuing both market and non-market values. These are summarized in Table 4.1 and discussed briefly below. A more detailed discussion of valuing market and non-market impacts, with some examples, is provided in Chapter 5.

Table 4.1 Methods for valuing market and non-market benefits

MARKET IMPACTS			
Market prices (consumer and producer surplus)	Productivity impacts	Defensive expenditure or substitute cost methods	
NON-MARKET IMPACTS			
Revealed preference			
Benefits transfer	Travel cost methods	Hedonic pricing	Control and treatment group experiments
Stated preference			
Willingness to pay	Willingness to accept	Choice experiments	

Note: Consumer surplus is the difference between the price a consumer pays and the price the consumer is willing to pay for a good or a service. Producer surplus is the difference between the price the producer receives and the cost of production (including a return on capital)

Source: ACIL Allen. A full description of the techniques identified in the above table is provided in Chapter 5.

4.4.1.1 Market impacts

What are they?

Market impacts are those costs and benefits that can be quantified from observing and consumption of goods and services in freely operating markets. They include benefits calculated from prices and quantities traded in markets or in productivity improvements for the suppliers of data as well as for the users of data. Productivity improvements can be lower costs for the same output or increasing output for the same input. They are extremely important to increasing economic welfare and economic growth.

Some benefits accruing to consumers and society cannot be estimated easily from market factors or productivity impacts. In such cases, the benefits can be quantified in terms of time saved, reduction in average annual damage costs from natural disasters, reduction in costs to consumers, or reduction in health costs.

How are they used?

The value of geospatial data can be estimated where it is sold to users in an open market by multiplying the average price received by the quantity traded. In doing so, it is important to be aware of the extent to which the markets are operating freely without impediments to competition.

Where data is provided free by governments, it is not possible to draw on market prices paid by users. However, benefits can be estimated using non-market impact techniques listed in Section 4.4.1.2 below. There will also be productivity improvements for users as well as for participants in the geospatial data supply chain.

Productivity improvements can include lower costs, higher output or both and can be estimated from case studies and research. These can be scaled up to sector wide benefits by estimating the level of adoption across sectors.

The techniques for doing this are discussed in Section 5.3 of Chapter 5.

4.4.1.2 Non-market impacts

Non-market impacts present a more difficult challenge as there is no market price on which to quantify value. However, economists have developed techniques to value some of these non-market values. These techniques can be broadly classified as revealed preference and stated preference methods.

4.4.1.2.1 Revealed preference

What is it?

Revealed preference methods require observable data about behaviors or information related to the value of the non-market good or service. They estimate the value of a good or service by comparing outcomes for a treatment group that has access to the non-market benefit to a control group that does not have access to the non-market benefit.

Well-known revealed preference methods that are popular for estimating the value of a non-market good or service include benefits transfer, travel cost, hedonic pricing, and various control-and-treatment group methods (Smart A, Coote A, Millar B, Bernknopf R, 2018).

How is it used?

Revealed Preference methods have been used in valuations of non-market goods such as access to national parks or features of environmental value. They are generally less intensive and do not usually require as much expertise as State Preference Methods.

The techniques for undertaking revealed preference methods are discussed in Section 5.4.1 of Chapter 5.

4.4.1.2.2 Stated preference

What is it?

Stated preference methods use surveys or experiments to determine how much individuals would be willing to pay or willingness to accept an outcome in hypothetical or laboratory settings. These approaches are particularly useful when the data to support revealed preference methods are

unavailable, as is often the case with public goods. Examples of stated preference methods include contingent valuation (willingness to pay or accept (WTP/WTA)) and choice modelling.

How is it used?

Revealed preference and stated preference methods generally require specialists to undertake them and can be expensive. However, there are examples in the literature that can provide data that can be used in benefits transfer approach.

The techniques for undertaking state preference methods are discussed in Section 0 of Chapter 5.

4.4.2 Valuing costs

Cost benefit analysis is concerned with the resources required to establish an investment project, whether they are internally financed or financed by another party as might occur in a public private partnership. Costs are broken down into capital costs and recurrent costs.

4.4.2.1 Capital costs.

Capital costs are built up from all the inputs discussed in Section 3.2 of Chapter 3 above. In the case of a public private partnership, capital costs contributed by the private party, or parties should be included at the time are incurred, assuming the main proponent is a government agency.

Subsequent transfers of assets between the parties or payments by the proponent to a private partner would be a transfer payment and not included in the cash flows for the CBA.

Periodic upgrades or replacement of software or hardware should be recorded as a capital cost when they occur.

4.4.2.2 Operating costs

Operating costs include all operations, maintenance and other costs incurred as part of service delivery. This would include license fees and charges for use of third-party software and services, data access charges, rent, insurance and any taxes and levies.

In the case of a Public-Private Partnership (PPP), costs associated with operations and maintenance of any capital items considered part of the project should be included.

4.4.2.3 Financial and accounting charges

Expenses related to the cost of doing business, such as accounting fees or bank account keeping fees, are to be included in the costs.

Depreciation is not included in the cash flows as capital investments and periodic upgrades are included in the cash flows as they occur.

Draw down and repayment of debt and interest payments for debt are not included in the cash flows as they are transfers between parties that cancel each other out. Instead, capital items are recorded on the date that they occur in the cash flows. Interest charges are not deducted as they are allowed for in the discounting process that is applied to the cash flows.

The Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) metric is a good method for determining whether an expense is a true economic cost or a transfer payment. If a financial or

accounting charge is part of EBITDA, then it should be included in the calculation of costs for a cost benefit analysis.

4.4.2.4 Costs incurred by beneficiaries

Beneficiaries of an initiative are also likely to incur costs in order to utilize the geospatial data provided. This could include costs associated with installing new software, paying license fees or training staff.

Costs incurred by beneficiaries are best deducted from the benefits calculation and estimated from consultation with beneficiaries.

4.4.3 Preparing cash flows

The benefits and costs associated with an initiative should be entered into a cash flow table in the year that they are forecast to occur. An example of a cash flow table for a hypothetical investment is provided in Table 4.2 below.

The analyst will need to decide on an evaluation period over which the benefits and costs are to be assessed. Cash flows are generally characterized by a period of initial investment followed by a period over which benefits will accrue.

The selection of an evaluation period can be made on a case-by-case basis. The implementation period will depend on the nature of the investment. The benefits realization period will depend on reasonable estimates of the time over which the benefits are expected to accrue. An evaluation period that is too short may miss significant benefits accruing over the longer term.

Estimates will vary depending on the situation in each country, but a reasonable period could be expected to be ten to fifteen years depending on the circumstances. The World Bank methodology for undertaking a cost benefit analysis assumes an implementation period of five years followed by a seven-year period of use leading to a twelve-year evaluation period (World Bank, 2022).

The period of evaluation can be considered on a case-by-case basis. We have used a fifteen-year period for example illustrated in Table 4.2.

Casting benefits out beyond twenty years is probably not reasonable given the speed of technological change but up to twenty years may not be unreasonable in some cases, particularly with projects with long-lived capital.

Table 4.2 shows benefits listed by case study and benefits for each case study. The costs are also listed. The net cash flow is then calculated by deducting the total costs from the total benefits.

Table 4.2 Example of a cash flow table

Year number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year	Currency	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Benefits (net of user costs)																
Revenue from sale of cadastral and other data	US$m	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Savings in data capture and storage	US$m	50,000	2,010,000	1,510,000	500,000	500,000	-	-	-	-	-	-	-	-	-	-
Savings in land cover and enviormental monitoring	US$m	-	-	-	-	100,000	150,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Productivity improvement in local government	US$m	-	-	-	-	200,000	400,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
Reduced average annual damage from natural disasters	US$m	-	-	-	-	500,000	1,000,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Land market growth	US$m	-	-	-	-	1,000,000	3,000,000	4,000,000	5,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000
Increase in agricultural productivity	US$m	-	-	-	-	100,000	3,000,000	4,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
	US$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	US$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	US$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total net benefits	Dom	65,000	2,025,000	1,525,000	515,000	2,415,000	7,565,000	10,465,000	12,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000
Costs																
Capital costs																
Initial capital costs	US$m	400,000	6,920,000	5,520,000	3,500,000	3,400,000	-	-	-	-	-	-	-	-	-	-
Capital replacement	US$m	-	-	-	-	-	-	-	-	-	-	1,000,000	-	-	-	1,000,000
Total capital costs	US$m	400,000	6,920,000	5,520,000	3,500,000	3,400,000	-	-	-	-	-	1,000,000	-	-	-	1,000,000
Opoerating costs																
Operations and maintenance	US$m	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Leases and charges	US$m	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Wages and salaries	US$m	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Total recurrent costs	US$m	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000
Salvage value (+ or -)	US$m															0.10
Total costs	US$m	1,150,000	7,670,000	6,270,000	4,250,000	4,150,000	750,000	750,000	750,000	750,000	750,000	1,750,000	750,000	750,000	750,000	1,750,000
Net cash flow	US$m	- 1,085,000	- 5,645,000	- 4,745,000	- 3,735,000	- 1,735,000	6,815,000	9,715,000	11,715,000	13,715,000	13,715,000	12,715,000	13,715,000	13,715,000	13,715,000	12,715,000

4.4.4 Salvage value

In some cost benefit analysis, analysts include a salvage value at the end of the evaluation period to account for positive cash injections such as the sale of assets or intellectual property, or negative cash items such as reinstatement costs, for example, in the case of say a mine. A line for possible salvage value is included in Table 4.2. This line can be left blank if there is no salvage value.

4.4.5 No account for inflation

In most cost-benefit analyses, the impact of inflation is not taken into account. The cash flows are recorded in real terms rather than nominal terms. This is on the basis that inflation affects cost and benefits equally. If there are specific components of costs or benefits that are not subject to the same inflationary effects, it should be considered when calculating future costs or benefits in real terms.

4.5 Assessing the economic performance

4.5.1.1 The cost benefit model

The aim of the cost-benefit analysis is to express the economic impact of an initiative or policy change. To achieve this, the benefits and costs are aggregated to determine the net benefit or impact. This is achieved by building a cost benefit model to record the benefits and costs of cash flows over time and then calculate a present value of the net benefits and costs of the various options.

In general, a model can be constructed using easily accessible electronic spreadsheet software. The model will record benefits and costs in a cash flow over the defined evaluation period. It will also calculate the investment performance parameters to be reported in the evaluation.

4.5.1.2 Discounting future benefits and costs

The costs and benefits from implementation of the UN-IGIF are spread over time. To compare future costs with future benefits, the future cash flows need to be discounted and brought into present value terms. To perform a cost benefit analysis, it is necessary to choose a discount rate for this purpose (NSW Treasury, 2023) (Department of Treasury and Finance, 2013).

Discounting future cash flows can be viewed from two main perspectives, both of which focus on the opportunity cost of the cash flows implied by the timing of payments. [23]

The first perspective is the observation that individuals generally prefer consumption today rather than in the future. This is referred to as the rate of time preference.

The second perspective is that flows of costs and benefits resulting from a project also have an opportunity cost. The concept of opportunity cost recognizes that a given public investment will occur at the expense of an alternative public investment. In the case of governments, funding a project

[23] Opportunity cost is a concept that captures the value of a resource in its next most valuable use. The opportunity cost of funds required for a geospatial project can be viewed as the value of those funds in the next most valuable use of those funds.

creates opportunity costs either through the interest paid for borrowed money, or from the benefits forgone when the funds are not available for alternative projects.

Both perspectives demonstrate that the need to discount future cash flows can be viewed in terms of the opportunity cost of the cash flows, whether this is the cost of delaying consumption, or the alternative project opportunities forgone.

The discount rate in a cost-benefit analysis being undertaken in real terms should not include an adjustment for inflation.

In most countries, the central treasury or finance agencies will provide guidance on the appropriate discount rate to use. The discount rate for most governments will include an element of systematic risk that applies to all government programs and projects (NSW Treasury, 2023). [24]

Typical discount rates range from 3 per cent to 7 per cent but depend on the circumstances in each country. It is good practice to test the sensitivity of a project's economics to a higher and lower discount rate to see if the project is materially affected by changes in the discount rate. The process of testing the findings for sensitivity to assumptions is discussed in 4.7 below.

The discount rate should not be adjusted for project specific risks. Specific project risk is best accounted for by using expected values for costs and benefits and performing sensitivity analysis.

4.5.2 Assessing economic impact

The preferable metrics to use for evaluation of an investment or policy the implementation of the UN-IGIF are:

Net present value (NPV)

The net present value is the present value of the benefits less the present value of the costs calculated over the evaluation period.

$$NPV = Present\ value\ of\ the\ benefits - present\ value\ of\ the\ costs$$

Cost benefit ratio (CBR)

The cost-benefit ratio is the ratio of the present value of the benefits divided by the present value of the costs calculated over the evaluation period.

$$CBR = \frac{Present\ value\ of\ the\ benefits}{Present\ value\ of\ the\ costs}$$

Other metrics include the Internal Rate of Return (IRR) and the Return on Investment (ROI).

The internal rate of return is the discount rate where the present value of the benefits equals the present value of costs. One concern is that the IRR calculation assumes that the financing rate and the reinvestment rate for an organization are the same as the IRR. This is a problem when the calculated

[24] Systematic risk refers to unavoidable market risk that affects all initiatives of governments and cannot be reduced by further diversifying a portfolio of initiatives.

IRR differs significantly from the financing rate and reinvestment rate of an organization. To overcome this problem a Modified Internal Rate of Return (MIRR) can be used. This takes into account the actual financing and reinvestment rate.

The return on investment (ROI) is calculated as the difference in the undiscounted sum of all benefits less costs to the sum of the undiscounted costs. It is a measure that does not consider the opportunity cost of capital and can be misleading for projects that have a long life (Zwirowicz-Rutkowska, A, 2013).

The IRR and ROI are not the preferred approach for a cost benefit evaluation.

An explanation of each of these metrics and the advantages and disadvantages of each metric is provided in Annex C.

Calculating the present value of a benefit or a cost incurred at a future date

The net cash flows generated by the analysis are converted to a present value by discounting future values by the discount rate. The discounted value of a net benefit occurring at a future date is calculated using the following formula:

$$PV = \frac{B(n)}{(1+r)^{(n-1)}}$$

Where:

PV=present value of net benefit

B(n)= benefit in year n

r = discount rate

The stream of benefits and costs are then discounted across each year of the evaluation period and the discounted stream summed together to produce the present value of the benefits and costs. An example of a discounted stream of benefits is shown in the following formula:

$$PVB = \frac{B(1)}{(1+r)^0} + \frac{B(2)}{(1+r)^1} + \frac{B(3)}{(1+r)^2} + \frac{B(4)}{(1+r)^3} + \ldots\ldots\ldots\ldots\ldots + \frac{B(n)}{(1+r)^{(n-1)}}$$

or

$$\text{PV}= \sum_1^n \frac{B(n)}{(1+r)^{(n-1)}}$$

Where PVB = the sum of the discounted benefits from year 1 to year n.

The NPV and BCR are then calculated from the following formulae:

$$NPV = \sum_1^n \frac{B(n) - C(n)}{(1+r)^{(n-1)}}$$

$$BCR = \sum_1^n \frac{B(n)}{(1+r)^{(n-1)}} \Big/ \frac{C(n)}{(1+r)^{(n-1)}}$$

Where:

B(n)= benefit in year n

C (n)= cost in year n

r = discount rate

An example of a workbook calculating the economic cost benefit ratio and net present value of the hypothetical investment has been provided in conjunction with this report.

An example of these calculations is provided in Table 4.4, using the costs and benefits of the hypothetical project shown in Table 4.2 above.

A positive NPV or a BCA greater than 1 indicates the investment or policy change will create an overall benefit for society.

The good news is that these calculations can be undertaken easily using available spread sheet models. A sample of a cost-benefit calculation has been provided with this Funding Guide.

The impact of discounting on the cash flows is shown in in Table 4.3.

Table 4.3 Example of reporting economic impact

Discount rate	3%	7%	10%
NPV US$ million	75.6	48.9	35.2
BCR	3.59	2.93	2.52

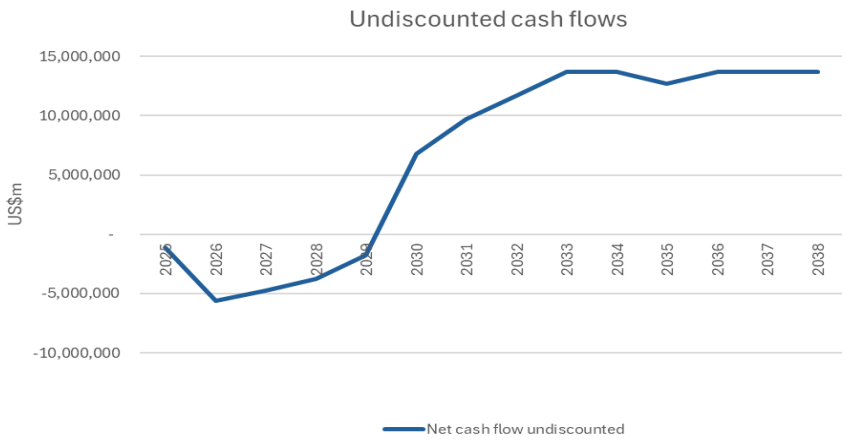
Source: ACIL Allen sample model.

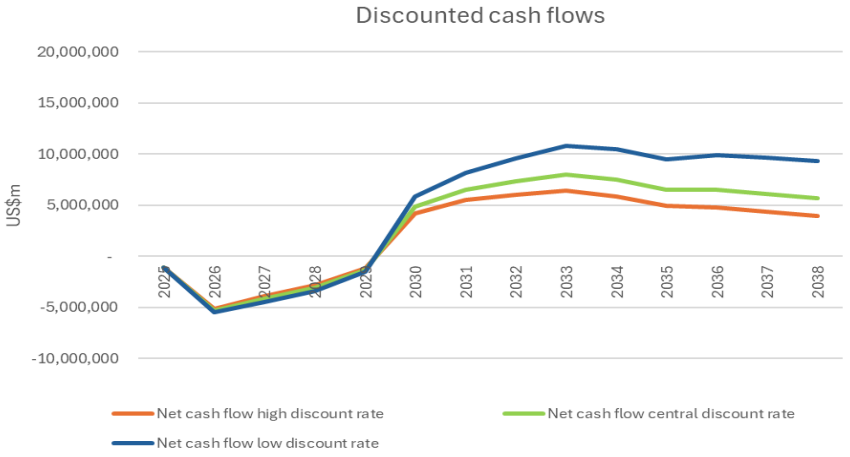
On the basis of these results, the investment in the hypothetical project would create additional economic value at the discount rates used in the analysis. At a 7 per cent discount rate every dollar invested in the project would deliver 2.93 dollars of value.

Table 4.4 Discounting cash flows to calculate a net present value and cost benefit ratio

		PV 3%	PV 7%	PV 10%	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Benefits (net of user cos	US$m	104,787,221	74,229,013	58,341,106	65,000	2,025,000	1,525,000	515,000	2,415,000	7,565,000	10,465,000	12,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000	14,465,000
Costs	US$m	29,172,694	25,344,825	23,128,630	1,150,000	7,670,000	6,270,000	4,250,000	4,150,000	750,000	750,000	750,000	750,000	750,000	1,750,000	750,000	750,000	750,000	1,750,000
Net cash flow					- 1,085,000	- 5,645,000	- 4,745,000	- 3,735,000	- 1,735,000	6,815,000	9,715,000	11,715,000	13,715,000	13,715,000	12,715,000	13,715,000	13,715,000	13,715,000	12,715,000
Net present value	US$m	75,614,527	48,884,188	35,212,475															
Benefit cost ratio		3.59	2.93	2.52															

Figure 4.6 Comparison of undiscounted and discounted cash flows.





4.6 Identify distribution and qualitative impacts

4.6.1 Qualitative impacts

The quantifiable costs and benefits are the main component of a cost-benefit analysis. However, in many cases, quantification will not be practical. A significant proportion of the value created by investment in geospatial services such implementation of the UN-IGIF is in non-market or intangible areas such as improved environmental outcomes, sustainable development, improved access to services or improved social cohesiveness.

It is important that qualitative impacts of an initiative are included in the cost benefit analysis process and reported in conjunction with the quantitative results. This ensures that the extent to which each option aligns with both economic and societal goals of government can be fully documented in the assessment and in the business case that will be presented to decision makers.

For example, the most recent economic assessment undertaking by the General Authority for Survey and Geospatial Information describes the benefits to the tourism industry in both quantitative and qualitative terms. It first describes the total value of tourism the Kingdom of Saudi Arabia and then describes how geospatial information informs and supports tourism management in Saudi Arabia and cites examples of applications in other countries including maintenance of a tourist attraction data base in Serbia and China, crowd management in China and India and during Mecca at the time of the Hajj Pilgrimage and 3D virtual tours in Saudi Arabia. Providing an overall value of tourism augmented by descriptions of applications can help explain potential value even in situations where exact quantitative data is not available.

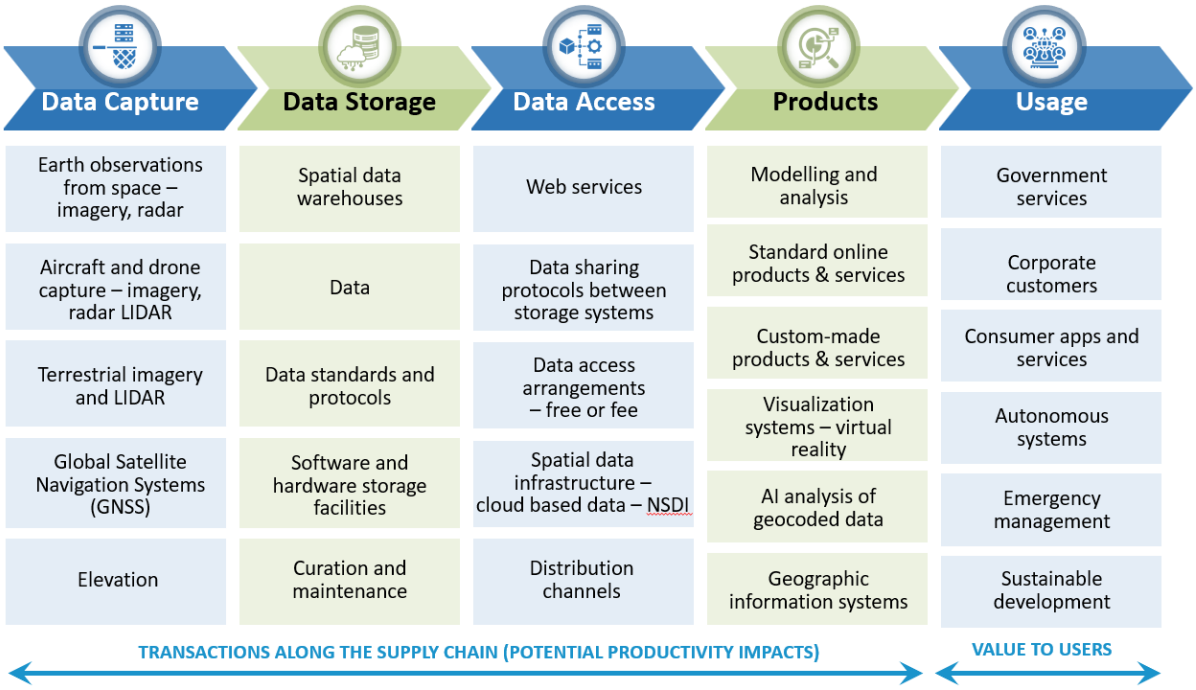
In another example a socio-economic study of the value of geospatial information in Georgia outlined qualitative assessments of value examining cultural heritage, the national statistics office, defense, and piped water and sewage. In each case studies were cited, and examples of benefits identified but not quantified (NAPR, 2022).

4.6.2 Distributional impacts

Geospatial data is in most cases an intermediate good which means that the value that is generally created downstream of its immediate provision. Its full value is usually realized after it has been used by organizations or individuals.

An example of a geospatial value chain is shown in Figure 4.7.

Figure 4.7 Example of a GI value chain



Source: ACIL Allen

As one moves along the supply chain, the value of geospatial data increases as it is stored, accessed, and then incorporated into products. The economic impact of implementation of the UN-IGIF is derived from several sources:

- Adoption and use of the products and services by governments, industry, consumers, researchers and society to create better outcomes for the economy, society and the environment.
- Improvements in productivity along the supply chain from data capture to production of products.
- Broader societal benefits associated with sustainable development and environmental outcomes.

The distribution of benefits from the use of geospatial products and services may also have implications for different groups in society. For example, the impacts may differ for high- and lower-income groups or groups with good access and poor access to infrastructure and services. Documenting the impact for different groups of society can be an important part of a business case where overarching policies focus on specific groups in society.

Transactions occur along the supply chain between service providers and hosting represent transfer payments and are not added into the calculation of national economic benefits. However, improvements in the productivity of the supply chain can be part of the economic benefit. The allocation of improvements to different parts of the supply chain can be material in estimating distributional effects. For example, purchase of products and services can be important to the suppliers of those services with implications for employment in these service industries.

Documenting such distributional outcomes can be an important part of a cost benefit analysis to inform policy makers of key beneficiaries of the investment.

4.7 Assess risk and test sensitivities

4.7.1 Assessing risks

It is advisable to undertake an assessment of the key risks associated with the investment or policy proposal or the options under examination and identify potential risk management strategies for each option. This can include:

- Mapping the project delivery steps and the program impacts leading to the generation of the costs and benefits.
- Identifying significant risks.
- Canvassing steps to manage the risks.

Mapping such risks can be important in the final selection of options and recommendations on the findings of the evaluation.

4.7.2 Sensitivity testing

Sensitivity testing is important to assess the robustness of the analysis to changes in key assumptions or parameters on which the evaluation was based. A CBA should test the sensitivity of the results to changes in assumptions on which the analysis is based.

Sensitivity testing can include different assumptions for:

- The discount rate used. Usually, the results are tested for a high and low discount rate.
- High and low benefit outcomes.
- Different delivery times of benefits.
- High-cost and low-cost outcomes.

Sensitivity testing of key assumptions may need to consider that assumptions may not move in isolation. It may be necessary to test different scenarios of assumptions in some cases.

An example of sensitivity testing on the model template provided with this report is summarized in Table 4.3.

Table 4.5 Example of sensitivity testing

Discount rate	3%	7%	10%
Central Economic Results			
NPV US$ million	75.6	48.9	35.2
BCR	3.59	2.93	2.52
Benefits reduce by 20%			
NPV US$ million	44.1	26.6	17.7
BCR	2.51	2.05	1.77

Source: ACIL Allen from hypothetical example

On the basis of this example, the analyst could conclude that the results are still positive for a 20 per cent lower level of benefits and a discount rate of 10 per cent.

In practice it would also be appropriate to test the impact of higher costs than estimated and the impact of delays in delivering the project and the benefits.

4.8 Selecting the preferred option and reporting the key findings

4.8.1 Consideration of the results for the options considered and relative merits

Selection of the preferred option, or consideration of a single option, should be based on consideration of the results of the analysis including:

- NPV or BCA outcomes.
- Robustness of the results to changes in key assumptions based on the sensitivity testing.
- qualitative benefits and costs identified in the process.
- The key risks and risk management strategies recommended to manage risk if necessary.
- The distributional effects were considered important to the objectives of the project.

In some cases, governments may benefit from higher revenues from land taxes as a result of better geospatial information on who should be paying tax. From a national economic perspective, the benefit of higher taxes received by governments are offset by the higher taxes paid by landowners reducing landowners' income. While the higher taxes don't add to the overall economic benefit, additional tax revenue will be of interest to government.

4.8.2 Recommendation of the preferred option

With the consideration of all the factors for the options or option considered, the recommendation should include a clear discussion of the recommended option and the reasons for the recommendation. Depending on the situation, the recommendation should include:

- Strategic fit with the objectives of the project to government overarching policies and objectives.
- Quantitative and qualitative benefits and costs.
- Robustness of the findings to changes in key assumptions.
- Overall level of risk and contingency plans to address those risks.
- Distribution effects, where relevant.

4.8.3 Examples of cost benefit analysis of geospatial information systems and services.

There are many examples of estimation of the economic and social impacts of investment in geospatial information systems and services. Two relevant examples are assessments made for the Republics of Georgia and Moldova using the IGIF framework.

The assessment of the economic impact of investment in geospatial services in Georgia estimated a benefit cost ratio of 3.3 based on quantification of 15% of use cases identified. Sensitivity testing suggested that the cost benefit ratio could range from 2.58 for a low bound estimate and 4.19 for a higher bound estimate (NAPR, 2022).

The assessment of the economic impact of investment in geospatial services in Moldova estimated a benefit cost ratio of 3.99 Sensitivity testing suggested that the cost benefit ratio could range from 3.17 for a low bound estimate and 4.82 for a higher bound estimate. (Agentia Relatii Funciare si Cadastru a Republicii Moldova, 2021).

These reports along with other relevant economic impact assessment reports can be found in the GeoVSI data base (www.geovsi.org).

5 Valuing benefits and costs

The main points in this chapter

Socio-economic impact assessment often involves assessment of tangible and intangible benefits. Economists have developed methods of estimating both.

The meaning of value

From a socio-economic viewpoint the total value of an investment or policy change can have both use and non-use values. Use values include those associated with direct use such as production of agricultural products, ecological function values such clean water and options values such as protection from natural disasters. Non-use values include existence values and bequest values.

Most economic evaluations of investments in geospatial infrastructure and services canvas both market and non-market use values.

Consumer and producer benefits

Both consumers and producers stand to benefit from investment in the UN-IGIF. Cost benefit analysis can embrace both, but often focuses on the benefits to production of goods and services in quantitative analysis. Improvements in productivity for both the government and the private sector are generally included in analysis of the impact of geospatial information management systems.

Valuing tangible benefits

Tangible benefits can be easily valued where there is a known market price and quantity. They can also be inferred from the impact of geospatial management systems on those that benefit from the systems in both the private and public sectors.

The concept of value add is important to assessing sector wide economic impacts. The value add of a firm is the revenue earned by the firm less the cost of inputs. Gross value add for an economy is the main component of Gross Domestic Product which is an indicator of economic output for a nation. Estimates of the impact of productivity improvements on the gross value add for a sector, resulting from the use of geospatial management systems, are important measures of their economic impact.

Valuing intangible benefits

Intangible benefit can often be valued through techniques referred to as revealed preference or stated preference methods.

Revealed preference methods draw on observable data about behavior or information that is related to the value of the non-market good being assessed.

Stated preference methods use surveys or experiments to assess individual's willingness to pay for a non-market good or service.

5.1 Introduction

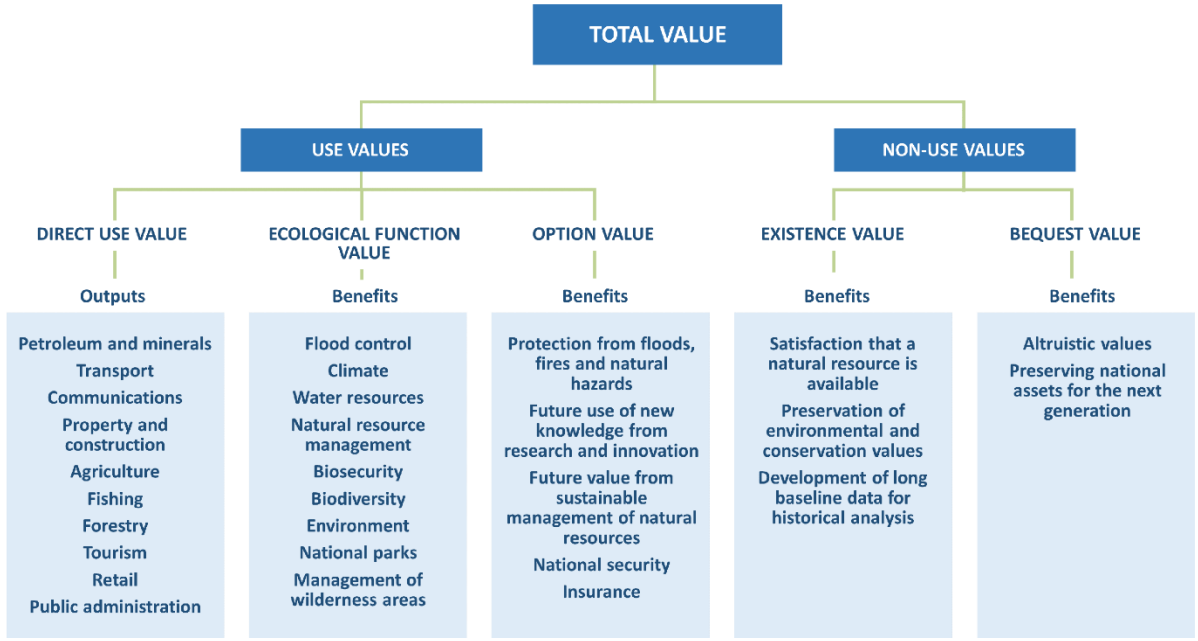
It is important for those preparing estimates of value and costs that the different valuation methods are understood and that the main economic concepts and principles underlying these estimates are consistent with the requirements of ministries of finance or equivalent, investment banks and donors.

As discussed in Chapter 4, a socio-economic assessment must consider both tangible and intangible benefits. Estimating intangible benefits such as improvement in environmental outcomes can be challenging but economists have developed methods of doing so. The following outlines approaches to estimating the economic value of both quantitative and qualitative impacts. It has been prepared as a reference resource for those engaging with economists in the course or undertaking a socio-economic analysis to support a business case for investment in the UN-IGIF.

5.1.1 The meaning of value

A starting point for considering estimates of value is to clarify what is meant by the term value. A framework for considering the different concepts of value is provided in Figure 5.1.

Figure 5.1 The nature of value!



Source: Based on a conceptual framework from Young. (Young, M D, 1992)

Direct use values are generally the easiest to quantify. They could be improvements in productivity for government or industry or the value of goods and services sold in a market.

There could also be value to consumers from savings in time, better access to health services or more convenient and more efficient use of public transport.

Examples of use values include:

- Increased sales for value added sellers of fundamental geospatial data.
- Lower costs along the geospatial value chain.
- Productivity improvements by users of the geospatial data that can include lower costs or an increase in revenues for industry from the use of geospatial data.
- Improved health outcomes and increased life expectancy for society.
- Time savings to consumers and organizations in transacting personal and business affairs.
- Reduced average annual damage costs from natural disaster events.

Other use values can be more difficult to estimate. They can be in the form of an environmental function value which includes improvements in environmental outcomes, more sustainable use of resources or maintenance of biodiversity.

Geospatial data can also have options value. When valuing location data, it is important to consider both existing and future users. Location data can create options to develop new and valuable services in the future. Options values also include values from protection from natural disasters, preservation of security (both personal and national), or insurance against floods fires and property damage.

Non-use values also arise in the form of existence value (such as the existence of rainforests or coral reefs, even though some may never visit them), or bequest value derived from preserving natural assets for future generations.

Whether the value of the UN-IGIF is derived from use values or non-use values, they generally support many of the objectives set out in the United Nations Sustainable Development Goals.

5.2 Approaches to estimating value of geospatial data

Researchers have noted that many of the benefits that result from investment in location data and NSDIs are not found in traditional markets, requiring different approaches to valuation (Craiglia, Novak, 2006). In addition, some geospatial data is provided by government agencies as a public good at no cost. Valuing these data can be challenging, as there is no market price at which the data is bought or sold.

Economists have developed different approaches to estimate the value for both tangible and intangible benefits. These approaches and the economic concepts behind them are discussed in the following sections.

5.2.1.1 Economic welfare analysis

Economic welfare analysis describes the economic value of a good or a service. In a market, the value to society of a good or service is measured by consumer and producer surplus. The concept behind producer and consumer surplus is illustrated in the supply and demand model outlined in Box 5.

If the diagram in Box 5 is specified in annual terms, the sum of producer and consumer surplus (the shaded areas) represents the annual value to society of a good or service. The diagram is based on

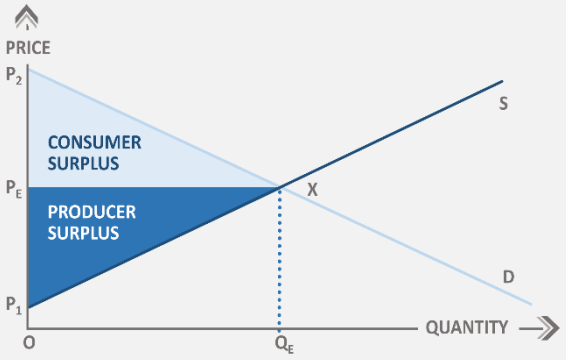
what economists call an efficient market.[25] Many markets are not efficient where market power, lack of information or the provision of some services for free, affect the price outcomes. However, the concept of producer and consumer surplus is still relevant in these markets.

The concept of consumer and producer surplus is important for assessing the impact of policies and programs for investments under the UN-IGIF framework because both producers and consumers benefit. It is the change in producer and consumer surplus that represents the total value of the policy, program, or investment. Consumer surplus can be difficult to estimate, especially when the value is not priced in a market such as the value of a clean environment. However, there are methodologies to do so, and these are discussed later in this chapter.

Welfare analysis is best suited to evaluating a product or service that is uniform in quality and availability. Although geospatial information may not necessarily be uniform in quality and availability, the concepts of producer and consumer surplus are important when approaching the valuation of location data. For example, (Pollock, 2008) and (Houghton, 2011) used changes in consumer surplus to estimate the value of providing geospatial and other data at different prices by government.

Box 5 – Consumer and producer surplus

The figure below depicts demand and supply curves in a perfect market. This is a market where neither an individual producer nor an individual consumer can influence the final market price.



The line S represents the market supply curve that shows the cost to society of producing an extra unit of a good or service. In this case the higher the price, the more producers are willing to supply.

Line D represents the market demand curve which indicates the maximum amount that consumers are willing to pay for incremental increases in the quantity of the good or service. In this case, the lower the price, the more consumers are willing to purchase. The interaction between demand and supply determines the market price (P_E) for the good or service.

Consumer surplus is the difference between what consumers would be willing to pay for a good or service (the total benefit to consumers) and what they have to pay (the cost to consumers). In the diagram it is the area between the demand curve and the price line (P2XPE). Producer surplus is the difference between the revenue received for a good or service (total benefit to producers) and the costs of the inputs used in the provision of the good or service (economic cost to producers). In the diagram, it is the area between the price line and the supply curve (P_1XP_E).

(Marshall, 1890) (Hanley N, et al, 1997)

[25] An efficient market is one where individual producers and consumers interact by selling and buying a good or a service which results in a selling price where the marginal cost of an additional unit equals the marginal value to consumers at a given quantity. No producer or consumer can influence the final market price which is determined by supply and demand. The model also assumes perfect knowledge by consumers and producers of the costs of production at different levels of production (Hayek, Individualism and economic order, 1948).

5.3 Valuing tangible (market) benefits

5.3.1 Direct benefits

Direct benefits are the value of the benefits with reference to market outcomes from provision of a good or a service. Increases in output or reductions in inputs are quantified and combined with market prices to estimate monetary value.

In cases where there is an operating market for geospatial data, the value can be determined from the price and quantity operating in the market. For example, increases in output can be combined with average market prices to estimate monetary value.

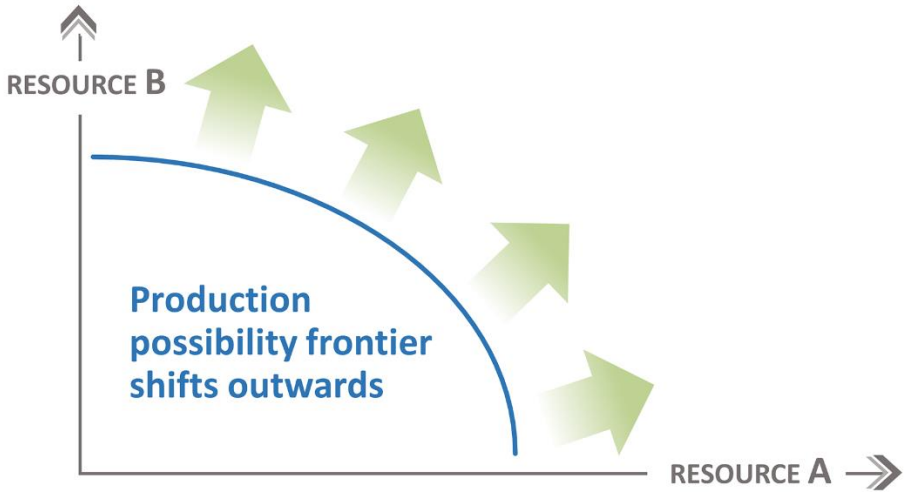
5.3.2 Productivity benefits

Improvements in productivity are also a measure of economic benefit. Productivity is measured as the level of output for a given level of input. Improving productivity can result in:

- Cost savings in producing the same level of output of goods and services.
- Increased output of goods and services for the same level of input costs.
- Lower costs for government in managing and regulating environmental, health and social services.
- Lower costs for industries such as agriculture, transport mining and construction.

From an economic perspective, the economic impact of geospatial information can be summarized as the ability to deliver more output for a given combination of resource inputs. Ultimately this benefits the whole economy moving the production possibility for the country to a higher level as illustrated in Figure 5.2.

Figure 5.2 Geospatial information and the economy's productive capacity



Source: (ACIL Tasman, 2008)

Estimating productivity impacts has been an effective way to estimate the impact of geospatial information on government and industry. For government it can be savings in sharing geospatial information, savings in delivering government services or improving delivery of government services. For industry it can be more efficient production of goods and services such as food and fiber, transport,

property and construction and other commercial services or creation of new products and services that lead to increases in revenue.

Studies of the impact of productivity on government and industry can be very effective ways to evaluate the economic impact of geospatial information as most government agencies and businesses are able to estimate productivity effects through cost savings or increased output with existing resources.

5.3.3 Quantifying the benefits from a productivity improvement

The benefits delivered by a productivity improvement can be calculated at the business unit, enterprise, or sector level.

5.3.3.1 Business unit or enterprise level

At business unit level, the value of a productivity improvement is calculated with the following formula:

$$Value\ of\ productivity\ improvement = productivity\ improvement\ \% * relevant\ costs$$

Estimating the level of attribution to geospatial information is an important step. Most innovations involve more than just geospatial information input. There may be investment required in information technology, sensors and training for example that contribute to the overall productivity benefit. It is important to estimate the extent to which the productivity improvement can be attributed to geospatial information. This is referred to as the attribution level.

5.3.3.2 Sector level

GI investments generally lead to productivity benefits across an industry sector. For example, Global Navigational Satellite Systems (GNSS) have enabled sectors such as transport, agriculture, fisheries and forestry, mining, and construction to improve the overall productivity of those sectors.

Productivity impacts at the enterprise level can be extrapolated to the sector level using estimates of adoption across the sector and statistics on the value added for the sector. Such extrapolation requires an estimate of the level of adoption in the sector.

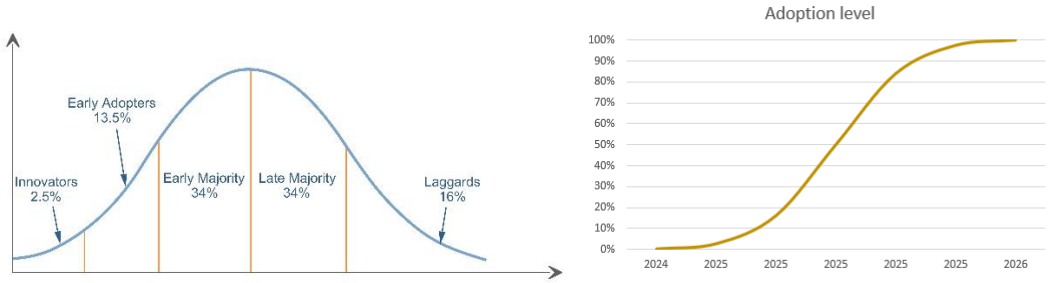
5.3.4 Level of Adoption

Adoption of new business practices is rarely linear. A conceptual framework for adoption rates was proposed by (Rogers, 2003). The diffusion of new innovation was postulated by Rogers to be characterized by different classes of users adopting a new innovation. This was depicted as a normal distribution transiting from early adopters to majority adopters and finally laggards as shown in

Figure 5.3. This translates into the S-curve shown on the right-hand side of

Figure 5.3.

Figure 5.3 Rates of adoption



Source: (Rogers, 2003)

To estimate the likely impact of an investment in geospatial information for a sector, it is necessary to estimate the level of adoption across the sector. For example, the use of Global Navigational Satellite Services (GNSS) in transport could take several years to be fully adopted by the transport sector. The level of benefits delivered by GNSS will be affected by the rate of adoption over time.

In practice adoption rates are likely to vary from this idealized model. However, the model provides a guide to analysts when thinking about the rates of adoption that have occurred or can be expected to occur in future following investment in a GI system or an NSDI.

Box 6 - Estimating level of adoption across a sector

Estimating adoption requires consultation with users or surveys to assess how widely a geospatial supported technology is being applied across a sector. For example, in the case of the use of Earth Observations from Space to monitor canopy cover in forestry enterprises it would be necessary to estimate the number of forestry enterprises that are using this approach. The level of adoption can then be estimated by adding up the total revenues of the organizations that use the technology and dividing by the total revenue for the forestry sector. The latter can be obtained from Input Output tables published as part of the national accounts of the country or available through UN statistical data.

5.3.5 Value added

The second step in estimating the benefits to a sector of investing in geospatial information is applying the productivity impact, and the level of adoption across the sector to the value added by the sector.

Value Added for an enterprise producing a good or a service is the difference between revenue received and the cost of inputs.

$$Value\ added = revenue - cost\ of\ inputs$$

Value added can be estimated at the enterprise level or at the sector level. When quoted at the sector level it is referred to as Gross Value Added (GVA) for the sector.

Value added is important because the sum of GVA added across all sectors is the main component of Gross Domestic Product (GDP).[26] GDP is an important measure for the economic and development aspects of sustainable development in the UN Department of Economic and Social Affairs.

$$GDP = gross\ value\ added + taxes - subsidies$$

Most nations publish GVA figures in their national accounts. The UN Statistical Division also maintains a National Accounts Main Aggregates Data Base for Member which includes estimates of Gross Value Added by industry sector.[27]

Once the analyst has estimated the productivity improvement at the enterprise level and the level of adoption across the sector, it is possible to estimate the impact of the productivity improvement for the sector as a whole from the estimate of productivity at the enterprise level and the level of adoption across the sector.

The productivity impact at the enterprise level (Pe) can be calculated by dividing the value of the productivity improvement at the enterprise level by the value added by the enterprise.

$$Pe = \frac{Value\ of\ the\ productivity\ impact\ at\ the\ enterprise\ level}{The\ value\ added\ by\ the\ enterprise}$$

The value added by the enterprise can be calculated by deducting the cost of inputs from the enterprise revenue. [28]

The value of the productivity improvement at the sector level can then be estimated by scaling up the value from the enterprise to the sector using the following formula:

$$Impact\ of\ the\ productivity\ improvement\ on\ a\ sector = Pe * A * GVA$$

Where:

Pe= productivity impact at enterprise level

A = level of adoption by enterprises across the sector

GVA = gross value added for a sector

This represents the economic benefit to the sector in question that can be attributed to geospatial information (Smart A, Coote A, Millar B, Bernknopf R, 2018).

---

[26] Gross domestic product = the total value added from goods and services plus taxes less subsidies. Note: Taxes only includes indirect taxes such as sales taxes and excises. Direct taxes on land, labor and capital (such as land taxes, income taxes, and company taxes) are included in GVA.

[27] The UN estimates of Gross Value Added by sector can be found at https://data.un.org/Data.aspx?d=SNAAMA&f=grID%3A201%3BcurrID%3ANCU%3BpcFlag%3A0.

[28] The value added of the enterprise can also be approximated by adding the cost of wages and salaries to the earnings before interest, taxes, amortization and depreciation (EBITDA). This is a technical area best left to an economist to estimate.

Box 7

The use of productivity and value add analysis can be seen in a report on the value of the National Positioning Infrastructure in Australia prepared in 2022 for Geoscience Australia. This study used case studies to estimate the value of a GNSS augmentation program for the surveying and mapping, agriculture, mining and construction sectors in Australia. (ACIL Allen, 2022)

5.3.6 Indirect benefits – defensive expenditure or substitute cost approaches

Some benefits accruing to consumers and society cannot be estimated easily from market factors or productivity impacts. Examples include the delivery of better water quality standards, improved location of health services or managing natural hazards such as landslides, fires, floods and ocean inundation.

In such cases, the benefits can be quantified in terms of time saved, reduction in average annual damage costs from natural disasters, reduction in costs to consumers, or reduction in health costs through better management of water quality.

Box 8

An example of a substitute cost evaluation was the use of information contained in geological maps maintained by the US Geological Survey. In this analysis, the value of information contained in geological maps was embodied in reducing the probability of environmental and other damage costs through better decision making by governments. (Bernknopf, 2004).

Defensive expenditure includes items such as the costs that are expected to be incurred to neutralize a damaging event. Examples could include the cost of pollution control or money spent on preserving biodiversity.

As an example, the expected benefits of improved flood control can be estimated from the expected reduction in average annual damage costs from future flood events.

Box 9

An average annual damage cost approach was used for example, in relation to the impact of the use of Earth Observations from Space to produced better outcomes from future flooding events in Australia ((ACIL Allen, 2015).

Approaches to defensive expenditure or substitute cost measures require specialized expertise in probability analysis and cost information that can be challenging to collect. However, there are techniques that can be applied by specialists if the case is justified.

5.4 Valuing intangible (non-market) benefits

Intangible benefits represent non-market benefits that society enjoys. Non-market benefits are any good or service that individuals can benefit from without purchasing them directly. Examples of such benefits include the value to society of a national park, of a clean environment or of better community health. In such cases, consumers do not have to pay directly for the services provided. This does not mean that they do not value them and hence have value. Many systems that leverage geospatial information and NSDIs deliver such benefits.

Economists have developed methods to estimate the value of such nonmarket benefits that can be used in economic assessments of investments in the geospatial sector. There are two general approaches to estimating the value of non-market benefits:

- revealed preference methods.
- stated preference methods.

These methods aim to measure the value to consumers or society and represent attempts to estimate consumer surplus.

5.4.1 Revealed preference methods.

Revealed preference methods draw on observable data about behavior or information that is related to the value of the non-market good being assessed. Revealed preference methods are based on observable data about behaviors or information related to the value of a non-market good or service.

Commonly applied revealed preference methods include benefits transfer techniques, travel cost methods, hedonic pricing, and control group and treatment group methods.

5.4.1.1 Benefits transfer techniques

Benefits transfer techniques can be used to estimate the value of an intangible or non-market good or service by drawing on the results of comparable studies elsewhere. For example, it can be possible to assess the value of a marine park by drawing on the findings of other studies into the value of other marine parks. This approach has the advantage of being a low cost and relatively straightforward approach to estimating the value of a non-market good.

There are generally two approaches to undertaking benefits transfer studies. Average value or unit value transfer methods involve reviewing prior studies to establish the average value of a unit of the non-market good or service. An example of this includes making regional estimates of the average value per person per day of recreational resources such as camping or sightseeing. A discussion or benefits transfer techniques can be found in (Rosenburger, R & Loomis J, 2001).

Benefit function transfer, or value function transfer, involves using a model to estimate the value attributed to different aspects of a non-market good or service. One approach involves examining prior studies that have already estimated the value associated with different aspects of the non-market good or service.

Alternatively, the researcher can examine the findings of a large number of existing studies to identify those aspects of a non-market good or service that are associated with the highest willingness to pay.

Box 10

An example of a benefits transfer method is research that used geospatial data on the location of roads, river and ecological factors to estimate the direct and indirect use values associated with land in the Rio Bravo Conservation area in Belize can be found in (Samuelson, P, 1958).

The benefit function transfer method is generally considered to produce a more accurate reflection of value because it does not assume that the non-market good has the same value as the average value approach.

An issue that needs to be considered when using the benefits transfer method is converting values from countries with different income levels and standards of living. In such cases, consideration must be given differences in GDP per head of population, population size and physical characteristics of the country where the benefits have been estimated and the country in which the evaluation is being undertaken.

When making comparisons between countries it is preferable to use purchasing power (PPP) exchange rates rather than market exchange rates to allow for different purchasing power between countries. The World Bank publishes PPP exchange rates (World Bank, 2024).[29]

The main challenge in using benefits transfer techniques is finding suitable comparison studies and estimating the appropriate transfer rate. In practice a simple comparison adjusted using PPP adjusted GDP factors is likely to be suitable for most assessments of investments in an NDSI for member countries.

There are various databases available that hold repositories of relevant studies that can be used to find useful studies.

Examples of such data bases including the GeoVSI data base of socio-economic evaluations of geospatial initiatives (www.geovsi.org), the EVRI environmental data base of economic evaluations of environmental and health valuation studies (https://evri.ca/en/content/about-evri), the ENCA data base for estimating the value of natural capital (https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca). The World Bank also provides guidelines for evaluation of sustainable development (www.worldbank.org)

5.4.1.2 Travel cost methods

Travel cost methods are used as a proxy to estimate the willingness of individuals to pay for access to a particular non-market good such as a public asset. It is based on the premise that the amount of money that individuals are willing to spend to access a good or service is an indication of the value of that good or service to them. Typically, the technique estimates the cost of travel by individuals to assess the good or service in question, such as a national park.

[29] PPP is the rate of currency conversion that equalizes the purchasing power of different currencies by eliminating the differences in price levels between countries. The PPP rate is usually quoted in US$ equivalent to the local currency unit (LCU). The World Bank and the International Monetary Fund publish PPP rates. (https://databank.worldbank.org/source/world-development-indicators/Series/PA.NUS.PPP).

The technique requires information about the users of the good or service, the location from which they are travelling and the number of individuals who have travelled to or are planning to travel to the location.

There are some problems with this method that need to be carefully considered. The method does not estimate the user's willingness to pay for the good or service. Rather it estimates the minimum amount that users are willing to pay for them to access it. Users may be willing to pay more than the cost to access it.

It is also possible that the travel costs include visits to other features other than the good or service being assessed. Techniques have been developed to deal with multi-destination trips (Mendleson R.J et al, 1992).

The travel cost method is useful for confirming the value of a non-market good or service such as a national park or natural feature when no other information is available.

Box 11

An example of use of the travel cost method in estimating the value of wetlands in Sardinia can be found in a report by Rusciano et al published the Journal Water in 2023. The study estimated that the value of recreational uses of wetlands in the area to be €1.25 million per year. (Rusciano, V., Ruberto, M., Ballara, S., Fasolino, N., Pellegrini, E., Zucaro, R., 2023)

5.4.1.3 Hedonic pricing

Hedonic pricing is a technique where the price of a good or service is estimated by considering its internal characteristics and external factors associated with its use. It can be used to estimate the value of environmental or ecosystem services by considering their impact on the price of an item such as land or a home (Hargrave, 2021).

For example, the value of proximity to a lake could be estimated by comparing the price of housing stock adjacent to the lake compared to housing stock remote from the lake. The sum of the additional value of houses located adjacent to the lake provides an estimate of the value of the lake to the community.

In order to conduct a hedonic pricing analysis, the researcher needs to gather data on pricing and other characteristics, including location. There are both parametric and non-parametric approaches to undertaking hedonic pricing analysis. This is an area for a specialist data analyst for which the cost of analysis may not be within the scope of a cost benefit analysis of the value of geospatial management systems. However, other studies may provide opportunities to adopt a "benefits transfer" approach to inform an analysis.

5.4.1.4 Control and treatment group methods

Control and treatment group methods are a further approach that has been used to value non-market goods. The approach involves comparing a treatment group that has access to a non-market good to a control group that does not.

The approach requires that the control and treatment group are otherwise similar. The approach for estimating the value of the non-market good involves examining the trend over time for a particular outcome.

For example, (Miller, 2016) used fixed effects, such as location, month, and year to show that areas with weather warning systems in the United States have fewer fatalities and injuries from tornadoes than what occurred in areas without a weather warning system. The value of the weather warning system can be estimated from the value of the number of injuries and fatalities that are avoided.

Box 12

(Houghton, 2011) estimated the change in consumer surplus for users of geospatial data provided by Geoscience Australia when the data was made free in 2001. He did this by comparing downloads of geospatial data when the data was made available at a price, with downloads after the data became free (as Open Data. From this data he was able to estimate the change in consumer surplus that resulted from the change in pricing policy.

5.4.2 Stated preference methods

Stated preference methods use surveys or experiments to determine how much individuals would be willing to pay for a non-market benefit such as clean water or a healthy environment. Stated preference methods are basically a willingness to pay approach to estimating consumer surplus.

Stated preference methods may:

- Ask consumers to rank alternative value options to assess their preferences.
- Ask individuals the amount they are willing to contribute for access to a non-market good.

Stated preference approaches rely on approaches to survey design to ensure that individual's responses are reflective of the decisions they would make in practice. Researchers have devised several approaches to estimating the value of a non-market good to remove bias.

5.4.2.1 Contingent valuation

Under contingent valuation, individuals are surveyed to ask what they would be prepared to pay for a non-market good or what compensation they would be prepared to accept for lack of the good. These techniques are generally referred to as willingness to pay (WTP) or willingness to accept (WTA) methods.

The methods require good survey design that minimizes the incentive for respondents to strategically report value that does not reflect the true value that they would otherwise estimate.

One concern with contingent valuation is that there is an incentive for respondents to over or underestimate their true willingness to pay. However, there is little consensus on whether this method delivers higher or lower estimates than revealed preference methods (Smart A, Coote A, Millar B, Bernknopf R, 2018).

Box 13

An example of a willingness to pay study can be found in (Stoeckl et al, 2014). This study surveyed individuals that lived in areas adjacent to the Great Barrier Reef in Australia to assess how they valued various community defined benefits in the adjacent waters of the reef. The report estimated that the collective monetary value of a broad range of services provided by the Great Barrier Reef was likely to be between $AU15 billion and $AU20 billion. The results were used to support estimates of the value of earth observations from space in contributing to management of water quality in the Great Barrier Reef Marine Park.

5.4.2.2 Choice experiments

Choice experiments (attempts to overcome strategic behavior in responses) ask individuals to choose between different baskets of public or private goods. When setting up a choice experiment, the researcher must develop an attribute list for each option being compared. In the case of an economic evaluation, it is essential that one attribute capturing the cost of alternatives should be included.

By presenting each respondent with randomly distributed prices shown to all respondents, it is possible to estimate how much the average respondent values one option over another. Choice experiments offer more control over the variety of responses that might be recorded. They can enable the researcher to explore several different aspects of the non-market good or service and the interactions between those aspects.

Choice experiments require carefully structured surveys and can be resource intensive.

Box 14

There is a discussion on how to design and analyse a choice experiment that provides credible value estimates of the value of an environmental good for the purpose of decision making or policy analysis in the book A Primer on Non-market Valuation (Holmes T, et al, 2017)

5.5 Conclusion

There are many techniques that economists can draw on to estimate the tangible and non-tangible benefits that investments in geospatial information management systems can deliver. A key purpose of this chapter has been to provide background to the concepts and methods that economists might use to value the benefits. This chapter provides readers with reference material to assist in discussion with economists when considering undertaking an evaluation.

The selection of method should be considered in the light of the size of the investment and its importance to national and regional priorities as determined by Member States within the context of the UN-IGIF.

There have already been many studies of the value of geospatial information on which analysts can draw to assess the benefits. As work proceeds and more studies are completed, additional reports will become available that outline the benefits transfer approaches. This can be expected to help lower the cost of undertaking studies.

This will be important to the ongoing work of implementing the UN-IGIF agenda.

Glossary

Base Case	The Base Case scenario is defined as the continuation of the current arrangements as if the proposal under consideration is not implemented.
CE	Cost effectiveness
CGE modelling	Computable General Equilibrium Modelling
EBITDA	Earnings before interest and taxes
ECDIS	Electronic Display and Information System
EOS	Earth Observations from Space
GI	Geographical information
GIS	Geographic information system
I-O modelling	Input-output modelling
Marginal benefit	The additional benefit from an increase in consumption of a good or a service.
Marginal cost	The additional cost of a small increase in output of a good or a service.
MCA	Multi-criteria analysis
PNT	Position Navigation and Timing
PPP	Purchasing power parity (the rate of currency conversion that equalizes the purchasing power of different currencies by eliminating the differences in price levels between countries).
WPA	Willingness to accept
WTP	Willingness to pay
LIDAR	Light Detection and Ranging - a remote sensing method used to record and measure physical objects and the surface of the earth.

NPV	Net present value. This is the sum of the discounted benefits and costs over the evaluation period.
BCR	Benefit cost ratio. This is the ratio of the sum of the discounted benefits and the sum of the discounted costs over the evaluation period.
IRR	Internal rate of return. This is the discount rate at which the sum of the discounted benefits is equal to the sum of the discounted costs calculated over the evaluation period.
MIRR	Modified internal rate of return. This is a modified version of the internal rate of return that takes into account the financing and reinvestment rate.
Sensitivity testing	This is a process where the results of an investment evaluation are tested for their sensitivity to changes in key assumptions.

References

ACIL Allen. (2015). *The value of earth observations from space.* Canberra: Geoscience Australia.

ACIL Allen. (2016). *The value of spatial information for New South Wales.* Sydney: CRC for Spatial Information.

ACIL Allen. (2022). *The Value of the National Positioning Infrastructure Program.* Canberra: Geoscience Australia.

ACIL Allen. (2024). *Economic Impacyt of geospatial services in Australia.* Brisbane: Geospatial Council of Australia.

ACIL Tasman. (2008). *The value of spatial information in Australia.* Canberra: CRC for Spatial Information.

Agentia Relatii Funciare si Cadastru a Republicii Moldova. (2021). *Moldova geospatial alighment to policy drivers.* World Bank.

Agentia Relatii Funciare si Cadastru a Republicii Moldova. (2021). *Moldova Socio Ecnomic Impact Assessment.* Agentia Relatii Funciare si Cadastru a Republicii Moldova.

Bernknopf, R. (2004). *Societal value of geological maps.* Washington: United States Geological Survey.

Bettinger, P. et al. (2009). Analytical decision making considerations for upgrading or changing geographic information system software. *Geospatial Technologies*, 238 - 244.

Bower R et al. (2008). General equilibrium modelling of the direct and indirect economic impacts of water quality improvement in the Netherlands at national and river basin scale. *Ecological Economics*, V66, Issue 1, pp127-140.

Craiglia, N. (2006). Report of the International Workshop on Spatial Data Infrastructures/Cost Benefit return on Investment. Ispra, Italy: Joint Research Centre, European Commission.

Craiglia, Novak. (2006). Report of the International Workshop on Spatial Data Infrastructures/Cost Benefit return on Investment. Ispra, Italy: Joint Research Centre, European Commission.

Crompvoets, J. et al. (2011). Practices to develop spatial data infrastructures: exploring the contribution to e-government. In S. Assar, I. Boughzala, & I. Bolydens, *Practical studies in e-government* (pp. 299-248). New York: Springer.

Deloitte. (2021). *Economic study into an Australian Continuous Launch Small Satellite Program for Earth Observation.* Canberra: Deloitte.

Department of Treasury and Finance. (2013). *Economic Evaluation for Business Cases - Technical Guidelines.* Melbourne: Victorian Department of Treasury and Finance.

Dodgson, J. S. (2009). *Multi criteria analysis: A Manual.* London: UK Department of Communities and Local Government.

Eade, J and Moran, D. (1996). Spatial economic valuation: benefits transfer using geographical information systems. *Journal of Environmental Management*, 48(2), 97-110.

EU. (2019). *DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.* Brussels: European Parliament.

Frontier Economics. (2022). *Measuring the Economic, Social and Environmental Value of Public Sector Location Data, Benefit Appraisal/Guidance.* London: UK Geospatial Commission.

Garvin, M., & Ford, D. (March-June 2011). Real Options in Infrastructure projects: Theory Practice and Prospects. *The Engineering Project Organization Journal*, 97-88.

Geudens T, et al. (2009). Assessing Spatial Data Infrastructure Policy Strategies using Multi-Actor Multi-Criteria Analysis. *International Journal of Spatial Data Infrastructure Research 2009*, Vol 4, 265-297.

GFDRR. (2019). *Building disaster resiliance in the Sub-suharan Africa Program: Activity Report 2018-2019.* Washington: Global Facility for Disaster Reduction and Recovery.

Griffin, E. et al. (2017). A marine spatial data infrastructure in New Zealand; a systematic review of the cost-benefits. *Journal of Spatial Science*.

Hanley N, et al. (1997). *Environmental Economics - in theory and practice.* Macmillan Publishers Limited.

Hargrave, M. (2021). Hedonic Pricing: Definition, how the model is uesd and example. *https://www.investopedia.com/terms/h/hedonicpricing.asp*.

Hayek, F. (1948). *Individualism and economic order.* London: Routledge Press.

HM Treasury. (2022). *The Green Book - Central Government Guidance on Appraisal and Evaluation.* London: HM Treasury.

Holmes T, et al. (2017). *Choice experiments.* Washington: Forest Service, US Department of Agriculture.

Houghton, J. (2011). *Costs and benefits of data provision.* Melbourne Australia: Victoria University.

Humphrey, C., & Brugger, F. (n.d.). *The role of Multilateral Development Banks in Financing the Sustainable Development Goals.* Zurich: Nadel Center for Development and Cooperation.

IMO. (1980). *International Convention of Safety of Life at Sea.* London: International Maritime Organisation.

Kotchen, M. J. and Levinson, A. (2023). When can benefit-cost analysis ignore secondary markets? *Journal of Benefit Cost Analysis*, 14: 114-140 doi:10.1017/bca.2022.22.

Kruse J, Crompvoets J, Pearlman J. (2018). *GeoValue - The Socioeconomic Value of Geospatial Information.* Boca Raton, Florida: CRC Press.

Marshall, A. (1890). *Principles of Economics.* London: Macmillan and Co.

Mendez, B. (2021). *Why 2020 was a year of geospatial thinking for WFP.* Rome: World Food Programme.

Mendleson R.J et al. (1992). Measuring recreation value with multiple destination trips. *American Journal of Agricultural Economics*, 74(4) 926-993.

Miller, B. M. (2016). *The not so marginal value of weather warning systems.* University of California: San Diego.

Ministry of Finance and the Public Service. (2024). *Estimates of Expenditure 2-24-25.* Kingston: Ministry of Finance and the Public Service.

NAPR. (2022). *Georgia - Socio Economic Impact Assessment.* Oslo: Kartverket.

Natioal Agency of Public Registry, Georgia. (2021). *Georgia Geospatial Allghnment to Policy Drivers.* National Agency of Public Registry.

NSW Treasury. (2023). *NSW Government Guide to Cost-Benefit Analysis.* Sydney: New South Wales Department of Treasury.

Pollock, R. (2008). *Models of Public Sector Trading Funds.* Cambridge UK: Cambridge University.

Rogers, E. M. (2003). *Diffusion of innovations.* New York: New York Free Press.

Rosenburger, R & Loomis J. (2001). *Benefit transfer of outdoor recreation use values. A technical document supporting the Forest Service Strategic Plan.* US Department of Agriculture, Rocky Mountain Research Station.

Rusciano, V., Ruberto, M., Ballara, S., Fasolino, N., Pellegrini, E., Zucaro, R. (2023). Assessing the Touristic Activiteis of Wetlands through the travel cost method: A case study. *Water*, 15, 41456.

Samuelson, P. (1958). Aspects of public expenditure theories. *Review of economics and statisitcs*, pp 332-338.

Scott, G. (2024). *A Joint Vision for Developing and Overarching Geospatial Framework.* New York: UN.

Smart A, Coote A, Millar B, Bernknopf R. (2018). GeoValue - The Socioeconomic Value of Geospatial Information. In C. J. Kruse J, *GeoValue - the Socioeconomic Value of Geospatial Information* (pp. 149-194). Boca Raton, Florida: CRC Press.

Stoeckl et al. (2014). A new approach to the problem of overlapping values - a case study of the Great Barrier Reef. *Ecosystm Services*, (10) pp 61-78.

UN Habitat. (2013). *GIS Handbook for Municipalities.* Nairobi: UN Habitat.

UN Habitat. (2020). *Financing sutainable urban development.* New York: UN Habitat.

UN_IGIF. (2022). *Strategic Pathway 3.* New York: UN_IGIF.

UNDP. (2022). *Terms of Reference - Muliti-Country Western Pacific iIntegreated HIFV and TP Programme.* New York: UNDP.

UN-GGIM. (2019). *The Global Fundamental Geospatial Data Themes.* New York: UN-GGIM.

UN-GGIM. (2019). *UN Department of Economic and Social Affairs.* New York: UN-GGIM.

UN-IGIF. (2020). *Needs Assessment and Gap Analysis.* New York: UN-IGIF.

UN-IGIF. (2023). *A Strategic Guide to Develop and Strengthen National Geospatial Information Management.* New York: United Nations.

UN-IGIF. (2023). *Appendices - Strategic Pathway.* New York: United Nations.

UN-IGIF. (2023). *Assessing and analyzing.* New York: United Nations.

UN-IGIF. (2023). *Integrated Geospatial Information Framework - A strategic guide to develop and strengthen national geospatial information management.* New York: United Nations Integrated Geospatial Information Framework.

UN-IGIF. (2023). *Strategic alignment and benefits.* New York: United Nations.

UNSD. (2019). *2019 Statistics Division in Brief.* New York: UN.

USAID. (2013). *Opent Geographic Data for Disaster Risk Reduction in Nepal.* US Agency for International Development.

USAID. (2017). *Incorporating Geospatial Analysis into USAid biodiverity program design.* Washington: US Agency for International Development.

USAID. (2020). *Harnessing the Power of geospatial data analytics for rapid resonse in emerging markets.* Washington: US Agency for International Development.

World Bank. (2020). *Baseline Assessment - Word Bank Implementation Methodology.* New York: World Bank.

World Bank. (2020). *The Power of effective geospatial information management in South Korea: development and application.* Seoul: World Bank Group Korean Office.

World Bank. (2021). *Integrated Geospatial information Framework, Country Level Implementation: Templates and Tools.* New York: World Bank.

World Bank. (2022). *Generic Process Description, Socio-Economic Impact Assessment, World Bank Implementation Methodology.* New York: World Bank.

World Bank. (2023). *Geospatial Alignment to Policy Drivers - World Bank implementation methodology.* New York: World Bank.

World Bank. (2024). *PPPs for policy making: a visual guide to using data from the ICP - uses and limitations of PPPs.* Washington: World Bank.

Young, M D. (1992). *Sustainable investment and resource use: Equity, Environmental Integrity and Economic Efficiency.* Paris: Parthenon Press, Charnford and UNESCO.

Zwirowicz-Rutkowska, A. (2013). Economic Dimension of Spatial Data Infrastructure - Overview of Assessment Approachs and Methods., (pp. GeoConference on Informatics, Geoinformatics and Remote Sensing).

Annex A – Other methodologies

The main points

This Annex discusses other commonly adopted methods for underrating economic assessments of investment proposals or policy change.

Input output (I-O) analysis is a quantitative economic technique that estimates the wider impacts of a proposed project or investment on the economy. An input-output analysis estimates how many goods or services (inputs) from other sectors of the economy are required to produce a given output in the sector in which the project is located.

While I-O modelling can be used to assess the wider economic impact of an intervention of a proposal and understand its linkages with other sectors of the economy, it cannot be used to weigh the relative economic merits of a proposal or policy change based on quantifiable benefits and costs.

Computable general equilibrium (CGE) modelling is a quantitative method applied to estimate the economy wide impact of an initiative within a particular country or region. CGE models look at the economy as a complete system of independent agents and recognise that changes in one sector can have repercussions throughout the entire economy.

To run a CGE model comparison between an evaluation case and a base case, it is first necessary to estimate the productivity impacts of investment or policy change on specific sectors of the economy under an evaluation case. These are then fed into the CGE model which calculates the outputs (GDP, Incomes etc.) at the new equilibrium level for the economy. Comparison of the outputs for the evaluation case and a base case gives the economic impact of the initiative.

CGE analysis is most applicable where the impacts of an initiative are likely to be felt across multiple sectors of the economy.

Real options analysis is a field of analysis that assesses the value of flexibility in the planning process. Real options approaches can estimate the value of different timing strategies where such uncertainties exist.

Although very powerful, real options is a very specialised technique (whether applied quantitatively or qualitatively) that requires a high amount of expertise from the practitioner.

Multi-criteria analysis (MCA) is an approach where the performance of an investment or policy change is assessed by scoring, ranking and weighing the impacts rather than expressing the impacts in monetary terms. MCA is effective when there is a very clear basis for scoring project options against criteria.

MCA involves subjective judgments on values. MCA does not inform the decision-maker whether individual proposals deliver a net social benefit or the optimal scale of a proposal.

Input-output (I-O) analysis

5.5.1 What is it?

Input-output analysis is a quantitative economic technique that estimates the wider impacts of a proposed project or investment on the economy. An input-output analysis estimates how many goods or services (inputs) from other sectors of the economy are required to produce a given output in the sector in which the project is located.

Input-output tables are generated from the national accounts of many countries. These tables show the interdependencies between different sectors of the economy and how much output may become an input to another sector. The tables can be used to develop multipliers that represent the total amount of goods or services that must be produced to meet the final demand for that good or service.

Typical outputs from an I-O analysis can include wider impacts on gross domestic product (GDP) or regional product, employment impacts and impacts on wages and salaries.

I-O analysis has come under scrutiny in the past because of the limitations of some of its assumptions. Assumptions in the model include a fixed input structure in each industry, a fixed input price structure that means that they do not change in response to changes in demand, and an unlimited supply of labor and capital assumed to be available. The analysis tends to mean that it predicts bigger economic effects compared with other modelling. This has led to criticism of the technique compared to other techniques such as Computerized General Equilibrium (CGE) modelling.

5.5.2 How is it used?

While I-O modelling can be used to assess the wider economic impact of an intervention of a proposal and understand its linkages with other sectors of the economy, it cannot be used to weigh the relative economic merits of a proposal or policy change based on quantifiable benefits and costs.

An example of the use of I-O analysis can be found in an economic study into an Australian Continuous Launch small satellite program for earth observation (Deloitte, 2021).

General equilibrium modelling

5.5.3 What is it?

Computable General Equilibrium Modelling (CGE) is a quantitative method applied to estimate the economy wide impact of an initiative within a particular country or region. A CGE model accounts for complex interactions between economic agents in an economy, including producers, households and governments, to assess the wider impact of investments and policy changes including the flow on effects from the changes that the initiative produces.

CGE models look at the economy as a complete system of independent agents and recognize that changes in one sector can have repercussions throughout the entire economy. A CGE model is a representation of all markets in an economy. The model solves for a suite of prices, by commodity and factor inputs to balance supply and demand in all markets. Most CGE models are based on social accounting matrices drawn from a country's national accounts. The number of sectors represented in

the model can typically be up to ninety for international models and up to 150 for country specific models. In practice sectors are generally aggregated to around 30 to 40 sectors to improve computation time.

The outcomes that can be produced from a CGE model include:

- Gross domestic product (GDP) or Gross Regional Product (GRP)
- Incomes
- Welfare
- Impact on the value added by sector
- Consumption
- Trade
- Investment
- Employment

Analysis of the impact of an investment or policy change is normally undertaken by comparing the outputs of the model with the initiative (the evaluation case) and the outputs without the initiative (the base case).

To run a CGE model comparison between an evaluation case and a base case, it is first necessary to estimate the productivity impacts of investment or policy change on specific sectors of the economy under the evaluation case. These are the first-round impacts of the initiative. These are then fed into the CGE model which calculates the outputs (GDP, Incomes etc.) at the new equilibrium level for the economy. The comparison for the outputs for the evaluation case and the base case gives the economic impact of the initiative.

An example of the use of CE modelling can be found in a report published in October 2024 on the economic impact of geospatial services in Australia (ACIL Allen, 2024)

5.5.4 How is it used?

CGE analysis is most applicable where the impacts of an initiative are likely to be felt across multiple sectors of the economy. The method is based on market-based outcomes and does not consider non-market outcomes such as environmental spillovers or social goods and services. It can be very useful in circumstances where assessment against national economic goals is a high priority for the analysis.

CGE modelling requires a high level of specialist expertise with experience in developing scenarios within the model and interpreting the results.

An example of the use of CGE modelling can be found in a report on the value of national positioning infrastructure undertaken in Australia in 2022 (ACIL Allen, 2022).

Real options

5.5.5 What is it?

An important feature of investment in geospatial information is the options that it creates for other users and organizations to develop new products and services that are not obvious at the time that the investment decision is made.

The timing of such developments can be subject to considerable uncertainty. Where such uncertainty exists, it can be useful to value flexibility to defer some of the decision making until that uncertainty is resolved.

The technique, referred to as Real Options, is a field of analysis that assesses the value of flexibility in the planning process. For example, investment in the UN-IGIF might be undertaken by a single large investment across a number of government departments or undertaken by different government and private users over time. Real options approaches can estimate the value of different timing strategies where such uncertainties exist. The technique takes into account the capacity for adaptive management at different stages of a project where there is a relatively high level of uncertainty about how the project might deliver benefits. To some extent this is the case with investment in UN-IGIF where the potential beneficiaries cannot be predicted with certainty but there is certainty that the payoffs will be large.

A Real Options technique is less useful when an investment must be made up front where and where there is limited scope for flexibility in the timing and nature of the investment decision. The technique also requires a high level of specialist expertise and is only justified where there is flexibility available and where the potential payoffs are high. More information on real options techniques can be found in (Department of Treasury and Finance, 2013) and (Garvin & Ford, Real Options in Infrastructure projects: Theory Practice and Prospects, March-June 2011).

5.5.6 How is it used?

Although very powerful, real options analysis is a specialized technique (whether applied quantitatively or qualitatively) that requires a high amount of expertise from the practitioner. The method has only been discussed in two of the reviewed documents (Smart A, Coote A, Millar B, Bernknopf R, 2018) and (Frontier Economics, 2022).

Multi-criteria analysis

5.5.7 What is it?

One of the challenges of cost benefit analysis is that it does not necessarily provide a complete picture of the socio-economic benefits of an investment because it tends to focus on quantifiable impacts. Muli-criteria analysis (MCA) is an approach that incorporates both quantitative and qualitative criteria. In an MCA, the performance of an investment or policy change is assessed by scoring, ranking and weighing the impacts rather than expressing the impacts in monetary terms.

The impacts and performance are based on literature search, expert opinions, and stakeholder consultations. A typical process for an MCA involves the following steps:

- Define the projects or policies to be assessed
- Agree on assessment criteria
- Assign weights to each criterion
- Objectively assess the impact for each criterion either on the basis of quantitative data or on the basis of a performance scale
- Calculate the impacts: the numerical score is multiplied by the weight
- Rank the options based on the numerical score and apply a sensitivity analysis.

5.5.8 How is it used?

MCA is effective when there is a very clear basis for scoring project options against criteria and where this evaluation framework is agreed and documented *before* the analysis has commenced. However, MCA involves subjective and non-testable judgments on values. MCA does not inform the decision-maker whether individual proposals deliver a net social benefit or the optimal scale of any proposal.

The use of MCA are suitable for projects and/or projects where the major benefits cannot be valued or are impractical to value (as may be the case in some social infrastructure investments). MCA can also be used to screen out less prospective options so that the analyst can focus the cost benefit analysis on a smaller number of priority options.

MCA approaches were proposed in the 2000s as a way to address the societal and environmental aspects of the benefits of investing in geospatial information.

For a more detailed discussion of MCA see (Dodgson, 2009) and (Department of Treasury and Finance, 2013). (Geudens T, et al, 2009) also discusses MCA in assessing policy strategies for spatial data infrastructure.

Annex B – Direct and indirect benefits

A summary of definitions of direct and indirect benefits is provided in Figure B.1.

Figure B.1 Definitions of direct and indirect benefits from selected studies.

Report	Direct	Indirect
Kotchen J., Levinson A. (2023)	Market impacts immediately accruing from the initiative	Economic impacts accruing for other markets
GEOSA (2022)	Direct benefits are realized from direct casual relationships and can include cost savings, efficiency gains and productivity increase from the implementation of a GI initiative.	Indirect benefits are those that cannot be directly realized or observed. They are achieved in addition to the direct benefits.
New South Wales Treasury (2023)	Impact on producers and consumers of goods and services associated with the initiative	Impact on third parties not directly involved in the consumption of the primary goods and services
ACIL Allen (2023)	Immediate socio-economic impacts	Additional impacts as economy reaches a new equilibrium
HM Treasury (2022)	Quantifiable and qualifiable impacts to the public sector organization making the investment	Quantifiable and qualitative impacts to other public sector organizations
UK Geospatial Commission (2022)	Economic benefits from the initiative	Social and environmental benefits from the initiative
Victorian Government Department of Treasury and Finance (2022)	Market impacts of the initiative	Economic, social and environmental benefits external to the initiative
Word Bank (2021)	Economic impacts from the initiative	Social and environmental benefits from the initiative
Kruse et al (2018)	Value of benefits from market outcomes	Value of benefits not relying on market outcomes
PWC (2013)	Monetary impacts	Qualitative impacts

Source: ACIL Allen

Annex C – Metrics for assessing an investment or policy change

Metric	Description	Comment
Net present value (NPV)	An NPV is the sum of the discounted net benefits of a project.	NPV is a useful tool for confirming the present value of the project. However, it is important to recognize that the NPV will also vary with the scale of the project when ranking options.
Cost benefit ratio (BCR)	A BCR is given by the ratio of the present value of a project's benefits from the project to the present value of its costs and can be interpreted as every one dollar of research costs delivers 'X' dollars of benefits.	BCA is useful for showing the multiple of the present value of benefits to the present value of costs. The BCA is useful when ranking projects of different scale.
Internal rate of return (IRR)	The IRR is a metric typically used in financial analysis to estimate the profitability of potential investments. The IRR is the discount rate that sets the net present value (NPV) of the change in value of the activity benefitting from the investment over the evaluation period equal to zero in a discounted cash flow analysis. This approach normalizes cashflows and produces a single annual rate of return for an investment.	The internal rate of return provides a single rate of return for an investment. The normal IRR calculation assumes that all surplus cash from the project can be reinvested at the IRR and all borrowings are financed at the IRR rate. This can mean that the IRR will overestimate returns that differ significantly from the investment and borrowing rate. To overcome this disadvantage, the Excel program has produced a Modified Internal rate of return (MIRR) that allows the analyst to enter a reinvestment and financing rate. If an IRR produces an extremely high result, it may be preferable to use the MIRR formula.
Return on Investment (ROI)	A simple indicator that shows the total percentage increase or decrease of an investment. It is calculated by taking the change in value of the activity from start to finish and dividing this amount by the initial investment.	The ROI ignores the social discount rate effect and can overestimate the return on investment for projects where the benefits are expected to accrue over more than one or two years. It is not appropriate for evaluation of investment in geospatial information systems and infrastructure such as NSDIs.