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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE
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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE PRIMER

Hatfield Consultants

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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE PRIMER

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EXECUTIVE SUMMARY

While people have used maps for thousands of years to record and share information about places and to tell stories, in the current digital age, maps are increasingly complex, dynamic, and integrate many types of geospatial data and services. Using maps and geospatial data, we can better understand our environment and address the challenges society faces, including climate change, public health, trade and economic development, and natural resource management.

The Canadian Geospatial Data Infrastructure (CGDI) helps us to find, use, and share geospatial information. The CGDI does not refer to a database or system, but rather, a collection of publicly available data and resources such as standards and policies to help ensure compatibility and interoperability. Enabling Canadians to find, access, and use geospatial data benefits society, the environment, and the economy.

For Canadian organizations, the support that CGDI provides is important because:

- Collecting data is expensive and the CGDI helps users to discover data that already exists and to share data and information they have produced and want others to use.
- Standards ensure geospatial systems can communicate in a world where digital systems are increasingly connected and reliant on each other. Without standards, these inter-connected systems could not be developed or would not function the way they were intended to function.
- Digital technology is developing rapidly and CGDI helps users to build capacity, collaborate, and to keep pace with technology evolution and trends, such as open data and open standards.

This CGDI Primer is intended to help new and current users of geospatial data increase their understanding of spatial data infrastructures and to recognize the benefits and advantages of participation in the CGDI. The information in this Primer may be useful to users with variety of roles and functions within their organizations, including new practitioners, environment and lands managers, data managers, planners, policy analysts, researchers, and social and environmental service providers.

Complementing this Primer, a CGDI Cookbook provides numerous step-by-step “recipes” related to data, technology, policies, standards, partnerships, and human resources. The recipes are designed to be standalone “how-to” documents to help integrate different components of CGDI into users’ activities. A glossary of CGDI terminology helps new and novice users understand the technical terms that are used.

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1.0 INTRODUCTION TO THE CANADIAN GEOSPATIAL DATA INFRASTRUCTURE

Maps are representations of the Earth's surface and contain geospatial data, which is the information that describes a place, feature, area, or event. In the current digital age, maps are increasingly complex, dynamic, and built from many types of data collected in different ways such as professional survey, remote sensing, and observations by citizens. We use geospatial data every day, even if we often don't realize it. When we check a weather forecast, navigate using a smartphone app, or tag the location of a photo on social media, we are creating and using geospatial data.

Geospatial data does not simply help us get from place to place. It supports many activities of governments, community groups, Indigenous Peoples, non-government organizations (NGOs), academics, and the private sector. Using geospatial data, we can better understand our environment and address the challenges society faces, including climate change, public health, trade and economic development, and natural resource management. This type of data is increasingly important to the Canadian economy.

Just as we need infrastructure like streets and street signs, electricity, and rules of the road to keep our communities running, we need infrastructure to help us manage and share geospatial data. This infrastructure includes technologies (hardware and software), data, policies, standards, partnerships, and human resources that allow us to create, access, use, and share geospatial data. Countries around the world have agreed to certain standards and policies to help keep geospatial data organized and to ensure that it can be shared and used. In Canada we call this the **Canadian Geospatial Data Infrastructure (CGDI).**

The CGDI does not refer to a database or system, but rather, a collection of publicly available data and resources such as specific policies and standards to help ensure compatibility and interoperability**.** Available to all Canadians, this infrastructure allows anyone to find, use, and share geospatial information. This allows geospatial data to be accessed and used when and as needed to benefit people, the environment, and the economy.

CGDI Vision

Canadians have open, secure and continually available access to comprehensive location-based information about Canada through the community-sustained Canadian Geospatial Data Infrastructure in support of prosperity and well-being for all.

NRCan 2012

1.1 WHY IS THE CGDI IMPORTANT?

Canada's ability to manage its economy, society, and the natural resources and ecosystem services on which all Canadians depend requires that we tackle complex, interrelated issues across a vast and diverse geographic area. Addressing these issues depends on up-to-date, multi-disciplinary information almost all of which has a geographic component. For a country, a region, or community, *geography always matters* for planning and decision-making. Geospatial information describes places, objects, or phenomena and is fundamental to questions such as: Where is the highest flood risk? How can we improve mobility? What areas of forest are most vulnerable to pests or wildfires? Why are community healthcare outcomes different? And how can we balance resource development and environmental protection? To measure, understand, monitor, and respond to challenges, it is critical to have the right information, tools, and ability to collaborate. Increasingly, this requires research, policy, and decisions that depend on the integration of large amounts of information and standardized data from different sources, scales, and timeframes.

Priority policy areas supported by the CGDI

Indigenous reconciliation: Geospatial data is essential to the recognition and implementation of Indigenous rights, which includes lands and natural resources management, to economic opportunities for Indigenous communities, the protection of Indigenous culture and cultural practices, and Indigenous economic development.

Climate change adaptation: understanding climate change and planning effective adaption requires integration of data developed by climate scientists, information about the built environment and other social, economic, and environmental data.

Disaster risk management: preparedness, emergency response, and disaster recovery from events such as flooding and wildfires depend on geospatial data to identify vulnerable areas, develop response plans, and implement mitigation measures.

Health: geographic information is central to studies in epidemiology, population health, and ensuring Canadians have access to necessary health services.

Energy: planning the development, distribution, and efficient use of Canada's energy resources, including oil & gas and renewables, with an emphasis on energy efficiency.

Food security: farmers, scientists, companies, and policy makers depend on geospatial data to understand and address issues such as agricultural sustainability, drought, pollution, biodiversity and pollinators, and soil erosion.

Urban planning **and infrastructure**: Canadian cities are growing and changing rapidly. Geospatial data is key to managing growth, planning energy-efficient infrastructure, and ensuring safe, sustainable, resilient and livable urban regions including urban forests.

Ocean management: geospatial data supports better policies and decision-making on important issues related to marine safety and responsible shipping, marine environment, and economic development of Indigenous and coastal communities.

1.2 BENEFITS OF THE CGDI

The use of geospatial information contributed $20.7 billion to Canada's Gross Domestic Product in 2013 and generated approximately 19,000 jobs (HAL et al. 2015).

In Canada, the use of geospatial data has evolved from commercial desktop computer software used by a few experts in an organization, proprietary and commercial data sources, to widespread sharing and use of data through internal networks, web and cloud-based systems, and mobile devices, plus widespread use of open data and open software and standards. Supported by the CGDI, many people now access, analyze, and share geospatial data within and outside of their organization. This growth in geospatial data and applications makes a substantial contribution to the Canadian economy.

The CGDI has made it much easier for experts and non-experts to access and use geospatial data. CGDI supports users to combine their efforts in developing data, technical capacity, skills, and knowledge. CGDI policies, standards, and protocols are critical to enable collaboration and sharing among users.

Importance of the CGDI for Canadian Organizations

Collecting data and information is expensive.

CGDI helps users to discover data that already exists to avoid the duplication of effort. In turn, data producers have an interest in ensuring that potential users know what data is available, current, and accurate.

Example: The Canadian Council on Geomatics works to advance geomatics activities between federal, provincial and territorial governments. The goal is to reduce duplication of effort between government bodies and to facilitate easy access of geospatial information for the benefit of Canadians.

Digital technology is developing rapidly.

Change in the technology industry is constant and CGDI helps users to adopt standards technologies and applications, stay up-to-date, and to adapt to potentially disruptive change.

Example: GeoConnections works with international organizations such as the Open Geospatial Consortium to identify, assess, and respond to technology trends.

Geospatial data standards ensure systems can communicate.

We live in a world where digital systems are increasingly connected and reliant on each other. Standards ensure that inter-connected systems can be developed and share and access data.

Example: CGDI supported standards ensure that geospatial information such as weather forecasts can be accessed, used, and published to multiple platforms and devices (see Box 1).

Building capacity and collaboration.

CGDI datasets, technologies, policies, and standards provide a framework for potential users to understand the capacity needed to use spatial data infrastructure. Where capacity gaps exist, training materials and other resources exist to support CGDI users with varied capacities.

Example: GeoConnections recently completed a User Needs Assessment for the CGDI (see Box 2) to ensure that needs of current and potential users of the CGDI were understood so that the program could plan to support the next generation of CGDI users.

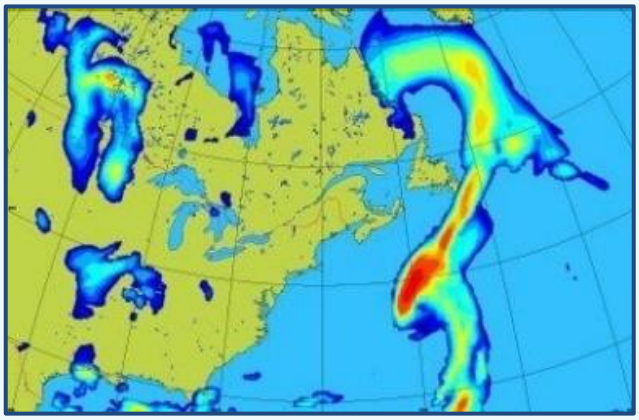
Box 1 Enabling access to Canadian meteorological and oceanographic data through CGDI supported open geospatial standards.

The Meteorological Service of Canada provides Canadians with data and information on weather, water, climate conditions, forecasts, and warnings. It also shares data and information so that specialized users and developers can integrate data into workflows and applications. This mandate can be challenging to meet given the immense variety of meteorological information and the equally complex set of potential applications for such information.

CGDI supported open standards are critical to ensure that weather forecast information can be accessed, used, and published to multiple platforms and devices The Meteorological Service of Canada developed GeoMet to provide access to open data via Open Geospatial Consortium (OGC) standards such as the Web Map Service (WMS). MSC GeoMet serves over 2500 time-enabled datasets, which include a real-time North American weather radar mosaic (1 km and 4 km resolution), numerous numerical weather prediction models, as well as current conditions.

The benefits of using MSC GeoMet include:

- Ability to integrate, combine and incorporate meteorological layers with an organization's own data and tools.
- Ability to build custom interactive web maps and mobile apps.
- No downloading of files is required to access the weather layers.

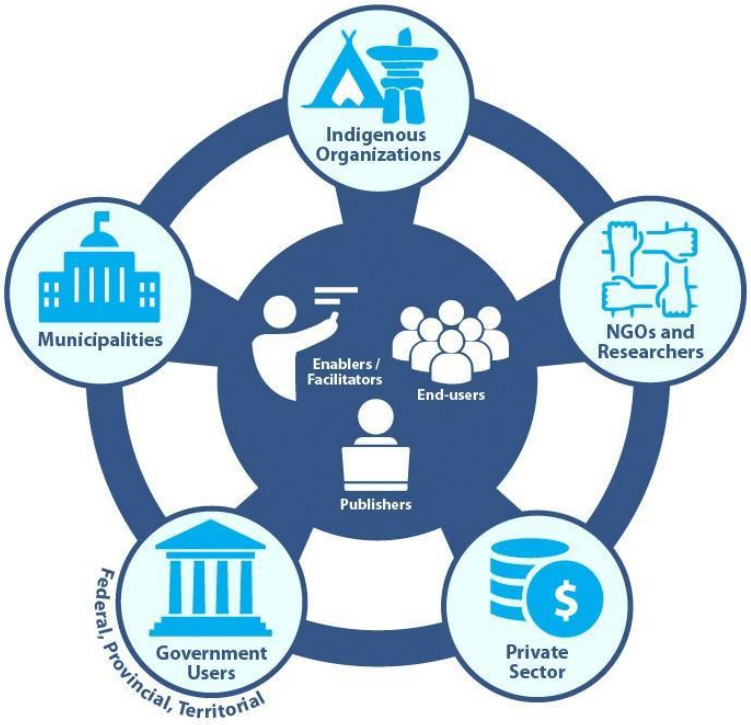


- Ability to view data over specific areas of interest without the need to download or load data outside this area.
- The data are always up to date.
- Ability to view multiple layers or data fields simultaneously.

Source: Environment and Climate Change Canada 2018

2.0 CGDI USERS

As Canadians we are all users of the CGDI. Some of the most important organizational users are municipal or regional governments, Indigenous governments or organizations, the private sector, NGOs, and research and education institutions. Formally, we also define three categories of user based on their primary role with geospatial data. An organization or individual can take more than one of these roles, and a few organizations take on all three:



Publishers create and curate geospatial data of specific interest to their constituency. They develop and share geospatial data and tools within their area of expertise. They have the right to share geospatial data within their organizations, among a group of organizations, with the public, or a combination thereof. The ways in which they publish data varies and may include direct distribution of data and tools or developing web applications.

Enablers/Facilitators provide frameworks that promote or facilitate the use of geospatial data by different users. Such frameworks may be technical (e.g., a web-based application that enables users to access geospatial information), regulatory, (e.g., guidelines on geospatial data standardization, or open data policies), administrative (e.g., acting as a moderator of users, or as manager of user privileges), or financial (e.g., provision of funding to support the development or use of geospatial data and tools).

End-users utilize geospatial data in decision making or in business and rely on applications to produce usable outputs. For example, end-users for soil data could include farmers, gardeners, researchers, scientists, municipal government officials, and staff responsible for preparing soil reports.

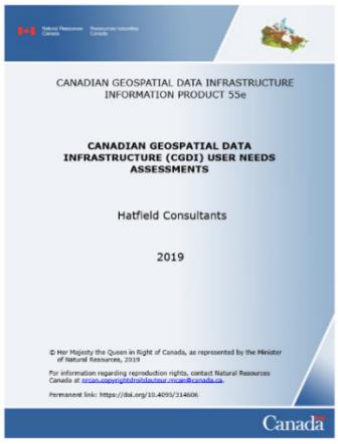
Box 2 User Needs Assessment for the CGDI.

A cross-Canada User Needs Assessment (UNA) for the CGDI conducted by Natural Resources Canada in 2018 aimed to better understand the current uses, needs, and aspirations of all stakeholders with regards to geographic information in Canada. This included government agencies, Indigenous communities, academic institutions, and the private sector.

Online surveys and phone interviews reached nearly 100 Indigenous organizations and communities, and 60 other organizations across Canada. A consultation process was completed to validate the UNA findings, and to ensure the recommendations and priorities of Indigenous organizations and communities were accurately captured. The UNA summarizes user requirements in terms of:

- Thematic Data Requirements;
- Technology, Applications, and Tools;
- Policy, Standards, and Governance;
- Training and Capacity Building; and
- Collaboration and Intuitional Arrangements.

The UNA highlights considerable interest among Indigenous organizations to increase their use of geospatial data and to participate in geospatial initiatives. The English and French versions of the UNA report are available in the CGDI Resource Centre.



Federal, Provincial, and Territorial Government Users

In Canada, all levels of government are major publishers, enablers, and users of the CGDI. Federal, provincial, and territorial governments may act as suppliers, developers, marketers, enablers, and/or consumers of geospatial data.

Governments act as publishers when they provide and publish geospatial data on online open data platforms. In the case of the federal government, this includes certain units of government compiling, maintaining, and updating geospatial data on topics of interest to them. At the same time, governments act as end users or consumers of geospatial data when they obtain and utilize data published by others. Finally, governments act as enablers when they provide a framework by which the public can access geospatial data freely or provide funding for external organizations to collect geospatial data.

User profile – Agriculture and Agri-food Canada

Agriculture and Agri-food Canada (AAFC) works with farmers and food producers to support the growth and development of the agriculture and agri-food sector. AAFC policies, programs, research and technology help farmers and food producers succeed in Canadian and global markets. Among its responsibilities, AAFC produces interactive agriculture-related maps, geospatial data, and tools, including an annual crop inventory, agroclimate data, and soils of Canada. AAFC publishes data and information on areas of Canada related to agricultural resources, production, and climate. In addition, AAFC consumes geospatial data produced by other government departments, such as climate data from Environment and Climate Change Canada.

AAFC publishes the Canadian Drought Monitor, a national drought severity map and report that AAFC publishes monthly to help farmers and food producers adjust to changing drought conditions.

Indigenous Organizations

Like the federal and provincial governments, Indigenous organizations can be publishers, enablers, or end users of geospatial data. In general, the capacity of Indigenous organizations for producing, accessing, and using geospatial data varies substantially across Canada (Hatfield Consultants 2019). According to a 2018 CGDI User Needs Assessment, Indigenous organizations most frequently act as end-users of geospatial data, downloading and consuming datasets from a variety of sources and using them for analysis and planning. However, many Indigenous organizations also produce and publish their own data, including environmental monitoring and observation, documentation of traditional uses, and delineation of traditional territory boundaries, where applicable. For many organizations, sensitive geospatial data remains restricted to members or managers, with only selective information available publicly. Some Indigenous organizations also act as enablers by administering online geoportals where users can access and download project-specific datasets, managing geospatial data on behalf of other organizations, and providing opportunities

for training and mentorship in geomatics. The First Nations principles of OCAP® are a set of standards that establish how First Nations data should be collected, protected, used, or shared.

Municipalities

Canadian municipalities play an important role in CGDI as users and publishers. While capacity for working with geospatial data varies substantially across the country, municipalities often create, publish, and share geospatial data pertaining to municipal or regional matters. As publishers, many municipalities create a multitude of maps to communicate information about traffic patterns, parking, zoning, land uses, property delineations, recreation, social services, and public transportation to residents. Some of these maps are based on data provided to them by federal, provincial, or territorial governments.

Increasingly, Canadian municipalities are also enablers for geospatial data and CGDI by creating their own online open data platforms. Through these platforms, individuals and organizations can access and download relevant geospatial data layers for their own use. Many municipalities in Canada have done so as a response to demand from residents.

User profile – Tsilh'qotin National Government

The Tsilh'qotin National Government (TNG) developed its Stewardship Portal with a strong focus on enabling (or facilitating) the use of spatial data for land stewardship and management.

The Portal allows TNG to organize and manage internal geospatial data and data contributed by external parties (such as government agencies or natural resource development companies). Users access certain datasets based on permissions determined by TNG and according to existing agreements for collaboration and data sharing.

TNG has dedicated staff who are trained in the use, processing and analysis of geospatial data and are skilled in the use of GIS.

User profile – The City of Edmonton

The City of Edmonton was an early adopter of municipal open data in Canada when it launched its open data platform in 2010. Since then, the city has published over 2100 datasets, visualizations, and maps for free use, analysis, and re-distribution.

The city's open data policy helps citizens, researchers, NGOs, and the private sector understand how decisions are made and raw data collected by the city is transformed into useful, contextual information (City of Edmonton, 2019).

Private Sector

Canadian businesses across all sectors require access to geospatial data to provide services to consumers, other private sector clients, and government. Many private sector users act as publishers and end users. A business objective may be to collect and share geospatial data with customers, clients, and regulators.

Some examples of roles that the private sector can play in CGDI are as follows:

- Commercial remote sensing companies build and launch satellites that collect images of the Earth, process images for different uses, and distribute them to clients using a web interface. They act as publishers, enablers, and end users.
- Mining companies collect geospatial data at existing or potential project sites to share with regulators, investors, and stakeholders. They act as publishers.

- Ride-hailing apps use street maps and geolocation services to help drivers locate their passengers accurately. They acquire this data from municipal, provincial and/or federal governments, acting as end-users.

NGOs and Researchers

Research and non-government organizations, such as Universities and non-profits may use and publish geospatial data based on their mandate (e.g., conservation or public health). An objective may be to conduct analyses, answer research questions, and/or share spatial data with the public, businesses, Indigenous communities, or government. Some NGOs and research institutions also enable other users by promoting geomatics education, training, and careers as part of their mandates.

User profile – Ducks Unlimited Canada

Ducks Unlimited Canada supports the development of the Canadian Wetland Inventory (CWI) with several partners.

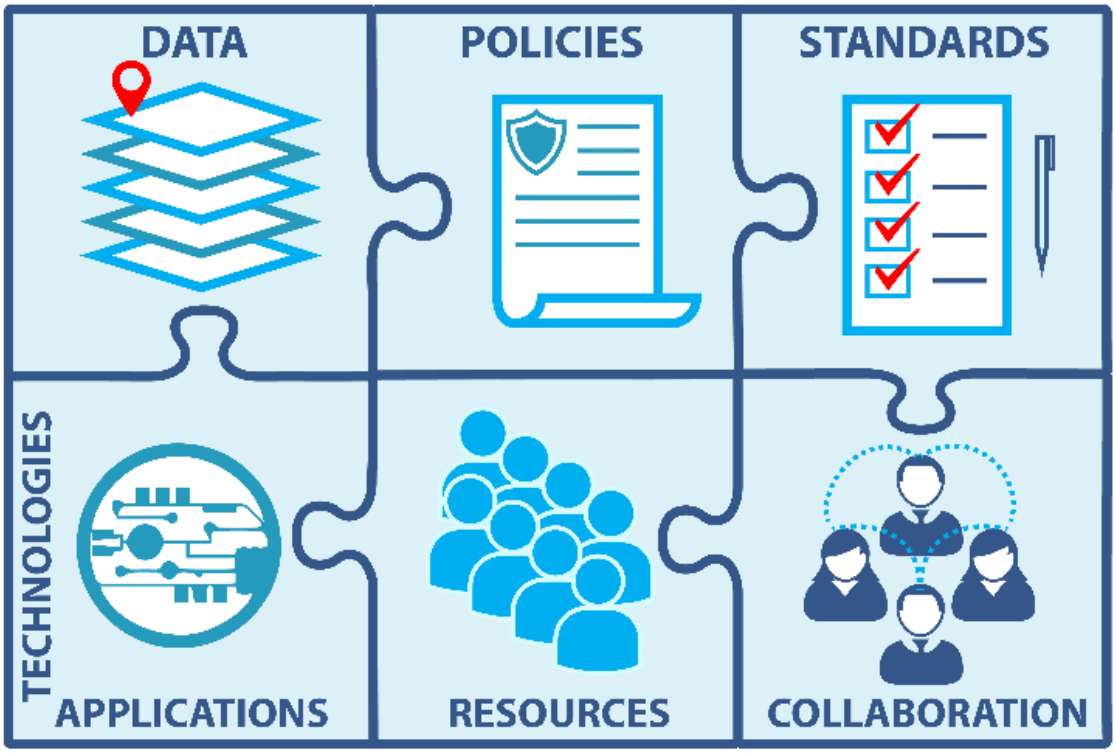
To provide access to data and CWI progress across Canada, Ducks Unlimited Canada published a CWI Progress Map that displays wetland areas across Canada. An interactive map created using several international, CGDI-supported geospatial standards identifies areas where wetland inventory data are available. The map makes wetland information readily available for a broad range of users.

3.0 COMPONENTS OF THE CGDI

The process to establish the CGDI began in the late 1990s with the aim to help Canadians gain new perspectives into social, economic and environmental issues, by providing an online network of resources that improve the sharing, use and integration of information tied to geographic locations in Canada (GeoConnections 2012).

GeoConnections is a national partnership between federal government and Canadian stakeholders in the geomatics sector. Founded in 1999, the program's mandate (see Box 4) is to lead the CGDI to provide endorsed standards-based access to shared national geospatial data as a common public asset. Priority themes are public health, energy, safety/security, environment, and matters of importance for Indigenous peoples.

CGDI refers to the collection of data, technology, policies and standards, collaborations, and human resources that is required to harmonize Canada's location-based information. This harmonization allows Canadian organizations to find, use, and share geospatial data online. In this section, we will explore each of these components.

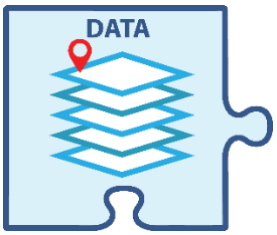


CGDI Guiding Principles

- **Open**: To enable better decision making, the CGDI is based on open, barrier-free data sharing and standards that allow users to exchange data.
- **Accessible**: The CGDI allows users to access data and services seamlessly, despite any complexities of the underlying technology.
- **Evolving**: The network of organizations participating in the CGDI will continue to address new requirements and business applications for information and service delivery to their respective users.
- **Timely**: The CGDI is based on technologies and services that support timely or real-time access to information.
- **Sustainable**: The CGDI is sustained by the contributions of the participating organizations and broad user community and through the infrastructure's relevance to these groups.
- **Self-organizing**: The CGDI enables various organizations to contribute geospatial information, services and applications, and guide the infrastructure's development.
- **User and community driven**: The CGDI emphasizes the nurturing of and service to a broad user community. These users, including Canadians in general, will drive the CGDI's development based on user requirements.
- **Closest to source**: The CGDI maximizes efficiency and quality by encouraging organizations closest to source to provide data and services. Thereby eliminating duplication and overlap.
- **Trustworthy**: The CGDI is continually enhanced to protect sensitive and proprietary data. The CGDI offers this protection through policies and mechanisms that enable data to be assessed for quality and trusted by users.

NRCan 2012

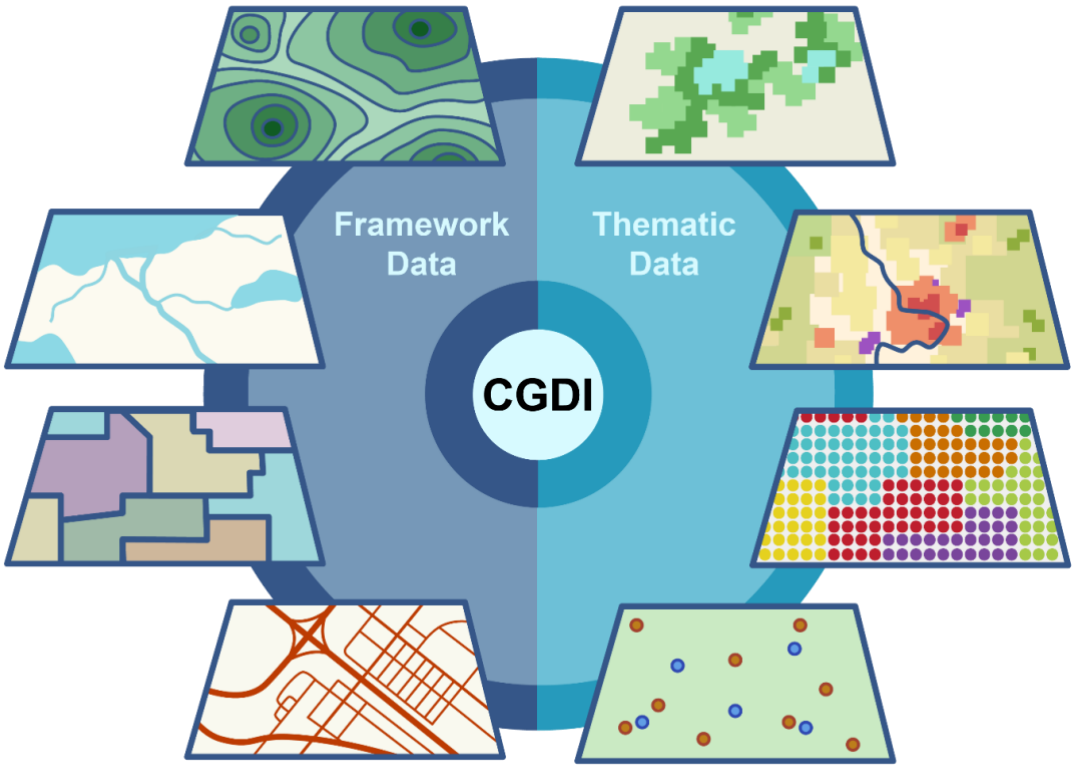
3.1 FRAMEWORK AND THEMATIC DATA



Data is a significant component of the CGDI. Geospatial data can describe key features of a place on the Earth's surface, such as elevation or the location of lakes, rivers, roads and towns or cities. These are features of the landscape that are useful to see on any map of Canada. Geospatial data can also describe characteristics that occur over time, such as changes in local weather conditions, forestry operations, or urban growth.

Framework data, sometimes called basemap data, are the essential datasets that provide context and reference for all of Canada, depicting consistent information that can be used across all sectors and organizations. Examples include the boundaries that delineate provinces and territories and physical features such lake and river systems.

Thematic data, as the name implies, are datasets that can be meaningfully grouped according to a primary theme. Depending on the perspective of the user, it is possible for datasets to be considered part of multiple themes. For example, a wetland inventory dataset might be considered an important part of a wildlife/biodiversity, climate change, or water resources thematic data. International standards encourage consistent categorization of data, e.g., the International Standards Organization (ISO) 19115 standard *Topic Category* defines general subject topics. The Open Government Portal (open.canada.ca; see Box 3) defines 18 thematic *subjects* for open data. Open Canada enables users to discover and access Government of Canada open thematic and framework data.



Box 3 Open Canada

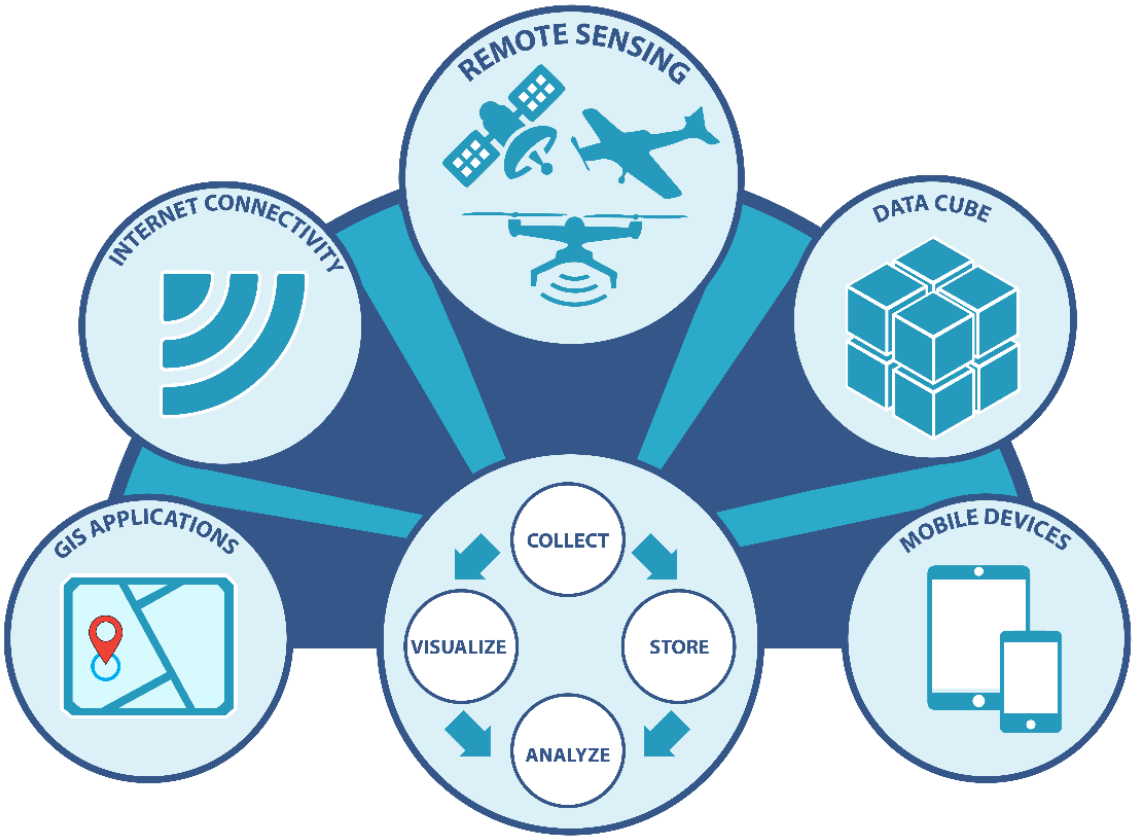
The Government of Canada (GoC) Directive on Open Government took effect in October 2014. It promotes information management practices that enable the proactive and ongoing release of government information. National Action Plans on Open Government set out the Government's commitments to improve access to government information including financial transparency, upgrading digital services and make government more open for Canadians. The planned activities are based on the principles, best practices, and accountability mechanisms established by the international Open Government Partnership (OGP). The OGP brings together government reformers and civil society leaders to create action plans that make governments more inclusive, responsive and accountable. The OGP is overseen by a Steering Committee composed of representatives of governments and civil society organizations, which Canada Co-Chaired in 2018-2019.

The Open Government Portal launched as a pilot in 2011 and relaunched at its current domain, open.canada.ca in 2014. The portal provides one-stop access to the GoC's searchable open data and open information resources. The Open Data section of the portal allows users to browse datasets by topic (e.g., health, demographics, law, language, education, etc.), by keyword search, and by using various filters (e.g., data type, jurisdiction, organization, etc.).

The Open Maps section of the portal provides access to the Government of Canada's geospatial information through the Federal Geospatial Platform and allows users to combine, visualize and analyze geospatial data and collaborate with other users.

3.2 TECHNOLOGIES AND APPLICATIONS

Many free, open-source, and commercial technologies and applications enable CGDI users to collect, store, analyze, and visualize geospatial data. As technology advances there are new ways to collect and use geospatial data, and the CGDI's adoption of internationally accepted open standards ensure that the CDGI adapts with technology development. Important technologies and tools relevant to the CGDI are summarized below.



Smartphones and Mobile Devices

Smartphones have revolutionized the way Canadians access, use, and generate geospatial information and mobile applications are critical technology for the CGDI. Across Canada, smartphones enable users to explore location-specific information and navigate, capture, and publish geospatial data. The standards supported by the CGDI help to ensure that users of smartphones and their apps have access to and integrate geospatial data.

Location-based services are critical to many businesses, individuals, and government organizations to obtain information from users where activities take place. For example, organizations working in marketing may obtain information about their customers, skiers may obtain information about avalanche conditions, and drivers may obtain information about road congestion.

Geographic Information Systems Software and Applications

A plethora of free open source software and commercial software systems and applications enable us to make and view digital maps, and perform powerful geospatial analyses. International geospatial standards adopted by the CGDI ensure applications can read and store numerous data types and metadata standards that are used by different software applications.

Remote Sensing

Remote sensing technology encompasses hardware, software and analytical capabilities to acquire, process and deliver remotely sensed data. Common platforms are satellites, aircraft and drones, which can carry a variety of sensors to record data.

Satellite sensors acquire images of the Earth's physical features and environment from space. An ongoing revolution in satellite remote sensing provides users with numerous advances in spatial resolution, spectral information, frequency of observation, and cost-effectiveness provisioned as open data. In Canada, remote sensing data is used by government agencies and public institutions to create and update key framework and thematic datasets.

Drones or remotely piloted aerial systems (RPAS) are another area of rapid innovation in remote sensing. The companies, platforms and capabilities of systems, not to mention the rules around their use, are evolving rapidly. The emergence of small, affordable drone technology and advances in highly automated mapping promise new data capture capabilities.

Other types of remote sensing can include weather sensors that collect information about temperature, wind, and precipitation, and sensors for intelligent transportation systems.

Internet and Connectivity

Location-enabled devices and use of Internet-enabled services are a key part of the digital revolution. High-speed Internet and mobile communications networks are important for the CGDI, allowing us to access and share geospatial data over the Internet. Our connectivity is supported by technologies such as direct service line (DSL), or cable and wireless technologies, such as mobile or satellite broadband.

Most Canadians (82%) have Internet access that meets the minimum performance standard established by the Canadian Radio-Television and Telecommunications Commission (CRTC), which is 50 megabit per second download and 10 megabit per second upload (CRTC 2016). Canadians without high speed Internet access, most of whom live in rural and remote communities, may not be able to benefit from the same geospatial services and applications. Therefore, it is important that Internet and connectivity continues to improve and become more affordable, while developers of CGDI applications consider users that have relatively low Internet speeds.

3.3 POLICIES

Policies are a broad range of practical instruments such as guidelines, best practices, directives, procedures and manuals related to how geospatial data is produced, accessed, maintained, and shared. Organizations working with geospatial data benefit from understanding and adopting policies that allow data to be used by many users for many applications (Natural Resources Canada

2014). GeoConnections develops a range of guidelines, best practices, and directives that apply to day-to-day operations as well as the legal and administrative requirements for managing data access, quality, ownership and integrity.

The CGDI Resource Centre contains a wealth of information on policies, including several primers on topics that are typically of high interest for users of spatial data infrastructure, such as privacy. Organizations may adopt CGDI operational policies or use them as a base to create their own SDI policies (Table 1). For example, policies related to organizational data sharing, data archiving and retention, software access, and training. Many public sector organizations use open data policies to make their data available publicly and free of charge.

Table 1 Selected policies and primers available in the CGDI Resource Centre.

Document Title	Policy Topic	Date
Intellectual Property Law Backgrounder	Protected Information	2011
Best practices for sharing sensitive environmental geospatial data		2010
Geospatial privacy awareness and risk management guide for federal agencies		2010
The Geospatial Data Quality Guide	Access, Management and Dissemination	2016
Geospatial Data Preservation Primer		2015
How to Share Geospatial Data Primer		2012
Free and Open Source Software licensing primer		2012
Primer on the Policy Implications of Cloud Computing		2012
Archiving, Management, and Preservation of Geospatial Data		2005

The First Nations Principles of OCAP® are an example of policies governing ownership[1]. The principles provide overarching guidance with respect to individual and collective ownership of data and information, control over data and information management, access to data and information, and possession as the mechanism for facilitating ownership. The CGDI Resource Centre provides an Open Data Report on Dissemination of open geospatial data under the Open Government Licence – Canada through OCAP® principles (The Firelight Group 2019). The report explores the opportunities and challenges of opening Indigenous data and the benefits, limitations, and contradictions of First Nations geospatial data within an open data regime. Specifically, the research aims to examine how, or if, the Government of Canada can observe OCAP® principles while disseminating First Nations geospatial data under Open Government Licence – Canada.

3.4 STANDARDS

To communicate and share geospatial data we need our systems to follow a common language. Using application communication and data standards helps users to integrate different data sources, applications, and systems.

Geospatial standards are technical documents that provide details about interfaces or encodings, principles or rules that establishes norms for technical systems. For most CGDI users, standards are invisible since they are primarily used by software developers or data producers to build geospatial applications or products. However, compliance with these standards ensures key CGDI

[1] *OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC).*

framework and thematic datasets are discoverable and usable across disciplines, jurisdictions and organizations.

If each province and territory in Canada used a different set of geospatial standards, it might not be possible to add geospatial data delineating their boundaries to a map at all, or boundaries might be in a different place for every province and territory. Imagine if the border between the Yukon and Northwest Territories was in a different place depending on which territory or source you accessed the data from!

The following key standards categories (semantics, syntax and encodings, and services) are utilized in CGDI to support interoperability (NRCAN 2019).

Semantics

In the context of geospatial data, semantics refers to the meaning and structure of concepts used to represent various geographic phenomena. Standards in this category provide information on the properties of the datasets as well as their context. Metadata captures the basic characteristics of a geographic data or information. The **North American Profile of ISO 19115:2003** – Geographic Information – Metadata was prepared to meet the specific geographic needs of data producers and users in Canada and the United States of America.

Syntax and Encodings

The syntax of geospatial information relates to how the information is coded to allow communication between systems. The syntax is the encoding format used for the transfer and the visualization of geographic data. Rules in encoding standards allow spatial information defined in an application schema to be coded into a system-independent data structure suitable for transport or storage. Encoding rules specify the types of data to be coded, and the syntax, structure and coding schemes used in the resulting data structure, which may be stored on digital media or transferred using transfer protocols. An example encoding standard is **Keyhole Markup Language** which is popularised due to its association with Google Earth, a common software application used to browser satellite images of the Earth. Keyhole markup language is an XML language for expressing geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers.

Services

Standards for web services provide capabilities for manipulating, transforming, managing, or presenting geographic information. The goals of web service interoperability are to provide seamless and automatic connections from one software application to another and the seamless flow of data between web-based applications and services. Web services encapsulate linguistic resources and tools and combine them in a common service-oriented architecture. Examples include **Web Map Service** (WMS), **Web Feature Service** (WFS), and **Catalogue Services for the Web** (CSW).

3.5 COLLABORATION

Collaboration and partnerships are fundamental to the CGDI and a key driver for its development – without collaboration between users, the access, creation, sharing, and integration of geospatial data and technology would be much more difficult. Collaboration using the CGDI provides many benefits such as to reduce duplication of effort and to maximize the value of investments that Canadians have made to create data and applications. The Meteorological Service of Canada development of GeoMet to provide access to meteorological data (see Box 1) shows how open geospatial standards can enable collaboration. Some other examples of collaboration to develop and share geospatial data to benefit Canadians are illustrated below.

National Hydrometric Program

This program provides for the collection, interpretation, and dissemination of surface water quantity data and information that is vital to meet both water management and environmental needs across the country.

The hydrometric program involves agreements between ECCC and each of the provinces and territories. An important component is commitment of the partners to maintain national standards, develop hydrologic expertise, implement efficient modern technology, and provide water resource data and information to all those who need it.

Canadian Land Cover Data Project

The objective was to use existing land cover data from provincial and federal organizations to produce a harmonized database consistent with international standards.

Led by Agriculture and Agri-Food Canada (AAFC), a land cover community of practice was formed to address the challenge to reconcile the various classifications and semantics into one consistent set of classes that meets national needs.

Product definition primarily involved the Mapping Information Branch of Natural Resources Canada, in collaboration with AAFC and the Canadian Forest Service (CFS). Product implementation was completed by the Mapping Information Branch. Other partners included the Canadian Space Agency (CSA) and Government of Ontario.

Alberta Merged Wetland Inventory

The Alberta Merged Wetland Inventory depicts wetlands within the province of Alberta for the period 1998 to 2015 classified to the Canadian Wetland Classification System (CWCS) at the major class level: marsh, bog, fen swamp, and open water.

35 component wetland inventories were merged to create this wetland inventory product. These individual wetland inventories utilized four different wetland classification systems with different source imagery and different resolutions. They were reclassified to the CWCS five major classes.

Key partners included Alberta Environment and Parks, Ducks Unlimited Canada, and Environment Canada.

3.6 HUMAN RESOURCES

The CGDI wouldn't work without knowledgeable users, but this does not mean everyone needs to be a GIS or Remote Sensing expert. Most Canadians are already users of the CGDI – even if they do not realize it. Many organizations that use geospatial data benefit from people with the skills to collect, analyze, interpret, share, and manage geospatial data. If you're looking to develop your CGDI knowledge, skills and capacities, the following checklists are a good place to start.

Useful skills and capacities for new CGDI users

Data

- Navigate online geoportals to find relevant spatial datasets
- Manage collections of geospatial datasets
- Create GIS data from field surveys

Using GIS Software

- Produce maps and symbolize different layers
- Conduct simple GIS analysis such as buffer or overlay

Remote Sensing

- Obtain images from online sources
- Interpret base satellite images

Policies and Standards

- Understand metadata
- Understand or develop geospatial policies

Useful skills and capacities for CGDI advanced end-users and publishers

Data

- In-depth knowledge of data sources in Canada
- Data management including geospatial databases and metadata
- Quality assurance and quality control of datasets
- Make data available as a spatial web service

Using GIS Software

- Conduct complex GIS analysis including the use of scripts for analytics
- Produce web maps and web services

Remote Sensing

- Process satellite images to create thematic maps, e.g., land cover
- Integrate time series of images to assess change

Policies and Standards

- Create metadata compliant with metadata standards
- Implement and develop geospatial policies

4.0 LEARN MORE AND GET STARTED

To support new and existing users of the CGDI, Natural Resources Canada has supported the development of a **CGDI Cookbook** and additional training resources, so that organizations and individuals can advance their knowledge and become proactive CGDI stakeholders. The CGDI Cookbook contains a series of recipes for new and advanced CGDI users and publishers.

The CGDI Cookbook is intended to help new and current users of geospatial data increase their understanding of spatial data infrastructures and to recognize the benefits and advantages of participation in the CGDI. The information in this Cookbook may be useful to a variety of roles and functions within organizations, including new or in-training geomatics practitioners, environment and lands managers, data managers, planners, policy analysts, researchers, and social and environmental service providers. This Cookbook describes the components of the CGDI and provides step-by-step "recipes" related to data, technology, policies, standards, partnerships, and human resources.

NRCan is also piloting the concept of **CGDI Starter Kits**, which are designed to help new and novice CGDI users to quickly get started and begin to obtain value out of geospatial datasets available through the CGDI. The Starter Kits includes:

- A curated catalogue of existing, open framework and thematic geospatial data according to geographic areas or themes (e.g., climate change, water resources management).
- Downloadable Starter Kit data packages formatted to be easily opened in desktop GIS applications (e.g., ArcGIS and QGIS).
- Technical guidance on using the Starter Kit, including how to access linked datasets via spatial web services and downloading to a local computer/server.
- Links to existing or complementary activities and resources, such as the CGDI Cookbook.

5.0 ACRONYMS

AAFC	Agriculture and Agri-Food Canada
CFA	Canadian Forest Service
CSA	Canadian Space Agency
CGDI	Canadian Geospatial Data Infrastructure
CRTC	Canadian Radio-Television and Telecommunications Commission
CWCS	Canadian Wetland Classification System
DEM	Digital elevation model
DSL	Direct service line
ECCC	Environment and Climate Change Canada
GIS	Geographic information system
ISO	International Organization for Standardization
MOU	Memoranda of Understanding
NGO	Non-government organizations
OGC	Open Geospatial Consortium
RPAS	Remotely piloted aerial system
SDI	Spatial Data Infrastructure
TNG	Tsilhqot'in National Government
UNA	User Needs Assessment
WFS	Web Feature Service
WMS	Web Map Service

6.0 GLOSSARY

Application	A program or software that is designed and coded to perform a certain function for the user.
Bandwidth	The rate of data transfer in computing, measured in bits per second. Bandwidth is often used as a measure of Internet performance.
Basic GIS skills	Describes CGDI users who can comfortably view and use maps as part of their profession. Users may use GIS software to create maps and perform basic operations such as map overlay and identification of features occasionally (e.g., once per month).
Buffer	A basic GIS operation that creates a zone or space around a feature on a map, typically measured in units of distance or time.
Catalog	An application that is used to organize and manage metadata.
Commercial software	Software that does not have source code that is publicly available. Commercial software is typically built by individual developers or companies and sold to users.
Computer suitable for running GIS software	Most GIS software applications have requirements for hardware and software. It is always a good idea to review these before downloading or purchasing software. In general, computers running GIS software should have the following specifications: ▪ at least 8GB of RAM; ▪ CPU speed of 2.2 GHz hyper-threading (HHT) or multi-core; ▪ at least 500GB of hard drive storage; ▪ a 64-bit operating system; ▪ a 3D graphics card if 3D imaging will be utilized.
Data format (geographic)	A way of encoding geographic information into a digital file. Some geographic data formats include: Shapefile, GeoTIFF, and Keyhole Markup Language (KML).
Data portal/geoportal	A type of web portal used to find and access geospatial data and associated services and applications (e.g., to view or analyze data) via the Internet. Geoportals are a key element of the CGDI. The federal government has a national geoportal at open.canada.ca; and most provincial and territorial governments have geoportals where users can access regional data.
Data quality	Refers to completeness of the dataset, processes used to create and maintain it, and amount of validation or verification performed on the dataset. ISO 19157:2013 is an international standard that establishes principles for describing the quality of geographic data.
Digital Elevation Model	A way of capturing elevation using a bare-earth raster grid referenced to a vertical datum.
Expert GIS skills	Describes CGDI users who advanced skills in GIS analysis, visualization, and computing. Expert users typically have formal training or advanced degrees in geomatics, and work with complex geospatial datasets daily.
Framework data	Framework data are the essential datasets that provide context and reference for all of Canada, depicting consistent information that can be used across all sectors and organizations. For example, the boundaries that delineate provinces and territories and physical features such as lakes and rivers are framework data.
Geomatics	The discipline concerned with the collection, distribution, storage, analysis, processing, and presentation of geographic.
Geospatial data	The information that is used to describe a place, object, or event on the Earth's surface.

GIS software	A Geographic Information System (GIS) is a framework for gathering, managing, and analyzing location-based data. It organizes spatial information into layers and visualizes them using maps. GIS software includes computer programs and applications that allow people to use a GIS. Some examples include Esri ArcGIS and QGIS.
High-speed internet	Internet access that meets the minimum performance standard established by the Canadian Radio-Television and Telecommunications Commission (CRTC): 50 megabit per second download and 10 megabit per second upload.
Intellectual property	The legal right to ideas, inventions, and creations in the industrial, scientific, computing, and artistic fields. Intellectual property in the geospatial data field can include datasets themselves as well as applications or programs.
Intermediate GIS skills	Describes CGDI users who can comfortably work with geospatial data as part of their profession. Users may have formal training in GIS and use software to analyze and visualize geospatial data and perform advanced operations using statistical analyses regularly (e.g., more than once per week).
Licence	The permit or authority to own or use geospatial data or a geospatial product.
Metadata	Information that describes a geospatial dataset. Reading metadata can give a user information such as: the source of the data; the date and time that it was collected; and the type of map projection it uses.
Open Data	Structured data that is machine-readable, available at no cost, and encouraged to be used and built upon without restriction.
Open Geospatial Consortium (OGC)	An international voluntary organization that builds consensus on developing and implementing open standards for geospatial content and services. OGC has hundreds of member organizations across the globe from governments; multi-lateral institutes; universities and colleges; private companies; and NGOs; who collaboratively develop and promote geospatial standards.
Open source software	Software that people can download, inspect, modify and enhance freely. Software is considered open source when its source code (the computer commands that make up the software) is publicly available.
Overlay	In geomatics, an overlay is a basic operation in which two or more maps or layers covering the same geographic area are superimposed on top of each other, with the objective of showing the relationships between features that are in the same geographic space.
Policies	A broad range of practical instruments such as guidelines, best practices, directives, procedures and manuals related to how geospatial data is produced, accessed, maintained, and shared.
Radar sensor	In satellite remote sensing an active system that emits microwave energy and measures the energy reflected (or backscattered) from objects. As the radar satellite platform orbits a two-dimensional image of the surface is developed.
Raster data	A type of data model that represents features on the Earth's surface using a grid of individual cells, each containing information such as temperature or chemical composition.
Remote sensing	Hardware (sensors), software, and analytical capabilities used to acquire, process and deliver remotely sensed data from satellites, aircraft and drones to name a few.
Shapefile	A simple, nontopological format for storing the geometric location and attribute information of geographic features.
Spatial accuracy	Describes how close the information about a feature on a map matches its real-world position or characteristics.
Spatial resolution	Refers to the level of detail in a geographic digital image. It is usually expressed as pixels per line, dots per inch, lines per millimeter, etc.

Spatial data infrastructure	The collection of data, technologies, policies, standards, and institutional arrangements that facilitate the production, use, and sharing of geospatial data at the organizational, national, or international level.
Standards	Geospatial standards are technical documents that provide details about interfaces or encoding and allow systems to follow a common language.
Tabular data	Data that describes features on the Earth's surface using information sorted into columns and rows.
Thematic data	Sector or theme-specific data such as forest cover or population density. Thematic datasets are typically layered with framework or basemap data.
Vector data	A type of data model that represents features on the Earth's surface using points, lines, and polygons.
Web Services	A way of sharing a georeferenced map image over the internet. Two commonly used Web Services that are endorsed by CGDI include: ▪ Web Mapping Service (WMS) – includes a standard protocol or set of rules that computers follow to read and display raster information without the user needing to download it locally. ▪ Web Feature Service (WMS) – includes a standard protocol or set of rules that computers follow to read and display vector information without the user needing to download it locally.

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